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Confederation of Indian Industry

Skill Gap Study for
Wind Energy Sector
in India



Implemented by:

giz Deutsche Gesellschaft für Internationale Zusammenarbeit (GIZ) GmbH

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Published by
Deutsche Gesellschaft für Internationale Zusammenarbeit (GIZ) GmbH

GIZ Office
46, Paschmi Marg, Vasant Vihar
New Delhi - 110057.

FOREWORD



Mr Sujoy Ghosh, Chairman, Renewable Energy Council, CII-Sohrabji Godrej Green Business Centre and Vice President & Country Managing Director – India, First Solar

India has made considerable progress in expanding its renewable energy capacity. Since the 1990s, the wind sector has played a pivotal role in India's renewable energy journey. India has demonstrated its ability to develop wind projects at scale, manufacture high-quality and cost-competitive wind turbines locally, and serve global markets. India's wind manufacturing sector is one of the true examples of 'Make in India' and 'Make for the World.' It is worthy to mention that India achieved record wind capacity addition of 6 GW in FY 2025-26. As the country's wind sector is growing manifold, it is important to ensure availability of skilled workforce to manufacture, build, operate, and maintain wind assets throughout their operating life of around 25 years.

In this context, the ***Skill Gap Analysis for the Indian Wind Energy Sector*** gains importance. This study has examined the workforce requirements and skill gaps in the wind sector through consultations with turbine and component manufacturers, independent power producers, EPC companies, operations and maintenance service providers, training institutions, and industry associations. Job roles, required skill sets, and the readiness of the training ecosystem to bridge the skill gaps have been analysed. Based on the study, considerable opportunities are available for skilling in safety, power electronics and advanced controls, wind resource assessment and simulation software, digital diagnostic systems, condition monitoring, and predictive maintenance. Capacity, hub height, rotor diameter, and generation from wind turbines are also on the rise and manufacturing these modern and highly efficient machines requires a specialised workforce and upskilling.

Workforce safety and the specialised skill sets required for offshore wind development in India have also been examined in the study. It also highlights important challenges related to recruitment, on-the-job training, retention, and the efforts required in these aspects. Addressing these challenges will require concerted efforts and investment from industry, academic and training institutions, and other stakeholders.

I would like to appreciate GIZ, the Skill Council for Green Jobs, and the Confederation of Indian Industry for this timely collaborative effort. I hope this assessment will serve as a useful reference for industry, training institutions, and the Government in developing the skilled workforce needed to support India's wind energy ambitions.

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List of Acronyms and Abbreviations

Abbreviation	Full form
AEP	Annual Energy Production
AI	Artificial Intelligence
AICTE	All India Council for Technical Education
ALMM	Approved List of Models and Manufacturers
ART	Advanced Rescue Training
BESS	Battery Energy Storage System
BR	Blade Repair
BST	Basic Safety Training
BTT	Basic Technical Training
CAPA	Corrective and Preventive Action
CFD	Computational Fluid Dynamics
CII	Confederation of Indian Industry
CMS	Condition Monitoring System
CoHE	Control of Hazardous Energies
DGT	Directorate General of Training
EFA	Enhanced First Aid
EHS	Environment, Health and Safety
EPC	Engineering, Procurement and Construction
ERP	Enterprise Resource Planning
FOWIND	Facilitating Offshore Wind in India
FTE	Full-Time Equivalent
GBC	Green Business Centre
GIS	Geographic Information System
GIZ	Deutsche Gesellschaft für Internationale Zusammenarbeit
GW	Gigawatt
GWEC	Global Wind Energy Council
GWO	Global Wind Organisation
GWWO	Global Wind Workforce Outlook
HSE	Health, Safety and Environment
HUET	Helicopter Underwater Escape Training
HV	High Voltage
ILO	International Labour Organization
IPP	Independent Power Producer
IRENA	International Renewable Energy Agency
ITI	Industrial Training Institute
IWTMA	Indian Wind Turbine Manufacturers Association
LiDAR	Light Detection and Ranging

Abbreviation	Full form
LOTO	Lock Out Tag Out
MNRE	Ministry of New and Renewable Energy
MSDE	Ministry of Skill Development and Entrepreneurship
MW	Megawatt
NCAER	National Council of Applied Economic Research
NCVET[AM3.1]	National Council for Vocational Educational Training
NDT	Non-Destructive Testing
NIWE	National Institute of Wind Energy
NOS	National Occupational Standards
NPTI	National Power Training Institute
NSQF	National Skills Qualifications Framework
O&M	Operations and Maintenance
OEM	Original Equipment Manufacturer
OFC	Optical Fibre Cable
OJT	On-the-Job Training
PLC	Programmable Logic Controller
PPC	Power Plant Controller
QP	Qualification Pack
RCA	Root Cause Analysis
RLMM	Revised List of Models and Manufacturers
ROC	Remote Operations Centre
SCADA	Supervisory Control and Data Acquisition
SCGJ	Skill Council for Green Jobs
SGRE	Siemens Gamesa Renewable Energy
SLS	Slinger Signaller
SoDAR	Sonic Detection and Ranging
ToT	Training of Trainers
VGF	Viability Gap Funding
VSDP	Vayu Mitra Skill Development Programme
WINDA	Wind Industry Database
WTC	Wind Turbine Components
WTG	Wind Turbine Generator

Abstract

India's wind energy sector is entering a new phase of growth, supported by expanding renewable energy targets, year-on-year (YoY) increasing repowering opportunities, strengthening of domestic manufacturing, development of wind hybrid projects and the long-awaited emergence of offshore wind. This Wind Sector Skill Gap Assessment evaluates the current and future workforce requirements across the complete wind energy value chain, encompassing wind resource assessment, project development and engineering, turbine and component manufacturing, transportation and logistics, civil and electrical construction, turbine installation, testing and commissioning, grid integration, operations and maintenance (O&M), repowering, and decommissioning.

The assessment examines existing and emerging job roles, workforce availability, technical and practical competency gaps, recruitment challenges, training infrastructure, and evolving skill requirements across different occupational levels. Emphasis is placed on competencies associated with larger and more advanced wind turbines, digital O&M, drone-based inspection, AI-enabled predictive maintenance, advanced manufacturing, data-driven asset management.

The emergence of offshore wind introduces an additional layer of workforce requirements, including specialized capabilities in marine engineering, offshore foundations and structures, subsea electrical systems, offshore installation and commissioning, specialized vessel operations, marine logistics, and offshore health and safety. The study also benchmarks relevant international workforce development and training practices to identify approaches that can be adapted to the Indian wind sector. The assessment ultimately aims to provide actionable recommendations for industry, training institutions, Government agencies, and skill councils to strengthen competency-based training, address critical skill gaps, improve industry and academia alignment, develop a future-ready workforce capable of supporting India's long-term wind energy and broader wind-hybrid renewable energy ambitions.

Executive Summary

India Wind Sector Skill Gap Assessment up to 2030

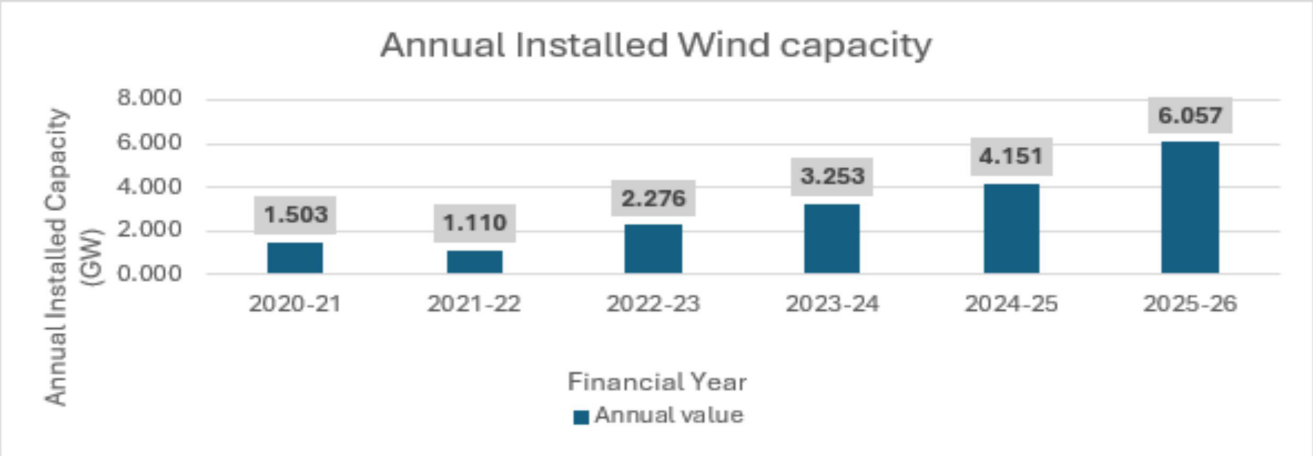
India stands at a critical juncture in its renewable energy transition, with wind power playing an important role in expanding to meet 500 GW of non-fossil electricity generation capacity, strengthening energy security, and supporting the country's long-term decarbonisation objectives. As installed wind capacity increases towards the national target of 100 GW by 2030, the availability of a skilled workforce will be essential to support domestic manufacturing, project development and construction, commissioning, and long-term operations and maintenance (O&M).

India's wind sector has developed capabilities across turbine manufacturing, component supply, engineering, procurement and construction (EPC), independent power producers (IPPs), and asset management. However, continued capacity expansion and the changing technical requirements of wind power projects create a need to strengthen workforce planning, improve access to specialised training, and align qualifications more closely with industry requirements. Addressing these needs will help support safe project execution, equipment reliability, productivity, and the long-term performance of wind assets.

Baseline vs 2030 Workforce Projections

Based on a reported wind-sector employment baseline of approximately 67,400 jobs in 2024 and installed capacity of 50.04 GW, a capacity-proportional model estimates the total workforce at approximately 79,700 in 2026, corresponding to installed capacity of 59.2 GW. If the employment-to-capacity ratio remains constant, the workforce associated with the national target of 100 GW could reach approximately 1.35 lakh by 2030.

Figure 1: Y-o-y capacity addition in wind sector



This represents an indicative increase of approximately 55,000 workers, or around 69%, between 2026 and 2030. These figures are approximate, modelled planning estimates rather than verified workforce headcounts or official forecasts. They illustrate the potential scale of workforce expansion associated with the capacity target. Actual workforce requirements will depend on factors such as manufacturing localisation, project execution models, technology choices, productivity improvements, and O&M requirements. Replacement demand due to attrition and cumulative employment effort across project activities should be assessed separately from total workforce projections.

Table 1: Indicative Wind-Sector Workforce - 2026 Baseline vs 2030 Projection

Indicator	Estimate
Reported workforce baseline (2024)	67,400
Installed wind capacity (2024)	50.04 GW
Installed wind capacity (September 2026)	59.2 GW
Estimated total workforce (2026)	79,700
Target installed wind capacity (2030)	100 GW
Projected total workforce (2030)	134,700
Indicative workforce increase (2026-2030)	55,000
Indicative workforce growth (2026-2030)	69%

Workforce Requirements and Employment Effort

In addition to the projected total workforce, the assessment estimates employment effort associated with the deployment of additional capacity and repowering activities. Based on an additional 40.8 GW required to reach 100 GW from the September 2026 installed capacity of 59.2 GW, the assessment estimates 64,872-103,224 FTE job-years across manufacturing, project deployment and construction, IPP activities, and O&M. Repowering and life-extension activities contribute a further estimated 20,198 FTE job-years, based on the additional capacity assumed in the assessment.

The resulting quantified employment effort is approximately 85,070-123,422 FTE job-years. These figures represent cumulative employment effort associated with the assessed activities and should not be interpreted as the number of distinct workers employed at a single point in time. They are also not directly additive to the projected total workforce figures in Table 1.

Table 2: Indicative Employment Effort for Additional Capacity and Repowering

Activity	Estimated employment effort
Manufacturing	22,440-30,600 FTE job-years
Project deployment and construction	18,360-24,480 FTE job-years
IPP workforce	16,320-30,600 FTE job-years
O&M for additional capacity	7,752-17,544 FTE job-years
Subtotal: additional capacity to 100 GW	64,872-103,224 FTE job-years
Repowering and life extension	20,198 FTE job-years
Total quantified employment effort	85,070-123,422 FTE job-years

Note: The employment-effort estimates use the coefficients and capacity assumptions set out in the assessment. FTE job-years are cumulative employment measures, not direct headcounts. Replacement demand and offshore wind employment are not included in this total.

Core Insights

The assessment identifies several areas requiring attention to ensure that workforce capabilities keep pace with the expansion and operational requirements of India's wind sector :

- Manufacturing and component capabilities: Wind turbine and component manufacturing require skilled personnel across mechanical and electrical production, fabrication, assembly, quality assurance, testing, and industrial maintenance. Workforce development needs to keep pace with domestic manufacturing and evolving equipment requirements.
- Project development, construction and commissioning: Wind projects depend on coordinated civil, electrical and mechanical activities, including foundations, turbine erection, lifting operations, cabling, grid connection, testing, and commissioning. These activities require technical competence, effective contractor coordination, and consistent implementation of safety procedures.
- Operations and maintenance: As the installed fleet expands, maintaining turbine availability and asset performance will require technicians and engineers with capabilities in preventive and corrective maintenance, electrical and mechanical troubleshooting, condition monitoring, fault diagnosis, and digital monitoring systems.
- Workplace safety: Wind-sector activities involve working at height, lifting and rigging, electrical hazards, confined spaces, and remote-site operations. Consistent safety training, practical assessment, and competency verification are important across construction and O&M activities.
- Training capacity and industry alignment: Training institutions and qualification frameworks need to reflect current industry practices and provide sufficient hands-on exposure to relevant equipment, tools, and work environments. Industry participation in curriculum development, practical assessment, and workplace training can help improve the alignment between training outcomes and job requirements.
- Workforce planning and retention: Capacity additions create demand for new entrants and experienced personnel, while attrition and workforce mobility generate replacement needs. Workforce planning should distinguish total workforce projections, annual recruitment, replacement demand, and cumulative employment effort.

