How Can India's Existing Industries Join Clean Energy Supply Chains?

Outlining Implications for Industrial Strategy in the Energy Transition

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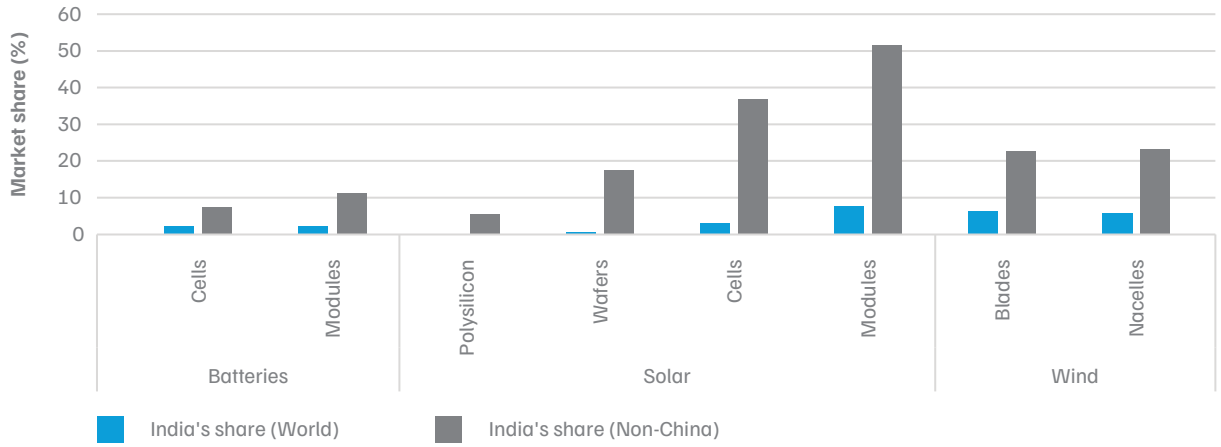


Image: iStock

Executive summary

India has sought to position itself as a manufacturing hub for clean energy technologies through a combination of production-linked incentives (PLIs), tariff and non-tariff measures, research and development support, and broader industrial policy interventions. While fiscal support and protectionist interventions have helped scale downstream industries in assembly of final products, India has continually remained import-dependent across critical and technologically advanced segments of clean energy manufacturing (CEEW 2024). This is detrimental to India's broader industrial strategy, as manufacturing's share of GDP has seen little change over the past decade, and employment generation has remained incremental. India's Economic Survey 2025–26 underscores this gap, particularly in a context where India accounts for only 2.9 per cent of global manufacturing GVA and 1.8 per cent of exports (PIB 2026a).

Figure ES1. India has the potential to become a leading clean energy manufacturing hub outside China



Source: ClimateDeck by Rhodium Group 2025 (accessed 2026)

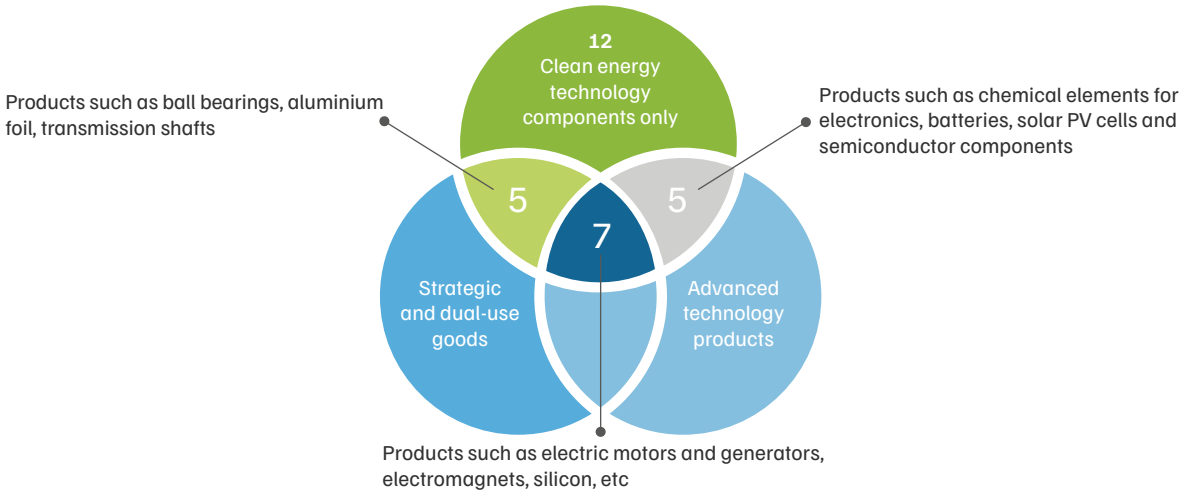
Parallelly, the global demand for clean energy technologies has grown rapidly. Countries are increasingly seeking to secure footholds across clean energy value chains (CEVCs), not only to accelerate decarbonisation, but also to strengthen economic and strategic resilience (CSIS 2022). Since 2018, China, the United States, and the European Union have together accounted for nearly 86 per cent of global clean technology manufacturing investment (Bjerkan-Wade et al. 2026). In this competitive landscape, India's next phase of growth will depend on whether it can expand its foothold towards complex intermediate products, where required manufacturing knowhow, scale economies, and incumbent advantages remain significantly higher. Success in scaling the value chain as per 2030 targets could position India as one of the most significant manufacturers in the non-China market (Figure ES1).

Understanding the industrial linkages behind clean energy manufacturing

While the opportunity is real, success is not automatic. Becoming a significant manufacturing hub in upstream and midstream segments requires a more expansive set of capabilities in manpower, materials, and machinery. A substantial body of research highlights that countries tend to move into products requiring similar productive knowledge, supplier ecosystems, machinery, and skill bases, often referred to as the 'principle of relatedness' (Pinheiro 2025; Chen, Poncet and Xiong 2017; Li and Neffke 2024). Understanding these industrial linkages can therefore help shape CEVC industrial policy around foundations that already exist.

Clean energy value chains are deeply interconnected with wider manufacturing ecosystems. Components, materials, and technologies used across CEVCs frequently serve multiple downstream sectors, occupying structurally important nodes within production networks. For instance, ball bearings used in wind turbines are also critical to automotive and industrial machinery industries, while rare earth magnets essential for electric vehicles are equally important for defence and other strategic sectors. As a result, the returns to India's entry in these value chains, and conversely the costs of exclusion, extend far beyond the energy sector itself. Assessing these linkages for solar PV, wind turbines, and lithium-ion batteries, this paper finds outlines two essential findings:

Figure ES2. Overlapping HS classifications indicate that clean energy manufacturing is deeply embedded within broader strategic and industrial ecosystems



Source: Authors' compilation from HS code classifications

- **Strengthening capabilities in clean energy value chains could generate simultaneous co-benefits for India across industrial upgrading, export competitiveness, and strategic resilience.** Among the large set of products where India currently lacks competitive manufacturing capability, CEVC components consistently rank among the most knowledge-intensive and sophisticated. Further, India's unrealised clean energy manufacturing potential lies in products that also carry strategic significance. CEVCs intersect with value chains for advanced technology products and strategic and dual-use goods[1], which are themselves increasingly central to contemporary industrial policy competition (Figure ES2).

