ReNew

Beyond 2030: India Ready to Scale

Laying the manufacturing, infrastructure and work-force foundations for India's next renewables surge.

A POLICY NOTE



Foreword

India has made significant achievements in leading the global energy transition. The addition of over 170 GW of non-fossil fuel capacity in less than eight years is a testament to bold targets and visionary policies. In a remarkably short time, we have built the world's third-largest renewable energy footprint, powered largely by domestic capital and demand.

But our work is far from over. As we look towards our ambitious goal of 500 GW of non-fossil fuel capacity by 2030, and further towards Viksit Bharat by 2047, the time to prepare for our next great leap is now.

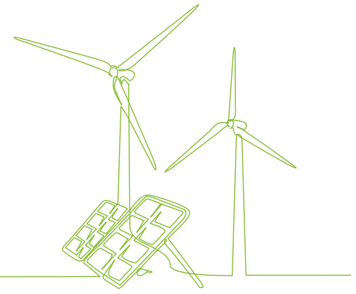
India is well-positioned for this next chapter. We have fundamental strengths: a supportive ecosystem for growth, the immense potential of our workforce, and our rising influence on the world stage. But geopolitics, technology, capital flows, and competition are evolving rapidly. Some disruptions may pass, but others will reshape the global landscape for years to come. To lead through this change, India must adopt a clear strategic lens—identifying emerging opportunities, anticipating risks, and charting a resilient path forward.

I hope this paper informs our collective approach. While it must be deliberated with care, what matters most is that it leads to decisive action—so India continues to lead the world in renewable energy, not just in ambition, but in execution. At ReNew, we have contributed to India's renewable energy journey for the last 15 years of our existence and we are committed to doing so in the future as well.

Sumant Sinha
Founder, Chairman and CEO, ReNew

ReNew

15 YEARS OF ENERGY. IMPACT. TRANSFORMATION.





Executive Summary

Aim of this Report

This report is a prompt to act now to lay the foundations for India's post-2030 clean energy surge, seizing economic opportunities and fortifying energy security on the path to *Viksit Bharat, a developed India,* by 2047.

India's rapid, policy-driven growth has already pushed it past key Paris Agreement milestones ahead of schedule. With visionary leadership and bold action, India is now a global front-runner in the clean energy transition. This paper looks ahead 10 years and outlines how India can sustain momentum, navigate global market shifts, and secure long-term leadership in renewable energy. The emphasis is on long-lead initiatives that must be set in motion now to deliver impact beyond 2030. Measures to address shorter-term operational matters have not been dealt with here.

Major Trends Shaping the Next 10 Years

Accelerated Domestic Deployment & Scale:
India is set to add renewable energy capacity at unprecedented rates, with an average of 50+ Giga Watt (GW) annually targeted post-2025. This will rise to 75–100 GW annually through the 2030s to align with the vision of the Viksit Bharat. This is more than the capacity India, the US and Australia cumulatively added in the year 2024. This scale of deployment will need an associated surge in the underlying infrastructure, materials, workforce and capital.

Accelerated International Deployment & Scale:
Global solar deployment is set to nearly triple to 1,000 GW annually by the early 2030s[1]. Half of this will be outside China. Sixty percent of this half, equal to about 300 GW will be in traditional markets such as the US, EU and Japan. Emerging economies across Africa and South America will collectively constitute about 100 GW deployment per annum – similar in scale to India. Both sets of countries will present export opportunities in specific segments of the market.

Geopolitics is re-shaping longer term export and technology access opportunities:
The US is focusing on building its own supply chain and is likely to maintain high tariffs long-term. The EU and Japan aim for independence in key areas like solar cells and rare earths, while sourcing other components globally. Both are investing in innovation to reduce reliance on China. Europe in particular, is seeking partnerships to build manufacturing supply chains leveraging their innovation. India, with it's large domestic market and fundamental manufacturing strengths is well-positioned to be a strategic supplier. This also provides an opportunity for it to access critical technologies.

Rising competitive intensity and the China factor:
South East Asia and the Middle East are fast becoming key cleantech exporters, fueled by strategic investments and evolving trade ties. Meanwhile, China is intensifying

its export-led growth, defying expectations of a pivot to domestic consumption to absorb surplus capacities, that advanced economies expected to nudge it towards through trade barriers. By redirecting trade to ASEAN and African markets and tightening controls on advanced technologies and industrial inputs—backed by robust state financing. Beijing is reinforcing its global footprint. This trajectory signals a future of heightened trade tensions, with more protectionist measures and intermittent disruptions likely across major economies. It highlights the need for India to build strategic partnerships and domestic capabilities to ensure resilience and counter-responses.

Technology Shifts:
Solar is now and likely to remain the dominant force in global energy, powered by rising efficiency, pairing with cheaper storage, and growing use of green fuels. Battery prices fell 20% in 2024, boosting renewable integration. India's green ammonia costs hit record lows, closing the pricing gap with fossil-based ammonia. Spend by countries on clean energy innovations has doubled in the last 3 years and innovation in solar, hydrogen, AI-driven grids, and storage will define future energy leadership.

Persistently Volatile Capital Flows and Deepening Capital Base in India:
India is a top global FDI destination, but persistent geopolitical risks and US interest rate volatility may affect foreign inflows. Fortunately, domestic capital, already funding 70% of renewable energy needs, remains stable. US$9 trillion is expected to enter India's financial markets by 2035, due to rapid economic growth and high financial savings rate[2]. There is an opportunity to channelize this investment towards renewables, with financial and electricity sector reforms that enable more institutional capital to generate the scale of equity and low-cost debt capital.

Industrial Decarbonization Demand: Carbon pricing covered 27% of global emissions in 2024, and more countries are adopting taxes, trading schemes, and CBAMs. With 25% of global emissions tied to trade and the gaining profile, a global CBAM regime is likely to emerge, especially for industrial goods. Smart negotiation at an early stage can unlock major export opportunities for India's clean energy-based molecules.

Skills Gap: In 2023, the total clean energy jobs in India reached 1.02 million, with a potential to reach 3.4 million jobs by 2030. India has shortfall now, that is expected to widen with growing deployment. We also need to bridge the productivity gap to be competitive. The Solar PV module output per worker/year in India is approximately 25-30 MW compared to 40-50 MW in countries like China and Germany.

Strategic Pillars for Future Readiness

India's energy transition beyond 2030 hinges on its ability to execute at scale, innovate across technologies, and mobilize its workforce. Recommendations across three foundational areas are listed below.