Strategic Recommendations and Action Plan

A coordinated roadmap involving industry, training institutions, government agencies, and the relevant skill council is required to address identified workforce development needs.

Pillar I: Industry Actions

1. Industry-aligned induction and competency assessment: Strengthen structured induction programmes for new entrants and require practical competency verification before workers undertake safety-critical tasks independently. (Timeline: Immediate and ongoing).
2. OEM-led technical training: Expand training opportunities in partnership with turbine and component manufacturers, EPC contractors, IPPs, and O&M providers. Training should address equipment-specific installation, commissioning, troubleshooting, and maintenance requirements. (Timeline: Months 0-12).
3. Apprenticeships and workplace exposure: Promote structured apprenticeships, supervised workplace learning, and graduate trainee programmes to bridge the gap between classroom instruction and site requirements. Internships should carry significant credit weight and be placed through institutional industry contacts rather than left to students to arrange (Timeline: Months 0-24).

4. Retention and career progression: Encourage employers to develop transparent career pathways, competency-based progression, appropriate site welfare arrangements, and continuing professional development opportunities. (Timeline: Months 0-18).

Pillar II: Academic and Training Institution Actions

1. Curriculum modernisation: Review relevant ITI, diploma, and engineering curricula with industry and the skill council to incorporate wind-sector applications, electrical and mechanical troubleshooting, working-at-height safety, and digital monitoring. Structured alumni feedback should form the basis of this review, including alumni surveys after course completion and alumni representation in syllabus revision. (Timeline: Months 6-18).

2. Practical training infrastructure: Upgrade selected ITIs and wind training centres with suitable electrical, mechanical, safety, and maintenance training equipment, supported by access to industry facilities where appropriate. Provision should include exposure to the resource assessment software used in industry (Timeline: Years 1-3).

3. Regional Centres of Excellence: Develop a phased approach to specialised training facilities, with equipment and course offerings determined by regional industry demand and a feasibility assessment. (Timeline: Years 1-4).

4. Recognition of Prior Learning (RPL): Assess and certify eligible experienced workers whose existing skills can be demonstrated against relevant occupational standards. (Timeline: Months 0-24).

Pillar III: Government and Skill Council Actions

1. Workforce planning and monitoring: Establish a coordinated mechanism to track capacity additions, occupational demand, training output, placement, and retention, distinguishing workforce stock from annual hiring and job-year measures. (Timeline: Months 0-6).

2. Qualification and assessment updates: Review relevant Qualification Packs and assessment standards with industry to ensure that occupational competencies reflect current equipment, work practices, and safety requirements. (Timeline: Months 0-18).

3. Targeted training support: Prioritise public skilling resources for occupational areas and regions where evidence demonstrates significant training needs and where employers can support practical training and employment pathways. (Timeline: Years 1-3).

4. Offshore wind skills planning: Undertake a detailed study for offshore wind, including specialist safety, installation, marine logistics, and O&M requirements, before establishing costed workforce targets. (Timeline: Years 1-3).

Costed Implementation Roadmap, 2026-2030

The proposed roadmap translates these recommendations into an indicative set of interventions. The costs below are planning estimates rather than approved budgets*.

Table 3: Decision-Oriented Action Matrix, Indicative Costs and Outcome KPIs

S. No.	Intervention	Implementing agencies / . partners	Timeline	Proposed scale and cost . assumptions	Indicative outlay	Key performance indicators (KPIs)
1	Full qualification training for new entrants	SCGJ, MSDE/ DGT, ITIs, training partners, OEMs and O&M companies	2026-2030	3,500 trainees × ₹22,050 per trainee, provisionally based on 420 hours × ₹52.50 per hour	₹7.72 crore	Number enrolled and certified; practical assessment pass rate; placement rate; six- and 12-month retention
2	Modular upskilling and Recognition of Prior Learning (RPL)	SCGJ, OEMs, developers, O&M providers and training partners	2026-2030	10,000 participants × ₹6,500 per participant.	₹6.50 crore	Number assessed, trained and certified; completion rate; employer satisfaction; placement and retention, where applicable
3	Upgrade ITIs and wind training centres	MSDE/DGT, State Skill Development Missions, SCGJ, ITIs and industry partners	6-36 Months	20 centres × ₹75 lakh per centre.	₹15.00 crore	Number of centres upgraded and operational; trainer capacity; annual enrolment; practical assessment results
4	Establish or strengthen a regional Centre of Excellence (CoE) for onshore wind	Relevant ministries, state governments, technical institutions, SCGJ, NIWE and industry	1-4 Years	One CoE × ₹30 crore.	₹30.00 crore	CoE operational; industry-linked programmes delivered; trainers and specialist workers trained; employer participation

* This roadmap has been developed based on industry consultation, VSDP programmes and qualification packs and comparable benchmarks developed for solar sector.

S. No.	Intervention	Implementing agencies / . partners	Timeline	Proposed scale and cost . assumptions	Indic-ative outlay	Key perfor-mance indica-tors (KPIs)
5	Establish a Cen-tre of Excellence for offshore wind safety and skills training	MNRE, NIWE, SCGJ, maritime training institu-tions, technical institutions and offshore indus-try partners	Phased imple-men-tation, aligned with offshore wind project readi-ness	One dedicated offshore wind CoE covering safety, technical skills, special-ist training and certification. Infrastructure, equipment and operating re-quirements to be established through a fea-sibility assess-ment	NA*	Feasibility assessment completed; CoE established and operation-al; offshore training and certification programmes developed; trainers quali-fied; training ca-pacity aligned with project requirements
6	Apprenticeship support	Relevant ap-prenticeship authorities, employers, OEMs, devel-opers, ITIs and engineering institutions	2026-2030	2,000 appren-tices × ₹1,500 per month × 12 months, sub-ject to eligibility and applicable support arrange-ments	₹3.60 crore	Number of ap-prentices sup-ported; com-pletion rate; participating employers; six- and 12-month retention
7	Owner and asset manager training	Developers, independent power produc-ers (IPPs), asset owners, O&M providers, SCGJ and training institutions	2026-2030	1,000 partici-pants × ₹6,500 per participant.	₹0.65 crore	Number trained; ability to interpret per-formance and condition data; adoption of structured con-tractor-perfor-mance reviews
8	Renewable ener-gy safety officer qualification framework	Relevant gov-ernment and electrical-safe-ty authorities, SCGJ, industry and training institutions	3-36 Months	One framework ₹8 crore.	₹8.00 crore	Qualification framework developed and approved, as applicable; training and assessment capacity estab-lished; number of officers quali-fied
	Subtotal: Direct programme inter-ventions				₹71.47 crore	

* To be determined; excluded from the current programme total

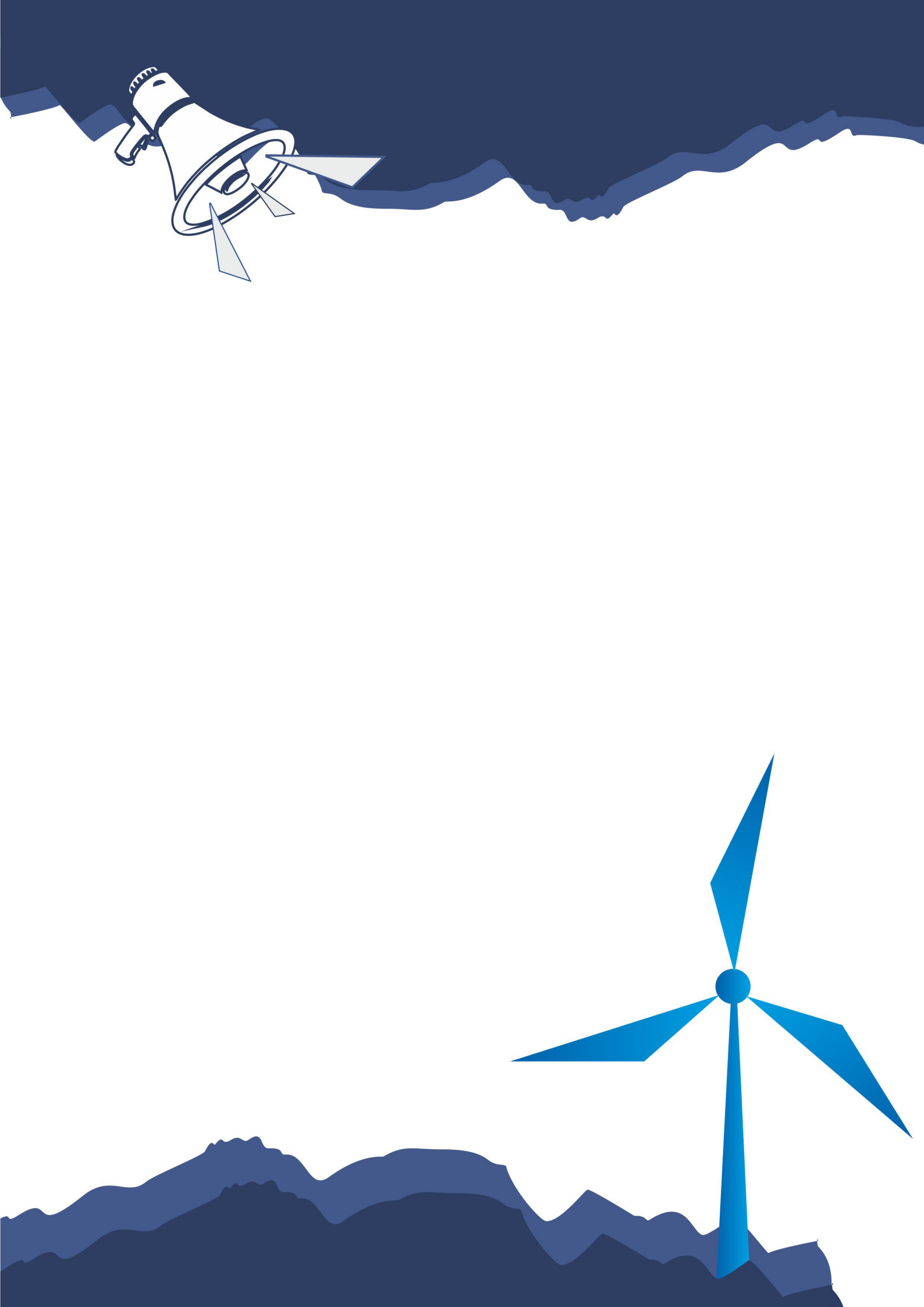
S. No.	Intervention	Implementing agencies / . partners	Timeline	Proposed scale and cost . assumptions	Indic-ative outlay	Key perfor-mance indica-tors (KPIs)
9	Programme coor-dination, monitor-ing and evaluation	Designated co-ordination body and participat-ing institutions	2026-2030	Provisionally 10% of quanti-fied direct pro-gramme costs	₹7.15 crore	Annual progress reporting; ex-penditure track-ing; training and employment outcome mon-itoring; period-ic evaluation and corrective action
	Total indicative programme outlay		2026-2030	Excludes the off-shore wind CoE pending costing	₹78.62 crore	

1. Indicative budget: The quantified programme outlay is ₹78.62 crore, excluding the proposed offshore wind CoE. The final investment requirement will be higher once the cost of off-shore wind CoE is established.
2. Offshore wind CoE: A feasibility assessment should define the facility's location, infrastructure, specialist equipment, training programmes, certification requirements, operating model and budget.
3. Apprenticeship support: The ₹3.60 crore provision assumes ₹1,500 per apprentice per month for 12 months, subject to applicable scheme eligibility and conditions.
4. Implementation and monitoring: Training volumes, costs, institutional capacity and certification requirements should be validated with the relevant government agencies and industry partners before implementation.

Conclusion

Reaching 100 GW of installed wind capacity by 2030 will require a substantial acceleration in annual installations, alongside management of an ageing fleet and the development of offshore capabilities. The findings of this assessment indicate that workforce availability, practical competency, retention and specialist training capacity warrant coordinated action across industry, training institutions and government.

The roadmap provides a basis for further consultation with industry, skill councils and relevant government agencies before implementation budgets and targets are finalised.

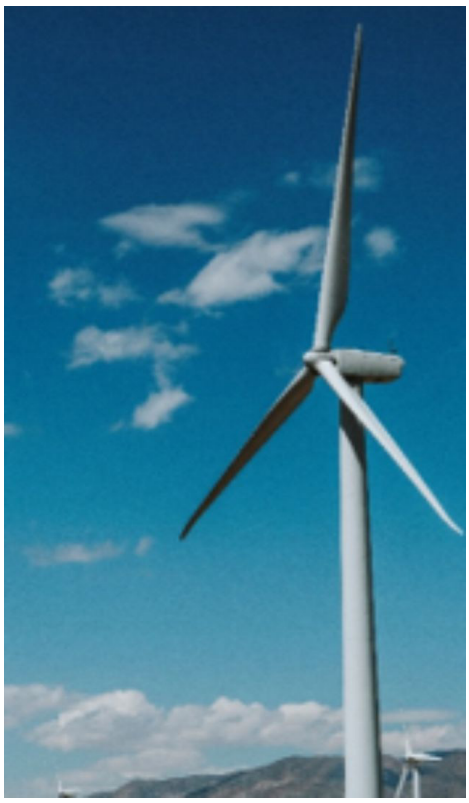


1. Background

1.1 Introduction

The global energy sector is undergoing a significant transformation as countries seek to strengthen energy security, reduce greenhouse gas emissions and transition towards low-carbon energy systems. Renewable energy has become central to this transition, with wind energy emerging as one of the major technologies supporting large-scale decarbonization of electricity systems. Continuous improvements in turbine technology, increasing turbine capacities, larger rotor diameters, taller support towers advanced control systems and digital operations and maintenance (O&M) are improving the technical and economic performance of wind energy projects.