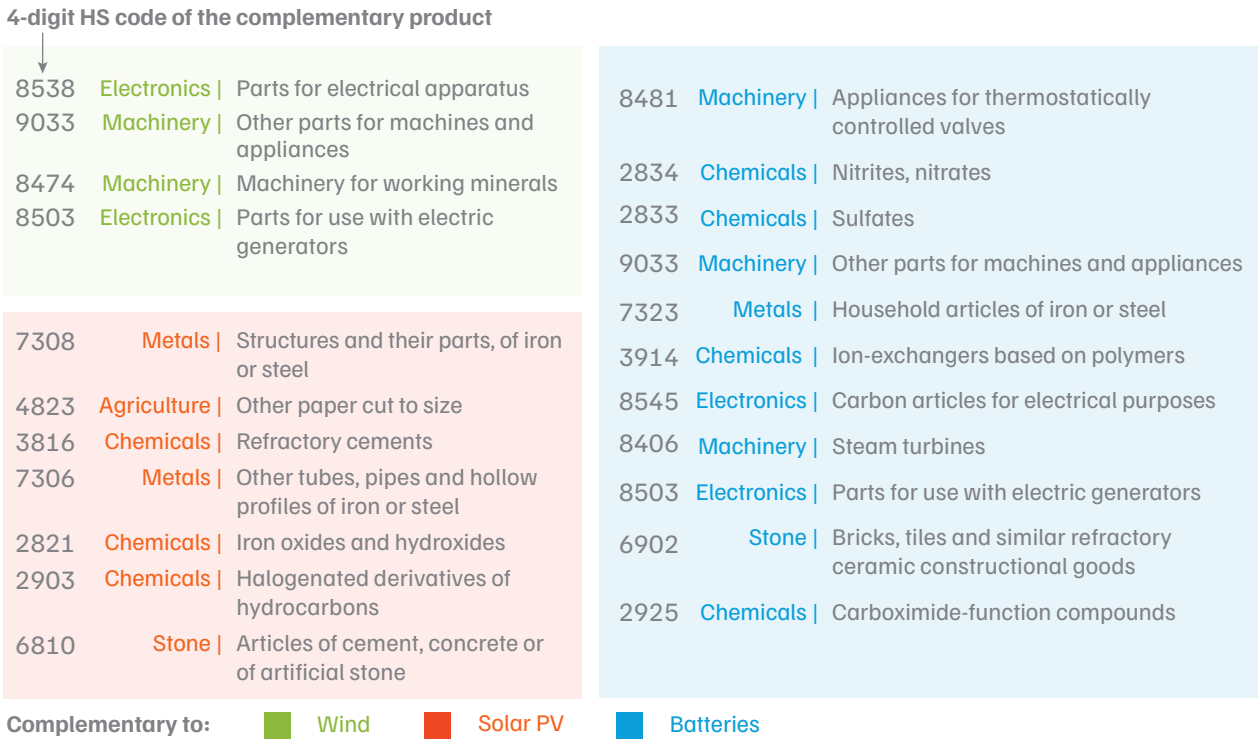
- **India can expand its footprint in CEVCs by building upon capabilities that already exist within the domestic economy**. Clean energy value chains are strongly connected to industries where India already has a comparative advantage, enabling a pathway for capability driven industrial diversification. These industries are concentrated in sectors such as metals, electronics, machinery etc. For India, this implies that strengthening and connecting existing industrial ecosystems could play a critical role in expanding its footprint across CEVCs.

Mapping India's capability foundations for clean energy manufacturing

Based on the product space framework developed by the Harvard Growth Lab, this paper maps the linkages between clean energy value chains and India's existing industrial base (Growth Lab at Harvard 2026). Specifically, it identifies the sectors whose productive capabilities most closely overlap with the requirements of solar PV, wind turbine, and battery manufacturing. Findings suggest that India's existing strengths in electronics, industrial machinery, metals, chemicals, and precision manufacturing are closely related (Figure ES3). This suggests that several entry points can be built upon capabilities that already exist within the domestic economy. Successful cases show how pre-existing capabilities in related industries are an important enabler—China, Japan, and South Korea consistently dominate multiple clean energy technologies, reflective of underlying strengths in advanced manufacturing and sophisticated chemical production (Net Zero Industrial Policy Lab 2025).

1. Dual-use items are goods, software, and technology that can be used for both civilian and military applications.

Figure ES3. India's existing industries feature many competitive product families that can support entry into clean energy manufacturing



Source: Authors' compilation from the Atlas of Economic Complexity 2024

At the same time, relatedness metrics should be interpreted as mere signals; they identify where similar capabilities exist, but cannot explain why certain industries have not yet scaled despite apparent alignment with the domestic production structure. Future research should identify different forms of industrial linkages, including shared inputs, capital equipment, labour skills, technical knowledge, and supplier ecosystems, and recognise the bottlenecks constraining their transferability. Mapping these gaps to appropriate policy responses will help accelerate capability diffusion and industrial entry.

Five implications for industrial policy in clean energy value chains

The global scale and rationale for industrial policy has evolved; national security, supply chain resilience, and geopolitical positioning now drive intervention in leading economies more than climate-related objectives do (Martín and Evenett 2025). Given India's ambitions, its approach to the clean energy technology sector has not kept pace with these shifts. The Economic Survey 2025–26 encourages a welcome change in perspective by framing manufacturing capacity as a 'strategic national asset'. It calls for the state to move beyond its regulatory role and act as a catalyst for structural transformation and technological sovereignty.

Clean energy value chains offer a valuable avenue for translating this vision into practice. Drawing on the analytical findings of this paper, the following implications intend to guide policymakers towards the strategic, institutional, and diagnostic priorities that will shape India's ability to build globally competitive manufacturing capabilities over the coming decade.

- **Clean energy manufacturing should be treated as an industrial and strategic opportunity, not merely a self-reliance agenda for decarbonisation**. The case for domestic component manufacturing is strongest where it reinforces broader industrial and technological capabilities—generating long-term resilience across multiple sectors, signalling more durable policy support, and crowding in private investment.

- **Protection and incentives are necessary but insufficient—the capabilities underpinning manufacturing capacity are what determine long-run competitiveness, and many can be drawn from existing industrial strengths**. What determines whether capacity becomes competitive is the plumbing underneath it: workforce readiness, supplier networks, manufacturing knowhow, capital, and equipment.

New manufacturing avenues will require resisting protectionist temptations that are particularly acute in a moment of heightened geopolitical competition, and placing the hard work of strengthening underlying capabilities at the core.

- **Leveraging strengths in adjacent industries presents a significant coordination challenge, while being a self-reliant pathway of scaling new products**. Even where sectors appear statistically closely related, the relevant ministries may lack visibility into these complementarities, and firms may remain unaware of adjacent diversification opportunities. Gaps in information, incentives, or institutional mandates—which are needed to convert these overlaps into concrete industrial outcomes—must be bridged.
- **Existing capabilities can shorten the path to competitiveness, but they cannot compensate for capital, technology, and process engineering where those gaps are large**. Complementary capabilities alone cannot overcome constraints that arise from high capital intensity, minimum efficient scale requirements, or limited access to technology and knowhow. More complex products, such as polysilicon, wafers, lithium-ion cells, and rare earth magnets, are likely to additionally require long-term financing, technology partnerships, and anchor demand commitments.
- **Emerging manufacturing sectors must not remain statistically invisible. Strengthening industrial classifications is an enabling condition for data-driven industrial policy**. Existing industrial data taxonomies fail to represent emerging sectors. India cannot unilaterally revise harmonised standards, but it has previously designated temporary domestic codes for priority sub-sectors. This approach will help unlock firm- and subnational-level diagnostics that can inform more actionable and data driven policy.

The framework developed in this paper is intended to open a broader diagnostic conversation on industrial strategy. Its relevance extends well beyond clean energy manufacturing: the analytical approach, and the institutional shifts it calls for, are equally applicable to a wider landscape of deep-tech sectors where India's strategic ambitions increasingly lie.

1. India's clean energy manufacturing moment is still ahead of it

India has emerged as one of the most significant manufacturing bases outside China across several clean energy technologies. Backed by production-linked incentive (PLI) schemes, the Approved List of Models and Manufacturers (ALMM)[2], domestic content requirements, and import tariffs, India has built up meaningful manufacturing capacity across solar modules, wind turbines, and batteries. However, India remains significantly dependent on imports for technologically sophisticated upstream and intermediate inputs (CEEW 2024). Many of these components are characterised by high barriers to entry that arise from concentrated technological knowhow, capital intensity, process engineering requirements, the need for skilled labour, and deeply embedded supplier ecosystems.

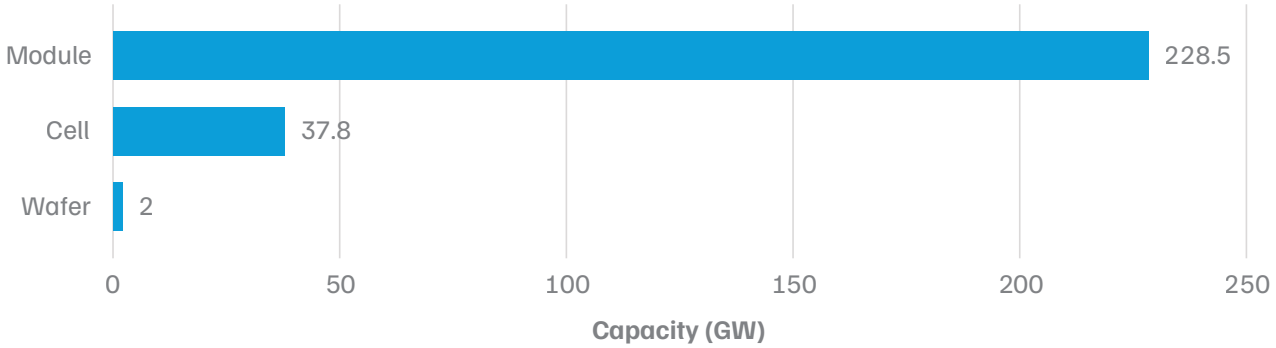
> Clean energy manufacturing should be treated as an industrial and strategic opportunity, not merely a self-reliance agenda for decarbonisation.