Manufacturing: Shift from capacities to building global competitiveness. India's solar manufacturing base is expanding, inching towards self-sufficiency for current demand in downstream components of the value chain (e.g. modules, cells). To meet the significantly higher domestic demand and seize export opportunities in the next decade, 4 policy priorities are recommended:

- **Catalyse significant investment across upstream parts of the supply chain** (wafers and polysilicon) through **domestic content** requirements and non-tariff barriers. MNRE has already deepened the value chain by proposing ALMM for wafers to be implemented by 2028. These will form the strategic core to both the semiconductor and cleantech industries – the main growth drivers over the next decade.
- **Drive down production costs** by proactively developing emerging disparate solar manufacturing clusters into integrated zones with co-located upstream and downstream players. These zones must be with reliable, low-cost power access, shared infrastructure and streamlined logistics to unlock cost efficiencies.
- **Launch a well-funded Solar Innovation initiative,** aimed to build ecosystem for India's leadership in next generation technologies. The initiative may include R&D support through the recently created Anusandhan National Research Foundation , carve-outs within the PLI scheme to drive private investment into non-silicon technologies, and establishment of Solar Innovation Zones near manufacturing clusters.
- **Accelerate solar export growth** by forging strategic trade partnerships with premium markets like the EU, US, and Japan through licensing, joint development and standards alignment. Simultaneously, make entry into emerging markets such as Kenya, Ghana, Tanzania, Colombia, and Peru (that are not tied to China and/or the US) with bundled technology-finance solutions for niche opportunities (e.g. solar applications in rural electrification, mining operations, and rooftop solar). Over time, build commercial depth and terrain familiarity to seize the more meaningful opportunities as ticket sizes and scale of deployment increase in these countries.

Rapidly Build Smart, Flexible Grids to Absorb Renewables at Scale and Cut Costs:
India needs to build 162,600 circuit kilometres of transmission lines (equal to 30% of its current capacity) between 2025 and 2032 to absorb the new renewables deployment envisaged. This amounts to building 56 circuit km of lines per day, an unprecedented rate of expansion. At the same time, the grid must be smarter, more flexible, and more resilient to accommodate the intermittent renewables. 4 strategic priorities are recommended:

- **Shift to 'Ahead of Demand' Transmission Building:** India must shift from reactive grid building to planning and constructing transmission 'before' renewable projects emerge. This will ensure capital efficiency and avoid stranded assets. This necessitates reforming the five-year planning process for both national and state grids, and significantly increasing investment in state-level infrastructure
- **Build transmission projects critical to the national grid through the Regulated Tariff Mechanism.** This will allow the Central Transmission Utility to build these projects. It can build these faster, enabled by a mix of statutory authority, administrative coordination, and streamlined compensation rules—advantages that private developers typically lack. Strict timelines for completion and accountability need to be placed too.
- **Accelerate build-out** of HVDC corridors, digital substations, and dynamic line ratings. to integrate 600+ GW of renewables by 2032. Streamlined execution through single-window approvals, Right of Way (RoW) reform, and inter-agency coordination.
- **Modernize market design** via smart meters infrastructure, time-of-use pricing, and demand response to improve grid flexibility and financial sustainability.
- **Scale energy storage** to 100 GW / 362 GWh by 2032, co-located with RE generation to reduce curtailment and enhance utilization.

Human Capital Development: Building a Future-Ready Workforce:
India's clean energy journey will stand on the shoulders of a highly productive workforce. A bigger, more automated, highly cost competitive and geographically diverse renewable energy sector requires India to achieve four shifts over the next five years

- **Build a wider base of 'specialist' and 'generalist' pool of people** especially for large scale deployment at the decentralised level, by expanding local skill hubs in high-potential states, aligned with national programs like Suryamitra and PM Surya Ghar.
- **Integrate skilling with schemes** by linking eligibility for PLI and VGF to workforce development outcomes.
- **Build a pool of digital and tech savvy workforce** leveraging India's rising strengths in Global Capability Centres. These GCCs can focus on leveraging academic partnerships, developing micro-credentials with existing institutions/ universities, and helping STEM graduates become site-ready specialists
- **Build a talent pipeline in Quantum Computing,** which is emerging as the next disruptor in the energy sector. It offers potential for breakthroughs that classical systems can't match, in areas like energy systems optimisation, simulation of advanced materials, management of big data sets from renewables and smart grids.

With bold vision, deep-rooted strengths, and strategic action, India must lay the foundation for its next renewables surge—one that will redefine global leadership in clean energy for decades to come.



01

Introduction

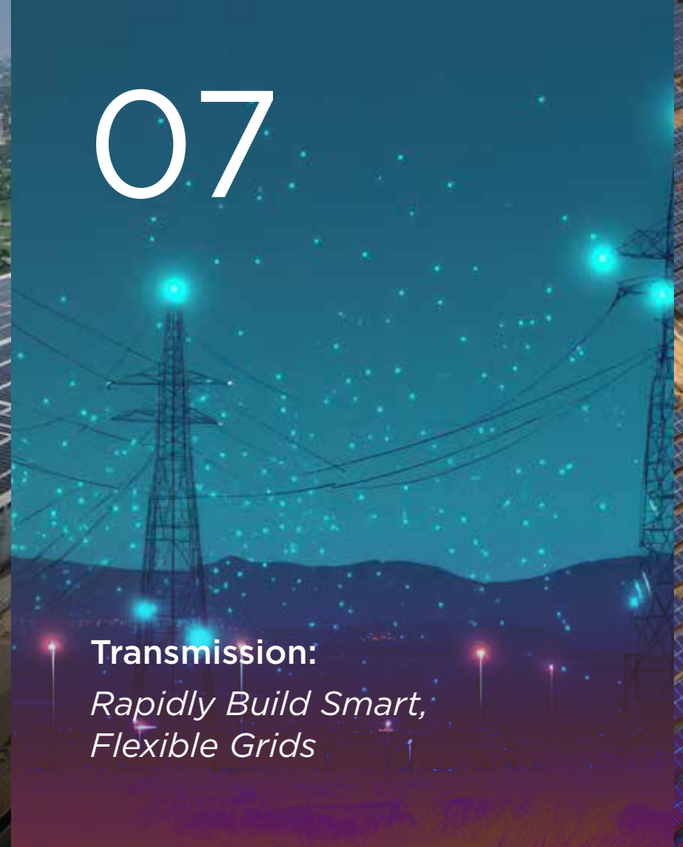
India's energy transition is integrated with the global environment, trade policies, and a new phase of clean technology competition. along with a focus on policy leadership, and growing solar PV manufacturing