Figure 1: Wind Turbines



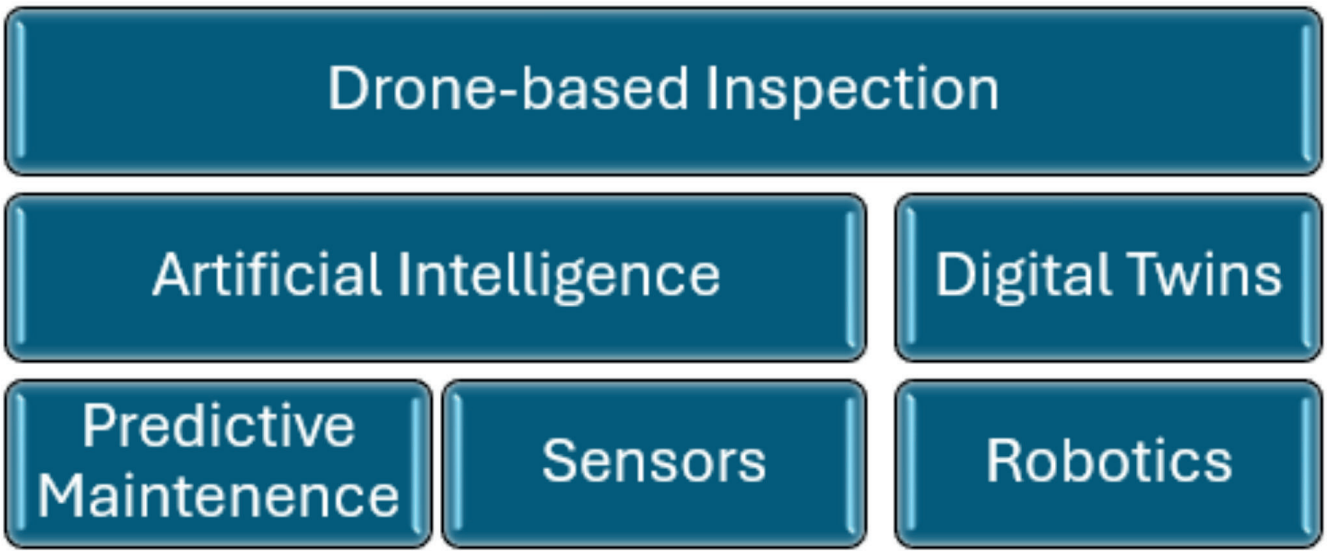
Global wind capacity has expanded substantially over the past decade. According to the Global Wind Energy Council (GWEC), continued expansion of onshore wind, combined with the development of offshore and floating offshore wind, is expected to generate substantial requirements for engineering, manufacturing, construction, installation and O&M capabilities.

Wind energy also has important economic and inclusive employment implications. Unlike an assessment based solely on installed capacity, the economic contribution of wind extends across a complex industrial value chain encompassing raw materials, castings and forgings, blades, towers, nacelles, generators, gearboxes, power electronics, transportation, civil infrastructure, electrical systems, project development, installation and long-term maintenance.

The International Renewable Energy Agency (IRENA) and International Labor Organization (ILO) estimated that global wind energy employment reached approximately 1.9 million jobs in 2024[1]. Employment is distributed across manufacturing, construction and installation, O&M, project development and supporting activities. As wind deployment increases, the availability of appropriately skilled personnel will become an important determinant of the industry's ability to expand efficiently.[2]

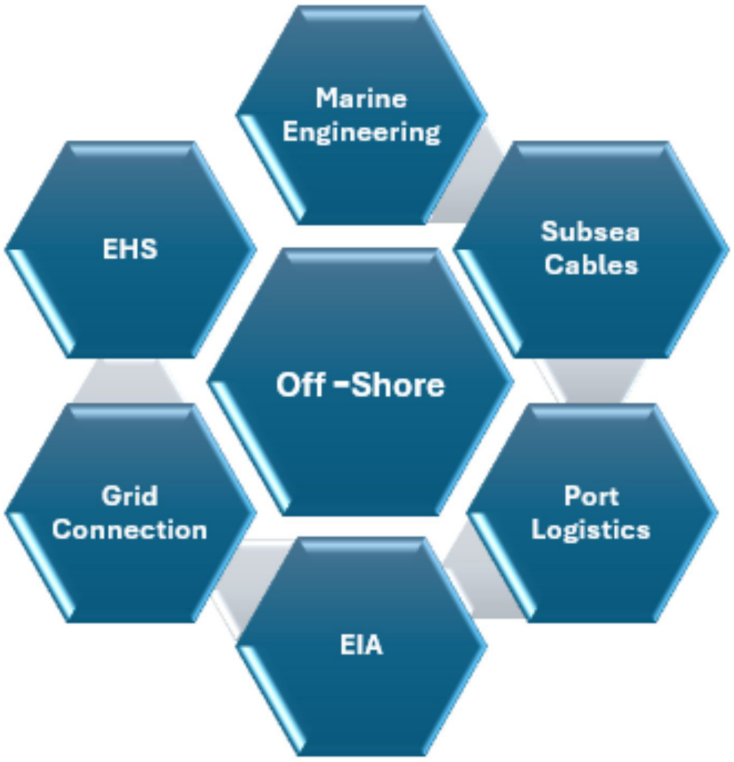
[1]Renewable energy and jobs: Annual review 2025
[2]https://www.irena.org/-/media/Files/IRENA/Agency/Publication/2026/Jan/IRENA_SOC_RE_and_jobs_2026.pdf

Figure 2: Technological Evolution



Offshore wind projects combine wind energy engineering with specialised marine and electrical infrastructure requirements. The project lifecycle involves distinct activities from early-stage site assessment and development through installation, commissioning, and long-term O&M.

Figure 3: Harnessing offshore wind energy



Consequently, workforce planning needs to evolve alongside wind energy deployment. The challenge is not limited to ensuring an adequate number of workers; it also requires ensuring that workers possess the technical, practical, digital and safety competencies required by modern wind energy systems.

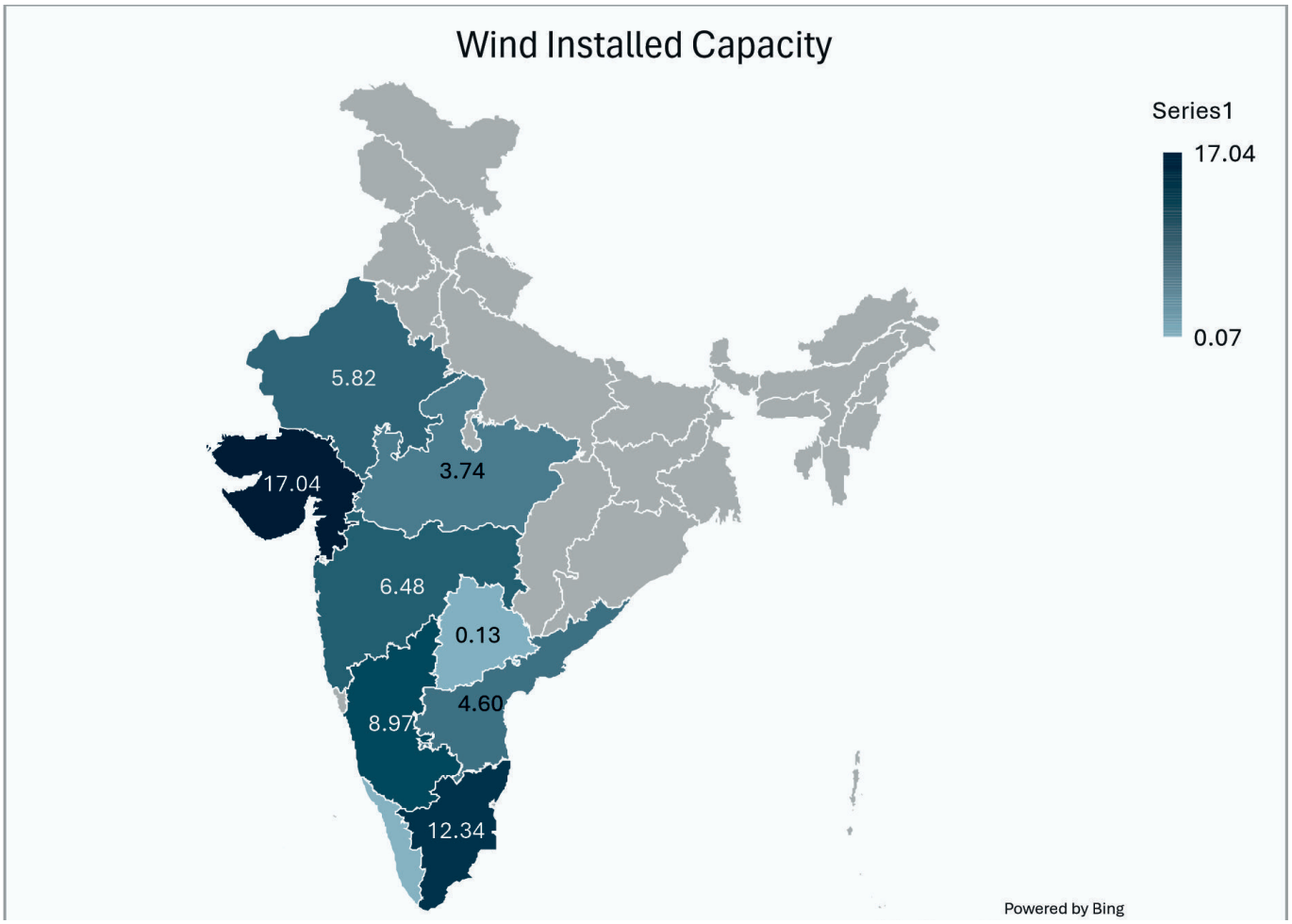
The present Wind Sector Skill Gap Assessment therefore examines India's current workforce ecosystem, emerging occupational requirements, industry recruitment challenges, training-system readiness and future workforce requirements up to 2030.

1.2. Wind Energy Sector in India

India has been an early adopter of wind energy among emerging economies. Commercial wind development began gaining momentum during the 1990s and subsequently expanded through fiscal incentives, state-level policies, renewable purchase obligations and private-sector investment.

Early wind development was concentrated primarily in states with strong wind resources, including Tamil Nadu, Gujarat, Karnataka, Maharashtra, Rajasthan and Andhra Pradesh.

Figure 4: Wind Installed Capacity



Source: MNRE, Installed Capacity as of 30.09.2026
**Values represented in GW*

Over time, India's wind industry has progressed from relatively small kW capacity wind turbine platforms towards modern multi-megawatt machines characterized by greater hub (tower) heights, larger rotor diameters and sophisticated power electronics control systems. This technological transition has improved energy capture but has also changed occupational and competency requirements.

The sector is now entering another phase of development characterized by larger onshore turbines, repowering, wind-solar hybridization, digital O&M and the emergence of offshore wind.

By 2030, India is aimed to double its wind capacity to 100 GW and scaling up to 452 GW by 2050. India, now as the world's 3rd largest wind equipment manufacturing hub with a capacity of 24GW per year can meet 10% of global demand through export by 2030. India scaling to a capacity addition of 15 GW annually could generate at least 1,54,000 jobs[3].

[3]https://www.gwec.net/news/indias-wind-capacity-expected-to-reach-107-gw-by-2030-gwec-india-wind-report-2025

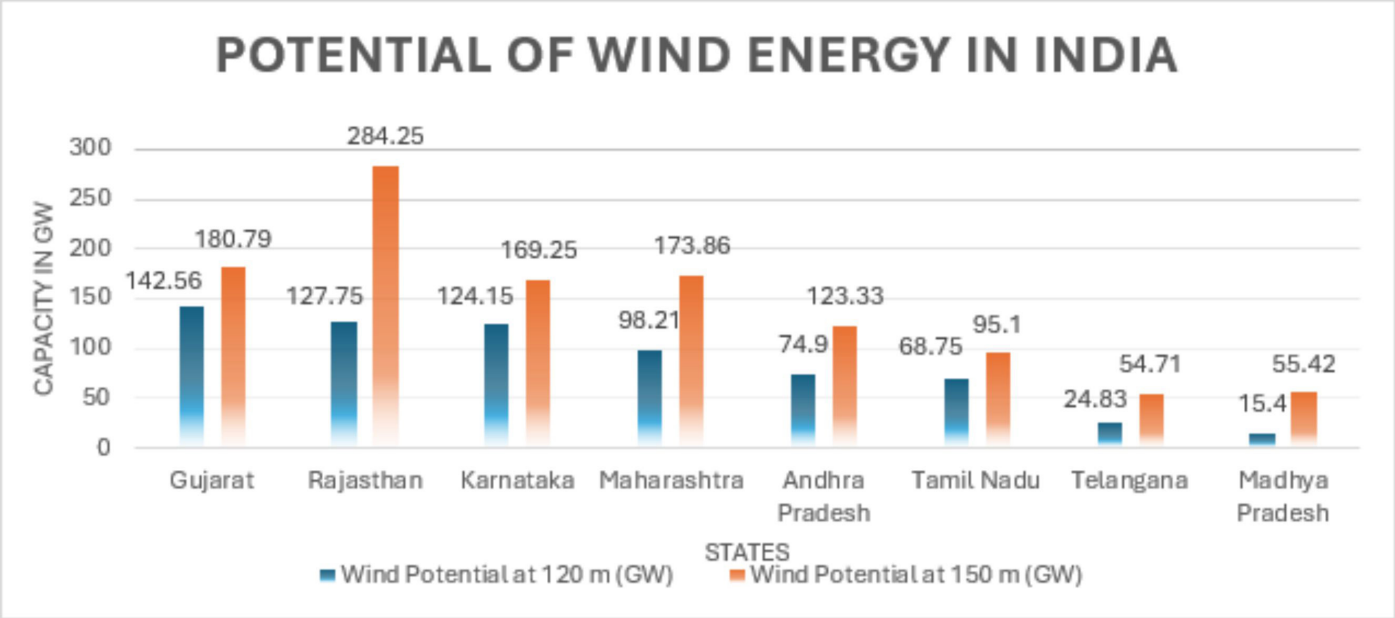
1.2.1. Current Wind Energy Landscape

India is one of the world's major wind energy markets. Installed wind capacity reached approximately 59.20 GW by 30 September 2026, making wind the second-largest renewable electricity technology in the country after solar PV.

India also possesses substantial untapped wind-resource potential. The National Institute of Wind Energy (NIWE) has estimated gross onshore wind potential of approximately 695.5 GW at 120 meters above ground level and 1,163.9 GW at 150 meters[4].