1.1 Current manufacturing capacities in solar, wind, and battery value chains

India's solar PV manufacturing sector has grown manifold over the years. As of September 2026, India's enlisted solar module manufacturing capacity stands at nearly 229 GW (MNRE 2026a), with rated capacity enlisted under the ALMM. Cell manufacturing is also expanding rapidly from a smaller base and stands at nearly 37 GW (MNRE 2026b). The industry remains concentrated in downstream segments; domestic ingot and wafer capacity stands at around 2 GW (Government of India 2026), and polysilicon capacity remains in its infancy, indicating continued dependence on imported upstream inputs despite efforts towards greater vertical integration. Expansion of the ALMM list for solar wafers and ingots is also expected to be in effect by 2028 (PIB 2026b).

2. The ALMM list specifies the approved solar technologies that can legally be used for government-backed, net-metered, and open-access solar energy installations in the country.

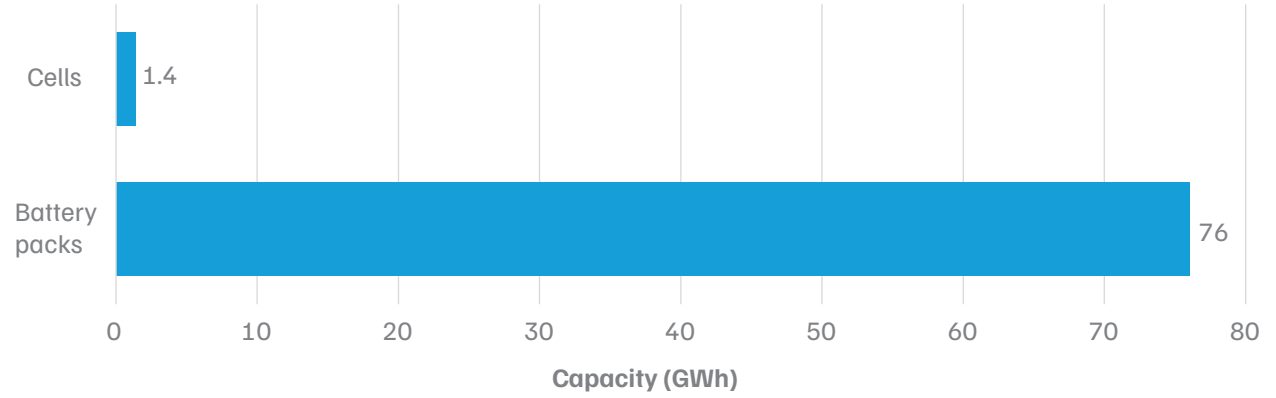
Figure 1. India is rapidly scaling solar manufacturing with nascent capacity in upstream components



Source: Authors' compilation from MNRE 2026a; MNRE 2026b; Government of India 2026

Battery manufacturing is at an earlier stage and has ambitious growth pipelines. Announced and under-construction projects could take battery cell manufacturing capacity beyond 200 GWh, while battery module manufacturing is also expected to expand significantly (Rhodium Group 2025). However, most of this capacity has yet to become operational, and production of battery active materials remains negligible. India's PLI scheme for Advanced Chemistry Cell batteries targeted 50 GWh of domestic capacity, but as of October 2025, under 3 per cent of that target has been commissioned (IEEFA 2026). Beneficiary firms have cited issues such as equipment import dependence, lack of skilled workforce, and limited availability of upstream materials like cathode and anode active materials (PIB 2026c).

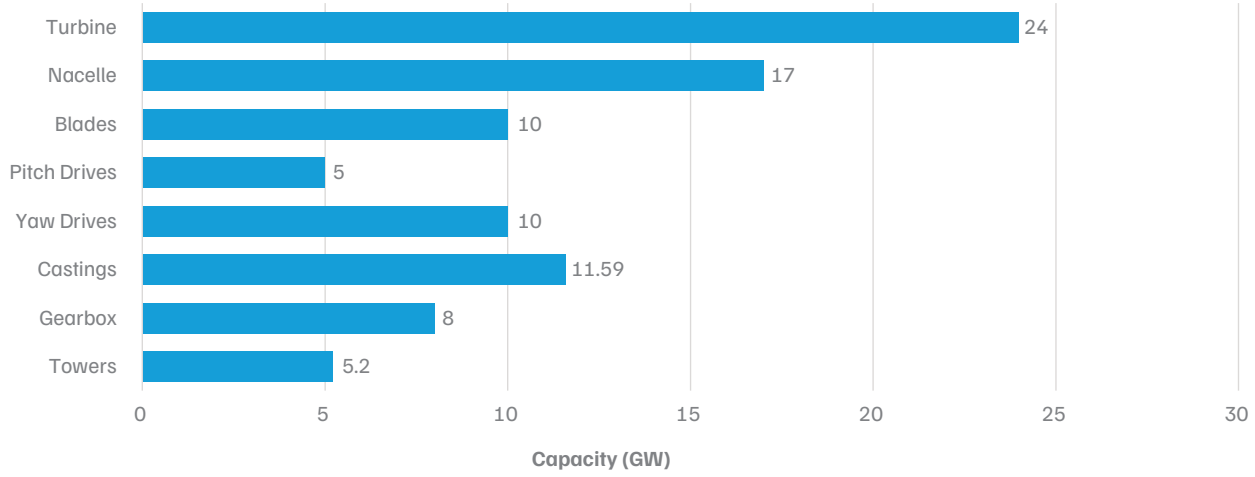
Figure 2. India's ambitions to scale battery manufacturing beyond downstream assemblies remain largely prospective



Source: Authors' compilation from IEEFA 2026

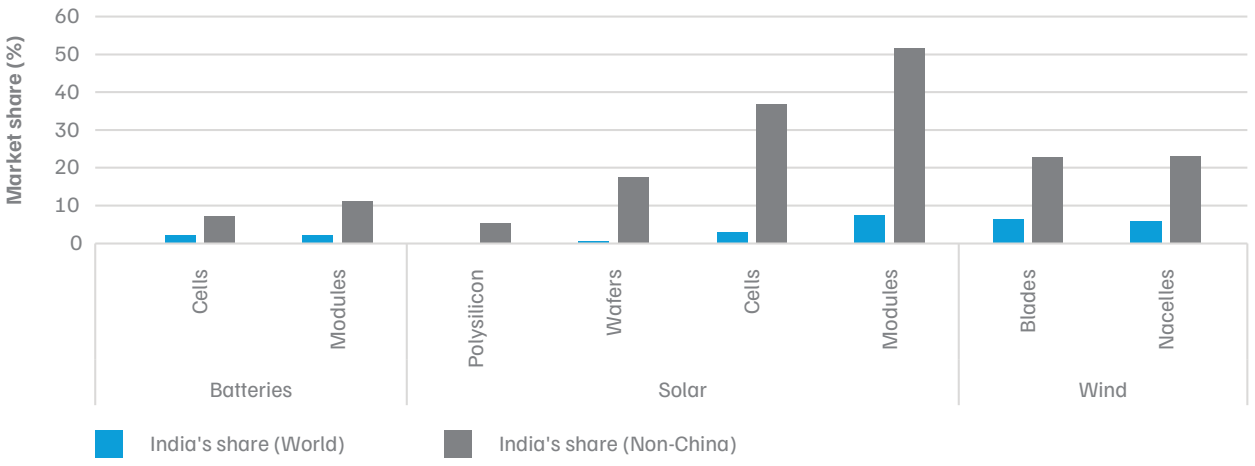
The wind turbine manufacturing sector is already relatively mature in India. The wind turbine manufacturing sector is already relatively mature in India. Wind turbine (nacelle and hub) manufacturing capacity increased from 18 GW to about 24 GW as on March 2026 (PIB 2026e). Components such as towers, gearboxes, castings, pitch and yaw drives are also produced in India at a smaller scale, while other segments lack domestic suppliers due to quality related issues and tough competition from low-cost imports (NITI Aayog 2024). In terms of cumulative current and anticipated capacity, India could emerge as one of the most significant manufacturing bases outside China across several clean energy technologies, positioning it as an increasingly important supplier in efforts to diversify global clean energy supply chains (Figure 4). The next phase of industrial development will depend on whether the country can move further upstream into materials, components, and intermediate products where technological complexity, scale economies, and incumbent advantages remain significantly higher.

