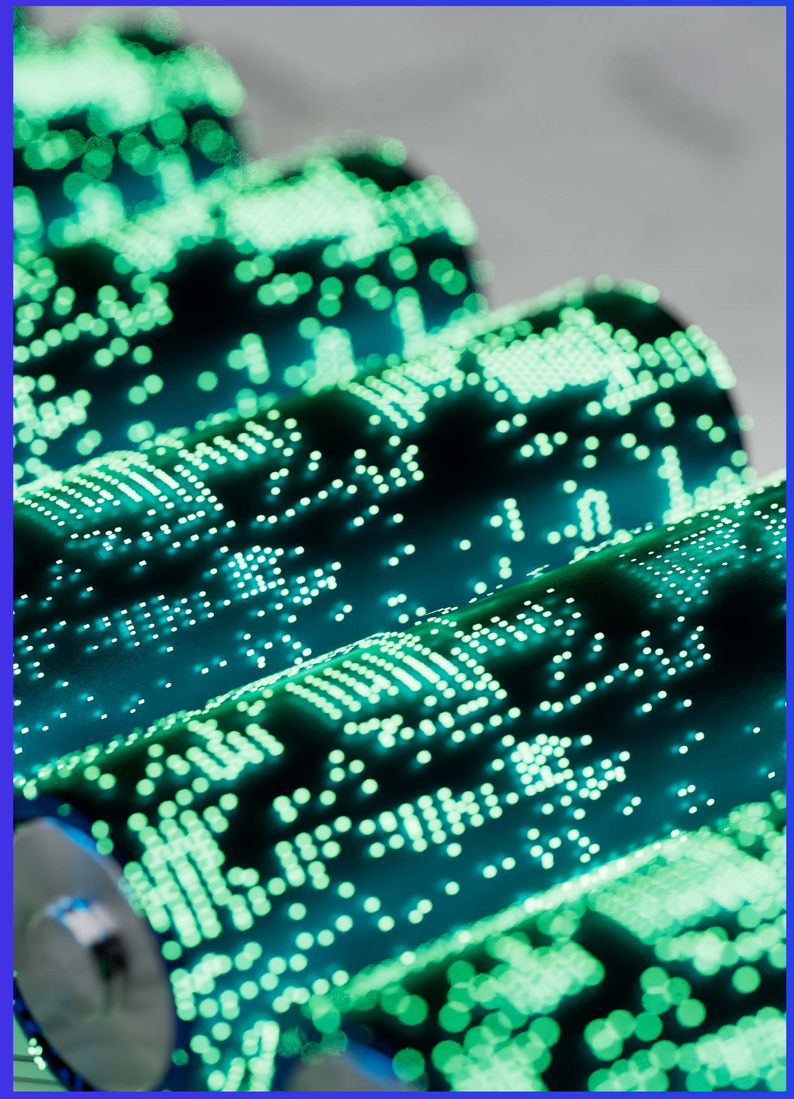
KPMG

Pivoting to leadership

Re-imagining supply chains for India's emergence as a credible alternative for global clean energy manufacturing

ENRich 2023



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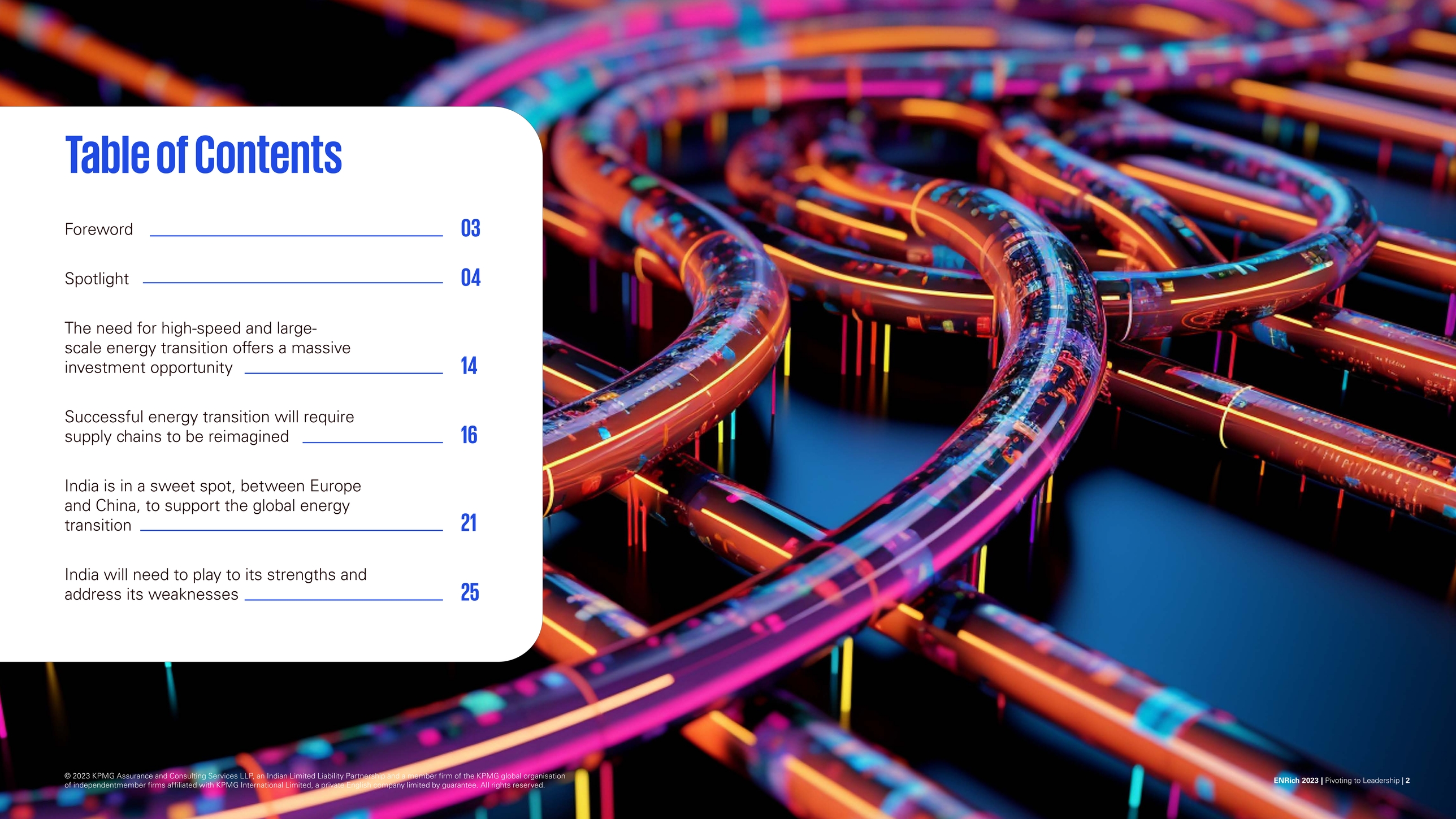


Foreword

Anish De
Global Head
Energy Natural Resources and Chemicals (ENRC)
KPMG International

Over the past decade India's standing in the global clean energy space has transformed. The scale of clean energy deployment has caught the attention of the world. In CoP 21 in Paris, India set out ambitious goals on the energy transition which were further reinforced and scaled at CoP 26 in Glasgow. We expect those ambitions to be exceeded.

However, in the past 5-6 years it has also become apparent that India is very vulnerable on some key dimensions. The growing economy needs ever more energy, and energy needs resources, materials and manufactured products and systems. Beyond energy projects development where India has excelled, the full value chain needs addressing. There is massive concentration of most clean energy manufacturing in China which places India and the rest of the world at great risk. The war in Ukraine has brought to the fore the broader challenges on energy security and the risk to the economy at large. As a very large energy importer India is extremely exposed, and alternatives that make the country less vulnerable are essential.

The risk India and the world faces fortunately affords great opportunity. If India gets the manufacturing and supply chain story right, it would serve not only the nation but also de-risk the world. Indeed, it is the expectation of many other nations that India would work to create new manufacturing and supply chains to serve them along with serving domestic needs.

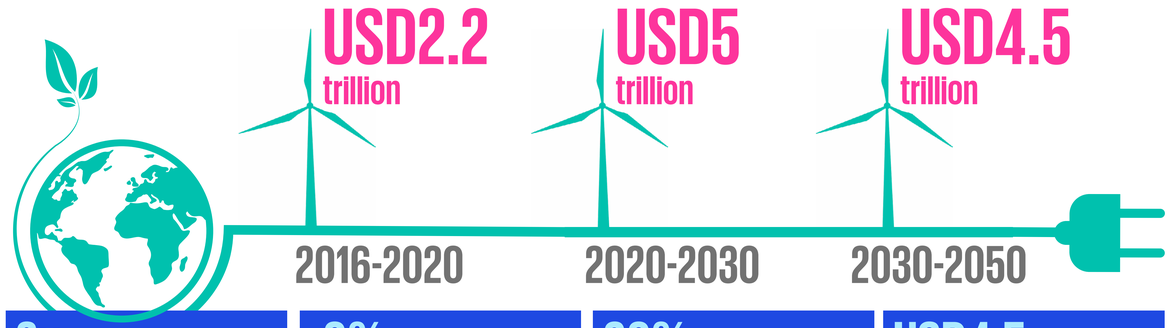
We believe that this is eminently possible. In this paper we identify the key imperatives in this regard. As KPMG in India we also believe that we have a significant role to play in this through our work with governments, industries, innovators and entrepreneurs, the financing community, civil society and other stakeholders. This paper is a significant initiative towards that end where we bring out the various dimensions that need to be worked on to turn this great opportunity into reality.

Spotlight

1

Rapid growth and climate change have created a pressing demand for energy transition, which might involve a global annual investment of USD4.5 trillion a year until 2050.

Estimated Average Annual Investment globally in Energy Transition



2x Global economy by 2050, driven significantly by emerging economies	**-8%** Reduced energy demand by 2050 compared to today for Net Zero	**38%** Share of E7 of global GDP by 2050 (G7 in contrast will be ~ 29%)	**USD4.5 trillion** Annual investment needed for clean energy investments by 2050, much of it front loaded
30% % Heavy duty transport and mobility use of global energy*	**30%** Share of heavy hard to abate industries in primary energy demand*	**30%** Ultimate energy share of built-up spaces *	**2,200 TWh** Energy requirement of IT industry today with 50% expected growth by 2030*

* Represents current values

Sources: Net Zero by 2050, IEA, 2023, Accessed 4th September 2023 | Goldman Sachs Global Investment Research, 2021, Accessed 31st August 2023 | Global Energy Transformation: A roadmap to 2050, International Renewable Energy Agency, Abu Dhabi, 2018, Accessed 31st August 2023 | Achieving Net Zero Heavy Industry Sectors in G7 Members, IEA, Paris, 2022, Accessed 31st August 2023 | Tracking Clean Energy Progress, IEA, 2023, Accessed 31st August 2023 | Digital economy and climate impact, Schneider Electric, 2021, Accessed 4th September 2023| Tracking Clean Energy Progress 2023, IEA, 2023, Accessed 4th September 2023, World Energy & Climate Statistics – Yearbook 2023, Enerdata, Accessed 4th September 2023

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India has set itself on course for a massive energy transition journey, creating an estimated average annual investment opportunity of USD350 – 400 Billion in energy transition technologies alone till 2047, when the nation celebrates 100 years of independence.