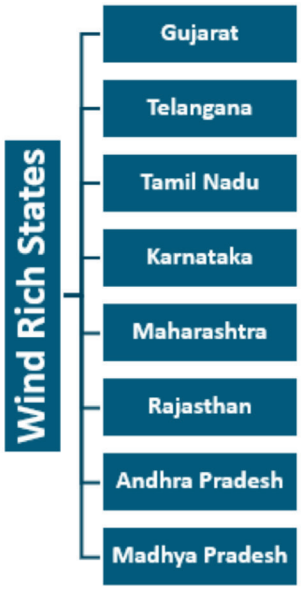
The difference between installed capacity and estimated technical potential indicates significant long-term opportunities for additional new green field wind deployment.

Figure 5: Potential of Wind Energy in India



Source: PIB (October 7, 2026)

Figure 6: Wind Rich States



Future expansion of wind energy will generate workforce demand not only during project construction but throughout the wind-project lifecycle along with the entire value chain.

[4]https://www.pib.gov.in/PressReleasePage.aspx?PRID=2272630&reg=3&lang=1

1.2.2. Geographic Concentration of Wind Development

Wind-energy development in India is geographically concentrated because project viability depends strongly on wind-resource availability, land characteristics, transmission infrastructure and state-level policy conditions.

This geographic concentration has important workforce implications. Wind technicians, site engineers, commissioning personnel and O&M teams need to be available near project clusters, which are frequently located away from major urban centers.

The geographic mismatch between training institutions and wind-project locations can therefore contribute to regional workforce shortages.

The wind sector differs from solar in offering career progression at all levels, including Level 1 workers, as experience is gained with specific turbine technologies. Exposure to multiple turbine brands increases opportunities for advancement and career growth, in India and internationally. This mobility also contributes to the high attrition rates discussed in Section 4.7.1.

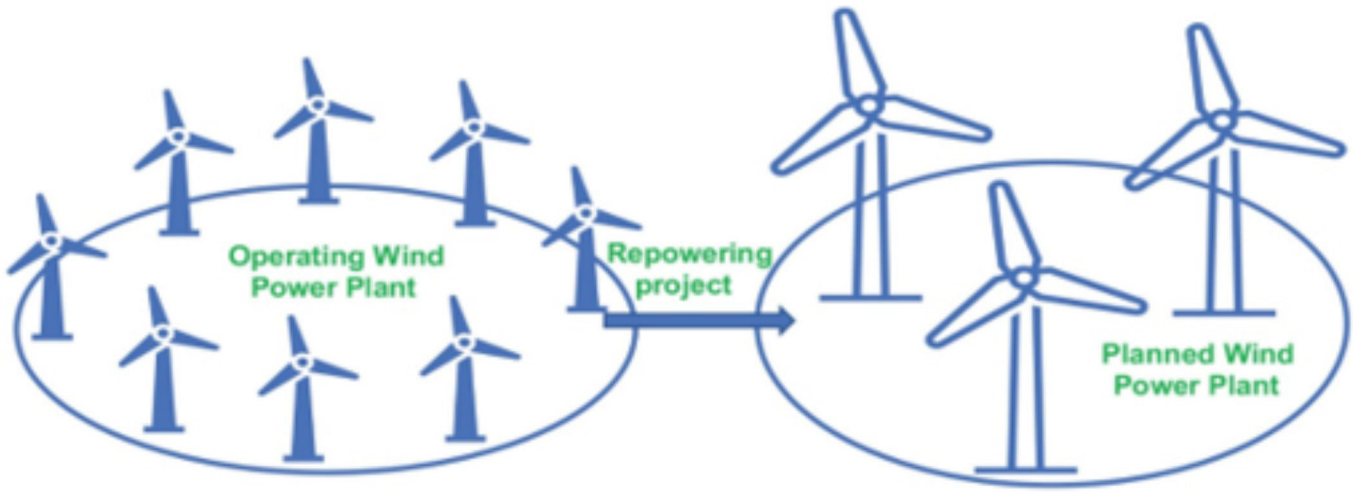
State-level skill planning is particularly important because workforce demand depends on the combination of existing installed capacity, future projects in pipeline, manufacturing presence and O&M requirements.

1.2.3. Onshore Wind and Repowering

Onshore wind is expected to remain the principal component of India's wind sector during the assessment period. However, a significant proportion of India's older wind fleet consists of comparatively small capacity kW size wind turbines installed at high-quality windy sites.

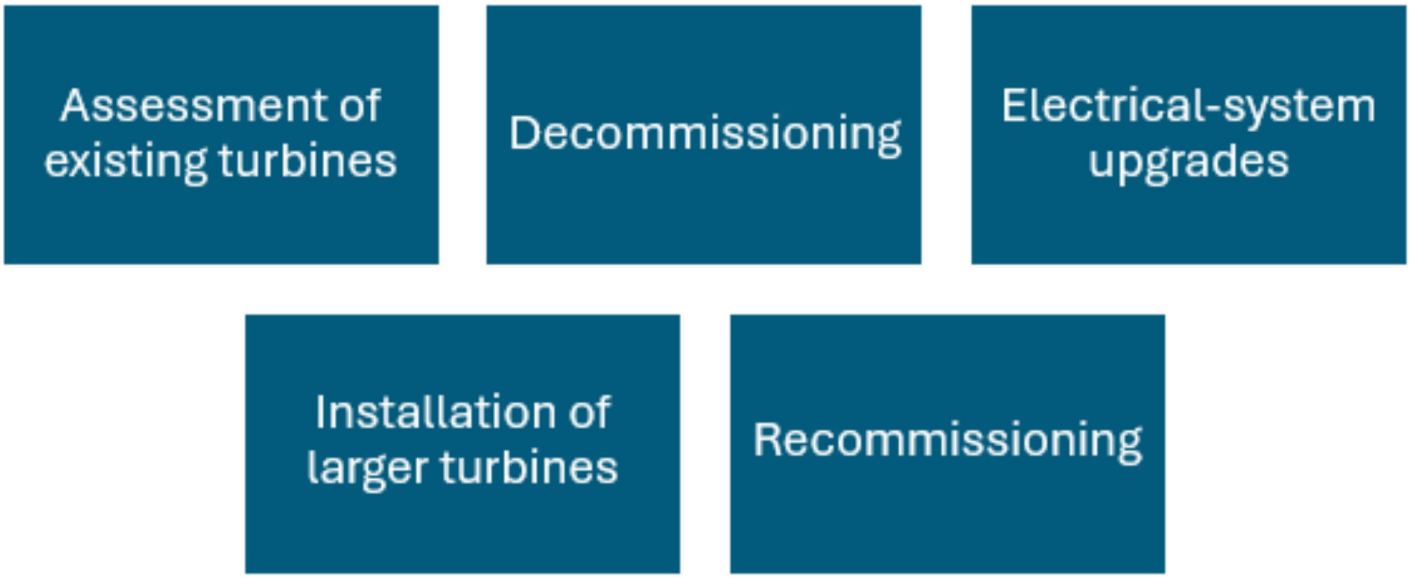
Repowering provides an opportunity to replace older machines with fewer but significantly larger and more efficient turbines. Repowering can increase energy generation from existing sites while utilizing established wind-resource areas and infrastructure.

Figure 7: On Shore Wind Repowering through micrositing with multimegawatt turbines[5]



[5]https://renewablewatch.in/wp-content/uploads/2024/02/R-41B.jpg

Figure 8: Repowering Requirements



Repowering creates both new employment opportunities and requirements for specialized technical competencies. Repowering therefore creates both new employment opportunities and requirements for specialised technical competencies. As turbines reach the end of their design life, repowering becomes a recurring activity rather than a one-time exercise, and continued advances in turbine technology make replacement progressively more attractive.

The transition towards larger-capacity onshore turbines and repowering of ageing wind assets is creating demand for specialized competencies across the project lifecycle. The workforce requires advanced skills in wind resource modelling, micro siting, turbine performance assessment, structural integrity evaluation, and repowering feasibility studies. Technical capabilities in high-capacity turbine systems, power electronics, grid-code compliance, SCADA analytics, condition monitoring, and predictive maintenance are increasingly critical. Repowering also demands expertise in decommissioning, component life assessment, foundation and balance-of-plant reuse, and integration of new turbines within existing or appropriately enhanced infrastructure. Emerging skills in digital twins, AI-based fault diagnostics, drone-enabled blade inspection, robotics enabled repair measures, LiDAR and advanced data analytics can significantly improve asset performance and reliability.

1.3. Rapid Expansion of Wind Capacity

India's broader target of achieving 500 GW of non-fossil electricity capacity by 2030 requires continued expansion of renewable-energy technologies, including wind. Wind capacity growth creates direct demand for personnel in manufacturing, project development, construction, installation, commissioning and O&M. However, workforce supply cannot be expanded instantaneously. Developing competent engineers and technicians requires training infrastructure, qualified trainers, practical equipment and workplace exposure. Workforce planning therefore needs to anticipate project deployment rather than react after skill shortages emerge.

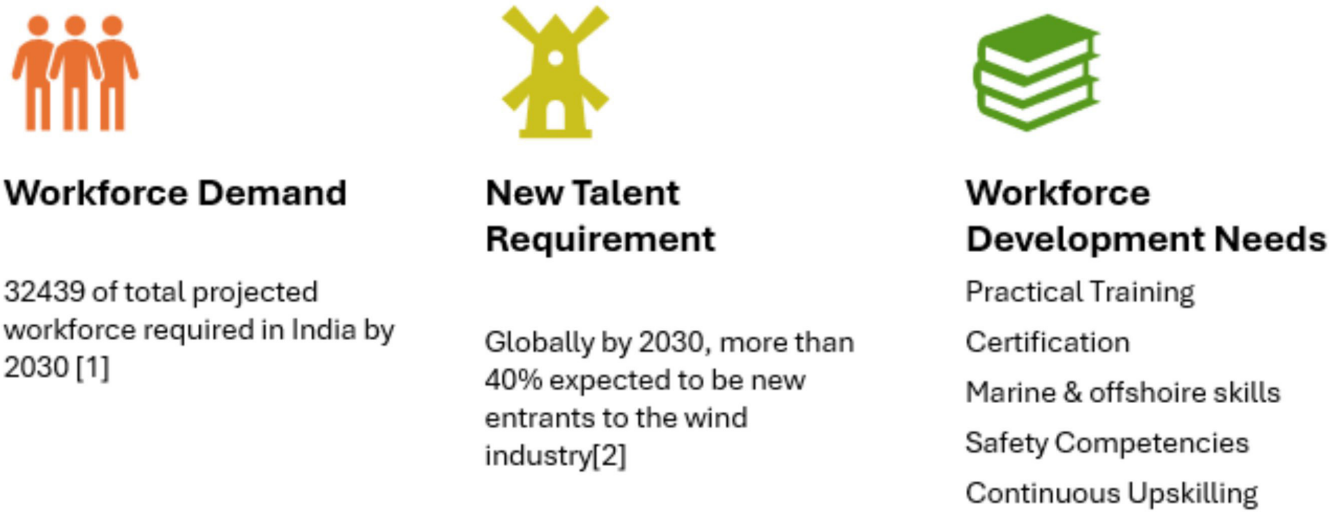
1.3.1. Changing Occupational Requirements

Wind-sector occupational requirements are undergoing a significant transition as O&M practices move towards digital, condition-based and predictive maintenance, as discussed in Section 2.1.3.

Evidence of this transition is already visible in recruitment patterns. A 2026 analysis of 544 wind-sector vacancies found that 28.1% explicitly required advanced digital skills, increasing to 44.3% among professional-level occupations[6]. Scientific programming, numerical analysis and simulation were among the prominent competencies identified.

The workforce requirement is also expanding rapidly. According to GWEC and GWO, approximately 628,000 technicians will be required globally by 2030, with more than 40% expected to be new entrants to the wind industry. This creates a simultaneous requirement for new workforce development and continuous upskilling of existing technicians. Consequently, occupations such as wind turbine technicians[7], O&M engineers and performance engineers are increasingly becoming hybrid roles combining mechanical, electrical, digital and analytical competencies. The skill assessment should therefore evaluate changes in competency requirements within existing occupations, rather than focusing only on employment growth or the creation of new job titles [8].

Figure 9: Occupational Requirements



Source : [1] Global Wind Workforce Outlook 2025-30; [2] GWEC: Global Wind Day 2026: Fast Facts about Wind

[6]Advanced digital skills demands and priorities in wind energy sector - PMC
[7]https://www.globalwindsafety.org/statistics/global-wind-workforce-outlook-2025---2030
[8]https://www.nature.com/articles/s41598-026-55076-w

1.3.2. Industry-Ready Workforce Challenges

Engineering graduates may possess strong theoretical foundations but limited practical experience with turbines, electrical systems, SCADA, commissioning procedures or industrial safety. Similarly, ITI and diploma graduates may possess mechanical or electrical skills but require wind-specific training before working independently on turbines. This creates a potential qualification-to-competency gap. A skill-gap assessment helps identify the competencies that employers find difficult to source and the additional training required to make workers job-ready.

Wind-turbine manufacturing involves several specialized industrial processes.

Table 4: Work force Challenge

Workforce Challenge	Industry	Skill/Training Required
Practical Exposure Gap	A graduate may understand turbine components theoretically but have limited exposure to nacelle inspection, gearbox maintenance or fault troubleshooting.	Hands-on turbine training, apprenticeships, simulator/lab exposure
Digital Skill Gap	An O&M engineer may need to identify abnormal turbine behaviour using SCADA alarms and condition-monitoring data, rather than relying only on physical inspection.	SCADA, CMS, data interpretation, predictive maintenance
Safety & Certification Gap	A technician working inside a nacelle or on a turbine tower must safely perform tasks at significant heights and respond to emergencies.	Working-at-height, rescue, first aid, fire awareness and electrical safety
Academia-Industry Gap	Engineering courses may cover electrical machines and power systems but provide limited exposure to wind turbine troubleshooting, commissioning and real operating data.	Industry-oriented curriculum, internships and practical projects
Offshore Skill Gap	Offshore technicians may have to reach turbines by vessel, perform maintenance in marine conditions and work with offshore electrical infrastructure.	Marine safety, sea survival, vessel transfer, offshore rescue and HV systems
Advanced Turbine Skill Gap	Increasing turbine ratings require technicians to work with larger components, advanced power electronics, controls and specialized lifting/maintenance procedures.	OEM-specific technical training and advanced electrical/mechanical skills

Workforce Challenge	Industry	Skill/Training Required
Continuous Upskilling	A technician trained primarily on older turbine platforms may need additional training when moving to newer digitally controlled turbine models.	Reskilling, OEM training and periodic competency development

Expansion of domestic manufacturing therefore requires a workforce with both general industrial competencies and wind-specific knowledge in order to comprehend the implications of wind characteristics in the design, manufacturing, installation and operation & maintenance of various components configured in the control systems.