Figure 3. India already possesses substantial wind turbine manufacturing capacity and continues to scale several components



Source: Authors' compilation from PIB 2026e; NITI Aayog 2024; Rhodium Group 2025

Figure 4. If planned capacities are realised, India could become a leading clean energy manufacturing hub outside China

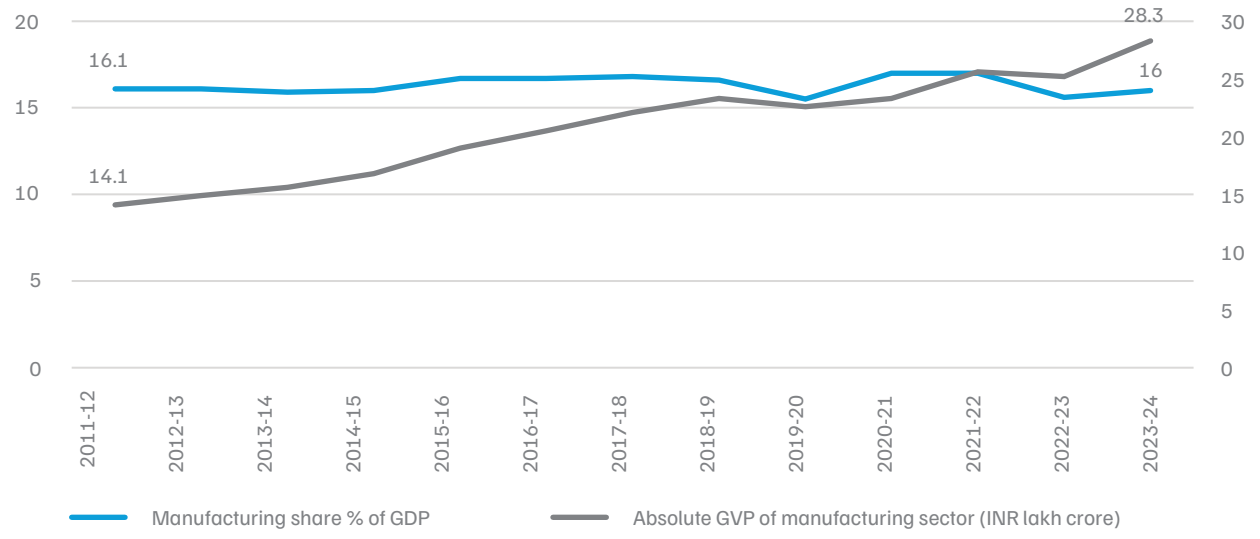


Source: ClimateDeck by Rhodium Group 2025

1.2 India's economic complexity and the green growth opportunity

For years, India has looked to increase the share of manufacturing to its overall GDP as a large and developing economy (NITI Aayog 2018; Gupta, Hasan and Kumar 2009). Despite periods of rapid economic growth, manufacturing's contribution to GDP has remained relatively stagnant and below that of several Asian economies during comparable stages of development (The Hindu 2025). India's absolute manufacturing GVA continues to grow steadily, but its share of GDP has not seen a major change in over a decade, as services continue to drive growth (Figure 5). Job growth in manufacturing has also been modest, with around 9 million manufacturing jobs created between FY12 and FY23 (Data for India 2025). In 2014, India launched the 'Make in India' initiative to turn India into a global manufacturing hub (PIB 2025a). Through a combination of policy measures, including the flagship PLI scheme across 14 strategic sectors, the government attempted to catalyse the manufacturing sector (PIB 2025b). Despite INR 1.91 lakh crore (~USD 20 billion) of committed incentives in PLI and years of market protectionism, the success has been limited.

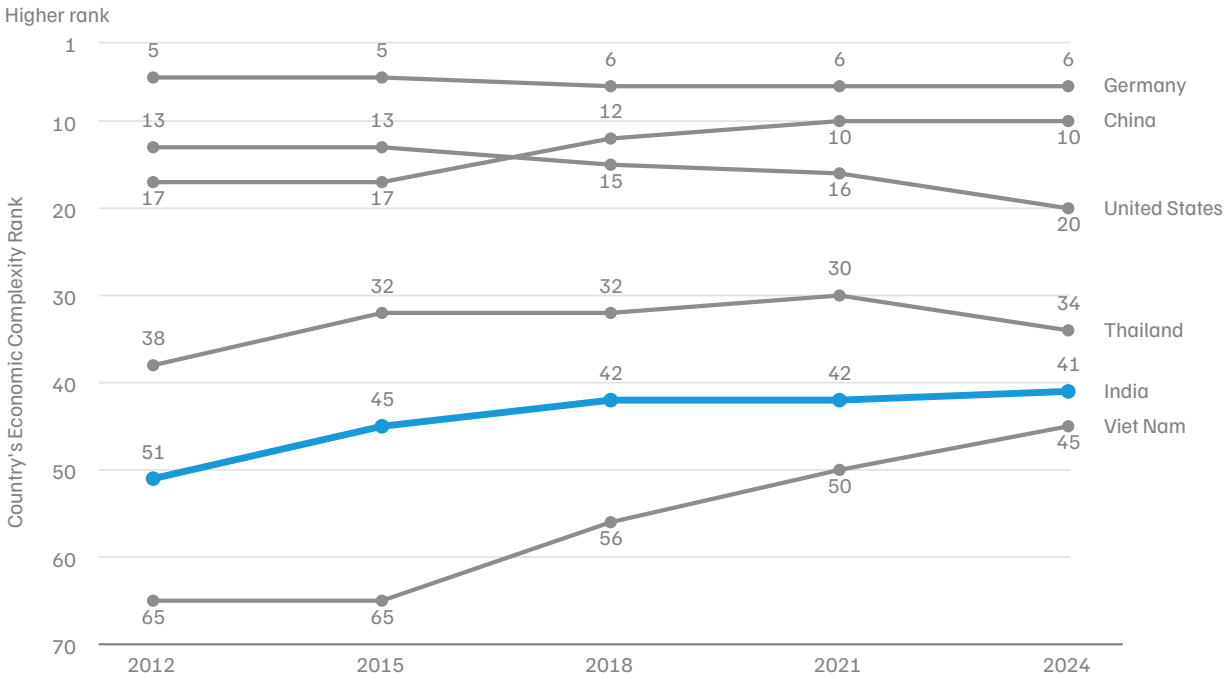
Figure 5. Manufacturing's share of India's GDP has declined steadily over a decade, underscoring limitations in existing industrial policy



Source: Authors' compilation from MOSPI Annual Estimates of GDP at current prices

The Economic Complexity Index (ECI) offers one useful lens through which to assess the manufacturing gap. The ECI captures the productive capabilities embedded in an economy, as indicated by the diversity and sophistication of its exports, which leads to long-term growth. India's export basket has gradually expanded to include more complex products, rising from 51st globally in the ECI in 2012 to 41st in 2024 (Growth Lab at Harvard 2026). However, India still trails behind many smaller manufacturing economies that have achieved greater export sophistication, such as Mexico, Vietnam, and Thailand (Figure 6).

Figure 6. India's economic complexity has improved steadily since 2012, but the gap with faster-moving manufacturing economies remains wide



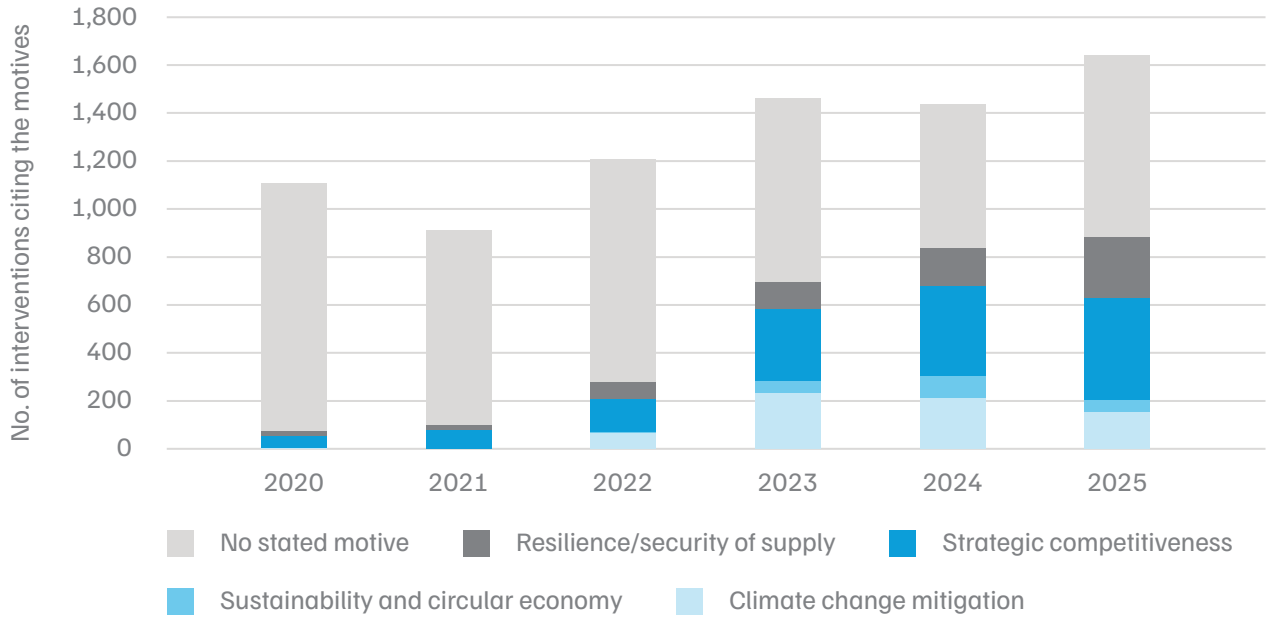
Source: Authors' compilation from the Atlas of Economic Complexity 2024