India between now and 2047

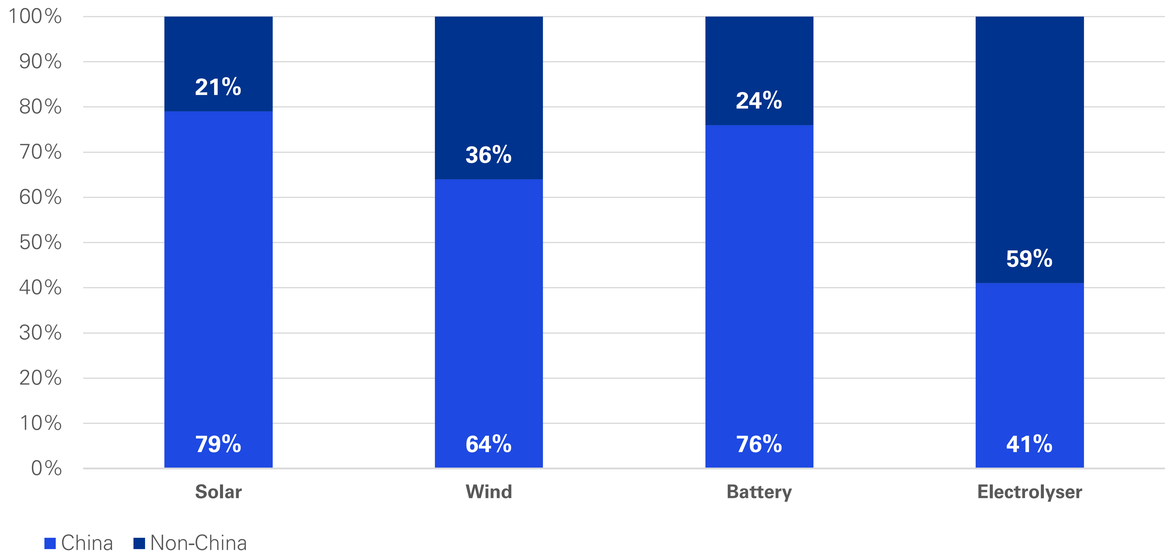
4.5x Increase in installed power capacity	**10x** Increase in RE installed capacity	**85%** Share of non-fossil fuel in capacity mix	**25 MMT** Annual production of green hydrogen
100% Passenger EV sales	**38%** Increase in share of forest cover	**65%** Level of ethanol blending in petrol	**USD350-400 bn** Annual investments for energy transition

Source: KPMG Analysis, CEA, 20th EPS Report, NITI Aayog, MoPNG, BNEF, MoEF&CC

3

The success of the global as well as Indian energy transition stories will depend on investment in supply chains, which are highly concentrated at present.

Current geographical concentration of renewable energy manufacturing (%)

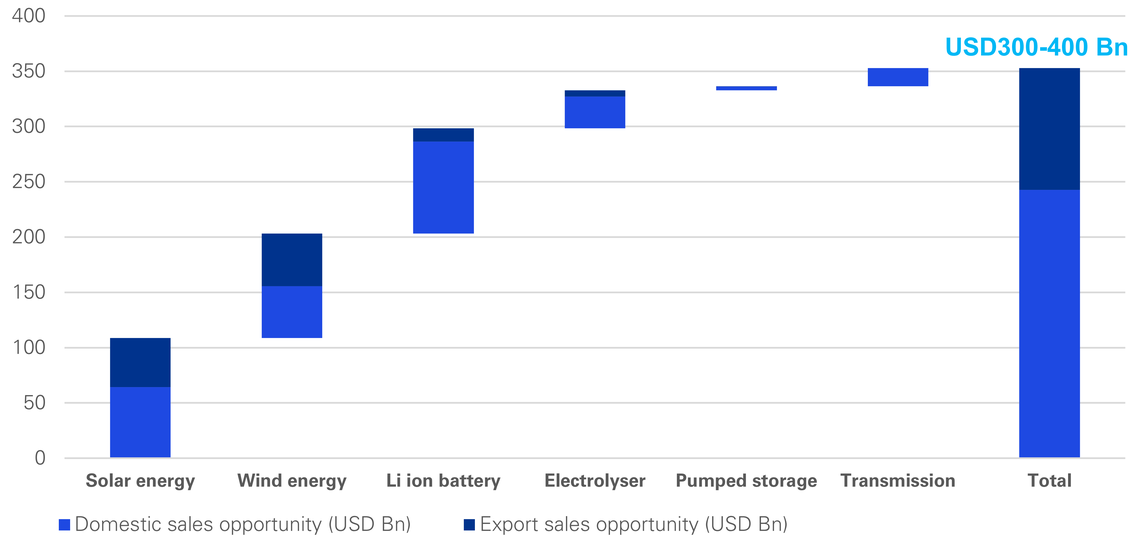


Source: The State of Clean Technology Manufacturing: An Energy Technology Perspectives Special Briefing, IEA, May 2023, Accessed 26 August 2023

4

India has the ingredients needed to develop as an alternative frontier for clean technology manufacturing. If both domestic consumption and exports are factored, it has a USD300-400 billion cumulative market opportunity that it can harness within this decade.

India's cumulative clean tech and ancillary equipment sales opportunity up to 2030



Source: KPMG Analysis

5

India needs to build razor-sharp competitiveness in manufacturing by using levers such as right sourcing strategy, value engineering, and others.

Five levers for competitive green energy manufacturing

Strategies

Strategy 1	Strategy 2	Strategy 3	Strategy 4	Strategy 5
Category sourcing strategy	Value engineering initiatives	Manufacturing efficiency through visual and digital enablers	Effective capacity expansion management	Knowledge management program (KMP) and Result Focused Skill Development (RFSD)

6

Energy transition could create ~5-6 million jobs by 2030 and ~9-10 million by 2047 in India, of which ~30 per cent could be required in the clean energy manufacturing sector. India needs to develop a strong skilling strategy for areas such as R&D, where there are significant skill gaps.

Job creation expected across the below three dimensions

India for India (I for I)

Of the ~8-9 million jobs needed to meet domestic ambitions, almost ~30 per cent will be in manufacturing and the rest in construction and installation, operations and maintenance, and fuel supply.

India for the world (I for W)

By providing ~10% of the required workforce in key regions such as North America, Oceania, MENA etc, India will be able to create ~0.8 million to 1 million jobs by 2050.

World from India (W from I)

India houses almost 50 percent of worldwide GCCs. Energy majors such as BP and Shell have opened GCCs in India. The momentum is likely to continue, as India offers large pools of talent and niche skills in areas like engineering, digital technology and data analytics.

Source: KPMG Analysis | India Briefing, 28th June 2023 - India's Global Capability Centers Market Estimated to Reach USD110 Billion by 2030, Accessed 31st August

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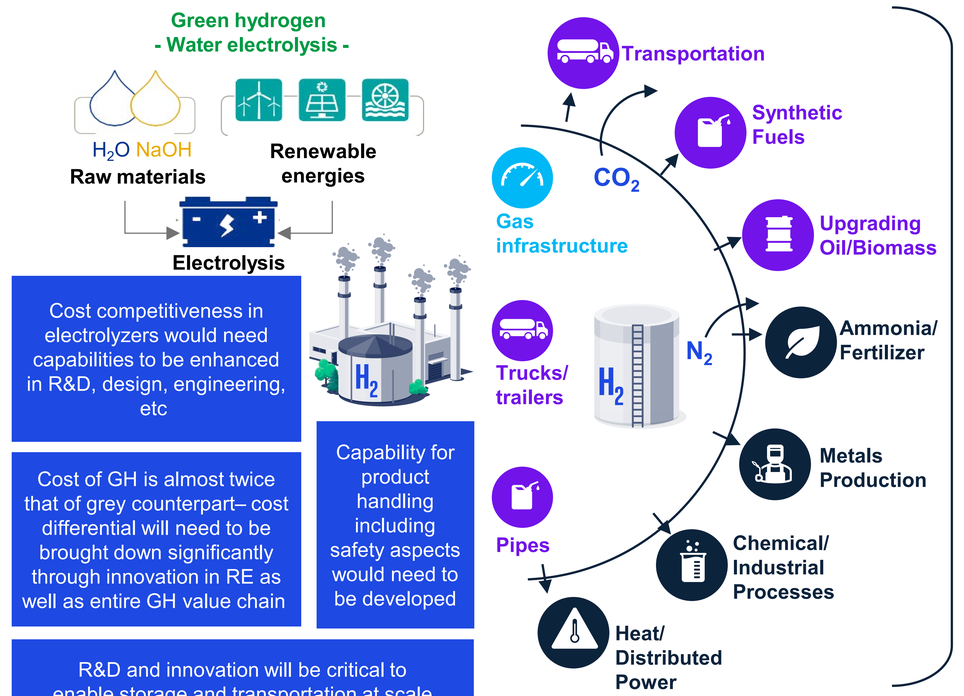
New technologies such as Batteries ,Green Hydrogen (GH) and Carbon Capture Utilisation and Storage (CCUS) demand deep skills and would need a more aggressive approach to talent development.

Green Hydrogen and its derivatives - a deep skills area



Cost competitiveness in electrolyzers would need capabilities to be enhanced in R&D, design, engineering, etc

Cost of GH is almost twice that of grey counterpart– cost differential will need to be brought down significantly through innovation in RE as well as entire GH value chain

Capability for product handling including safety aspects would need to be developed

R&D and innovation will be critical to enable storage and transportation at scale

R&D and innovation in end use technologies – fuel cell vehicles, hydrogen DRI, etc would need a strong focus

Supply chain and downstream applications space including green chemicals will require great focus in education, skills and innovation

Green Hydrogen will create a full ecosystem that will have to be synchronized and harmonized