1.4 Objectives of the Study

The primary objective of the Wind Sector Skill Gap Assessment is to evaluate the existing and future workforce requirements of India's wind energy sector and identify the interventions necessary to create an industry-ready and future-ready workforce up to 2030.

The specific objectives are to:

1. Assess the existing workforce structure across wind manufacturing, project development, construction, installation, commissioning and O&M.
2. Identify current competency requirements across engineering, technical, skilled-trade, supervisory and managerial occupations.
3. Assess workforce demand and supply gaps through skill mapping for job roles
4. Estimate future workforce requirements up to 2030 based on wind capacity growth, manufacturing expansion and O&M requirements.
5. Assess recruitment and retention challenges faced by wind-sector employers.
6. Evaluate training ecosystem readiness, including curriculum, faculty, laboratories, practical training, certification and industry exposure.
7. Assess state-level workforce and skill requirements in major and emerging wind energy states.
8. Evaluate alignment between industry requirements and training programs.
9. Identify priority interventions for industry, government, skill councils and training institutions.



2. Industry Overview

2.1. Overview of the Wind Energy Sector

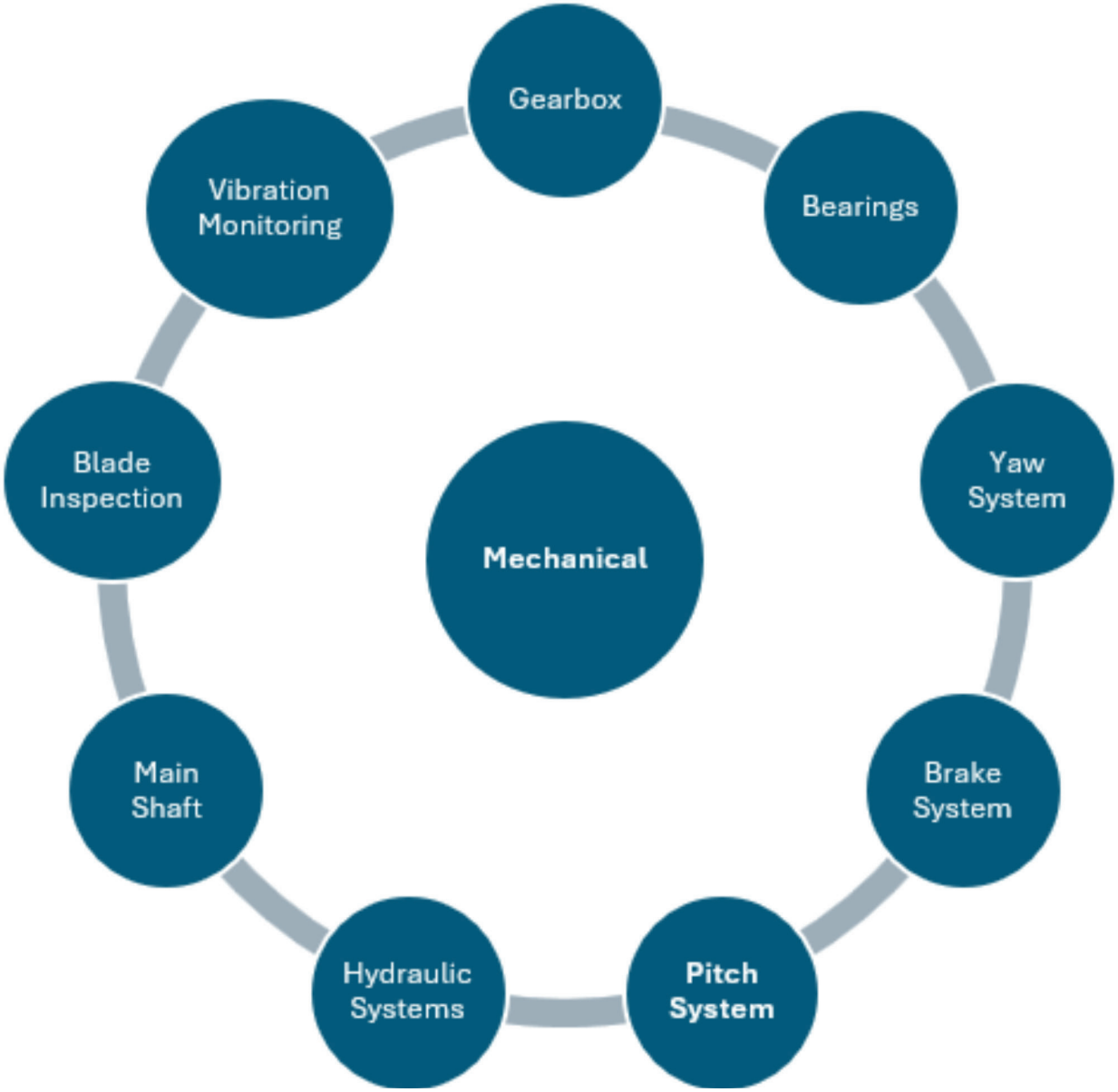
Wind energy is one of the most mature renewable-energy technologies and has become an important component of the global transition towards low-carbon electricity systems. Improvements in turbine design, higher hub heights, larger rotor diameters, advanced blade materials, sophisticated power electronics and digital control systems have significantly increased the energy capture and reliability of modern wind turbines. At the same time, the development of offshore wind, repowering, hybrid renewable-energy projects and digital O&M is expanding the technological and occupational scope of the industry.

Competency requirement in wind energy sector:

Wind technicians require a considerably more specialized competency combination.

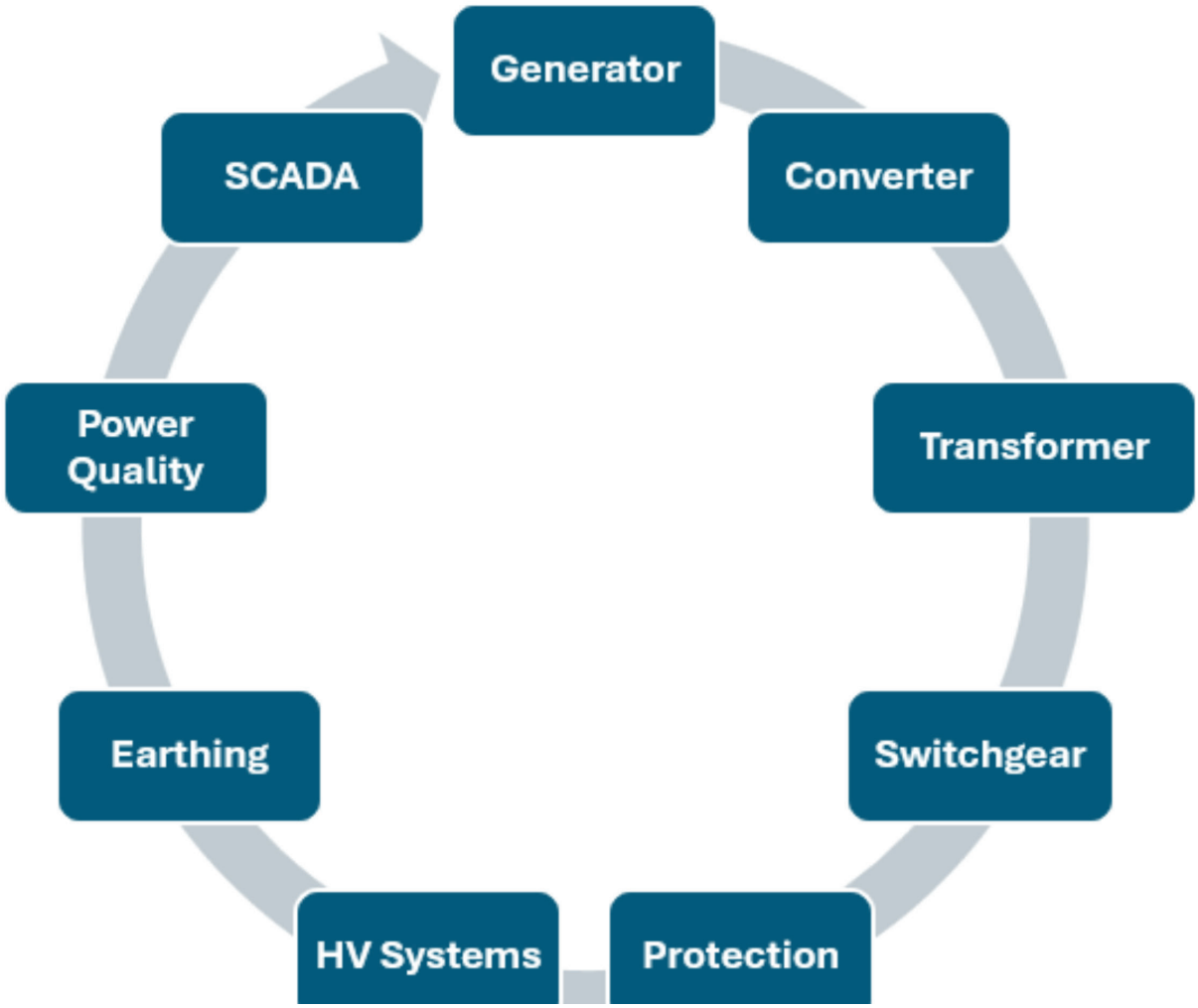
Mechanical

Figure 10: Mechanical Competencies



Electrical

Figure 11: Electrical Competencies



Safety

Figure 12: Safety Competencies



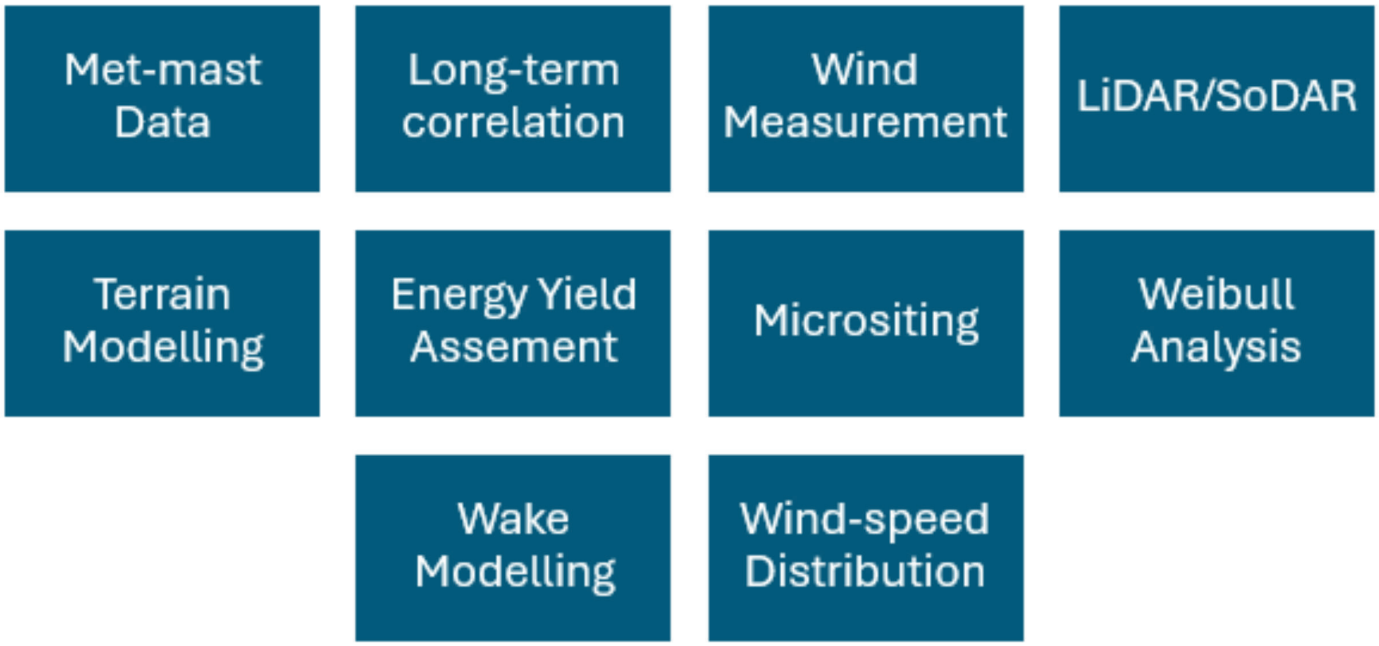
This national study highlights various competencies including the ability to climb turbines and work at height/confined spaces, together with mechanical and electrical O&M capability, fault diagnosis, gearboxes, bearings, wiring and hydraulic systems.

Physical fitness and high technical competence are required in the continuously evolving turbine technological innovations.

Wind-energy development is highly dependent on resource quality. Unlike conventional generation technologies, project location, turbine selection and expected generation depend heavily on wind speed, wind direction, terrain, air density, turbulence and long-term meteorological conditions.

The MSDE/NCAER study explicitly identifies resource assessment, site surveying and resource analysis as one of the "most sought after" skill shortage areas and cites that practical hands-on experience in one of the industry standard softwares such as WAsP, WindSim, Meteodyn, WindPRO for wind-resource assessment, and computational CFD based micrositing wind turbines in wind farms, would be a "must and inevitable" needed skill.

Figure 13: Technical skills for wind Sector



For India, wind energy is strategically important for three reasons. First, it provides a complementary generation profile to solar power and therefore contributes to diversification of the renewable energy mix. Second, India has developed a substantial domestic wind-turbine manufacturing and supply chain component ecosystem. Third, the sector generates employment across a wide range of engineering, manufacturing, construction, installation, commissioning and O&M activities.