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Manufacturing:

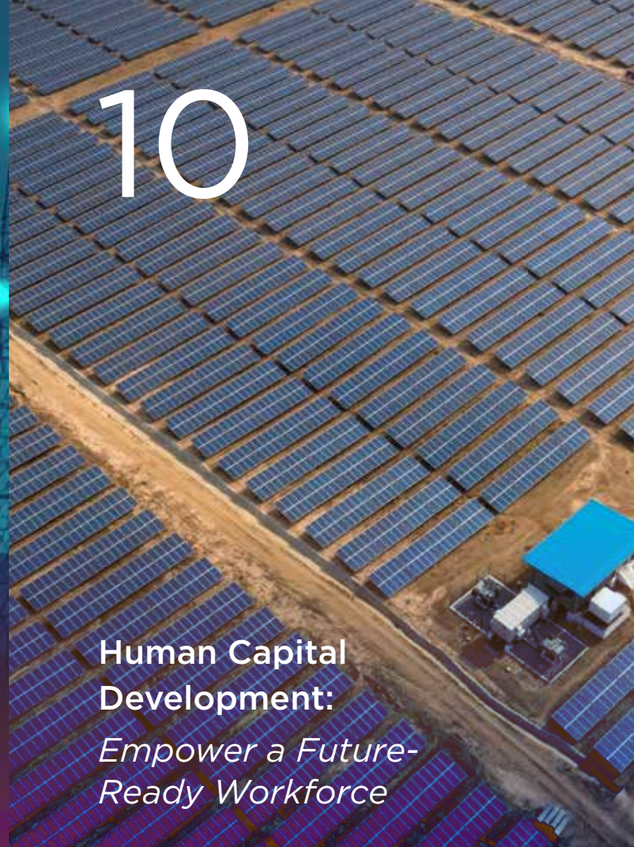
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4. Build a talent pipeline in Quantum Computing

Introduction

India had set it's targets high for the clean energy transition in the Paris Summit. Since then, the policies have been set in the right place, setting the stage for capital investments into shifting the energy mix to renewables. The targets set were 500 GW non-fossil fuel capacity[3] and 50% of installed capacity to be non-fossil fuel based by 2030[4]. In June 2025, India had ~242 GW of non-fossil fuel capacity installed, already exceeding the 50% target 5 years in advance[5]. The pace of execution has been accelerating, adding ~29 GW in the first 7 months of 2025, same capacity as was added in entirety of 2024[6].

Policy leadership has driven rapid execution, cementing India's global standing. The country now ranks 4th in total renewable energy capacity, 3rd in solar and 4th in wind[7]. Solar capacity growing at ~36% CAGR along with the strides made in green hydrogen (GH), energy storage and electric mobility showcase that it's not just about execution but also shaping global narratives. The National Green Hydrogen (GH) Mission was launched in 2023 to develop 5 MMTPA of GH with an outlay of ~$ 2bn by 2030[8]. More than 40 KTPA of GH offtake and 3 GW of electrolyser manufacturing have been awarded. In green ammonia, SECI has tendered over 720 KTPA at record prices of ~INR 50/kg (~$600/t)[9]. The Prime Minister's "Panchamrit" commitments and the momentum since COP26 provide a credible platform for long-term leadership.

India is also preparing itself for the high intermittency with dedicated transmission and focus on storage. In the last 2 years, the Indian grid expanded by ~25,000 circuit kilometers (ckm)[10], nearly equivalent to the entire transmission of the United Kingdom. Over 140GWh of energy storage has been tendered out in the same time across both long duration (6-8hr) pumped hydro projects and short duration (2-4hr) battery energy storage with a target of 235GWh by 2030[11].

India will need to more than double the annual deployment of renewable energy to stay on track for the Viksit Bharat agenda: To align with a 90% renewable share of installed capacity by 2047, much smoother execution is imperative. A total system size of nearly 2,100 GW with ~1,800 GW from renewables requires adding ~1,500 GW from 2025 to 2047. This would entail building ~80 GW capacity annually to account for additional requirements of repowering, retirement and variability reserves. This scale of deployment will need associated step up in the underlying infrastructure, materials, workforce and capital[12].

Rapidly growing Solar PV manufacturing, mature wind turbine manufacturing and cost-effective green molecules ecosystems poise India for exports growth. Through policy push like domestic content requirements, over 100 GW of Solar PV modules manufacturing[13] has been set up with progress being made vertically integrating into cells. Results from recent procurement auctions indicate that costs of Green Hydrogen and its derivatives are declining faster than expected, placing India to be a competitive player as an exporter to the EU in the CBAM regime. India has also started to develop value chains of energy transition materials like lithium and cobalt, and refining industry is expected to achieve scale by 2030, if the industry is protected through tariff and non-tariff barriers. India will, however, continue to rely on imports for ores for the foreseeable future.

India's energy transition is integrated with the global environment where trade policies are ever evolving, currency dynamics are changing, and a new phase of clean technology competition. India is getting affected by protectionist measures by countries like China, as it sees higher costs and extended delivery timelines for several inputs and machinery for solar, batteries and electric vehicles. Simultaneously, selective duty reductions and free trade agreements are opening alternate corridors. Tariff escalations in the United States across solar modules, wind turbines, transformers, and battery components is complicating market access for Indian exporters. Newer regions like Southeast Asia and Middle East are developing manufacturing hubs mainly focused on exports. This could go both ways for India. On the one hand export opportunities are expanding competitively in some markets, whereas on the other hand import costs and availability of key components like critical minerals, polysillicon remain sensitive to trade barriers, and foreign exchange.

Global energy demand remains on an upward path through the decade, led by electrification, heating / cooling, and data center demands. As global electrification accelerates, electricity demand in major economies is set to surge. Prospects of lower gas prices might affect the transition to clean electricity tougher in economies of North America and Europe, but overall electricity demand rise will still be significant.

Several technology and cost signals deserve attention. Battery prices are moving in India's favor. Average lithium-ion battery pack prices fell further by ~20% in 2024 to sub $100/kWh due to global overcapacity and lower input prices, along the same lines as module and its value chain prices. This necessitates Indian manufacturing to be cost effective for the best levelised cost of electricity in India and to have export optionality.