India now stands at a pivotal moment, having set ambitious goals for both clean energy technology manufacturing and broader industrial growth. At this time, the global context for industrial policies has also shifted (World Bank Group 2026; Evenett et al. 2024). What was once episodic and crisis-driven has re-emerged as a persistent regime across advanced and emerging economies (Martín 2026). The rationale motivating these interventions has also changed. Between 2009 and 2021, industrial policy in the United States and other Western economies was driven primarily by climate and competitiveness goals, but since 2022, national security, geopolitics, and supply chain resilience have become dominant motivations (Martín and Evenett 2025). Specific sectors have come under deliberate focus; including advanced technology sectors, defence and dual-use products[3], critical and industrial raw materials and minerals (McKinsey & Co. 2025; Martín and Evenett 2025).

Clean energy supply chains sit at the intersection of these pressures in a particularly consequential way. These value chains can comprise complex components that are used across many strategic industries. More upstream products, by virtue of their intermediate nature, feed into a larger number of downstream goods, playing a more central role in global production networks (Fetzer et al. 2024). As Figure 7 shows, intermediate products in these supply chains can continue to be affected by security centric industrial policies, despite climate change-related motivations taking a back seat in the global economy.

3. Dual-use items are goods, software and technology that can be used for both civilian and military applications.

Figure 7. Strategic competitiveness and security of supply have increasingly become primary motives for industrial policy interventions in green goods in the global economy



Source: Trade and Industrial Policy for the Green Transition Monitor 2026

Note: The category 'no stated motive' categorises interventions lacking a stated motive, or a motive different than the ones shown in the graph. Green goods include solar, wind, and battery products, fuel cells, and other green goods, but the list does not include green fuels such as biofuels and hydrogen, as well as strategic minerals such as lithium, cobalt, rare earths etc.

Amid fragmenting trade and a political economy in flux, many governments continue to adopt a defensive posture on clean energy technology trade (IEA 2026). Policy measures for low-carbon sectors also increasingly align with objectives of technological capability, supply chain resilience, and strategic autonomy (Hoekman and Nelson 2025). Framed as security centric, policies can secure greater buy-in and durability (German Marshall Fund 2025; McBride 2026). The result is the emergence of a new energy industrial strategy paradigm, one in which clean energy is as much a vehicle for economic and geopolitical positioning as it is a response to environmental challenges. Existing approaches in India, oriented largely around renewable energy deployment targets and import substitution, need to be expanded to navigate a landscape in which the strategic stakes and benefits are meaningfully higher.

2. Moving up the structural ladder: Dividends from clean energy value chains

In this paper, we assess the significance of clean energy manufacturing as a manufacturing-led growth opportunity through a wider lens—one where the relevant unit of analysis is the production network within which these supply chains are embedded. Three key metrics shed light on this: centrality, complexity, and opportunity gain. While several other aspects such as value addition, employment generation potential etc. are also highly relevant, these variables focus on how these technologies are positioned within, and reshape, the wider industrial landscape, hence amplifying the structural transformation and resilience benefits.

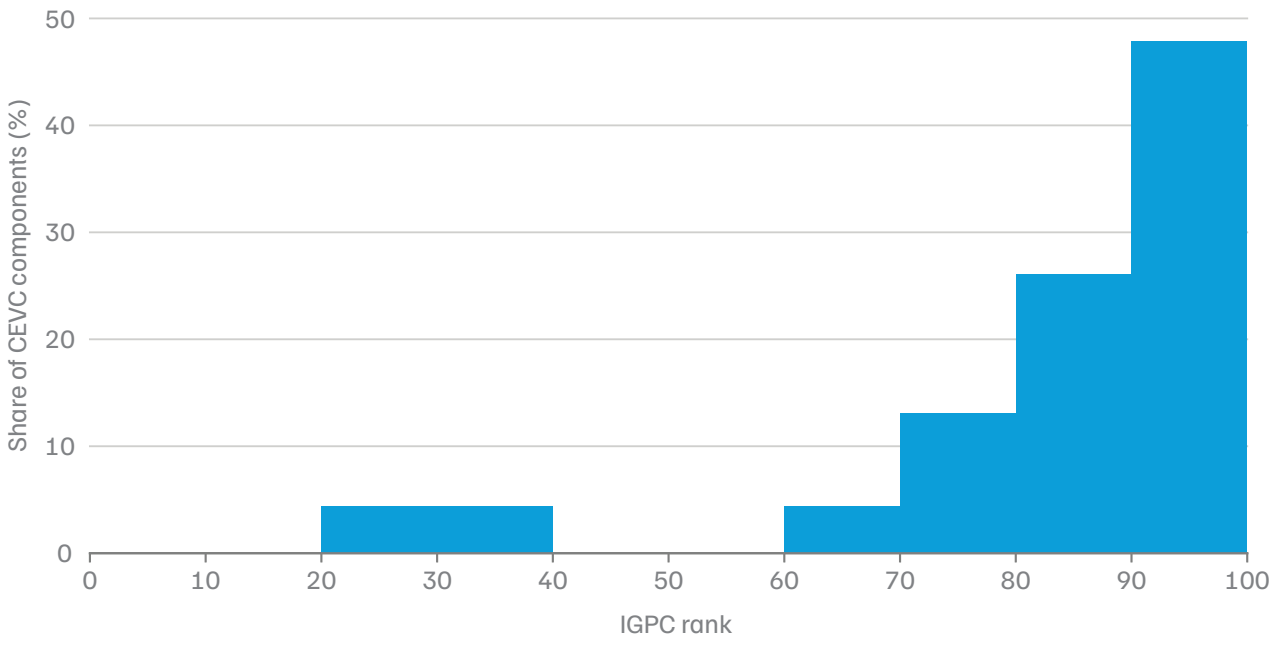
2.1 Centrality: Connectedness with various production networks

Product-level centrality highlights which components occupy critical positions within production networks. Highly central products are typically used as inputs across a wide range of industries, including various economically significant goods, and contribute meaningfully to global trade flows (Fetzer et al. 2024).

Many clean energy components are inherently cross-sectoral as they serve as inputs into a wide range of downstream applications. For instance, ball bearings used in wind turbine generators are also critical to automotive and industrial machinery, while rare earth magnets essential for renewable energy technologies are equally integral to defence sector goods.

This suggests that CEVCs are critical nodes of the industrial economy, implying both capability spillovers and risk propagation channels (Li et al. 2026). As shown in Figure 8, many CEVC products occupy central positions within global production networks, with majority of the CEVC products showcasing a high degree of centrality (IGPC rank above 80). Disruptions in the supply of such products can generate cascading effects across industries and geographies, amplifying their relevance for economic resilience. As such, countries with control of central products can hold significant geopolitical leverage.

Figure 8. Components spanning clean energy value chain products are structurally integral to production networks worldwide



Source: Authors' compilation from Fetzer et al. 2024

Note: The Index of Global Product Centrality (IGPC) ranks for products, as identified by their HS codes[4] (refer Appendix for HS codes). Ranging from 0 to 100, IGPC captures a product's systemic importance in global production networks, reflecting its trade intensity, its role as an input into other products, and its connections to other central goods. Higher ranks point to more centrality in production networks.

4. Harmonised System (HS) codes are standardised numerical identifiers used globally to classify traded products for customs, taxes, and statistics.