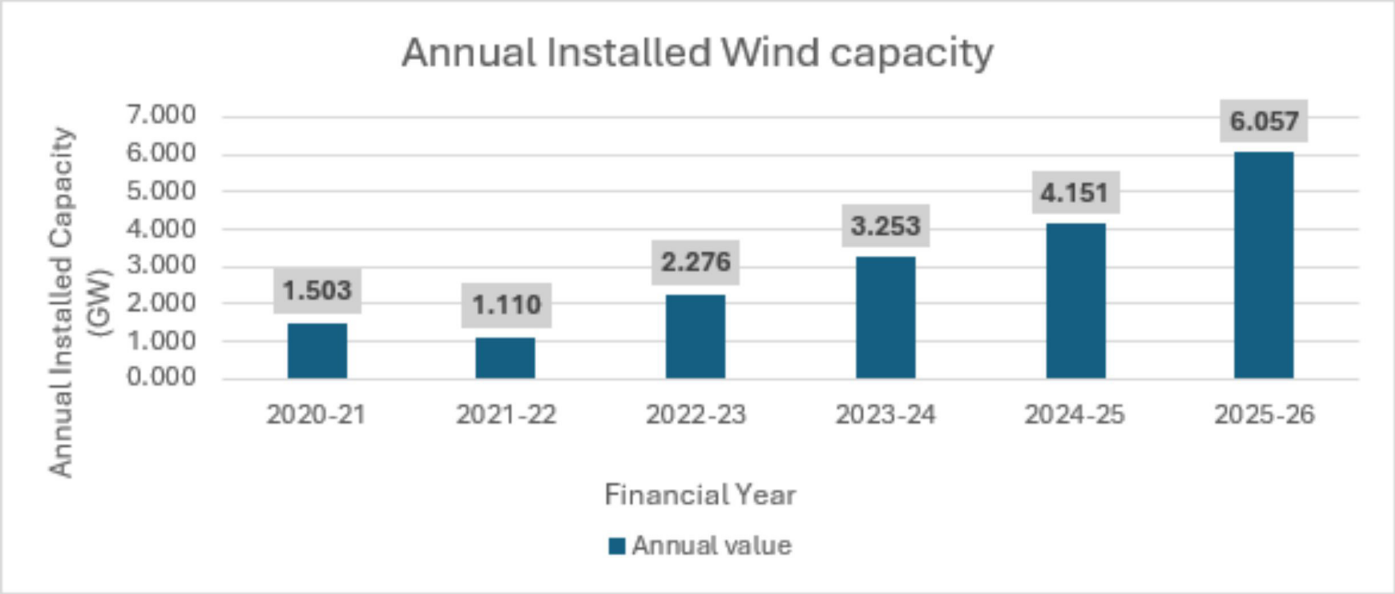
Unlike wind site engineering/project-construction employment, which is concentrated around the installation period, O&M employment continues throughout the operating life of the asset. Consequently, cumulative installed capacity is an important driver of recurring workforce demand.

2.1.1. Installed Capacity and Recent Growth

India currently has the fourth-largest installed wind-power capacity globally and reached 59.20 GW as of 30th September 2026, compared with approximately 48.2 GW at the end of 2024. The acceleration of installations is important from a workforce perspective because construction and commissioning requirements increase rapidly during periods of higher annual capacity addition.

Wind-energy development is concentrated primarily in resource-rich states including Gujarat, Tamil Nadu, Karnataka, Maharashtra, Rajasthan, Andhra Pradesh and Madhya Pradesh.

Figure 14: Annual Installed Wind Capacity [9]



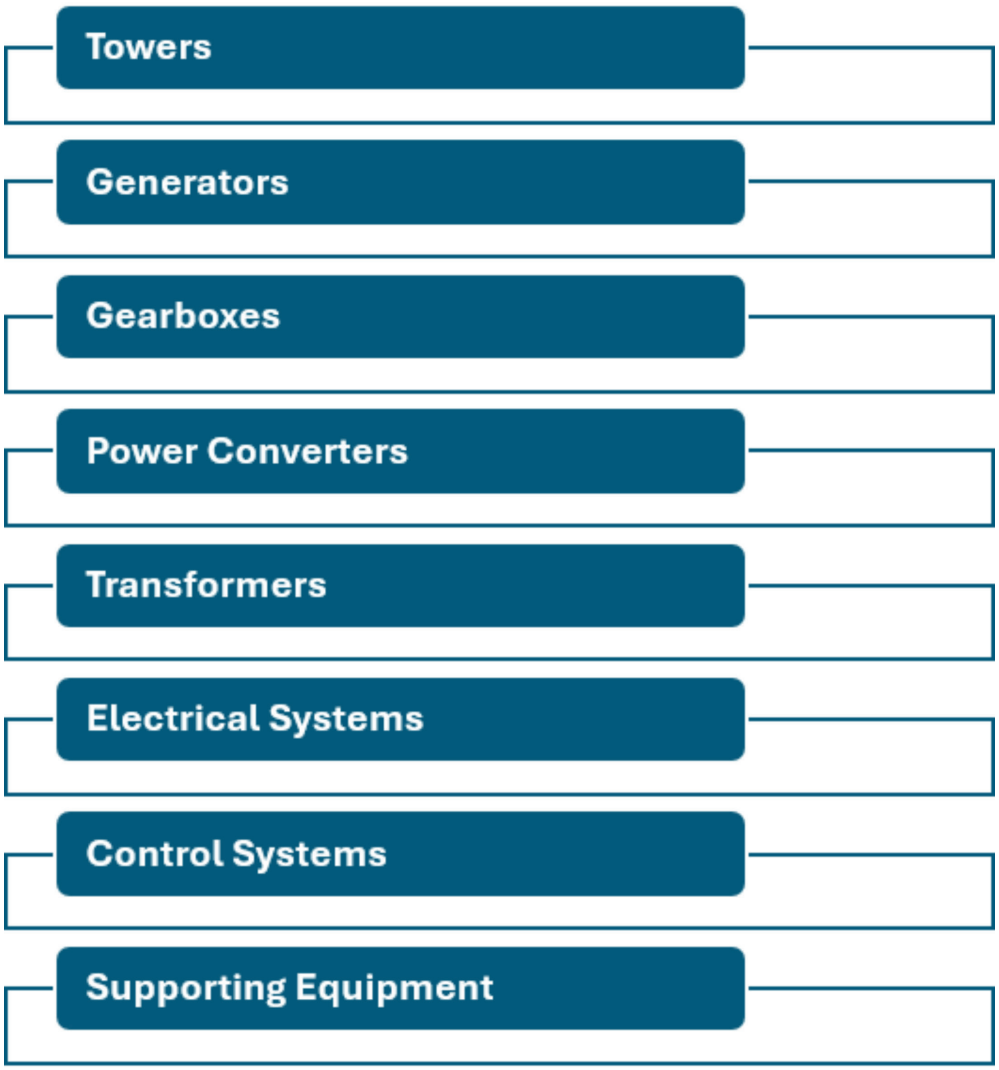
The geographic distribution of wind resources produces a corresponding distribution of employment, with manufacturing located near industrial clusters and ports and construction and O&M personnel required at wind farms in remote or semi-rural regions. This remains the case even where assets are centrally monitored using digital and AI-based data analytics. Consequently, national workforce availability alone does not guarantee workforce availability at project locations, since skilled workers migrate between regions for a range of reasons.

2.1.2. Domestic Wind Manufacturing Ecosystem

MNRE reports that approximately 70-80%[10] indigenization has been achieved in wind-turbine manufacturing. Around 14 manufacturers operate in the country through Indian companies, subsidiaries of international manufacturers and joint ventures. Domestic annual wind-turbine production capacity is approximately 24 GW, while turbine platforms available in India have increased to unit sizes of up to approximately 5.3 MW, and are made in India or assembled in India as per IEC-61400 series compliance standards and are type certified by international accredited bodies. It will be appropriate to mention that manufacturing in India (part of Asia and major wind manufacturing hub) is marginally cheaper than Europe and USA as technical skills of all engineering and science disciplines are available to be trained for manufacturing and production[11].

[9]https://mnre.gov.in/documents/guidelines/physical-achievements-kzN2kTMtQWa?pageTitle=Physical-Achievements
[10]Press Release Page | Press Information Bureau
[11]GETI, 2026 (Renewable Energy Talents-pages 37-40)

Figure 15: Domestic Manufacturing Ecosystem



The domestic manufacturing ecosystem encompasses:

This ecosystem creates employment across multiple occupational categories, including mechanical engineering, electrical engineering, electronics, power electronics, composites, metallurgy, welding, machining, automation, production engineering, equipment maintenance, quality assurance and supply-chain management.

The transition towards larger turbines creates additional manufacturing complexity. Longer blades require specialized composite-material processing and quality control. Larger towers increase requirements in plate forming, welding, dimensional inspection and coating. Higher-rated generators and converters increase demand for electrical and power-electronics competencies.

The manufacturing ecosystem is also evolving through stronger quality and localization requirements. MNRE's framework for approved wind turbine models and components, including RLMM-Wind - now known as ALMM (Wind) and ALMM-WTC, reinforces the importance of certification, quality assurance, traceability and compliant manufacturing processes.

From a skill perspective, manufacturing growth therefore requires not only additional production workers but also technicians and engineers capable of operating and maintaining increasingly automated and quality-intensive production systems.

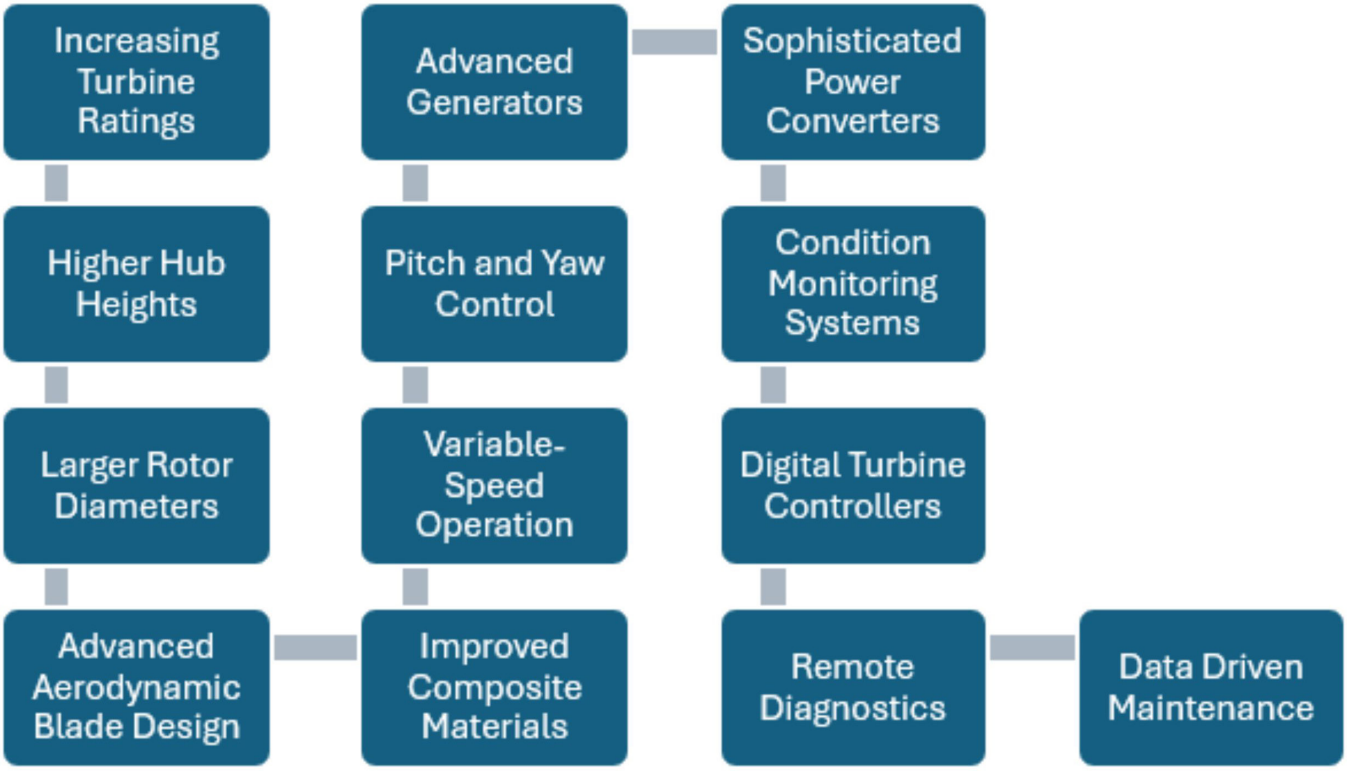
Stakeholder consultations indicated that Indian tower manufacturers generally do not have their own design or research and development (R&D) teams. They rely on original equipment manufacturers (OEMs) to provide design drawings, data sheets, material specifications, production processes and welding procedures. As a result, their role is mainly limited to fabrication rather than design. Multinational manufacturers maintain their design and R&D teams outside India.

2.1.3. Technology Evolution in Wind Turbines

Wind-turbine technology has evolved considerably over the last two decades. Earlier wind projects in India frequently used relatively small turbine ratings (Sub megawatt, less than 1000 kW sized) and lower hub heights (less than 70 m). Modern platforms employ significantly larger turbines, taller towers (up to 140 m plus) and longer blades (60 to 70 m).

The transition to larger turbines changes both construction and O&M requirements. Transportation becomes more complex because blades, towers and nacelles are larger. Installation requires higher-capacity cranes and specialized lifting operations. Maintenance increasingly involves advanced diagnostic systems and specialized working-at-height procedures.

Figure 16: Technology Trends in Wind Turbine



Digital technologies are simultaneously transforming turbine operations. Modern turbines continuously generate operational information through SCADA systems and condition-monitoring sensors. Analysis of vibration, temperature, electrical parameters, wind conditions and operating states allows potential failures to be identified before (predictive/preventive as well as prognostic) major breakdowns occur.

This shift from reactive maintenance towards predictive and condition-based maintenance is increasing demand for competencies in data interpretation, vibration analysis, sensor systems, remote diagnostics and asset-performance management.