Financial deepening positions India well to fund its energy transition, and reduce reliance on volatile foreign capital: India's clean energy sector is largely financed through domestic capital, with nearly 70% of renewable energy investments sourced from Indian financial institutions and markets[14]. Low reliance on international capital offers resilience amid the persistent global volatility. As India's economy expands, financial deepening will unlock a robust capital pool adding $9 trillion by 2035[15]. To channel this towards renewable energy, financial sector should enable greater participation from insurance, pension, and equity markets. Electricity sector should also ensure payment security and predictable returns for these investors. Achieving this shift will also align India's sticky high cost of capital and enhance long-term competitiveness.

Figure 1: India Electricity Capacity Addition by type

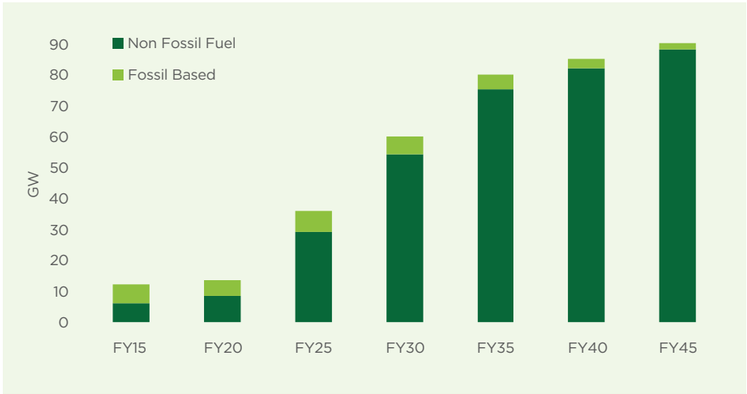


Figure 2: Charting India's Renewable Energy Progress



Table 1: Trade barriers to energy transition

Product Segment	Imposing Country	Target Countries	Trade Barrier Description
Critical Minerals	USA	China, India	Tariffs and export controls on lithium, cobalt, rare earths
	China	USA, EU	Export restrictions on rare earths, cobalt
	India	China	Export tariffs and customs controls
PV Modules & Cells	USA	China, Southeast Asia	Import tariffs up to 50% on solar panels and cells
	India	China	Customs duties & local content requirements
Wind Turbines & Components	EU	China	Safeguard tariffs on cheaper Chinese wind turbine imports
	India	-	Local content requirements with imports for WTGs

Pillar 1

Manufacturing: Shift from capacities to building global competitiveness

This note focusses only on the solar value chains, for ease of analysis. However, this is illustrative of other components like wind and batteries as well.

India's large market size and industrial policies have kick-started the solar manufacturing industry to meet the domestic requirements for next 5 years. Costs are higher than competitors but are coming down.

India is one of the fastest growing solar markets globally. Leveraging this market size, India's solar manufacturing sector has gained significant momentum in recent years, driven by a strategic mix of policy interventions like domestic content requirements for solar modules and cells, basic customs duties on imports and Production Linked Incentive for manufacturing. These measures have created a protective environment for domestic players to scale up.

India will need to deploy 40-45 Giga Watt per year of solar from 2025 till 2030 to meet the target of 500 GW of renewable energy capacity, announced by the Hon'ble Prime Minister at UNFCCC COP26 in Glasgow. Two points stand out from the perspective of where we currently are:

- India is now approaching self-sufficiency in production of the last leg i.e., solar modules with over 100 GW of announced production capacity. Actual production is however, about a third of this capacity, aligned to the demand and as newer plants are still ramping up operations.
- India may be approaching self-sufficiency for cells by 2026-2027. Most new investments are now focussed towards newer technologies (e.g. TopCon, HJT) that have higher efficiencies.

Weaknesses in upstream parts of the value chain and capital machinery expose India to cost inflation, technology lag, and geopolitical risk

There are major gaps and vulnerabilities in India's capacities further upstream into wafer and ingots manufacturing and polysilicon refining. Large players have announced plans for vertical integration, in phases, encouraged by the design of the PLI favouring deeper value chains. It's also in line with global trends, where integration is rewarded in the form of cost competitiveness and supply chain resilience.

India also faces several critical vulnerabilities in capital machinery and skilled workforce across the solar PV manufacturing chain – high quality refining equipment for polysilicon, equipment like diffusion furnaces, PECVD systems, laser tools, and screen printers for cells fabrication, and; several key inputs for modules assembly like laminators and silver paste are heavily imported.

Groundwork for post 2030 is needed now, to reduce vulnerabilities and seize economic opportunities

From 2030 onwards, the pace of annual solar deployment in India will more than double to 80-90 GW. This will be important for India to be on track for the 90% share of renewable energy installed capacity by 2047, as part of the Hon'ble PM's vision for Viksit Bharat. This will create a massive need for supply chain components. Table 2 shows that we are well placed to meet our domestic modules demand post 2030, but significant step up is needed in upstream parts of the value chain.

More export opportunities will have opened up too. Solar is now the fastest-growing source of electricity worldwide, outpacing wind, hydro, and fossil fuels. If this momentum continues, global solar deployment could surpass 1000 Gigawatt annually by the early 2030s. At least half of it will be outside China, and in countries seeking building of their own domestic manufacturing as well as supply chains diversification. India, with its scale and cost advantage, can become a preferred supplier—but only if it builds the foundation now.

Table 2: India's need for supply chain components till 2030 and expected timelines for self sufficiency

Component	Share of value added	Requirement p.a. till 2030	Requirement p.a. post 2030	Announced capacities	Status
Modules	15-20%	45 GW	90 GW	100 GW#	Self-sufficiency for both pre and post 2030.
Balance of Systems*	10-15%				India is highly competitive and a rapidly rising exporter
Cells	30-35%	45 GW	90 GW	26 GW#; 42 GW by 2027	Self-sufficiency for pre- 2030
Ingots & Wafers	20-25%	45 GW	90 GW	2 GW#; 60 GW integrated facilities have been announced.	Self-sufficiency likely for pre-2030 by 2028 as capacities materialise.
Polysilicon Refining	10-15%	~0.5 MMTPA	~1 MMTPA	No production currently. 20.7 GW awarded under the PLI Scheme	New investments are required
Ores (e.g. Quatz)	1-2%			Extensive quartz reserves, being mined for use in glass, ceramics, construction, and electronics.	