Source: KPMG Analysis

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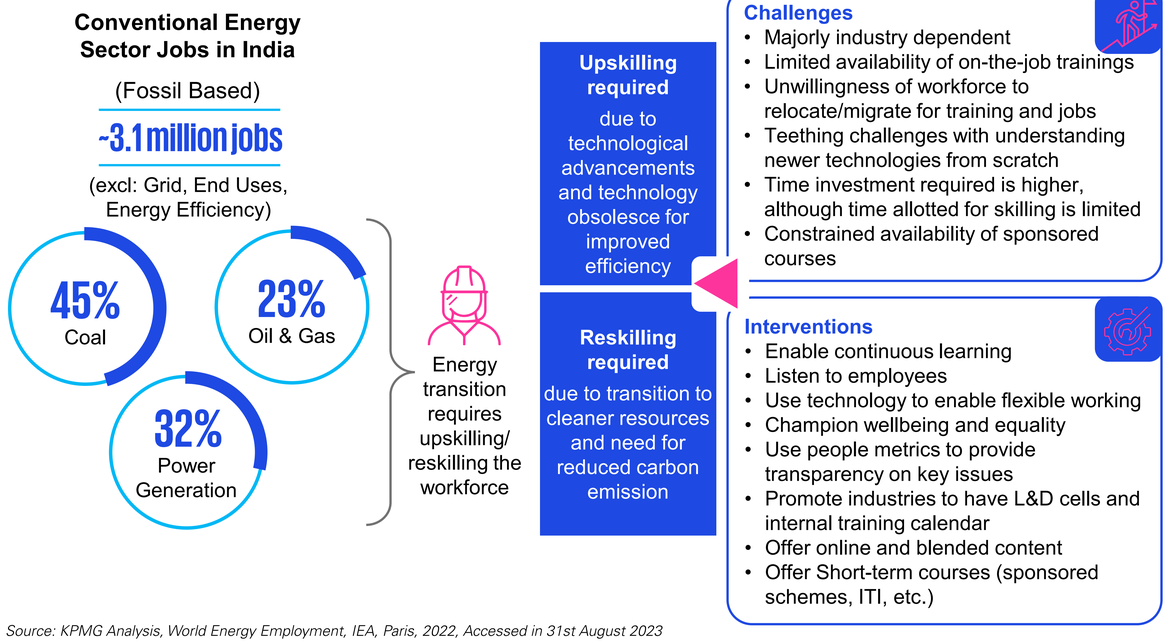
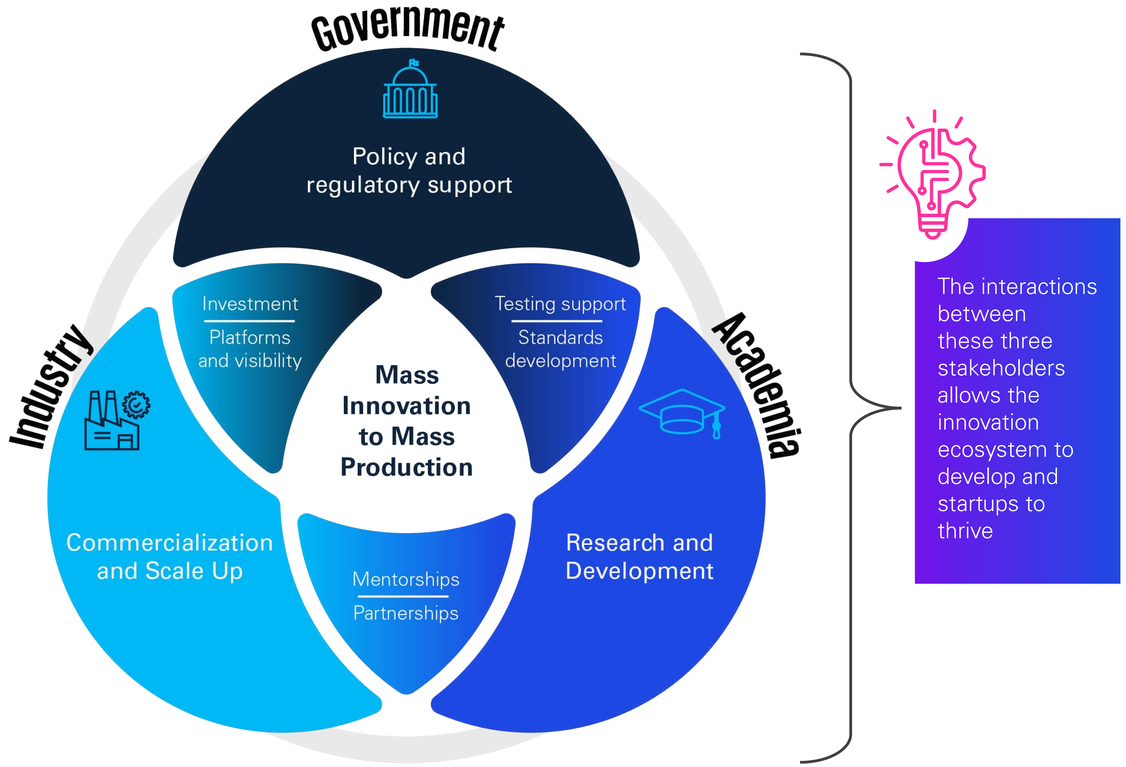
Reskilling/upskilling of people involved in conventional energy-related roles will need to be taken forward programmatically to ensure the availability of experienced talent, as well as to make the transition inclusive.

Reskilling/Upskilling required in conventional energy sector



Source: KPMG Analysis, World Energy Employment, IEA, Paris, 2022, Accessed in 31st August 2023

Government, industry and acedemia partnership holds the key to development of robust innovation ecosystem



Source: KPMG Analysis

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India needs to create an ecosystem that is deeply anchored in innovation by encouraging start-ups, ensuring collaboration among stakeholders and taking other appropriate steps.

10

Financing flows will need to be debottlenecked by targeting risks across technologies and value chains and establishing innovative commercial structures and instruments.

Variables and risk considerations across manufacturing segments

Risk considerations in manufacturing (High, medium and low based on level of uncertainty)	Green hydrogen equipment	Energy storage equipment	Wind equipment	Solar equipment	Carbon capture, utilisation and storage
Technology	🔴	🔴	🟢	🟢	🔴
Operating factors	🔴	🟡	🟢	🟡	🔴
Capital requirements	🔴	🔴	🟡	🟡	🔴
Raw material	🟡	🔴	🟡	🔴	🔴
Local manufacturing knowhow	🔴	🔴	🟡	🟡	🔴
Price variation	🔴	🔴	🟡	🟡	🟡
Affordability for end use segments	🔴	🔴	🟢	🟢	🔴
Overall	🔴	🔴	🟡	🟡	🔴

Source: KPMG Analysis

Analysis based on Indicative market intelligence and expert consultation

1

The need for high-speed and large-scale energy transition offers a massive investment opportunity

- **Rapid growth and climate change have created an urgent demand for energy transition, which will involve a global annual investment of USD 4.5 trillion in energy transition until 2050.**
- **To address its clean energy ambitions, India will need an average annual investment of USD 350-400 billion by 2047[1].**

The UN Secretary General, António Guterres, recently remarked that the era of global warming has been replaced by "global boiling." His comment highlights the **urgent need to achieve a Net Zero Emissions by 2050 Scenario (NZE)**, where global temperature rise is restricted to 1.5 degree Celsius.

NZE can be achieved through energy transition or by reforming global development systems by shifting from fossil fuel to cleaner energy sources like solar, wind, low-carbon hydrogen, biofuels and e-fuels, and technologies such as batteries, pumped storage and electric mobility aside from energy efficiency measures. It is also supported by the deployment of innovative technologies, such as carbon capture, utilisation and storage (CCUS) and plastic waste recycling.

Globally, almost USD4.5 trillion will be required annually from now until 2050[2] to cater to energy transition journey.

Rising demand for clean energy and its commercial potential[3]

Green hydrogen

Current	*Negligible*
2050	*USD116 Bn. / yr*

Battery electric vehicles

Current	*USD2 Bn. / yr*	65 X growth
2050	*USD131 Bn. / yr*	

Renewables

Current	*USD0.3 Tn. / yr*	3 X growth
2050	*USD1 Tn. / yr*	

Energy efficiency

Current	*USD0.3 Tn. / yr*	5 X growth
2050	*USD1.5 Tn. / yr*	

[1] Annual energy transition investment includes investment in clean energy technologies, necessary infrastructure and energy efficiency measures
[2] Net Zero by 2050, IEA, 2023, Accessed 4th September 2023
[3] World Energy Transitions Outlook 2022: 1.5°C Pathway, International Renewable Energy Agency, Abu Dhabi, 2022, Accessed 4th September 2023

India's energy transition will be triggered by its climate commitments and potential for energy security and self-sufficiency

India is not impervious to the climate crisis, which has been manifesting as extreme weather events across the country. Moreover, an ever-growing **demand for energy from its expanding population and infrastructure development initiatives is creating a need for it to fast-track energy transition.**

The country stated its climate ambitions through the enhanced Nationally Determined Contribution (NDC) in 2022 and Panchamrit Declaration during COP 26 in 2021. These commitments aim to make India a leader in energy transition by focussing on aggressive energy efficiency targets, a shift to clean fuels and self-sufficiency through backward integration.

India's climate ambition and current standing[4]

Scaling up clean energy – *amongst leading countries in RE capacity*	**Share of non-fossil fuel capacity**	**41%** in 2022	**62%** in 2030	**85%** in 2047	***In order to achieve the 2047 target, 10X growth will be needed***
	RE capacity	**160 GW** in 2022	**500 GW** in 2030	**1,600 GW** in 2047	
Domestic market and export hub for green hydrogen	**Annual production of green hydrogen**	**N/A** in 2022	**5 MMT** in 2030	**25 MMT** in 2047	***Opportunity for India to take lead in green hydrogen by leveraging its vast RE potential***
	Electrolyser capacity	**N/A** in 2022	**60 GW** in 2030	**180 GW** in 2047	
Making India a global leader in bio-fuels	**Ethanol blending**	**10%** in 2022	**20%** in 2025-26	**65%** in 2047	**Enhanced capabilities in bio-fuels will be vital to reduce energy imports**
	Ethanol Demand	**3 MMT** in 2022	**9 MMT** in 2025-26	**15 MMT** in 2047	
Enhanced electrification of economy	**Electricity in total consumption**	**17%** in 2019	**19%** in 2030	**27%** in 2047	**EV adoption in India to be supported by scaling up charging infrastructure in all areas**
	Passenger EV sales	**2%** in 2022	**30%** in 2030	**100%** in 2047	

Source: KPMG Analysis, CEA, 20th EPS Report, MNRE, MoPNG, Niti Aayog

In order to achieve its energy transition commitments, India will need to invest on an average ~USD 350 to 400 bn per year until 2047

It represents a massive opportunity that will not only help the country to emerge as a climate leader but also enable it to address energy security and access issues.

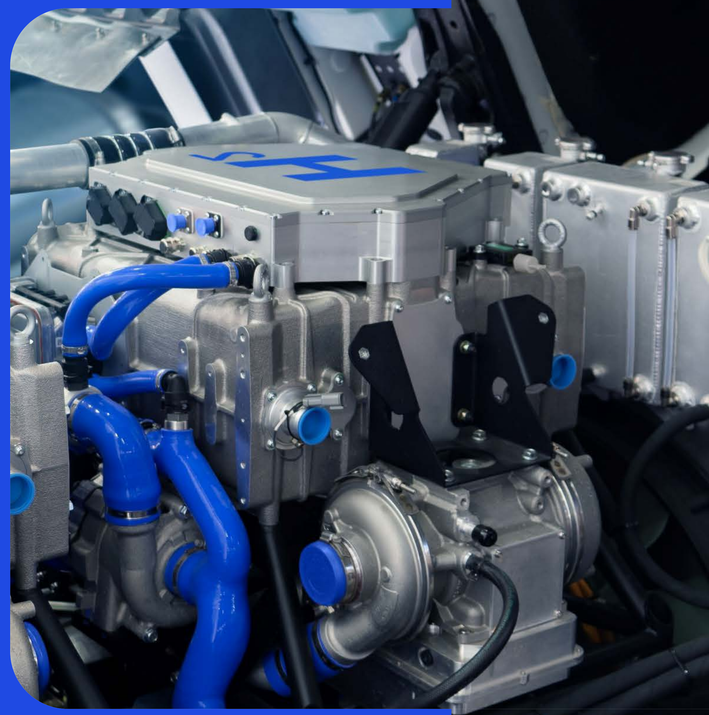
[4] CEA, Central government websites and media report and KPMG analysis

2

Successful energy transition will require supply chains to be reimagined

- **Effective energy transition depends on the development of diversified supply chains, which are highly centralised at present.**
- **Manufacturing for the domestic and global clean energy and ancillary industries (like transmission) presents a USD300-400 billion market opportunity for India by 2030 cumulatively**

The global energy transition represents a massive opportunity for the clean energy technology manufacturing market, but significant regional and technology disparities need to be addressed to take advantage of it.



The acceleration of the global and Indian energy transition will depend on investment in developing supply chains to meet capacity deployment needs until 2030 and beyond.

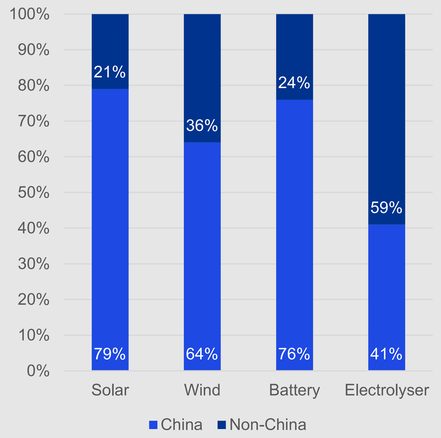
However, at present, **manufacturing capacity and pipelines are disproportionate across regions and technologies.** While some segments like solar are expected to witness an oversupply (which may help in exports, if cost competitive), others like wind only have the capability to meet deployment needs until 2030.