Stakeholder consultations highlighted a new manufacturing requirement as turbine sizes increase. Steel towers for 6 MW turbines have diameters of around 6 m, making them difficult to transport on Indian roads without changes to bridges and checkposts. To address this, towers need to be split into three sections along the height, using cuts at 120-degree angles, for transportation. This requires additional machinery and specialised skills.

Consultations indicated that leading tower manufacturers in India are capable of adopting this technology, and that OEMs are expected to begin requiring it within the next year.

2.1.4. Repowering of Existing Wind Projects

India's early development of wind energy means that several high-quality wind sites contain older, relatively low-capacity turbines. Repowering provides an opportunity to replace older machines with fewer, larger and more efficient turbines.

MNRE issued the National Repowering & Life Extension Policy for Wind Power Projects, 2023 in December 2023, superseding the Policy for Repowering of the Wind Power Projects issued in August 2016. The policy covers both repowering, meaning replacement with newer turbines, and refurbishment for life extension beyond design life.

The National Institute of Wind Energy has estimated the country's repowering potential at 25,406 MW, covering wind turbines rated below 2 MW.

Table 5: Repowering potential by state

State	Repowering Potential (MW)
Tamil Nadu	7,386
Gujarat	4,665
Maharashtra	3,431
Karnataka	3,023
Rajasthan	2,934
Andhra Pradesh	2,366
Madhya Pradesh	1,562
Kerala	28
Total	25,406

Source: National Institute of Wind Energy, as published in .MNRE's National Repowering & Life Extension Policy for Wind Power Projects, 2023

Repowering can increase generation without requiring entirely new wind-resource areas enabling more generation from highly windy sites. However, repowering involves technical and operational challenges including ownership aggregation, existing power-purchase arrangements - PPAs of turbines with varying capacity sizes, distributed ownerships, and having different end-of-life/expiry dates, transmission capacity, land aggregation/access issues and dismantling of old equipment.

This creates emerging skill requirements as envisaged by MNRE like new organizations such as WRPA (Wind Repowering Aggregators) activities in micro siting with new technology wind turbines replacing old wind turbines, consequent structural assessment, decommissioning, heavy lifting, material segregation, recycling, foundation assessment and electrical-system modification including grid evacuation.

Repowering is therefore not simply a one-time capacity-enhancement strategy; it represents a recurring opportunity every 20-25 years life of every machine, meaning a distinct future scope for continuous employment segment (WRPAs) within the wind value chain.

2.1.5 Policy and Regulatory Environment

India's wind energy development is supported through a combination of national policies, regulatory mechanisms and procurement frameworks, which have been considerably dynamic as against a stable policy, as electricity is state as well as central Government concurrent subject. This means legal skill set is also pertinent in the case of Wind sector policy governance and compliance to state and central regulations.

Major policy measures include:

1. National Offshore Wind Energy Policy.
2. National Policy for Repowering of Wind Power Projects and state specifics.
3. National Wind-Solar Hybrid Policy.
4. Tariff-based competitive bidding guidelines.
5. Transmission-related support.
6. Wind-resource assessment through NIWE.
7. Revised List of Models and Manufacturers for wind turbines.
8. Offshore-wind VGF support.

These interventions influence the workforce ecosystem indirectly by determining the pace, technology mix and geo spatial distribution of wind projects.

2.1.6. Employment and Workforce Implications

According to IRENA and ILO, India's wind energy sector supported approximately 67,400 jobs in 2024, compared with approximately 52,200 in 2023. [12]

Employment was distributed broadly across three major segments:

Figure 17: Employment Distribution



[12] Renewable energy and jobs: Annual review 2025

India's strong domestic manufacturing base means that wind deployment can generate employment beyond project sites. Manufacturing facilities support engineers, technicians, machine operators, quality professionals, logistics workers and supply-chain personnel.

The sector's future employment potential will be influenced by six major drivers: Technology will simultaneously change the competencies required within these occupations.

Figure 18: Future Employment Potential



Consequently, workforce planning should focus not only on employment quantity but also on occupational composition, competency requirements and geographically regional availability.

2.2. Wind Energy Value chain

The wind energy value chain encompasses a broad range of activities extending from wind-resource assessment and project development to turbine manufacturing, project construction, commissioning, operations and maintenance (O&M), and ultimately repowering, decommissioning. As the global wind industry expands towards larger onshore turbines, offshore wind, digital O&M and increasingly sophisticated manufacturing systems, the structure of the value chain and its associated workforce requirements are also evolving.

For the present assessment, the wind energy value chain is analyzed from both a global and Indian perspective. This approach helps identify areas where India already possesses established industrial capabilities, areas where the domestic ecosystem is developing, and emerging segments where new skills and workforce capabilities will be required.

Onshore Wind Energy Value Chain:

Resource Assessment & Site Development

↓

Project Development & Engineering

↓

Wind Turbine and Component Manufacturing

↓

Procurement & Supply Chain

↓

Transportation & Logistics

↓

Civil & Electrical Construction

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Turbine Installation

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Testing & Commissioning

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Grid Integration

↓

Operations & Maintenance

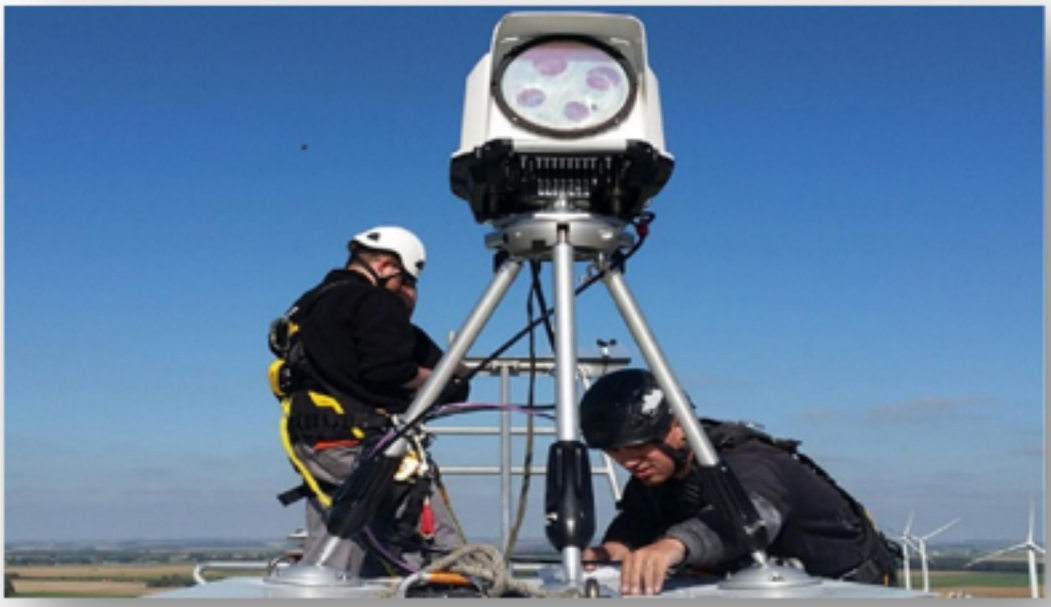
↓

Repowering / Decommissioning / Recycling

A. Resource Assessment & Site Development:

- Wind Resource Analysis - Wind data collection, assessment and interpretation.
- Meteorological Assessment - Wind speed, direction, turbulence and atmospheric conditions.
- LiDAR/SoDAR Technologies - Remote sensing, wind profiling and data validation.

Figure 19: Resource Assessment using LiDARs



- Micro-Siting - Optimal turbine positioning and layout optimization.
- Energy-Yield Estimation - Annual Energy Production (AEP) assessment and forecasting.
- Terrain Analysis - Topography, surface roughness and wake-effect assessment.
- GIS & Remote Sensing - Spatial mapping, land suitability and site identification.
- Technical industry standard Software Proficiency - WAsP, WindPRO, WindSIM, Meteodyn, and GIS-based modelling tools.
- Site Engineering - Site feasibility, accessibility and infrastructure assessment.
- Technical Reporting - Resource assessment documentation, uncertainty analysis and feasibility reporting.

B. Project Development & Engineering

- Project Engineering - Technical feasibility and engineering coordination.
- Turbine, Tower & Foundation Design - Turbine layout, structural and civil engineering.
- Electrical Systems & Grid Integration - Electrical design, protection and grid connectivity.
- Project Planning - Scheduling, budgeting and resource management.
- Techno-Economic Analysis - Cost estimation and project feasibility.
- Regulatory Compliance & Risk Assessment - Permitting, environmental clearances and risk management.
- Engineering Software - AutoCAD, ETAP, and Project Management platforms such as Primavera P6 and MS Project.

C. Wind Turbine and Component Manufacturing

- Blade Manufacturing - Composite layup, resin infusion, moulding, finishing and surface treatment.
- Composite Materials Processing - Glass and carbon fibre handling, resin systems, curing and material quality control.

- Tower Fabrication - Plate rolling and forming, heavy-section welding, flange machining, dimensional control and coating.
- Nacelle and Hub Assembly - Drivetrain integration, mechanical assembly, electrical panel assembly and functional testing.
- Generator and Power Electronics Manufacturing - Generator winding and assembly, converter manufacturing, control-system integration.
- Gearbox and Drivetrain Manufacturing - Precision machining, gear cutting, bearing assembly and lubrication systems.
- Welding and Fabrication - Certified welding to applicable structural standards, weld inspection and procedure qualification.
- Non-Destructive Testing - Ultrasonic, radiographic, magnetic particle and dye-penetrant inspection.
- Quality Assurance and Type Certification - IEC 61400 series compliance, traceability, documentation and third-party certification support.
- Advanced Manufacturing and Automation - Robotics, CNC machining, automated inspection systems and digital manufacturing execution.
- Production Planning and Industrial Engineering - Capacity planning, line balancing, throughput optimisation and shift management.

D. Procurement & Supply Chain

- Supplier & Vendor Management - Supplier identification, evaluation and vendor development.
- Strategic Sourcing & Procurement - Material sourcing, cost analysis and purchasing.
- Contract Management - Contract negotiation, compliance and supplier agreements.
- Logistics & Transportation - Planning and handling oversized turbine components.
- Inventory & Demand Planning - Stock management, material availability and demand forecasting.
- Digital Procurement Systems - ERP, SAP and supply-chain management tools.
- Quality & Risk Management - Supplier quality standards, supply-chain risks and delivery assurance.

E. Transportation & Logistics

- Over-Dimensional Cargo Planning - Route survey, clearance assessment and transport feasibility for blades, towers and nacelles.
- Route Engineering and Simulation - Turning-radius analysis, bridge and structure load assessment, obstruction identification and movement simulation.
- Permitting and Regulatory Coordination - Transport approvals, escort requirements and coordination with road and traffic authorities.
- Specialised Transport Operations - Blade trailers, hydraulic axles, self-propelled modular transporters and segmented tower handling.
- Port and Yard Handling - Component receipt, storage, stacking and load-out operations.
- Lifting and Handling Equipment Operation - Cranes, reach stackers and specialised lifting arrangements.
- Supply-Chain Scheduling - Sequencing of component delivery against installation programmes.
- Damage Prevention and Inspection - Transit inspection, securing arrangements and

condition reporting.

F. Civil & Electrical Construction

- Foundation Engineering and Construction - Geotechnical assessment, reinforcement, concrete works, anchor cage installation and curing control.
- Batching Plant Operations - Concrete mix design, quality control and testing.
- Access Road and Hardstand Construction - Earthworks, crane pad design and site preparation for heavy lifting.
- Internal Electrical Networks - Cable laying, jointing and termination, earthing systems and cable route design.
- Substation Construction - Switchgear installation, transformer erection, protection systems and control panels.
- Transmission Line Construction - Tower erection, stringing, insulator assembly and line testing.
- Survey and Setting Out - Total station and GNSS survey, levelling and positional verification.
- Construction Quality and Safety Management - Inspection and test plans, method statements and site HSE compliance.

G. Turbine Installation

- Turbine Assembly & Erection - Installation of towers, nacelles, hubs, blades and generator
- Heavy Lifting & Rigging - Crane operations, lifting procedures and load handling.
- Mechanical & Electrical Assembly - Component integration, bolting and electrical connections.

Figure 20: Turbine Installation



- Alignment & Precision Installation - Component positioning, alignment and mechanical calibration.
- Testing & Commissioning - System inspection, functional testing and commissioning.
- Health, Safety & Environment (HSE) - Working-at-height safety, lifting safety and regulatory

compliance.

- Digital Installation Technologies - Drone inspections, sensor-based alignment, remote monitoring and digital documentation.

H. Operation and Maintenance /ASSET Management

- Health, Safety & Environment (HSE) - Working-at-height safety, lifting safety and regulatory compliance.
- Performance optimization: Wind monitoring and turbine site specific seasonal tuning for best performance.
- Digital Twin technologies and centralized remote asset management platform.
- Supply chain management.
- AI/ML driven Robotic and craneless repairing methods and Technologies
- SCADA data analytics and preventive, predictive and prognostic maintenance.
- Wind power forecasting and performance monitoring of wind turbines operations.
- Grid evacuation monitoring along with state and central grid, power quality compliance and regulations.
- Reskilling and upskilling new workforce by scheduled on the job training in wind farm site project management .

2.2.1. Global Wind Energy Value Chain Scenario

The global wind energy industry has evolved into a large and geographically distributed industrial ecosystem. By the end of 2025, global installed wind capacity had reached approximately 1,299 GW, following record additions of around 165 GW during 2025.[13]

The global value chain encompasses turbine original equipment manufacturers (OEMs), component suppliers, engineering firms, project developers, EPC contractors, logistics companies, port operators, vessel operators, utilities, independent power producers, O&M service providers and specialized digital-service companies.

China represents the largest wind market and manufacturing base, while Europe continues to maintain substantial capabilities in turbine technology, offshore wind, engineering and specialized services. The United States is another major onshore market, while several emerging economies are expanding their wind project pipeline. India has significant role in the wind energy ecosystem global value chain next to China, Europe, and USA.

2.2.2. Global Logistics and Installation

Transportation and installation have become increasingly challenging as turbine dimensions have increased.