- Current operational capacity
* - Mounting structures, wiring, inverters, and packaging

Strategic Priorities for Next 5 Years

Domestic content mandates for upstream components is a priority for strengthening full value chain competitiveness

Government of India has rightly introduced domestic content requirements across the solar value chain in a phased manner, aiming to balance the urgency of renewable energy deployment with consumer affordability. However, to truly secure strategic autonomy and maximize the impact of the Production Linked Incentive (PLI) scheme, it is imperative that India now extends these mandates to include wafers, ingots, and polysilicon. There are three good reasons for doing so at the earliest

- 73 GW of RE capacity, mostly solar with storage, was tendered out in 2025-25. Similar trajectory is expected in the next 3 years. Each year of delay in mandating local content requirements for wafers and polysilicon results in more tenders being locked into pricing structures based on imported components. This is a big opportunity lost.
- Wafer and polysilicon manufacturing factories are highly capital-intensive and require 3-5 years to be established and stabilised. India will have meaningful self-reliance on this front by 2028-29 at the earliest, with an immediate start.
- It will take sustained policy and operational efforts to be internationally competitive. China's journey to driving down polysilicon costs through economies of scale took roughly 10–15 years. India can compress this timeline to 5–7 years by leveraging its late-mover advantage, provided it acts decisively and strategically. Global markets are in an oversupply phase currently and India can leverage this to acquire equipment and expertise at discounted rates, while planning for cost parity by 2032-33.

Proactively develop emerging solar manufacturing clusters into integrated zones with co-located upstream and downstream players to Unlock Cost Efficiencies

Gujrat, Rajasthan, Maharashtra, Tamil Nadu, Telangana, Uttar Pradesh and West Bengal are emerging as major geographical clusters for solar components manufacturing. This is on account of supportive investment policies of the states. These clusters, however, remain fragmented and unevenly integrated.

India must now take a more deliberate approach to developing geographical manufacturing clusters across the solar value chain to unlock deeper cost efficiencies and global competitiveness. A coordinated strategy, where upstream and downstream players such as polysilicon refiners, wafer slicers, cell producers, and module assemblers co-locate can dramatically reduce logistics costs, streamline supply chains, and accelerate technology diffusion.

Manufacturing is energy intensive and needs 24x7 reliable electricity. Access to low-cost electricity is a major differentiator for Chinese manufacturers. India can replicate the same in dedicated clusters – through measures such as streamlined open access, reduced cross-subsidy surcharges, pooled power procurement to reduce per-unit costs through scale or encouraging captive and group-captive RE projects.

India already has successful precedents to draw from, all of which have thrived due to conscious planning, shared infrastructure, and policy support. By replicating this model for solar manufacturing, India can foster innovation, attract investment, and position itself as a resilient, cost-effective clean tech leader.

India's long-term edge in global solar competitiveness will come not from scaling today's technologies, but from investing in tomorrow's breakthroughs. A major publicly funded R&D initiative under the aegis of Anusandhan National Research Foundation, complementing the PLI Scheme, is essential to drive this shift.

To build a true moat, India must shift focus from catching up to leapfrogging the technologies. China has already mastered the technologies it has chosen to scale, built deep control over its value chains—right up to raw materials like quartz—and is rapidly innovating across efficiencies, processes, and cost structures. This foundation makes it increasingly difficult for others to create new breakthroughs and catch up in areas where China has committed focus.

Rather than replicating China's path, India would be better served by channeling higher investments into next-generation technologies (see Table 3) that have a potential for better efficiencies and offer non-silicon pathways, reducing reliance on China's wafer and polysilicon dominance.

To drive this shift, India must swiftly ramp up activities of the Anusandhan National Research Foundation (ANRF) that was set up in 2023 as an apex body to strategically guide and fund scientific research, innovation, and entrepreneurship across disciplines. For solar, a small number of larger steps are recommended to draw in the strengths of both the public and private sectors

Table 3: Next Gen Solar Cell Technologies with Diversified Technology and Raw Material Supply

Technology	Efficiency Potential	Key Materials Used	Current technology repositories
Perovskite-Silicon Tandem	~33%*	Perovskite compounds + silicon	UK (Oxford PV), USA (Caelux), Germany
Copper Indium Gallium Selenide (CIGS)	~22–24%	Copper, indium, gallium, selenium	Widely available outside China
Cadmium Telluride (CdTe)	~21–22%	Cadmium, tellurium	USA (First Solar), Germany
Organic Photovoltaics (OPV)	~15–18%*	Carbon-based polymers	Lab-scale, materials globally sourced
Quantum Dot Solar Cells	~25%*	Lead sulfide, perovskite variants	Early-stage, non-China R&D hubs
Tandem III-V Cells	>35%*	Gallium arsenide, indium phosphide	Used in aerospace; supply diversified

* - Under laboratory conditions

Create a dedicated Solar Innovation Mission under ANRF with funding benchmarked to global standards: The Mission must devise mechanisms to provide grants for early-stage research, pilot projects, and commercialization support. To be comparable to competitors like China, the US, the EU and South Korea, an annual funding of US $200-300 million will be necessary.

Adjust PLI Scheme for Solar to incentivise new solar technologies and associated capital equipment: The current PLI is structured to build capacities and vertical integration in the high-efficiency crystalline silicon modules pathway, which risks locking India into legacy tech. Similar to the PLI for Alternative Battery Chemistries, future versions of the PLI for solar may create dedicated tracks for next gen technologies. Mandates or rewarding joint proposals from manufacturers and research institutions may also be considered.

Establish Solar Innovation Zones in close proximity to emerging manufacturing clusters in partnership with states and private sector: There is overwhelming evidence that co-locating R&D, supply chain, and manufacturing in geographical clusters accelerates the returns from R&D investments and translate into manufacturing competitiveness. China's Provincial Innovation Zones, the US's DOE Clean Energy Hubs, Germany's Fraunhofer Model and numerous other examples can provide useful learnings for India to establish, finance, operate and ensure local benefits from such zones.

Re-alignment of Trade and Industrial policies will help to develop new export markets and technology leap-frogging

India has successfully used its industrial and trade policies to erect barriers and level the playing field for Indian companies against state sponsored international competition. This has helped to build domestic capabilities. In fact, India was already exporting solar modules to the US, before tariff restrictions kicked-in.

India can unlock a significantly larger solar export opportunity, even amid rising global competition and cost pressures, by aligning industrial and trade policies, just as leading nations are doing to reinforce their clean tech advantage.

The EU, US, and Japan will remain high-volume and premium markets for solar exports, with annual deployment projected at 200–300 GW. These economies seek strategic autonomy in advanced technologies and diversified supply chains. While they lead in innovation, India offers continent-scale, cost-efficient manufacturing. By leveraging instruments such as licensing agreements, joint development frameworks, standards alignment, and IP cooperation, India can secure access to next-generation solar technologies and enhance its global competitiveness.