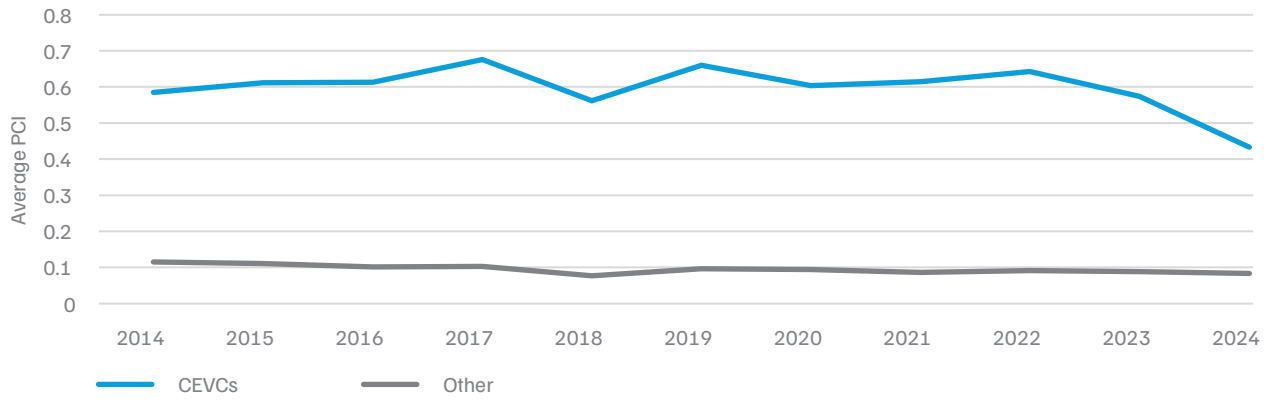
2.2 Complexity: Valuable economic diversification for India

The Product Complexity Index (PCI)[5], as defined within the Atlas of Economic Complexity framework[6], ranks products based on the depth and concentration of capabilities required for their production.

Countries typically achieve stronger productive and export diversification by moving into products that are more complex than their existing industrial base (UNCTAD 2025). However, with constraints on fiscal bandwidth and institutional capacities, industrial strategy must also consider the relative opportunity cost (Stojkoski and Hidalgo 2025).

Some products offer greater gains in productive capabilities than others. Figure 9, therefore, compares the evolution of average PCI scores for CEVC components where India lacks a comparative advantage, against the broader set of products with RCA[7] less than 1 for India. Higher-than-average PCI values of clean energy products suggests that scaling these could generate larger gains in India's overall economic complexity and industrial capabilities. As of 2024, a large majority of CEVC products remain below an RCA of 1, indicating significant scope for industrial upgrading.

Figure 9. Clean energy components are among the more knowledge-intensive and higher-value products that India does not yet manufacture competitively



Source: Authors' compilation from the Atlas of Economic Complexity 2024 (accessed 2026)

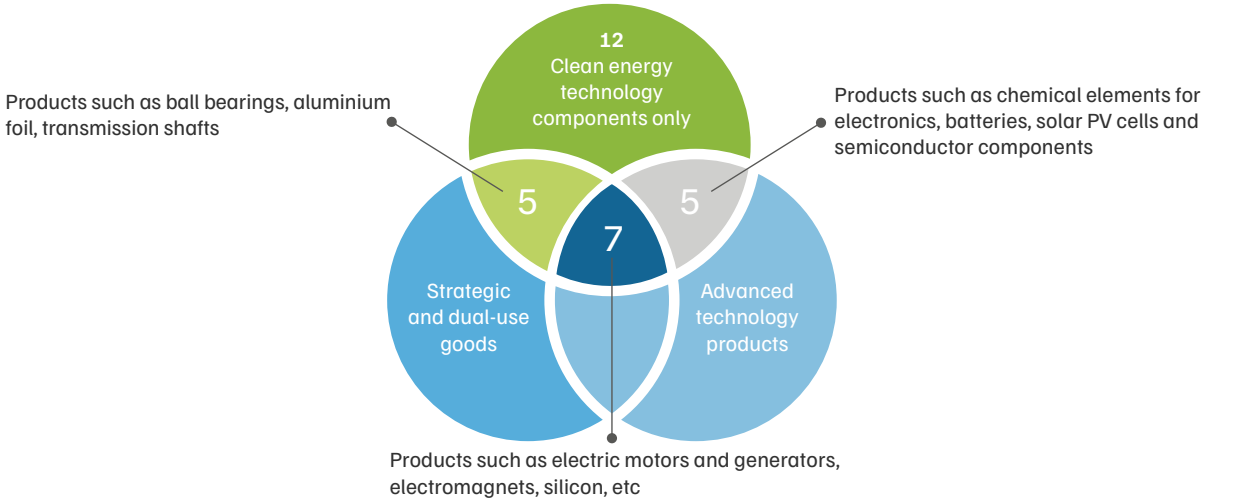
2.3 Opportunity gain: tapping new and strategic sectors

Opportunity Gain (OG)[8] captures the dynamic potential for future diversification. It measures the degree to which entering a given product expands an economy's access to an adjacent and often more sophisticated set of future production possibilities. However, the metric in itself does not capture a strategically significant co-benefit—that many of the sectors adjacent to clean energy value chains are also geopolitically consequential and not just economically valuable.

CEVCs can intersect substantially with sectors that sit at the centre of contemporary industrial policy competition—advanced technology products and dual-use goods. Product families within these sectors are identified based on established HS code lists in widely used global taxonomies (refer Appendix for details). Figure 10 maps these intersections at the product level.

5. PCI is calculated based on how many other countries can produce the product, and the economic complexity of those countries. In effect, PCI captures the amount and sophistication of knowhow required to produce a product.
6. The Atlas of Economic Complexity estimates product proximities from the export patterns of 128 countries over five decades of trade data, making them a structural property of the product space, rather than a feature of any individual economy.
7. Revealed Comparative Advantage (RCA) measures a country's export strength in specific goods relative to the world. An RCA index value greater than 1 suggests that a country has a 'revealed' comparative advantage in a particular product.
8. Opportunity outlook gain quantifies how a new product can open up links to more and more complex products.

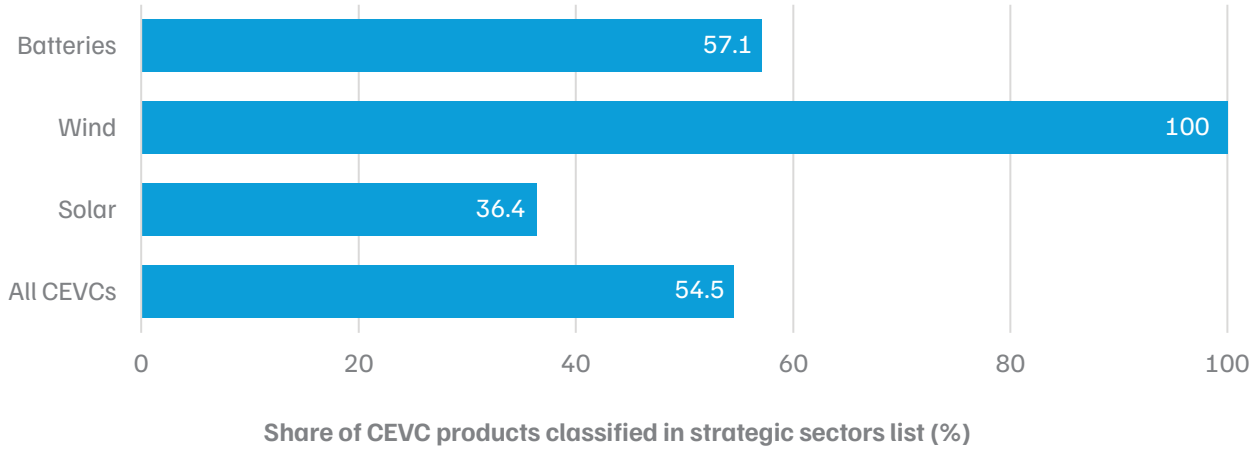
Figure 10. Overlapping HS classifications indicate that clean energy manufacturing is deeply embedded within broader strategic and industrial ecosystems



Source: Authors' compilation from HS code classifications (see Annexures)

Importantly, many of these adjacent and strategic sectors are also currently underdeveloped in India's manufacturing economy (Figure 11). In this sense, entry into clean energy manufacturing can serve as a bridge to higher-value and geopolitically significant sectors. About 54 per cent of CEVC products where India lacks comparative advantage are connected to at least one strategic sector; either in strategic and dual-use goods, or in advanced technology products (Figure 8). These product families include electromagnets (HS 8505), semiconductor devices (HS 8541), carbon articles for electrical purposes (HS 8545), instruments for measuring electricity (HS 9030) etc[9].