Global renewable energy supply chains are concentrated in China

Over the last 15 years, China's emergence as a global manufacturing hub has created an oligopolistic environment. The **centralisation of supply chains and the resulting lack of price control due to overreliance on a single country is a key risk for global renewable energy capacity deployment,** further intensified by disruptions and price shocks caused by Covid-19 and increasing geopolitical risks.

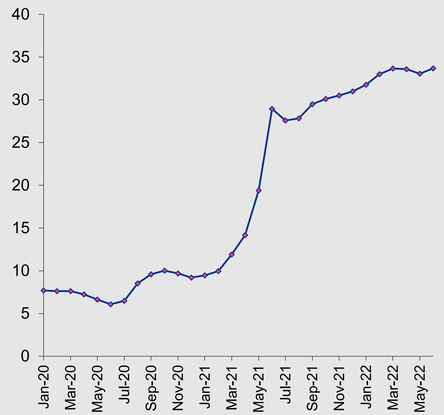
The surge in polysilicon prices in mid-2021 clearly exposes these risks. During the year, dominant supplier China witnessed operational disruptions and closure of large plants due to the pandemic and accidents, significantly impacting prices.

Current share of renewable energy manufacturing (%)



Source: The State of Clean Technology Manufacturing: An Energy Technology Perspectives Special Briefing, IEA, May 2023, Accessed 26 August 2023

Global polysilicon price trend (USD/kg)



Source: World Solar Technology Report, International Solar Alliance, October 2022, Accessed September 15 2023

The conflict in Europe has further exposed the potential fragility of global supply chains and the threat of unforeseen events to energy transition as a whole.

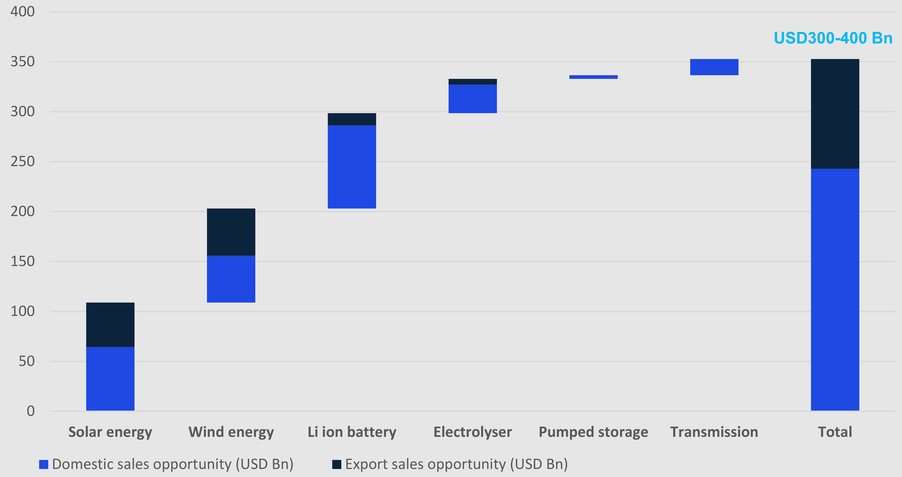
The emergence of China as a global manufacturing hub, coupled with the growing importance of the energy transition, has strongly linked supply chains with geopolitics. **As a result, there is a global attempt to diversify and secure renewable energy supply chains by adopting approaches such as the 'China + 1' strategy.**

Clean technology manufacturing in India presents a USD300-400 billion opportunity by the end of this decade

High captive demand, increased supplier base, government support, regulatory enablers and unique domestic capabilities make India a strong contender in this space. In addition to key clean energy equipment, India can also target manufacturing of balance of system components and transmission equipment.

Considering its domestic demand and potential for exports, the country can take advantage of a significant sales opportunity, in terms of manufactured product value, up to 2030.

India's cumulative sales opportunity up to 2030



Source: KPMG Analysis

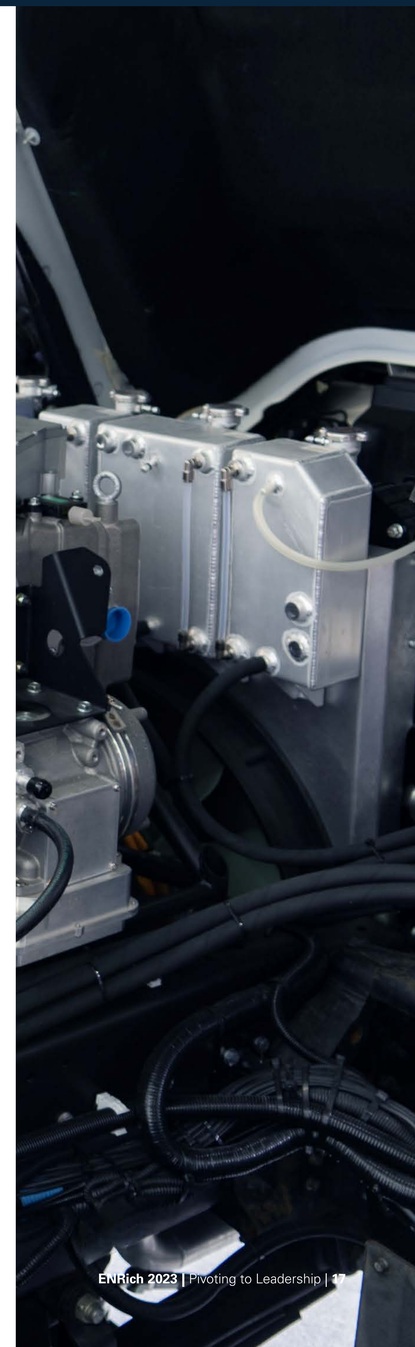
India has already surpassed its NDC of 40 per cent installed electricity capacity from non-fossil fuel sources, made under the Paris Agreement.[5] It now has the potential to develop its domestic capacity further to support its ambitious target of 500 GW non-fossil fuel installed capacity by 2030. This potential will drive the creation of a large market for clean energy equipment manufacturers in the country.

Additionally, India is seeking to supplement China as an export hub. This opportunity will initially be restricted to sectors with established manufacturing capabilities, such as solar and wind energy, but may develop to cover newer technologies such as electrolyser and battery manufacturing.

In order to support the significant capacity deployment, the country's transmission capabilities will need to be augmented with an estimated 50,890 circuit kilometre (ckm) of transmission lines and 4,33,575 MVA of substation capacity by 2030.[6]

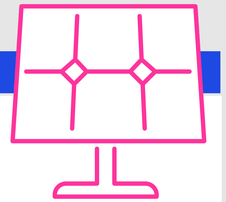
This will create additional manufacturing opportunities across the nation.

[5] Press Information Bureau, 2nd December 2021, Accessed 16 September 2023
[6] Renewable energy cover Final, Central Electricity Authority, December 2022, Accessed 16 September 2023



Domestic and global opportunities across segments that India can target in its path to leadership in clean technology manufacturing

Solar energy



Market drivers

- Established and mature technology
- Installation capacity growth expected upto 2030 and beyond
- Balance of module and inverter manufacturing opportunities

Domestic opportunity

- Over 220 GW of additional capacity likely by 2030
- Scaling up of existing domestic manufacturing capabilities and strong future pipeline
- Strong government support for manufacturing

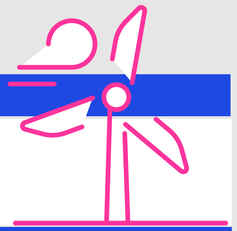
Export opportunity

- Trade tensions between China and US increase export potential
- 'China + 1' approach adopted by US and EU for supply chain diversification
- Indian modules cost competitive for US market

Global manufacturing adequacy upto 2030	Current domestic manufacturing capability	Scale up potential of domestic manufacturing
HIGH	MEDIUM	HIGH

Sources: Report on Optimal Generation Mix 2030 Version 2.0,CEA, April 2023, Accessed September 8 2023; KPMG Analysis

Wind energy



Market drivers

- Well-established technology for onshore and offshore applications
- Installation capacity growth expected upto 2030 and beyond
- High unit cost leads to large market potential

Domestic opportunity

- Over 50 GW of additional capacity likely by 2030
- Some domestic manufacturing capacity for onshore wind turbines
- Limited potential for offshore wind installations by 2030

Export opportunity

- Global shortfall in wind manufacturing capacity creates export potential
- 'China + 1' approach adopted by US and EU for supply chain diversification
- Unlikely to cater to offshore wind export market by 2030

Global manufacturing adequacy upto 2030	Current domestic manufacturing capability	Scale up potential of domestic manufacturing
LOW	MEDIUM	HIGH

Sources: Report on Optimal Generation Mix 2030 Version 2.0,CEA, April 2023, Accessed September 8 2023; KPMG Analysis

Li Ion battery
(for EVs and grid Scale storage)

Market drivers

- Established battery technology upto 2030, with chemistries such as LFP which are well suited for Indian conditions
- Strong demand from EV and grid-scale storage
- BoS/inverter manufacturing potential

Domestic opportunity

- Over 550 GWh of additional capacity likely by 2030, with EVs accounting for nearly two-thirds of the demand and grid storage accounting for the remaining one-third
- Investments in manufacturing plants and discovery of lithium reserves can drive domestic manufacturing

Export opportunity

- Limited export potential due to strong competition and nascent domestic manufacturing segment
- 'China + 1' approach has been adopted by the US and EU for supply chain diversification; but these regions are also developing their own manufacturing capabilities

Global manufacturing adequacy upto 2030	Current domestic manufacturing capability	Scale up potential of domestic manufacturing
HIGH	LOW	MEDIUM

Sources: Advanced Chemistry Cell Battery Reuse and Recycling Market in India, Niti Aayog, July 2022, Accessed September 12 2023; KPMG Analysis

Electrolyser

Market drivers

- Significant attention as part of energy transition
- Long-term growth potential beyond 2030
- Rapidly shifting global sector, this creates new market opportunities

Domestic opportunity

- 60 GW of additional capacity likely by 2030
- Strong government mandate for green hydrogen production
- Sector vital to decarbonisation and fuel import-reduction objectives

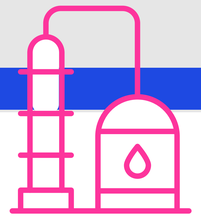
Export opportunity

- Significant investment in global manufacturing capacity leading to strong competition
- Long-term market outlook is unclear, and compliance with international regulations is essential

Global manufacturing adequacy upto 2030	Current domestic manufacturing capability	Scale up potential of domestic manufacturing
MEDIUM	LOW	MEDIUM

Sources: Harnessing Green Hydrogen: Opportunities for Deep Decarbonisation in India, RMI and Niti Aayog, June 2022, Accessed September 12 2023; KPMG Analysis

Pumped storage



Market drivers

- Established and mature technology
- Strong demand as variable RE share in electricity mix grows, with 90 GW expected by 2047
- Off-river projects have potential due to lower environmental impact

Domestic opportunity

- Over 10 GW of additional capacity likely by 2030
- Increased recent interest in sector
- Existing developers with several domestic projects active and under construction

Export opportunity

- Limited export potential as equipment is a small share of overall project costs
- Long construction timeline and dependence on topography limits deployments
- Fleet style construction can reduce costs

Global manufacturing adequacy upto 2030	Current domestic manufacturing capability	Scale up potential of domestic manufacturing
MEDIUM	LOW	MEDIUM

Sources: Report on Optimal Generation Mix 2030 Version 2.0,CEA, April 2023, Accessed September 8 2023; KPMG Analysis

Transmission

Market drivers

- Strong demand driven by growing electricity demand, need to support variable power, and modernization of existing grid to become resilient and flexible
- Regional energy planning and need for data & system security to also drive demand
- Development of large RE projects far from demand centres and ancillary services market will require significant transmission investment

Domestic opportunity

- Around 200 GW of additional transmission capacity required as per CEA plan for 500 GW RE by 2030
- Domestic manufacturing of equipment to be driven by government focus on developing Future Ready Transmission and Green Energy Corridor

Export opportunity

- Limited export potential as equipment may be procured in the country where the project is being developed
- Regional energy planning and cross boundary trade in Asia can drive demand for equipment

Global manufacturing adequacy upto 2030	Current domestic manufacturing capability	Scale up potential of domestic manufacturing
MEDIUM	MEDIUM	HIGH

Sources: Transmission System for Integration of over 500 GW RE capacity by 2030, CEA,. Accessed September 12 2023; KPMG Analysis

3

India is in a sweet spot, between Europe and China, to support the global energy transition

The country has the ingredients needed to be a clean technology manufacturing hub; The industry must strengthen its manufacturing and sourcing strategy and focus on value engineering, effective expansion management and other levers.