In parallel, India must expand into emerging markets with targeted engagement. Countries across Africa, South America, and Australia such as Kenya, Ghana, Tanzania, Colombia, and Peru are scaling solar deployment but remain less tied to China or the US. These markets present opportunities in niche applications like rural electrification, mining operations, and rooftop solar. India can enter with bundled technology-finance solutions and, over time, build commercial depth. Even in mature markets like Australia, strategic trade linkages such as tying mineral off-take to solar component supply can open new pathways for diversification.

Pillar 2



Transmission: Rapidly Build Smart, Flexible Grids

India's energy transition is at an inflection point. The country boasts of vast clean energy potential and has set an ambitious renewable energy target. This has been supported by one of the world's fastest grid developments. Yet, as renewables scale in geographically concentrated regions the power grid has begun to lag.

This paradox is akin to building a fleet of electric vehicles without constructing the roads they need to travel on. The utility of these vehicles is constrained in the absence of a reliable, accessible, and future-ready transport network. On similar lines, newer clean energy capacity addition is bottlenecked by a transmission system that must be urgently augmented and modernized to accommodate the scale, variability, and geographic dispersion.

This section moves beyond identifying the problem to present a tangible framework for unlocking the grid: planning ahead, strategic expansion, simplifying execution, holistic grid utilisation and demand-side measures.

Unprecedented Scale of Grid Expansion

As highlighted in the Introduction section, India's total system size is projected to reach ~2,100 GW by 2047, with ~1,800 GW coming from renewables requiring ~80GW addition annually from now. Achieving this will require hastened development of power evacuation capacity, deployment of energy storage to utilize new and existing capacity better and finally demand side measures to be optimally efficient.

Current Grid Build-out Plans: India's grid expansion plans are ambitious and multi-layered. While the current build out is fast (~25,000 ckm in ~2 years), it needs to be faster. As of July 2025, the grid comprised of 496,000 circuit kilometers (ckm) of lines and 1,369,000 MVA of transformation capacity. By 2032, the plan is to increase transmission length by 30% and transformation capacity by 80%, requiring the addition of 162,600 ckm of transmission lines and 1,094,000 MVA of transformation capacity within eight years. The grid must be capable of integrating over 600 GW of renewable energy by 2032, including ~300 GW of new solar and wind zones. It must also support new bulk loads such as green hydrogen and ammonia manufacturing hubs, which alone are expected to demand ~70 GW by 2031–32[16].

Regional Focus of Grid Expansion: Renewables potential is geographically constrained which is visible in the grid expansion plans. Western and Southern regions are the major beneficiaries of new transmission lines and substations to supporting large-scale renewables. For instance, Rajasthan alone has ~100 GW of solar and wind potential zones identified, with a detailed, phased transmission plan under implementation. Similar efforts are underway in in the hybrid potential rich southern states. The Green Energy Corridor schemes have already enabled the evacuation of ~20 GW of renewables[17].

Execution Challenges and Policy Reforms: Despite these advances, execution lags persist. Right-of-way (RoW) issues, land acquisition delays, compensation disputes, and fragmented coordination across agencies continue to slow progress. As per official data, over 50% of transmission projects bid under Tariff-Based Competitive Bidding have faced delays, often due to RoW and forest clearance challenges. The Ministry of Power issued new guidelines in June 2024 for enhanced RoW compensation, streamlined forest clearance, and online portals for faster approvals[18]. Regular meetings with district collectors and the use of PM Gati Shakti for route alignment are now standard practice.

Beyond Physical Expansion: Smart and Flexible Grids: While India's plans are robust in terms of physical expansion, the National Electricity Plan recognizes that this alone is not sufficient. The grid must be smarter, more flexible, and more resilient. This involves integrating advanced technologies such as hybrid and digital substations, high-temperature low-sag (HTLS) conductors, dynamic line ratings, phase-shifting transformers, and grid-forming inverters. The NEP also emphasizes the extensive deployment of energy storage systems both Battery Energy Storage Systems (BESS) and Pumped Storage Plants (PSP) to manage the intermittency of renewables looking to build over 100 GW of capacity.

Integrating Distributed Energy Resources (DERs): Large scale deployment of renewables under PM KUSUM and PM Surya Ghar will lead to significant portion of the capacity to be distributed making many consumers - prosumers (producer consumers). Requiring evolution for the integration of distributed energy resources (DERs), rooftop solar, and microgrids. While the NEP primarily focuses on bulk power transmission, the growing share of DERs necessitates new approaches to grid planning, including more granular forecasting, bi-directional flows, and enhanced distribution planning.

Strategic Priorities for the Next Five Years

The next five years are critical for transforming India's transmission sector into a strategic enabler of the energy transition. Five priorities emerge:

1. **'Ahead of Demand' Transmission Building**
   Just like roads guide where cities grow, transmission lines determine where renewable energy projects can be built—because electricity must be delivered to be sold. India must shift from reactive grid building to planning and constructing transmission 'before' renewable energy projects emerge. This means reforming the five-year planning process for both national and state grids, and significantly increasing investment in state-level infrastructure.
2. **Strategic Grid Expansion**
   India's grids have traditionally been built to transport electricity from eastern parts of the country to the southern and western parts, mostly to the urban centres. The best locations for producing renewable energy however, are in the western parts of India and southern parts of India and consumption growth is focused in the northern states. So, we needs a massive and quick grids build out in these geographies. Learnings from the last few years have shown that private sector build out of grids, enabled through Tariff Based Competetive Bidding, has been significantly delayed due to inherent limitations with

respect to Right of Way and administrative support. India must shift to build transmission projects that are critical to the national grid through the Regulated Tariff Mechanism. This will allow the Central Transmission Utility to build these projects. It can build these faster, enabled by a mix of statutory authority, administrative coordination, and streamlined compensation rules—advantages that private developers typically lack. Strict timelines and accountability need to be placed too.