Figure 11. India's unrealised clean energy manufacturing potential lies in products that also carry strategic and dual-use significance



Source: Authors' compilation from HS code classifications (see Annexures)

9. It should be noted that HS 4-digit codes represent an aggregate product family. A more granular treatment at the HS 6- or 8-digit level would allow a distinction between, for example, generic bearings and the precision variants, where tolerances, load specifications, and quality certification requirements etc. differ as per the end-use sector.

A recalibrated approach to clean energy manufacturing requires recognising that it is far from a self-contained sector. Its upstream inputs are among the most strategically contested inputs in the global economy, and its production networks can intersect with a wide range of industries where India already has a foothold or holds strategic ambitions. Their relevance and feasibility increasingly lie in their intersection with broader industrial ecosystems. Assessing the 'relatedness' between clean energy and other sectors is, hence, necessary for an industrial strategy that leverages existing strengths and is calibrated to the full range of dividends on offer.

3. Mapping India's industrial linkages to clean energy technology manufacturing

Broadly, countries can diversify into new sectors through three interconnected pathways: vertical integration into upstream and downstream stages of existing value chains; horizontal expansion into sectors related to existing strengths; and diversification into unrelated but dynamic sectors with long-term development potential (UNCTAD 2025). This paper explores the potential of complementing ongoing efforts with a horizontal push, which aims to utilise existing capabilities.

A large body of research suggests that effectiveness of industrial policy is magnified by pre-existing productive knowledge (Chen, Poncet and Xiong 2017; Pinheiro 2025). Global examples, such as Brazil's automotive sector, reinforce this observation; instruments like local content requirements (LCRs) have often not succeeded in producing globally competitive industries, if not accompanied by capability building measures, as prolonged protectionism led to high-cost structures, weak innovation, and limited export competitiveness (Cherif and Hasanov 2024). Conversely, Asian economies such as China, Japan, and South Korea consistently dominate multiple clean energy technologies, reflective of underlying strengths in advanced manufacturing and sophisticated chemical production (Net Zero Industrial Policy Lab 2025).





Image: iStock

The main challenge in horizontal expansion is in identifying inter-industry relatedness, and assessing the potential to leverage their complementary knowhow to achieve sustained manufacturing competitiveness. To identify these linkages, this paper utilises the product space map developed within Atlas of Economic Complexity at Harvard's Growth Lab. We identify existing domestic industries that can support India's entry into CEVC manufacturing, particularly in those segments where India does not yet exhibit comparative advantage, as measured by RCA. This approach draws on the concept and metric of product proximity10, developed by Hidalgo et al. (2007) and elaborated in subsequent work by the Harvard Growth Lab's Atlas of Economic Complexity. Higher proximity between two products suggests that they rely on similar underlying capabilities such as skills, machinery, supplier networks, and institutional knowhow, and that countries producing one are more likely to produce the other (more details on methodology in Appendix).

This approach should only be considered an indicative starting point, as proximity reflects probabilistic association. Industrial proximity may identify where entry is plausible, but it does not guarantee that large-scale manufacturing expansion will be economically viable. As such, our analysis does not explain the strength of linkage between sectors, nor does it contextualise the barriers to utilising a country's latent capabilities. As we conducted our analysis at the 4-digit HS code level, many industries and products have been aggregated together, which is helpful for testing the potential of a horizontal approach, but remains insufficient for arriving at actionable insights. Our findings provide a generalisable direction for future analysis—the key Indian sectors and manufacturing industries that show 'proximity' to clean energy technologies.

3.1 Identification of complementary industries using the product space

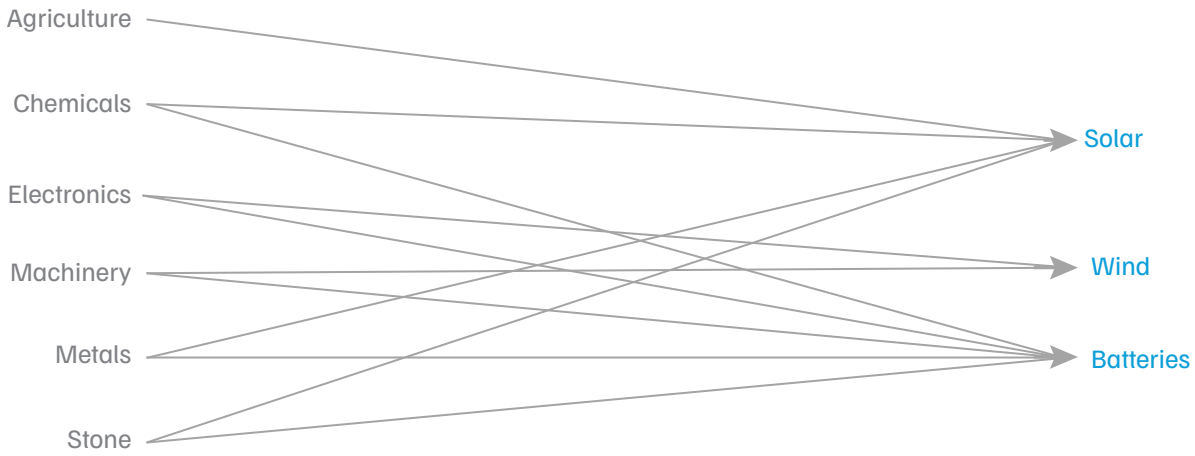
As shown in Figure 12, CEVC components are closely related to products in sectors such as metals, electronics, machinery etc. From these related products, only those where India exhibits a revealed comparative advantage (RCA) ≥ 1 are classified as complementary to CEVCs. The rationale is that if a country demonstrates RCA in a product, it is either already producing it, or can competitively produce it at scale (Mealy and Teytelboym 2020).

10. Proximity is measured by the probability of co-export, such that if a country exports product A, it also exports product B. Product proximities are fixed globally and measured using 128 countries' export data over 50 years.

Hence, Figure 13 represents established sectors whose productive capabilities potentially overlap with those required for manufacturing the corresponding CEVC component. These complementary industries (CIs) are expected to support faster indigenisation with lower barriers to entry into clean energy manufacturing.

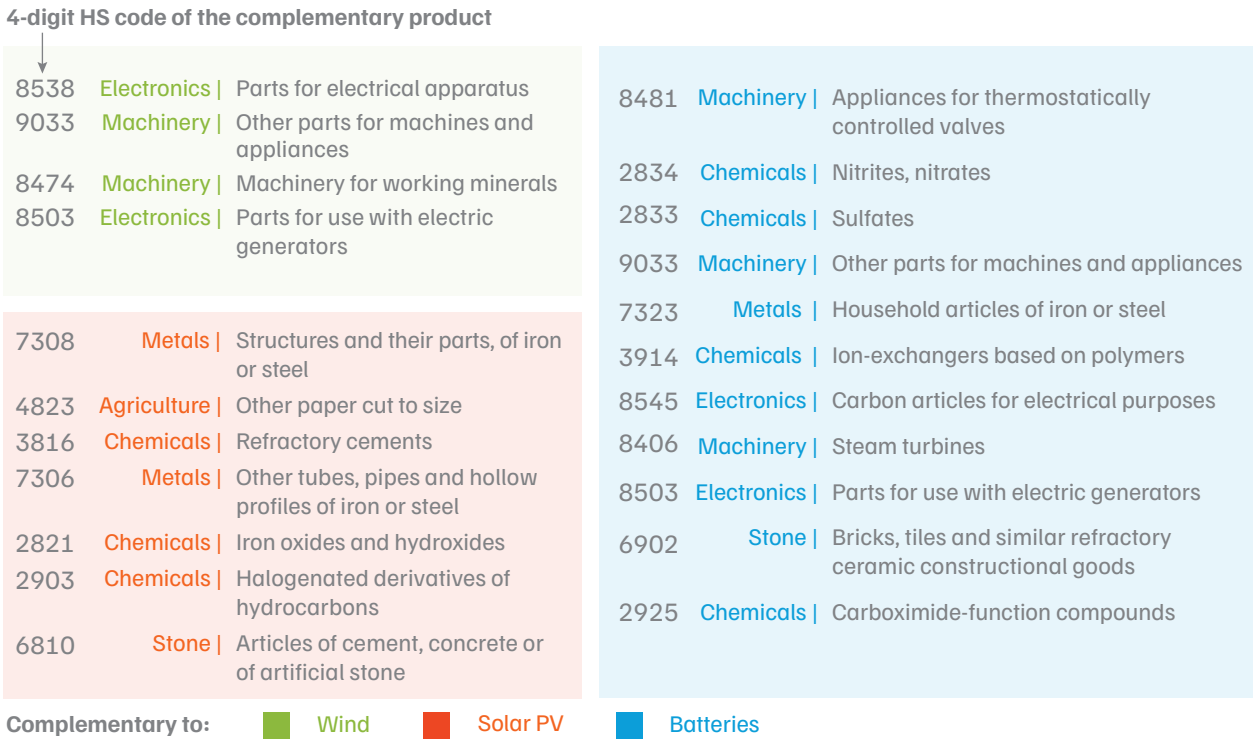
Figure 13 outlines the specific HS codes mapped as established and complementary to solar, wind, and battery value chains. We see diverse product categories linked to the clean energy sector, from electronic apparatus to various chemical products such as nitrates and sulphates. There are also a few overlaps in complementary product categories in the wind and battery sector, such as HS 9033 (other parts for machines and appliances) and HS 8503 (Parts for use with electric generators).