The global manufacturing landscape can be divided into cost-effective destinations that offer competitive pricing and developed hubs that stand out for their higher production costs but stringent regulations.

With a 28.4 per cent share in global manufacturing output[7], China is firmly placed at the top of cost-effective destinations due to government policies and suitable demography. On the other hand, Europe is known for its innovations, superior products albeit with high labour costs and strict regulations. The global economy is seeking a reliable source that can provide high-quality products at a competitive price.

India's supplier ecosystem including core commodities, sizable young and skilled workforce, emerging culture of innovation, and government initiatives make it a favourable destination for a wide range of manufacturing activities including in clean energy space. However, at present, clean technologies manufacturing is highly dependent on countries such as China and Australia for raw materials and Europe for technologies.

For example, in the manufacturing of solar modules, India imports 80-85 per cent of components like solar cells, glass, aluminium frames and encapsulants from China[8]. Furthermore, most of the machines used by Indian manufacturers are developed by Chinese original equipment manufacturers (OEMs).

India's import dependency (illustrative)[9]

Clean energy technology	India's requirements	Country/region India depends on at present
Green hydrogen	Mining of zirconium, nickel and palladium, and electrolyser technology	China and EU
Wind	Bearings, gearboxes and generators	China and EU
Solar	Metallurgical grade silicon, polysilicon, ingots and wafers	China
Li-ion battery	Mining, refining and processing of lithium, cobalt and nickel	Australia and China

[7] World Population Review, Manufacturing by Country 2023, Accessed 31st August 2023
[8] Understanding India's solar power growth story: An economic perspective, ET Energy World, Accessed 31st August 2023
[9] The state of play – The Role of Critical Minerals in Clean Energy Transitions – Analysis - IEA Accessed 27th August 2023, Achieving American Leadership in the Solar Photovoltaics Supply Chain, US Department of Energy, February 2022, Accessed 27th August 2023 and The Role of Critical Minerals in Clean Energy Transitions, IEA, Paris, 2021, Accessed 27th August 2023

Five levers for Indian companies in clean technology manufacturing

Indian manufacturers need to rapidly evolve a strategy to enhance their capabilities. **KPMG in India believes that five competitive levers would be critical in this regard.**

Strategies

Strategy 1	Strategy 2	Strategy 3	Strategy 4	Strategy 5
Category sourcing strategy	**Value engineering initiatives**	**Manufacturing efficiency through visual and digital enablers**	**Effective capacity expansion management**	**Knowledge management program (KMP) and Result Focused Skill Development (RFSD)**

Strategy 1 — Category sourcing strategy

Indian companies must identify reliable sources to ensure consistent supply of components for clean energy manufacturing and establish procurement processes that align with industry best practices.

Several companies in the country have proactively established strategic partnerships with leading Chinese firms.These collaborations have enabled these companies to meticulously map each component of their supply chain.

The base needs widening to include significant non-Chinese players and eventually a more domestic ecosystem of research and innovation. Some players have been actively engaging in an indigenisation drive by forming joint ventures with Indian manufacturers to source components locally.

Similarly, sourcing issues also need to be addressed in allied sectors such as transmission equipment. Fluctuations in the price of raw materials, copper, CRGO steel, transformer oil and aluminium needed to manufacture transformers are a key concern for industry players. In addition to this, large unutilized capacity, aggressive pricing by competitors, monopoly of labs and higher rates for short-circuit testing are some of the key issues to be addressed.

A few best practices of major energy players[10]

Common procurement practices	Best practices
Spot buying from multiple suppliers	Contracts with price indexation with 2-3 suppliers to procure at best cost and mitigate supply risks
Assessment of category risk based on experience	Structured and documented short- and long-term risk strategy for all categories
Single line quotes that make it hard to track raw material price movement	Detailed cost breakdown for insights into raw material requirement to take advantage of index-linked pricing
High-risk contracts without adequate clauses	Robust contracts with clauses that cover service quality and performance to mitigate every potential risk
Absence of specification for input materials, making quotes hard to compare	Clear specifications and aligned supplier quotes

Strategy 2 — Value engineering initiatives

To prioritise innovation and drive progress, **manufacturers should focus on approaches such as value analysis or value engineering (VA/VE).**

This strategic methodology enables the revaluation of existing designs and manufacturing processes to generate alternative solutions that lower product costs. Some companies in India have successfully used it to demonstrate significant benefits and cost reductions to the tune of 5-7 per cent.

Similarly, companies should opt for design optimisation, which requires teams like engineering, quality, procurement, sales and others to come together. Other ideas for optimisation that **businesses can leverage are competition benchmarking, zero based budgeting, supplier interactions, customer interactions and internal VA/VE exercises.**

Cost reduction across solar value chain through strategic implementation (illustrative)[11]

Category	Value engineering initiative	Cost-reduction potential (%)
Glass	• Thickness optimisation • Material content re-examination • Configuration change	4-5%
Aluminium frame	• Profile change to reduce weight/metre • Coating thickness optimisation	3-6%
Ribbon and bus bar	• Profile change • Design change	4-5%
Encapsulant	• Alternative chemistry for encapsulant • GSM optimisation	5-7%

[10] KPMG Analysis
[11] KPMG Analysis

Strategy 3

Manufacturing efficiency through visual and digital enablers

Green energy equipment manufacturers in the country must prioritise the optimisation of their existing facilities by balancing capacity management and enhancing Overall Equipment Effectiveness (OEE).

OEE can be boosted by using visual and digital enablers that help identify the cause of repeated failures. Through the application of core digital technologies overlaid with extensive analytics using artificial intelligence (AI), machine learning, IoT and others, visual and digital enablers make suggestions to help mitigate performance loss.

Similarly, rework and rejections are hidden capacity losses. A case in point is rejections generated by Taber & Stringer machines during the process of solar module manufacturing, which are detected at the lamination stage. Rework done in the post-lamination stage affects the 'first time right' score and capacity.

Several Indian companies are generating real-time data by using visual and digital enablers. More of them must adopt such innovative approaches to rapidly move up the value chain and develop the country as a global leader in the space.

Indicative list of possible digital interventions in solar module manufacturing[12]

Possible digital interventions – manufacturing

- Monitoring of RM wastages through IOT
- AI-based string and module defect detection
- Discrete process monitoring and control
- Operator and shift - wise defect and throughput analytics
- Real-time quality analysis of defects
- Vision-based soldering quality control
- Real-time process control and visualization
- Material management: Tracking and monitoring of RM wastage

Possible digital interventions – Overall

- Asset health monitoring via reports/dashboards/alarms and Andon integration, based on stated definition
- Advanced analytics-based predictive and prescriptive maintenance of equipment
- Surveillance: Safety detection of workers, face mask and social distancing detection, head counting, etc.
- Smart inventory and material management: Real-time tracking of inventory and waste reconciliation

[12] KPMG Analysis

Strategy 4

Effective capacity expansion management

Capacity extension is aimed at achieving a vertical ramp-up and has two key components – early equipment management (EEM) and original equipment manufacturer (OEM) management.

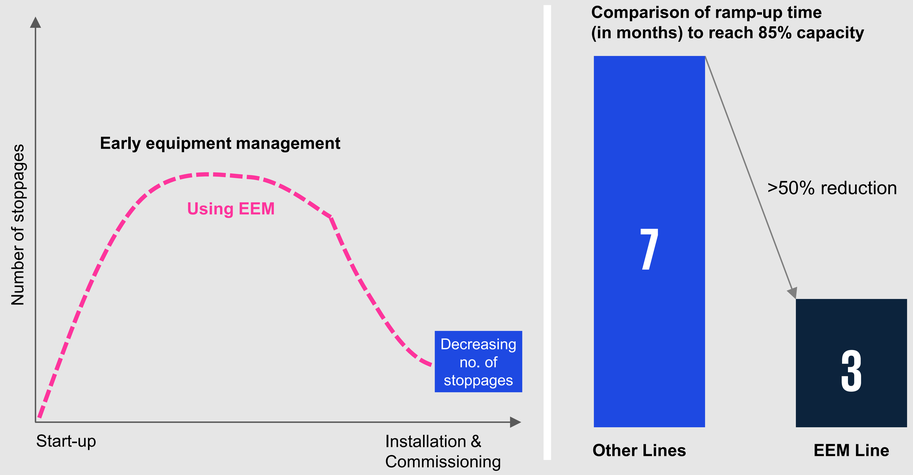
EEM covers the entire CAPEX lifecycle starting from starting from equipment design, manufacturing, installation, commissioning, operationalization, performance monitoring and spares management to continuous improvement. It also involves the documentation of learnings and problems faced during past installations.

OEM management, on the other hand, focusses on the relationship between a manufacturer and equipment provider or OEM.

Considering that Indian clean technology manufacturing companies are looking at rapid expansion at an exponential scale, effective capacity expansion through EEM and OEM management are extremely critical aspects for them.

These methodologies can help green manufacturers to register a nearly 50 per cent reduction in ramp-up time. They can also enable the establishment of a robust foundation for production launch and facilitate productivity optimisation during ramp-up to enhance long-term competitiveness.

Typical manufacturer's ramp-up time for EEM line versus other lines[13]



[13] KPMG Analysis

Strategy 5

Knowledge management programme and result-focussed skill development

Other tools that manufacturers can utilise to enhance their businesses include Knowledge Management Programme (KMP) and Result-focussed Skill Development (RFSD).