3. **Streamlining Execution**
   RoW challenges must be addressed through streamlined approvals, and coordinated planning across central and state agencies. A modern Right of Way (RoW) policy—modeled on highway development—can simplify land acquisition and reduce delays. A joint initiative between the Ministry of Power and the Ministry of Environment, Forest and Climate Change is needed to introduce a single-window approvals mechanism in a time bound manner and a standard operating procedure for addressing RoW issues during construction. Co-ordinated planning across CTU, STU and demand aggregators woudl ensure smooth functioning of such a framework without adding more layers to the process. Monitoring reductions in project timelines and cost overruns will be essential. As part of this, contracts need to be strengthened to hold transmission builders accountable for timely delivery
4. **Holistic Grid Utilization**
   Curtailment remains a persistent issue, with Rajasthan experiencing up to 48% solar output curtailment during peak periods. The target of ~80 GW of energy storage capacity, with storage co-located at RE sites, is imperative. Additionally, the grid remains underutilized during non-solar hours, which can be addressed by increasing deployment of co-located hybrid RE constructs which has been effectuated with the 3rd amendment of GNA. Operationalizing co-located storage and hybridization of existing solar and wind assets will improve the utilization of existing transmission investments.
5. **Market Design and Demand Management**
   Infrastructure development and utilisation alone cannot unlock the grid. Market design and power demand management must evolve to ensure efficient utilization, equitable access, and financial sustainability. Smart meter deployment is underway, targeting 250 million by 2026. However, progress is slow, and integration of advanced metering infrastructure, demand response, and time-of-use pricing must be accelerated. These reforms enhance grid flexibility and align operations with global best practices.

Conclusion

Grid modernization is not just a technical upgrade, it is a strategic pillar of India's energy transition beyond 2030. The scale of transmission expansion required is unprecedented. While current plans are ambitious, they must continue to evolve. The next five years will determine whether India can build a grid that is not only larger, but also smarter, more flexible, and more inclusive. India can transform its transmission system from a bottleneck into a backbone which is ready to deliver on the promise of a clean energy future by investing in infrastructure, scaling storage and smart technologies, and deepening market reforms.

Pillar 3



Human Capital Development: Empower a Future-Ready Workforce

India is witnessing a clean energy transformation – its build-out is not only about investments, favorable policies, transmission infrastructure, technology, and supply chains, but is also about human capital and its people. In 2023, the total clean energy jobs in India reached 1.02 million, part of the 16.2 million jump in the global renewable energy workforce[19]. The hydropower and solar PV sectors were the biggest job creators, providing around 453,000 jobs and employing 318,600 people, respectively[19].

As we move ahead to achieve our 500 GW target, the country has the potential to create 3.4 million jobs and employ around 1 million people by 2030 in the wind and on-grid solar sectors alone[20]. Further on, a multiplication is envisaged as India's deployment and manufacturing go up manifold.

The Government of India rightly considers skilling as a core infrastructure pillar. It has also accelerated its commitment to developing training, skills, and educational programs. The Skill Council for Green Jobs, established in 2015, has trained over 6,23,000 candidates to date[21], with over 100,000 in solar and other renewable energy domains. Some 86,000 trainees have been certified under the Suryamitra Training Program[22]. To add, recent initiatives like the Green Hydrogen Mission are also charting pathways for employment, bringing in over 8 lakh crore in investments and creating over 6 lakh jobs by 2030[23]. Similarly, the PM Surya Ghar Muft Bijli Yojana aims to transform India's energy landscape by providing free electricity to households, while creating 17 lakh direct jobs across various sectors, including manufacturing, logistics, among others[24].

While India is riding the green wave, there is also a risk of drowning in it. The sector faces a skills shortfall of 1.2 million people, which is expected to swell to 1.7 million by 2027 (according to TeamLease). There are distinct challenges at each stage of the value chain.

The energy transition we are witnessing is not just about physical infrastructure but is being driven by AI and data, giving rise to cross-cutting and digital skills among professionals, creating a demand for data analysts, cybersecurity experts, and technology experts proficient in SCADA systems and asset management platforms.

The STEM Paradox: As Figure 3 shows, there is a rapidly growing need for workforce in technical and engineering skills for the renewable energy sector. A large number of workforce gets trained in these skills. In fact, the world is producing more STEM graduates than ever before, with countries like China producing nearly 4.7 million STEM graduates annually. Similarly, as per UNESCO statistics, countries like Malaysia and Tunisia have one of the highest shares of STEM graduates, with 43.5% and 40% respectively. India has a large talent pool of STEM graduates as well, with a share of 34% of students picking STEM (nearly 2.5 million each year).

While the demand and supply of workforce with STEM skills is rising, the paradox is that uptake of STEM graduates in the renewable energy does not match 1:1 with the growing need. Only a small fraction of STEM graduates enter clean energy jobs.

Part of the reason is that many STEM graduates naturally choose careers in other fields e.g. technology, finance, or other industries. The more worrying reason is that companies do not hire them because they are not industry-ready. Many STEM graduates either lack sector-specific STEM training, encounter skills-to-jobs roles mismatch or an opportunity to update their skills suited to the emerging requirements in areas like energy storage, green hydrogen, e-mobility, and solar manufacturing.

Figure 3: Value Chain Analysis of Skills Gap across Sectors

SOLAR VALUE CHAIN ANALYSES

RESEARCH & DEVELOPMENT	MANUFACTURING	SUPPLY	PROJECT AND BUSINESS DEVELOPMENT	INSTALLATION & COMMISSIONING

Skill Gap

- Critical shortage of skills for advanced technologies like TOPCon, HJT, that requires expertise in precision testing, defect analysis, statistical process control, and expertise in automated manufacturing systems and robotics

Core Skill Required

Production Engineer, Process & R&D Engineer, Quality Control/Assurance Executive, Automation Specialist, Assembly Line Worker, PLC Programmer

Skill Gap

- Lack of skilled site engineers and semi-skilled technicians for construction and commissioning. Particularly acute at remote project locations, due to reluctance to relocate
- Significant deficit in the operations and maintenance phase, which requires a new set of skills for ongoing performance monitoring and low-skilled maintenance functions

Core Skill Required

Site Engineer, Installer, experienced Project Manager, Technician, Data Analyst, SCADA Expert



The energy transition we are witnessing is not just about physical infrastructure but is being driven by AI and data, giving rise to cross-cutting and digital skills among professionals, creating a demand for data analysts, cybersecurity experts, and technology experts proficient in SCADA systems and asset management platforms.