Figure 12. Clean energy value chains are strongly connected to various other industries, exhibiting opportunities for industrial diversification based on existing strengths



Source: Authors' compilation from the Atlas of Economic Complexity 2024

Figure 13. Multiple established and competitive product families within India's existing industries can directly support entry into clean energy manufacturing



Source: Authors' compilation from the Atlas of Economic Complexity 2024

Our findings can be instructional to industries with expertise in these product categories, to explore horizontal expansion or partnership in clean energy technologies. Accumulating capabilities from within the domestic economy can accelerate a self-reliant pathway to indigenisation. At the same time, this does not mean that low-proximity, high-ambition bets are never warranted; some clean energy technologies and their components may be sufficiently strategic that India should pursue them regardless of a larger capability gap. Moreover, technological change periodically creates windows in which competitive positions are not yet fully consolidated and barriers to trade, entry etc. have not been erected (Lee and Malerba 2017). Clean energy technology markets are characterised by intense competition, rapid innovation, and sustained price falls, making late entry into mature technologies both costly and strategically limited. Investing in a up-and-coming technological ecosystem to stay globally competitive is imperative and must be a complementary approach.

3.2 Implications for further research

There is evolving scholarship on how such analysis can inform actionable policy (Hidalgo 2023). Measures of relatedness should be viewed as diagnostic signals; they identify where potential capability overlaps exist, but don't illustrate why despite appearing well-aligned with the domestic production structure, certain industries have not yet emerged or scaled (Li and Neffke 2024). The analytical focus, therefore, shifts towards the barriers preventing latent capabilities from translating into production. This includes information asymmetries, coordination failures, missing inputs, and institutional bottlenecks. Importantly, proximity metrics do not distinguish whether relatedness stems from shared inputs, production processes, labour skills, or technological knowledge, even though these differences are critical for policy design. Future research should therefore differentiate between these linkages and map them to targeted policy responses, supported by more granular diagnostics. An illustrative framework is outlined in Table 1.

Table 1. Different types of productive relatedness call for different policy responses

Underlying linkage type	Plausible policy instruments
Shared input materials or intermediate components	Industrial clusters and parks, input demand aggregation platforms, buyer-supplier matching programmes, logistics and supply chain integration
Shared capital equipment	Machinery import duty concessions, technology upgradation funds, co-investment in common facility centres (testing, certification, prototyping)
Shared labour skills	Sector skill council alignment, apprenticeship linkages between incumbent firms and CEVC entrants, targeted reskilling and mobility programmes
Shared technical knowledge, such as metallurgy, chemistry, electronics assembly, requiring a meaningful step up in precision or specification.	Joint ventures, technology licensing frameworks, R&D support, local content requirements linked to knowledge transfer

Source: Authors' analysis

Researchers building more rigorous evidence to support such horizontal expansion should develop on these findings through supplementary approaches. These can include studying the flow of workers between industries, the strength of input-output linkages across industries, and the relatedness underpinning different technologies through patent citations, as per the co-classification of patents across technology classes. However, the feasibility of these data sources is often contingent on mature statistical infrastructure, or within countries with higher R&D activity and clear tracking of the same, limiting their applicability in certain contexts. Often, approaches such as input-output mapping are also limited by a reliance on static assumptions and may fail to capture the dynamic evolution of market forces and technological innovation (UNCTAD 2025).

4. From product space to production lines, how should industrial policy be designed?

Moving from a patchwork of adjacent industries to platforms for shared capabilities will require institutional mechanisms that can coordinate actors, resolve bottlenecks, and facilitate capability diffusion across the industrial ecosystem. Drawn from the analytical findings of this paper, the following implications are intended to orient future policymakers toward the strategic, institutional, and diagnostic considerations that will shape India's ability to build competitive clean energy manufacturing capabilities.

- **Clean energy manufacturing should be treated as an industrial and strategic opportunity, not merely a self-reliance agenda for decarbonisation.**

  India's clean energy ambitions have largely been framed around renewable energy deployment targets and import substitution. This framing understates the strategic case—CEVC components intersect with advanced technology products, dual-use goods, and production networks that extend well beyond the energy sector. The case for domestic component manufacturing is strongest where clean energy technologies reinforce broader industrial and technological capabilities—generating greater long-term resilience across multiple sectors, signalling more durable policy support, and crowding in private investment accordingly.

- **Protection and incentives are necessary but insufficient—the capabilities underpinning manufacturing capacity are what determine long-run competitiveness, and many can be drawn from existing industrial strengths.**

Through PLIs, local content requirements, and trade barriers, industrial policies so far have paid considerable attention to manufacturing capacity in India. This has helped deepen existing value chains. What determines whether capacity becomes competitive is the plumbing underneath it: workforce readiness, supplier networks, manufacturing knowhow, capital, and equipment. India's existing strengths in metals, electronics, machinery, and chemicals are closely related to multiple clean energy segments, hence these sectors can potentially help bridge the capability gaps in manpower, materials, and machinery. A deliberate horizontal push, which helps connect these industrial ecosystems to CEVC manufacturing requirements, must complement production incentives. New manufacturing avenues will require resisting protectionist temptations that are particularly acute in a moment of heightened geopolitical competition, and placing the hard work of strengthening underlying capabilities at the core.

- **Leveraging strengths in adjacent industries presents a significant coordination challenge, while being a self-reliant pathway of scaling new products.**

  These related sectors span multiple firms under the mandates of different ministries, state governments, and regulatory bodies, with no single institution possessing either the visibility or mandate to convert them into concrete industrial outcomes. Targeted efforts to facilitate capability diffusion—particularly where industrial relatedness is strong but underutilised—can help bridge this gap. For example, India's automotive and heavy engineering sectors already possess many of the capabilities needed to manufacture wind components such as bearings, castings, gearboxes and towers; the challenge is less technological than one of information, demand visibility, and coordination. Unlocking these opportunities will require lowering information and coordination asymmetries via inter-ministerial coordination and structured public-private dialogue.

- **Existing capabilities can shorten the path to competitiveness, but they cannot compensate for capital, technology, and process engineering where those gaps are large.**

  Despite the presence of transferrable capabilities in related sectors, significant gaps can remain in capital needs, standards requirements, technology improvement, and process engineering for many components. In such cases, coordination and information-sharing alone cannot overcome constraints that arise from high capital intensity, minimum efficient scale requirements, or limited access to technology and knowhow. A credible indigenisation strategy must recognise this distinction with technical realism. More complex products, such as polysilicon, wafers, lithium-ion cells, and rare earth magnets, are likely to require a more patient policy toolkit, including but not limited to long-term financing, technology partnerships, and anchor demand commitments. Distinguishing between these pathways and sequencing interventions accordingly will be critical.

- **Emerging manufacturing sectors must not remain statistically invisible. Strengthening industrial classifications is an enabling condition for data-driven industrial policy.**

  Understanding where capabilities are located and how they can be mobilised across firms requires more granular assessment at the subnational level. For example, how can the process expertise of a precision engineering firm in Tamil Nadu be leveraged by a clean energy component manufacturer in Gujarat when the two activities are closely related in the product space? The datasets useful in this regard—such as the Annual Survey of Industries (ASI) and Centre for Monitoring Indian Economy's (CMIE) Prowess—operate on industrial taxonomies that often lag behind on emerging sectors. Just as HS codes enable governments to track trade flows, administer customs, and implement trade policy, product classifications are the foundation for industrial diagnostics. If a product cannot be identified in official data, it is difficult to measure its scale, map capabilities, or design targeted interventions. While India cannot unilaterally revise internationally harmonised classifications such as National Industrial Classification (NIC) and National Product Classification for Manufacturing Sector (NPCMS) codes, it can introduce temporary domestic codes for priority sectors, as it did for platform economy workers in the 2025 Annual Survey of Unincorporated Sector Enterprises (ASUSE). Creating such classifications is a simple but essential first step towards a more evidence-based industrial strategy.

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