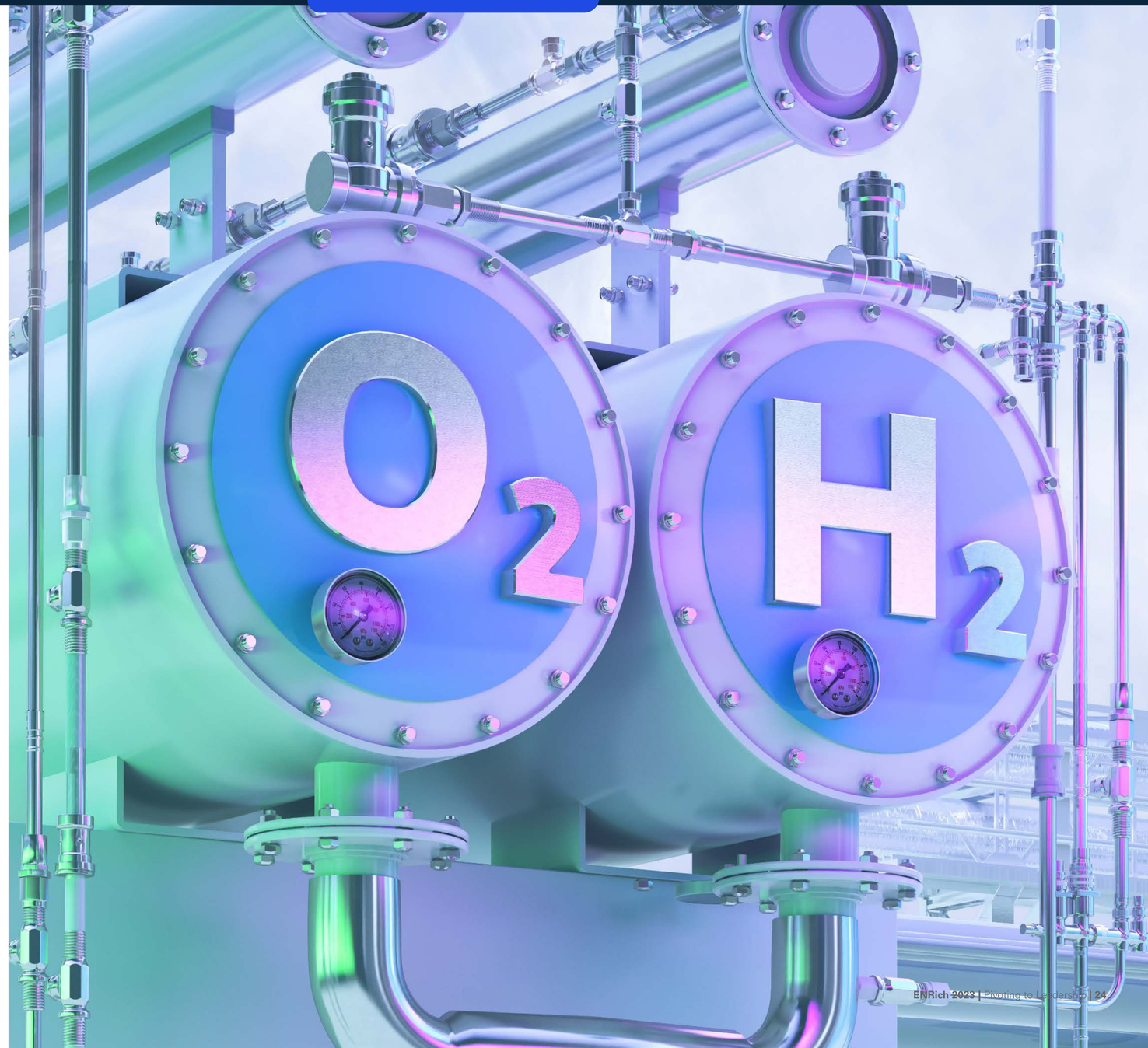
KMP refers to the effective organisation, capture and sharing of information throughout an establishment. **KMP helps leverage learnings from experience and successful initiatives/projects to avoid mistakes and drive improvements.**

Additionally, given that attrition is a key challenge across the green energy market, manufacturers can adopt RFSD. This approach focusses on existing challenges and skill deficits and aims to develop expertise across the technical and functional domains.

Illustrative RFSD framework[14]

Forklift maintenance	Types of sensors, uses and troubleshooting	Technical	RFSD topics	Functional	OEE/MTBF/MTTR/PM effectiveness	Autonomous maintenance
Bearing / belts / pulley , operations and upkeep	Chiller operations and troubleshooting				Root cause analysis	Condition-based maintenance and condition monitoring
Air compressor operations and troubleshooting	Drives and troubleshooting				Process – Cycle time/takt time	Situational leadership

Many Indian manufacturers have already embraced elements of the five competitive levers essential for success. However, there is a growing recognition that they need to do more to remain competitive in today's dynamic environment. To thrive in the globalised marketplace, they must prioritise efficient sourcing and innovation and invest in process management and skill development, facilitated by technology and comprehensive training programmes.



[14] KPMG Analysis

4

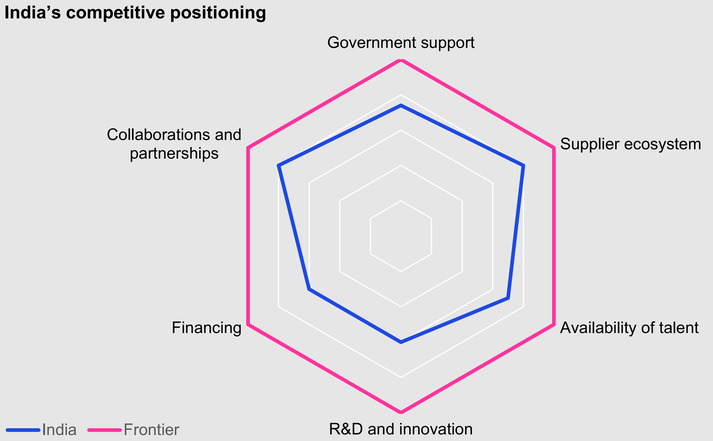
India will need to play to its strengths and address its weaknesses

- **Domestic and global energy transition could create a demand for 5- 6 million jobs by 2030 and 9 -10 million by 2047 in India; India must focus on developing skills in R&D, digitisation and core technologies. New technologies such as batteries, hydrogen and its derivatives, and CCUS demand deep skills and will need a more aggressive approach to talent development.**
- **Re skilling/upskilling people involved in conventional energy-related roles needs to be taken forward programmatically to ensure the availability of experienced talent which will also facilitate an inclusive transition.**
- **Skilling for energy transition should follow an industry needs driven approach where government and industry work in close conjunction to identify and address skill gaps as well as collaborate in development of curriculum**
- **India needs to create an ecosystem that focusses on innovation, for example, by encouraging start-ups and enabling collaborations.**
- **Financing flows will need to be debottlenecked by targeting risks across technologies and value chains with innovative commercial frameworks and instruments.**

An evaluation of India's manufacturing sector positions it favourably in terms of supplier ecosystem and collaborations and partnerships. While R&D, innovation and financing have emerged as key areas of concern, areas such as government support and availability of skills demonstrate scope for improvement

These are the areas on which the country must focus its efforts to achieve its target of becoming a frontrunner in global clean energy.

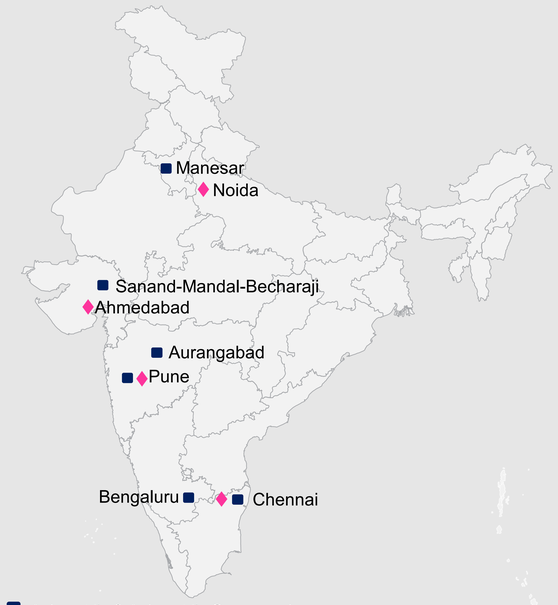
Critical enablers: India's competitive positioning on key values[15]



[15] KPMG India Industry sentiment survey from Industry leaders

Supplier ecosystem

Key manufacturing clusters



India is amongst the top 5 manufacturing countries in the world[16] and has a vibrant manufacturing ecosystem with manufacturing clusters[17] pan India spread across multiple sectors. Further, India has strong capabilities in processing which can be leveraged across various RE technologies.

- **Processing capabilities:** India provides essential services like machining, fabrication, processing and various other activities crucial for the clean energy production value chain. Its supplier network is adaptable and can be calibrated to serve the needs of this sunrise sector.
- **Geographic advantage:** Southern and western India have several clusters across the auto and auto ancillaries, industrial manufacturing and electronics sectors. These regions offer varying processing capabilities and are preferred investment destinations.

Key manufacturing clusters

Indian suppliers operating across sectors and geographies can provide components and assemblies in which they already excel. Their experience can be directly leveraged by green energy manufacturers, resulting in supplier consolidation and capability augmentation.

Given the differing processing needs of solar PV, Li-ion battery and electrolyser production, **the presence of clusters with diverse capabilities along with the existing auto sector and electronic manufacturing will enhance the country's manufacturing efficiency.**

[16] World Population Review, Manufacturing by Country 2023, Accessed 31st August 2023
[17] Great Places for Manufacturing in India: World-class Destinations for Multinational, Invest India, May 2020, Accessed 31st August 2023

Government support

Regulatory frameworks play a pivotal role in shaping economic growth.

The Indian government has rolled out numerous business-friendly policies, such as Remission of Duties and Taxes on Exported Products, PM Gati Shakti, India Industrial Landbank, National Single Window System and PLI schemes to position India as an attractive investment and manufacturing destination.

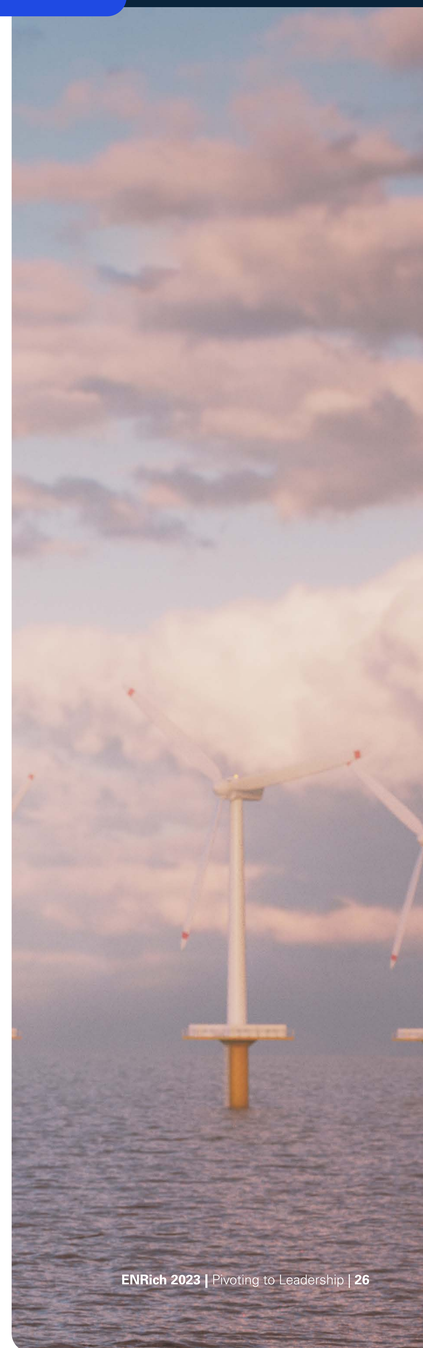
Its state governments have added to these schemes, providing an additional impetus to the manufacturing sector.

With regions such as EU providing aggressive support to clean energy manufacturing under EU Green deal provisions, the support on India side may have to scale up substantially to give a competitive edge.