WIND VALUE CHAIN ANALYSES

RESEARCH & DEVELOPMENT	ENGINEERING MANUFACTURING	SUPPLY CHAIN MANAGEMENT	OPERATIONS & MAINTENANCE	MANAGERIAL & OTHERS

Skill Gap

- The "lack of transferability of skills" limits the movement of a skilled workforce between industries
- There is a lack of certified turbine technicians; safety & height-work training, forecasting/O&M analytics skills

Core Skill Required

Geologist and Geo-physicist, Scientist/Design Engineer (Turbine components and assembly, blade/rotor design, design engineering), Wind Resource Analyst

Skill Gap

- The "lack of transferability of skills" limits the movement of a skilled workforce between industries
- There is a lack of certified turbine technicians; safety & height-work training, forecasting/O&M analytics skills

Core Skill Required

Site Engineer, Installer, experienced Project Manager, Technician, Data Analyst, SCADA Expert



BATTERY VALUE CHAIN ANALYSES

RESEARCH & DEVELOPMENT	ENGINEERING MANUFACTURING	OPERATIONS & MAINTENANCE	SUPPLY CHAIN MANAGEMENT	MANAGERIAL & OTHERS

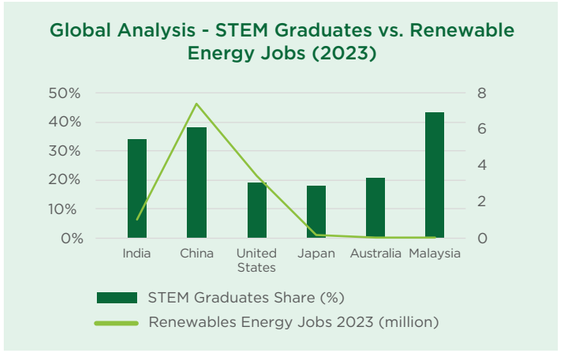
Skill Gap

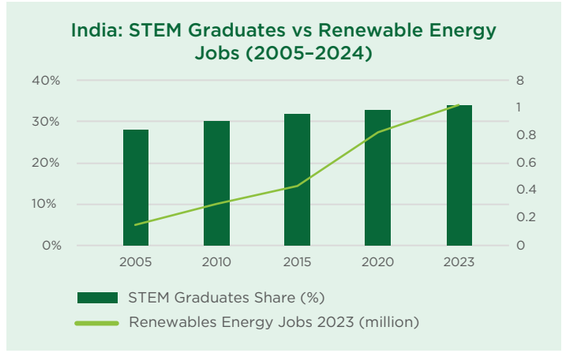
- India's battery manufacturing aims to reach 500 GWh of annual capacity by 2035, with a longer-term goal of 1 TWh by 2040
- High-value gaps lie in manufacturing-specific engineering (cell/process), testing & validation, and advanced SCM/tactical logistics for components.

Core Skill Required

Geologist and Geo-physicist, Scientist/Design Engineer (Turbine components and assembly, blade/rotor design, design engineering), Wind Resource Analyst







Another critical challenge is fixing the **leaky pipeline and the inclusion gap**. While India has the highest number of female STEM graduates in the world (43%)[27], they are heavily underrepresented in the energy sector, with only 11% women in renewable energy jobs in India[28], and are often disproportionately grouped in "feminized services". The skilling ecosystem should look at building gender focused courses and inclusive strategies, including a network of certified women trainers, safety and facilities on site, mentorship, and return-to-work programs.

Project ReNew Surya in alignment with Government Schemes

ReNew's Project Surya is a perfect example of targeted industry-aligned training programs. The program aims to train **1000 low-income women salt pan workers in the Little Rann of Kutch as solar technicians**, providing them with better opportunities, income, and improved livelihoods. **To date, 600 women have been trained, and from the initial four batches, 200 women have already secured job offers at a 7X income increase per month.** ReNew has also expanded this project to include other communities, such as coal mine workers, helping them transition to cleaner livelihoods.

This program is directly aligned with Government Initiatives like the PM Surya Ghar Muft Bijli Yojana and the PM-KUSUM Scheme, which have a focus on distributed renewables execution. The PM Surya Ghar scheme alone is expected to create approximately 1.7 million direct jobs. Project ReNew Surya can create a talent pool of women that can directly support the roll-out of these large-scale government schemes, creating an inclusive and effective skilling ecosystem.



Strategic Priorities for the Next Five Years – 3 Big Ideas

While India has targets, projects, and policy momentum, the next big leap is its "people". As India focuses on building the future workforce and utilizing its human capital to reap the green dividend, there is a need to focus on three big ideas –

Expand existing institutional capacity at sub-national/ local levels

Building on existing ITIs/ vocational institutes/ polytechnics, create "Local RE Skill Hubs" in every high-potential state. These hubs must be demand-driven, offering credentials aligned with emerging sectors, and measured by placement rates and site readiness, not just training volumes. These hubs should focus on strengthening existing national skilling programs, further leveraging existing programs like Suryamitra, Vayumitra, at the grassroots level to create local skilled workers

Integrating Skills with Schemes

Focus on embedding skilling across the value chain – manufacturing, investments, exports, making it an eligibility criterion to avail benefits in PLI, Viability Gap Funding in manufacturing, giga-factories, and electrolyser lines. We should also look at leveraging the International Solar Alliance as a skilling force multiplier – standardizing training, implementing safety codes, facilitating project deployment, helping address domestic bottlenecks, as well as trading skills with other partner countries, strengthening consistency and cross-border coordination

Harnessing the potential of energy Global Capability Centres (GCCs) in India

Over the years, the GCC market in India has witnessed a remarkable growth, with India hosting over 1700 GCCs, employing more than 1.9 million people[29]. According to statistics, more than 20,000 people are employed in energy GCCs. These GCCs can act as an asset for the transition, creating high-skill green tech jobs focused on digital twins for operations & maintenance, product engineering, and automation for clean-tech manufacturing. These GCCs can focus on leveraging academic partnerships, developing micro-credentials with existing institutions/ universities, and helping STEM graduates become site-ready specialists

With an extensive GCC network, local level skill hubs, and ISA-enabled skill standardization and trading, India is not only contributing to its steadfast commitment but is shaping itself as a leading player in the energy narrative beyond 2030.



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About ReNew

ReNew is a leading decarbonization solutions company listed on Nasdaq (Nasdaq: RNW, RNWWW). ReNew is committed to leading India's energy transition and has a green energy portfolio of ~18.2 GW (+1.1 GWh BESS) on a gross basis as of August 13, 2025, which is one of the largest globally.

The company operates 150+ sites spread across 10 states in India. In addition to being a major independent power producer in India, we provide end-to-end solutions in a just and inclusive manner in the areas of clean energy, value-added energy offerings through digitalisation, storage, and carbon markets that are increasingly integral to addressing climate change. The company was included in S&P Global's Sustainability Yearbook 2025—the only Indian company in the electric utility sector to feature in this list.

For more information, visit renew.com and follow us on LinkedIn, Facebook, X, and Instagram.

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