Government of India's PLI schemes[18]

Technology	PLI	Capacity addition
Solar PV manufacturing	USD2.2 billion	52GW
Green hydrogen production	USD1.57 billion	5MMT
Electrolyser manufacturing	USD0.5 billion	60GW
Advance chemistry cell batteries	USD2.46 billion	50GWh

[18] PLI Scheme Documents, Indian Renewable Energy Development Agency Limited, Accessed 31st August 2023 | RfS for Selection of Solar PV Module Manufacturers for Setting up Manufacturing Capacities for High Efficiency Solar PV Modules in India under the Production Linked Incentive Scheme (Tranche-II), Solar Energy Corporation of India, 18th November 2022, Accessed 31st August 2023



Availability of talent

India boasts a **vast working population and a young demographic with high proficiency in science, technology, engineering and mathematics (STEM).**

However, the pace of transition in the energy sector is as never before and with it accelerating skill development becomes a top priority as demand for jobs across sub sectors and job families is set to far outstrip the supply. The demand for skills increases if we factor in domestic as well as global requirements.

As per KPMG in India, energy transition could create a demand for 5- 6 million jobs by 2030 and 9 -10 million by 2047 across the three dimensions.

India for India (I for I)

Of the ~8-9 million jobs needed to meet domestic ambitions, almost ~30 per cent will be in manufacturing and the rest in construction and installation, operations and maintenance, and fuel supply.

India for the world (I for W)

By providing ~10% of the required workforce in key regions such as North America, Oceania, MENA etc, India will be able to create ~0.8 million to 1 million jobs by 2050.

World from India (W from I)

India houses almost 50 percent of worldwide GCCs. Energy majors such as BP and Shell have opened GCCs in India. The momentum is likely to continue, as India offers large pools of talent and niche skills in areas like engineering, digital technology and data analytics.

Source: KPMG Analysis | India Briefing, 28th June 2023 - India's Global Capability Centers Market Estimated to Reach USD110 Billion by 2030, Accessed 31st August 2023
Note: Job numbers include Direct & Indirect jobs; Technologies: Solar, Wind, Biofuels, Hydropower, GH, Battery, PSP & Grid

India needs to overcome capability gaps through skilling, upskilling and reskilling

An analysis of talent across India's technology value chains shows **gaps upstream because its workforce has been predominantly engaged in project development and operations.**

As India is now focussing heavily on manufacturing, it will need to prioritise skill development in areas such as **R&D, SCM, manufacturing and others.** Further, while there is an availability of talent for mature technologies such as solar and wind, especially for downstream activities, **new technologies like green hydrogen and CCUS will need a more aggressive approach to talent development.**

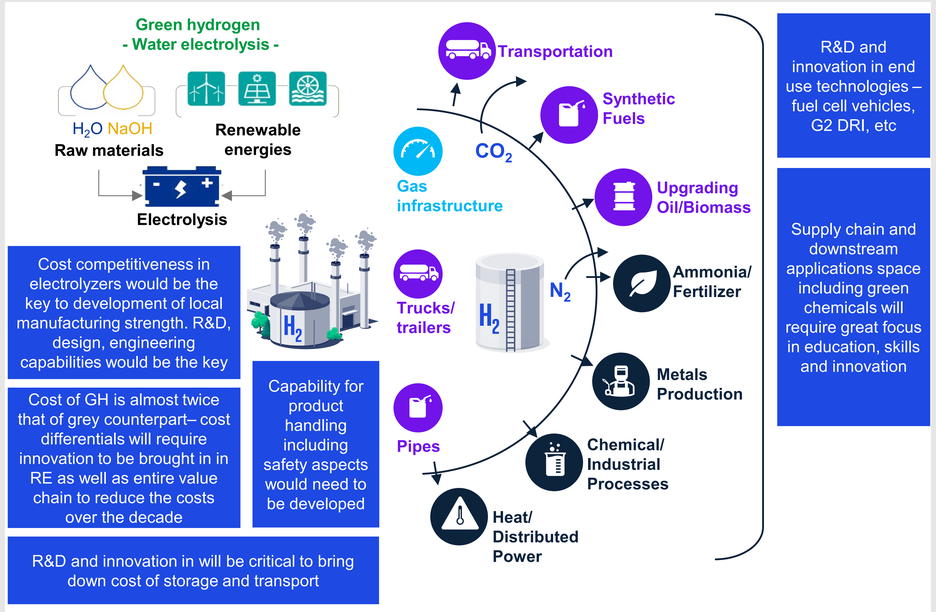
Skill mapping across clean technology value chain in India

	Primary Activities						
	R&D/ Innovation	SCM	Manufacturing	Project Design & Engineering	Project Management	Construction	Operations & Services
Solar	🟠	🟡	🟡	🟢	🟢	🟢	🟢
Wind	🟠	🟡	🟡	🟡	🟢	🟢	🟢
Bioenergy	🟡	🟡	🟢	🟡	🟢	🟢	🟡
Pumped Storage	🟡	🟢	🟢	🟡	🟢	🟢	🟡
Battery	🟡	🟠	🟠	🟡	🟢	🟢	🟡
EV Infrastructure	🟡	🟡	🟡	🟢	🟢	🟢	🟡
Green Hydrogen	🟠	🟠	🟠	🟠	🟠	🟠	🟠
CCUS	🔴	🔴	🔴	🔴	🟠	🟠	🟠

Source: KPMG Analysis
Analysis based on Indicative market intelligence and expert consultation

Given the significant emphasis on these technologies both in India and worldwide, it will be crucial for the country to take the steps needed to establish a well-defined plan and roadmap for relevant skill development.

Green Hydrogen and its derivatives - a deep skills area



Source: KPMG Analysis

While planning talent development and supply, India should have a clear strategy that considers both conventional and clean energy, as a pool of workforce from the conventional energy sector,especially from the coal value chain is likely to be available for re-deployment in sunrise sectors by 2030.

As per IEA energy outlook report 2021, 85% reduction in coal-fired power generation and 60% reduction in domestic coal mining is expected by 2040 in India leading to a job loss of ~0.5 million.The segment may continue to face a degrowth in jobs, as the government looks at phasing down coal.

Therefore, it is must for India to **focus on reskilling/ upskilling people involved in conventional energy-related roles** to ensure the availability of experienced talent that will facilitate an inclusive transition.

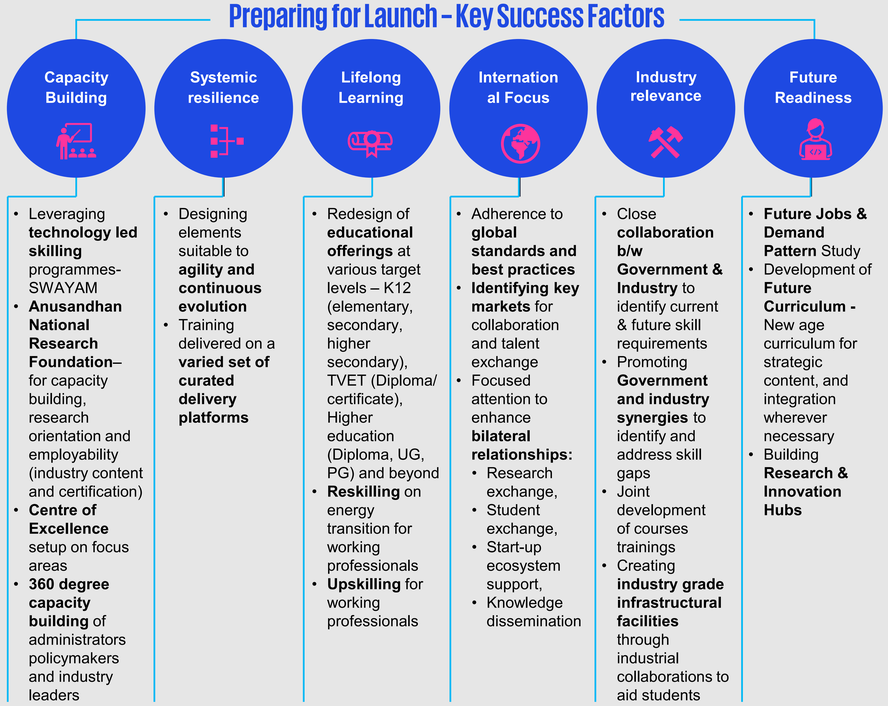
India needs to define a new approach to skilling to support the energy transition

The traditional education system is not aligned with the skill requirements of an era of energy transition. The skill gap is more pronounced in rural areas, the informal sector, and among women and underrepresented groups.

It is imperative that a new approach to skilling is defined to support the green energy revolution. The new approach will encompass

- An industry needs driven approach where government and industry work in close conjunction to identify and address skill gaps as well as collaborate in development of curriculum
- Design elements should keep in view the need for agility and continuous evolution by being closely connected with best practices across the world
- Different base curriculum content - structuring done de novo given the very different strategic content; post that existing content can be selectively included
- Varied target levels – primary, secondary and tertiary (or equivalent Indian nomenclature)
- Content could be delivered on a varied set of curated delivery platforms
- Creating industry grade infrastructural facilities through industrial collaborations to aid students (Centres of Excellence, digital infra, future labs, RDCs, etc)

Key success factors for a green skilling programme



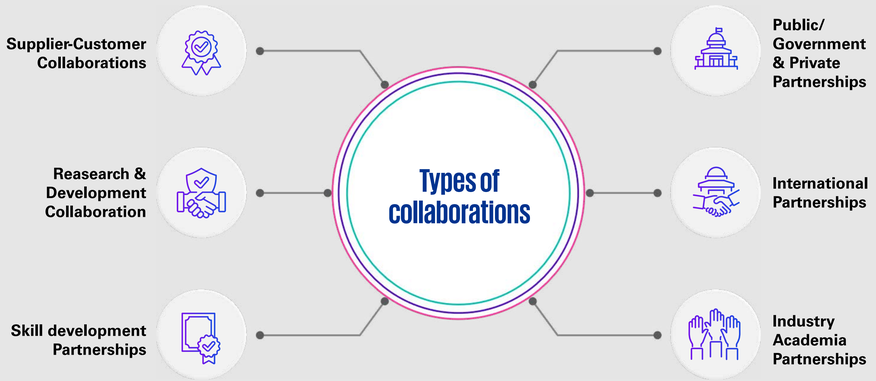
Source: KPMG Analysis

Collaborations and partnerships

India must focus on collaborations in existing and upcoming energy transition-related areas to accelerate technology innovation, supply chain development, commercialisation and deployment.

Moreover, industry leaders, in partnership with specialised domestic and international small or mid-size organisations and the government, must lead the way with active research and development, testing and demonstration, technology scale-up, large-scale deployment and commercialisation to ensure the development of the manufacturing sector for energy transition technologies.

Types of collaborations and partnerships that India should focus on



Public-private partnerships, in which governments contribute risk capital and incentives, can attract substantial investment for the development of manufacturing capabilities. The Government of India has taken a step in this direction with the introduction of incentives under the SIGHT programme, launched under the National Green Hydrogen Mission to support electrolyser and green hydrogen production.[19]

Other types of collaborations that offer long-term advantages are **industry-academia partnerships and research and development collaborations**. These partnerships provide tested technology for deployment as well as incentivise R&D organisations and academic institutions.

Businesses can tap supply chain advantages by forming strategic **collaborations with raw material and/or component suppliers.** They can sign long-term supplier agreements that provide benefits such as indirect vertical integration.

Industry players and technology providers can partner to innovate in emerging technologies. Such partnerships shape the future by offering a first-mover advantage and also enable companies to be prepared for change. **Collaboration with specialised domestic or international technology providers across the energy transition supply chain can deliver multiple benefits like knowledge sharing, risk reduction, better economics and an opportunity to leverage expertise and pool resources.**

A well-thought-out collaboration strategy can offer numerous benefits and help India to emerge as a hub that supports the shift towards clean energy.

[19] National Green Hydrogen Mission, MNRE, 13th January 2023, Accessed 31st August 2023

R&D and innovation

The clean energy manufacturing value chain in India is struggling with issues like low efficiency, scarcity of critical minerals and legacy ecosystems. This creates a need for innovation as a core element. As India seeks to advance on its climate ambitions while grappling with the trilemma of affordability, access and security, it must design a **comprehensive strategy focussed on encouraging all forms of innovation, whether they aim to 'improve', 'redefine' or 'disrupt'.**

Comprehensive support throughout the innovation value chain

Innovations that improve

Innovations that enhance existing products

Innovations that enhance existing processes to add value

For example, product improvements like increasing cell efficiency or process improvements like diamond wire sawing to reduce wastage during wafer cutting.

Innovations that redefine

Innovations aimed at redesigning an existing product to overcome challenges.

For example, replacement of critical materials in renewable energy equipment with inexpensive and widely available materials

Innovations that disrupt

Innovations that disrupt the status quo and change the course of the industry.

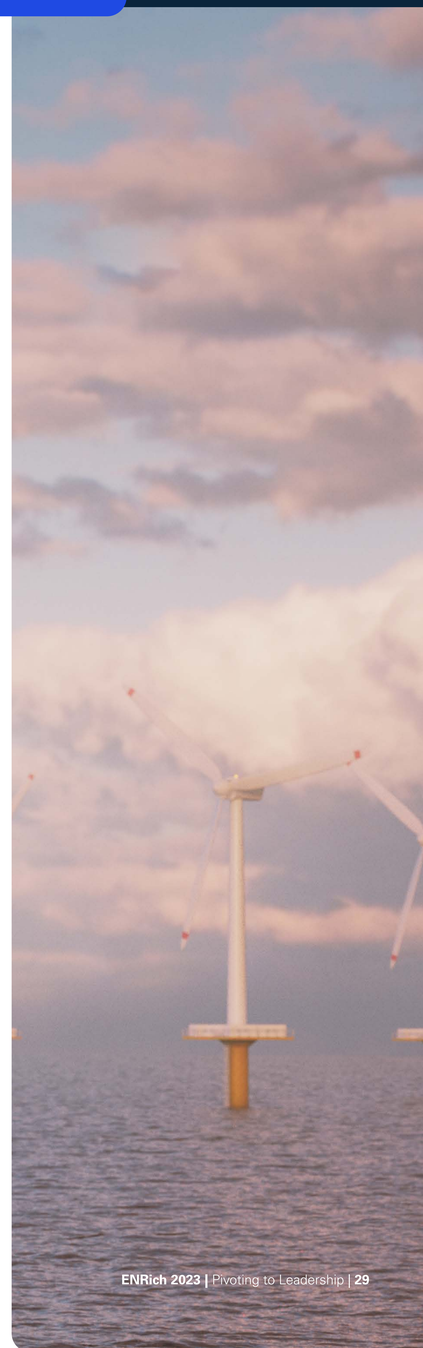
For example, wireless charging of EVs, Pervoskite solar cells, energy as a service, etc.

Source: KPMG Analysis

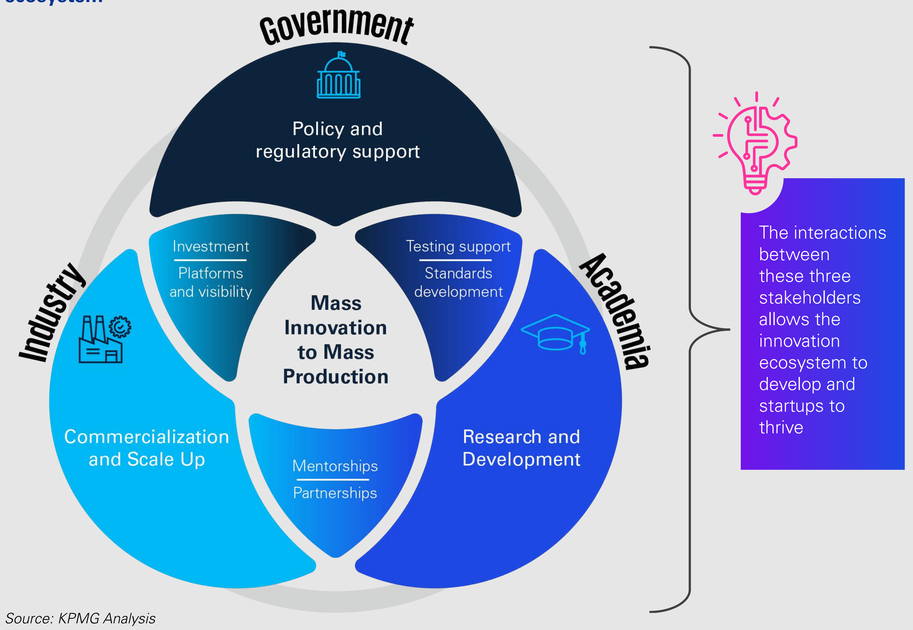
Start-ups can play a key role in the development of an innovation ecosystem

Economies that are open to disruption are more likely to thrive as the energy transition speeds up. In India. start-ups are increasingly becoming key stakeholders in the energy transition story by providing ideas, technologies and approaches to sectors traditionally dominated by large conglomerates.

Today's start-ups, having emerged from diverse backgrounds, bring a **unique viewpoint that shows a deep understanding of sectoral environments**. Companies are proving that start-ups can disrupt even established renewable energy segments. In India, Industry as well as academia are increasingly playing a very important role in fostering as well as mentoring innovative entrepreneurs, providing them seed funding support, expert guidance, opportunity to scale up their innovations and commercialize through partnerships. **KPMG in India's annual ENRich Conference, organised by the Energy and Natural Resources (ENR) business unit, is one such platform that for startups to showcase their energy and climate innovations**. However, the efforts need to be scaled up with academia, public and private partnership and be programmatically driven with government support.



Government, industry and acedemia partnership holds the key to development of robust innovation ecosystem



Source: KPMG Analysis

Financing

Variables and risk considerations across manufacturing segments

Risk considerations in manufacturing (High, medium and low based on level of uncertainty)	Green hydrogen equipment	Energy storage equipment	Wind equipment	Solar equipment	Carbon capture, utilisation and storage
Technology	🔴	🔴	🟢	🟢	🔴
Operating factors	🔴	🟡	🟢	🟡	🔴
Capital requirements	🔴	🔴	🟡	🟡	🔴
Raw material	🟡	🔴	🟡	🔴	🔴
Local manufacturing knowhow	🔴	🔴	🟡	🟡	🔴
Price variation	🔴	🔴	🟡	🟡	🟡
Affordability for end use segments	🔴	🔴	🟢	🟢	🔴
Overall	🔴	🔴	🟡	🟡	🔴

Source: KPMG Analysis
Analysis based on Indicative market intelligence and expert consultation

With risk comes opportunity. **As long as there is scale and the risks can be reasonably addressed through appropriate structures, India can turn these challenges to opportunities at scale.**

Creating an adequate capital pool will require focussed effort across specific areas, some of which have been discussed in the following section.

Development of dedicated capital pool for energy transition needs

Reliance on banks may not be adequate and **dedicated channels are likely to be a more successful approach to ensuring sustained funding for manufacturing.** Often the capital deployment in terms of clean technology has been focused on wind and solar power plants, however greater emphasis on the equipment manufacturing would be required to drive required shifts so that the value chain is equipped to provide for the required means to grow sustainability. Consequently, the domestic pool can have specific demarcation for identified areas which need greater investment focus.

Addressing cost of capital to encourage shifts

Organisations face significant demand for capital during transition, more so when experimenting with new technologies and approaches. New technologies need to be made affordable and implementable. Schemes and policies that promote demand and encourage production and consumption (for example demand mandates for green hydrogen) will ease capital flows. While PLI schemes have worked well so far, more work is needed in this area. Apart from sector-specific incentives, the transition also calls for an evaluation of the cost of capital. At present, there is no distinction between commercial and sustainable means of gathering capital, and there is an urgent need to focus on providing lower-cost capital in view of climate-related pressures.

Deployment of flexible financing structures

Guarantee structures, offtake commitments and policies to extend loan terms through interest waiver or term relaxation can help develop a more robust and targeted means of viability assessment. Risk-based interventions can be designed to extend mechanisms that support manufacturing in segments that face elevated risks.

Development of supportive policy and regulatory mechanisms

Sectoral policies need to be reviewed to iron out bottlenecks. For instance, promoting hydrogen as an energy source will require support to spur demand and develop scale.Norms must specify the use of low carbon content materials; production standards across manufacturing will need to reflect today's climate urgencies.

Enhancement of capabilities across financial infrastructure

India's financial infrastructure will need to be further developed. That will require policy development, including the notification of sustainable finance taxonomy. Coverage of segments such as cell, modules, batteries, electrolysers would not only emphasize their significance, but pave way for dedicated focus on spurring investments in these critical thematic areas. A structured definition of sustainable finance (taxonomy) and coverage of the segments will not only help banks develop a standard norm for classification but also help formulate rules to mitigate greenwashing.

A parametric scaling of investment requirements across core segments (clean technology manufacturing, hydrogen, CCUS and others) and critical assessment of value chain impediments to scaling capacity, will help develop targeted policies and regulatory interventions. Further, it is essential to invest in developing the capabilities needed to evaluate new asset classes and craft financial products that meet evolving requirements and beyond.[20] Credit and risk mechanisms used by financing agencies will need to be rewired to ensure that climate-related factors become a part and parcel of capital flow considerations.

[20] India Needs to Spend USD1.4 Trillion More on Clean Energy Shift, Bloomberg, 9th February 2021, Accessed 25th August

In Conclusion

We are at a time in history where the actions in the next few years will determine whether the course on global warming can be reversed. This will be a consequence of many interlinked actions. As this paper has attempted to establish, at the core of the transition to clean energy systems would be the manufacturing facilities and supply chains. To scale up and also reduce the massive concentration risks India will have a key role to play. The task is enormous, but fortunately a good start has been made through proactive policies of Government of India and also several states. Turning these policies to outcomes will require a large number of implementation actions in a series of action theatres. Through this paper we have dimensioned the needs but also called out the challenges and imperatives. We believe that all stakeholders, coming together can make this change happen in a manner that is economically rewarding, environmentally responsive and helps society at large in many ways. We remain open to ideas to further this journey and work closely and collaboratively with all stakeholders to make this a reality.

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Key Anchors

Anvesha Thakker

Raja Das

Content Writers

Abirbhav Mukherjee

Amit Dey

Anvesha Thakker

Arpita Gupta

Arvind Jamkhedkar

G Shivpriya

Gangadhar Krishnamoorthy

Kuldeep Insa

Paritosh Moghe

Raja Das

Reetesh Kumar

S Sathish

Sarthak Dhama

Saurabh Kamdar

Vivek T

Design Team

Angeeta Baweja

Marketing Compliance

Nisha Fernandes

KPMG in India contacts:

Anish De
Global Head,
Energy Natural Resources and Chemicals (ENRC)
KPMG International
E: anishde@kpmg.com

Anvesha Thakker
Partner and Industry lead - Clean energy,
Energy Transition Co-Lead: Global Decarbonization Hub
KPMG in India
E: anveshathakker@kpmg.com

S Sathish
Partner and Lead- Customer & Operations Transformation
KPMG in India
E: ssathish@kpmg.com

kpmg.com/in

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