Large turbine components require:

- Specialized heavy-haul vehicles.
- Route planning.
- High-capacity cranes.
- Specialized rigging.
- Port infrastructure.
- Complex lifting procedures.

[13]GWEC- Global Wind Report 2026

Offshore wind had created an additional specialized logistics industry involving installation vessels, service operation vessels, crew transfer vessels, ports and marine coordination, and India is set to develop skill sets in these areas.

Global workforce requirements therefore increasingly include heavy-lifting specialists, marine logistics professionals, offshore installation technicians and specialized crane operators.

2.2.3. Value Chain Implications for the Skill Gap Assessment

The wind energy value chain demonstrates that workforce demand is distributed across a much broader occupational base than turbine installation and maintenance alone.

The value chain assessment also indicates that skill gaps in great demand at all levels can occur at three different supply levels:

Workforce Availability Gap:

Insufficient number of workers available for occupations.

↓

Competency Gap

Workers are available but lack the technical competencies required by industry.

↓

Emerging Skill Gap

Existing training programs do not adequately cover new technologies such as offshore wind, predictive maintenance, advanced turbine platforms or hybrid systems, digital twin and Remote monitoring tools

Accordingly, subsequent assessment of workforce demand and supply should evaluate not only the number of available workers but also their qualification, experience, technical proficiency, certification status, geographic availability and readiness for emerging technologies.



3. METHODOLOGY

3.1 Overall Approach

This assessment combines industry research, analysis of existing data and learning from international practices. The work is organised into five stages:

- Stage 1 - Mapping the value chain: Mapping the activities involved in both onshore and offshore wind energy, as set out in Section 2.2. This identifies the job roles covered by the assessment.
- Stage 2 - Collecting primary data: Gathering information through structured discussions with industry stakeholders including the owners/developers of wind turbines/wind farms and an industry survey covering employers across the value chain, training institutions, industry associations and government agencies. The focus is on understanding workforce composition, required skills, recruitment challenges and existing training practices.
- Stage 3 - Estimating workforce demand: Estimating workforce requirements up to 2030 based on expected capacity growth and the number of full-time equivalent workers needed across different stages of wind energy deployment and manufacturing.
- Stage 4 - Assessing skill gaps and the training ecosystem: Comparing industry skill requirements with existing training programmes, qualification frameworks and the capacity of training institutions. This stage also examines the readiness of training infrastructure.
- Stage 5 - Developing recommendations based on stakeholder consultations from the wind industry: Recommending improvements to curricula, certification systems and training institutions, along with a costed plan for developing the workforce required to support the growth of the wind energy sector.

3.2 Stakeholder Coverage

Within each category, organisations were selected to represent both established and emerging segments of the sector, including conventional onshore wind operations, multi-brand asset management and service providers, and organisations with offshore wind preparedness experience or plans to enter the segment:

- Wind Energy Developers (Venture Capitalists and Owners of Wind Farms) & Independent Power Producers (IPPs) - Workforce requirements for project development, resource assessment, engineering, construction, grid integration and operations/asset management.
- Wind Turbine OEMs & Component Manufacturers - Skill requirements in blade, tower, nacelle, generator and gearbox manufacturing, automation, quality control and advanced production technologies.
- Government Agencies & Regulatory Bodies - Policy priorities, workforce development initiatives, occupational standards and institutional support for sectoral skill development.
- Skill Councils & Training Institutions - Existing active (MSDE/NCVET- validated) Qualification Packs (QPs), NSQF-aligned programs, training capacity, infrastructure availability and industry alignment.
- Academic & Research Institutions - Technical education, specialized research, curriculum development and industry-academia collaboration.
- Workforce & Industry Professionals - Practical competency gaps, training needs, occupational mobility, career progression and workplace safety.

Asset owners comprise legacy and small owners, captive and group-captive commercial and industrial owners, independent power producers, and public sector undertakings and utilities, with differing capability requirements across these groups.

3.3 Data collection methodology

The Wind Energy Sector Skill Gap Assessment adopts a structured, multi-stakeholder data collection approach to assess workforce availability, occupation competencies, recruitment challenges, training infrastructure and emerging skill requirements across the wind energy value chain in India. The methodology combines structured survey questionnaires and semi-structured stakeholder interviews to capture both quantitative workforce information and qualitative industry insights. The assessment encompasses onshore wind, repowering, turbine and component manufacturing, offshore wind development initiatives in India, grid integration and operations and maintenance (O&M).

3.3.1. Survey Forms

Structured survey questionnaires developed to collect information from wind project developers, EPC contractors, O&M service providers, training institutions and other relevant stakeholders.

The survey focuses on the following parameters:

- Workforce Availability - Existing manpower strength, occupational distribution and availability of skilled personnel.
- Skill Gap Identification - Shortages in technical, operational, engineering and supervisory competencies.
- Recruitment Challenges - Difficult-to-fill positions, hiring constraints and experience requirements.
- Training Requirements - Existing training programs, certifications, apprenticeships and upskilling needs.
- Emerging Technologies - Skills required for larger turbine platforms, offshore wind, repowering, digital twins, automation and predictive maintenance.
- Training Infrastructure - Availability of practical training facilities, turbine simulators, specialized equipment, qualified trainers and safety training infrastructure.
- Future Workforce Demand - Anticipated manpower requirements associated with project development, manufacturing expansion and technological advancements.

3.3.2. Stakeholder Interviews

Semi-structured interviews were conducted with senior technical and management personnel across the value chain assuring the industry to strictly adhere to confidentiality along with anonymity. A common discussion framework was used to ensure consistent coverage of key themes, while allowing flexibility to explore issues specific to each organization's role in the value chain. With participants' consent, interviews were recorded and transcribed for thematic analysis.

The interviews were focused on:

- Value Chain-Specific Skill Requirements - Technical competencies across resource assessment, manufacturing, project engineering, installation, commissioning, grid integration and O&M.
- Workforce Competency Gaps - Differences between existing workforce capabilities and industry-specific occupational requirements.
- Recruitment and Retention Challenges - Availability of experienced professionals, workforce mobility and retention in remote project locations.
- Training Program Effectiveness - Industry relevance of existing curricula, practical training, certifications and occupational standards.
- Emerging Skill Requirements - Specialized competencies in offshore wind, advanced turbine technologies, SCADA, digital twins, remote monitoring and AI-based diagnostics.

- Industry-Academia Collaboration - Opportunities for apprenticeships, industry-led training, faculty development and specialized centers of excellence.
- Skill Development Recommendations - Stakeholder perspectives on improving training infrastructure, qualification coverage and workforce readiness.

3.3.3 Data Consolidation and Analysis

Survey responses and interview findings were consolidated to assess workforce demand, occupational skill shortages, competency gaps and training requirements across the wind energy value chain.

Quantitative data was analyzed using descriptive statistics, including workforce distribution, recruitment requirements, reported skill shortages and training participation. Qualitative findings were examined through thematic analysis to identify recurring challenges and emerging competency requirements.

Where applicable, identified occupational requirements were mapped against existing Qualification Packs (QPs), National Occupational Standards (NOS), National Skills Qualification Framework (NSQF) levels and relevant wind industry safety and technical certification frameworks.

The analysis also distinguished between three dimensions of skill gaps:

- Workforce Availability Gaps: Shortages in the number of qualified personnel available for specific occupations.
- Competency Gaps: Differences between existing workforce capabilities and industry-required technical skills.
- Emerging Skill Gaps: Inadequate preparedness for offshore wind, advanced turbine platforms, digital technologies and evolving operational requirements.

3.4 Workforce Estimation Methodology

3.4.1 Unit of Measurement

For workforce planning, employment in the wind sector is classified into three categories:

- Direct employment - Jobs directly associated with wind turbine manufacturing, project engineering, installation, commissioning, and wind farm operations and maintenance.
- Indirect employment - Jobs generated across the wider supply chain, including component manufacturing, steel and composites, transportation, ports, electrical equipment, civil works, and related services.
- Induced employment - Jobs supported by the spending of wages earned by workers in direct and indirect roles.

This assessment focuses on estimating direct employment in the wind sector. Indirect employment is discussed qualitatively where relevant but is not quantified as part of the assessment.

3.4.2 Business Phases

Workforce requirements are estimated separately for wind project deployment and manufacturing.

Table 6: Phases across deployment and manufacturing

Deployment	Manufacturing
Business development	Material procurement
Design and pre-construction	Engineering and design
Construction and commissioning	Production
Operations and maintenance (O&M)	Business Development/Corporate functions

Manufacturing is assessed separately for each major wind turbine component: blades, nacelles, towers, hubs and control boxes.

3.4.3 Calculation Method

For project deployment, workforce requirements are calculated based on three factors: the number of people working on a project, the proportion of their time spent on it, and the duration of their work.

For each phase, the calculation is:

FTE (Job Years) = (Number of workers × Proportion of time allocated × Phase duration in days) ÷ Standard working days per year.

FTE per MW = FTE (Job Years) ÷ Capacity (MW).

Standard working days are taken as 260 for deployment phases, reflecting a five-day working week, and 365 for manufacturing, reflecting continuous production.

The workforce estimate for each phase is then divided by the project capacity- produced or served, or annual manufacturing capacity, measured in MW. This gives the workforce requirement per MW. The results from different survey responses are averaged, and the estimates for individual phases are added together to calculate the overall workforce requirement.

3.4.4 Employment Coefficients

Coefficients are developed for the following, using received wind industry responses in the study :

- Deployment: Job-years required per MW of installed capacity, classified by project phase.
- Manufacturing: Job-years required per MW of annual production capacity, classified by turbine component. Although India has an annual wind turbine manufacturing capacity of 24 GW, most manufacturing facilities are not operating around the clock and typically run only day shifts. Production primarily caters to the domestic market, with an estimated 17-25% of components being exported at present (IWTMA). However, manufacturer-wise data on the proportion of components exported was not available during stakeholder consultations.

Table 7: Employment Component

Employment component	FTE job-years per MW
Manufacturing	0.55-0.75
Project deployment, including construction-related activities	0.45-0.6
IPP	0.4-0.75
Operations and Maintenance	0.19-0.43
Combined direct employment intensity	1.59- 2.53

The traditional wind business model often saw original equipment manufacturers (OEMs) take on broader roles as project developers and operations and maintenance (O&M) providers. However, the business model has evolved alongside changes in policy and procurement mechanisms - from capital subsidies, generation-based incentives (GBI) and feed-in tariffs (FiTs) towards competitive bidding and bid-based tariffs (BiTs). In this evolving landscape, OEMs increasingly focus on supplying wind turbine generators (WTGs), components and spare parts, while independent power producers (IPPs) acquire existing wind portfolios or develop greenfield projects and oversee their ongoing operation and maintenance as part of their own or their clients' asset management.

3.4.5 Skill Classification

Workers are grouped into three skill levels based on the qualifications and skills required for their jobs. These categories are mapped to the National Skills Qualifications Framework (NSQF).

Table 8: Skill Classification

Skill level	Description	NSQF level
Low-skilled	Jobs involving routine, repetitive tasks that generally do not require formal education	1-2
Semi-skilled	Jobs requiring technical or vocational training, with responsibility for specific tasks and some problem-solving	2.5-5.5
Highly skilled	Jobs requiring an engineering or advanced degree, specialised knowledge and responsibility for completing technical work	6 and above

Stakeholder consultations showed that assessing skills in the wind sector is not just about looking at a person's qualifications. Employers explained that new recruits, even those with relevant engineering or vocational qualifications, usually need six months to one year of in-house training (otherwise classified as OJT: On the Job Training as a MUST) and supervised field experience before they can perform technical tasks independently. This means that having a qualification does not always mean a person is ready to work on the job. The assessment therefore considers both formal qualifications and the practical skills needed to perform the job independently.

Skill requirements differ substantially between wind project deployment and manufacturing. In deployment, approximately 62% of roles require highly or semi-skilled workers[14]. Highly skilled roles account for more than half of the workforce in business development and design and pre-construction, while approximately half of the workforce in construction, commissioning and operations and maintenance is classified as low to semi-skilled.In manufacturing, highly-skilled roles account for approximately 70-80% of the workforce across all phases.

Manufacturing demand is concentrated at engineering and advanced technical qualification levels, while deployment generates substantial demand at semi-skilled and low-skilled levels, particularly in construction and field operations. The workforce is classified by skill level for each business phase. This helps identify the types of training needed and the qualification levels at which demand is highest.

3.4.6 Capacity Trajectory

The workforce projections are based on the Government of India's target of 100 GW of installed wind capacity by 2030. According to the Ministry of New and Renewable Energy (MNRE), India had 59.20 GW of installed wind capacity as of 30th September 2026. Reaching the 100 GW target would require an additional 40.8 GW of capacity by 2030.

The study estimates how much new capacity would need to be installed each year to reach this target. This is important because the workforce required for construction and installation depends on the amount of new capacity added each year.

How Workforce Requirements Are Estimated

The study presents workforce requirements in three ways:

- Cumulative job-years: The total employment effort required to manufacture and install the additional wind capacity over the study period.

[14]CEEW-NRDC (2026)

- Annual workforce demand: The number of workers required each year for manufacturing, installation and commissioning, and operations and maintenance (O&M).
- Sustained employment: The workforce needed to operate and maintain wind farms as installed capacity increases. These jobs continue even after construction is completed.

These estimates are calculated using employment coefficients and projected capacity additions. Estimating annual and sustained employment also requires assumptions about the installation schedule, the share of equipment manufactured in India, the duration of project-related work, and the workforce needed for O&M.

3.4.7 Assumptions and Limitations

The assessment is based on the following assumptions and limitations:

- Workforce and capacity: It assumes that workforce requirements increase in proportion to capacity. It does not account for possible reductions in labour needs due to larger projects, improved technology or higher productivity.
- Accuracy of reported data: Employment figures provided by companies are used for the estimates, subject to further checks and validation as and when updated/refined and detailed data become available from the industry stakeholders.
- Jobs versus workers: The number of jobs created is not the same as the number of people employed. One person may work on several short-term projects over time, meaning the total number of jobs created can be higher than the increase in the overall workforce.
- Realistic capacity growth: Projections are based on expected capacity additions rather than total estimated wind resource potential. Not all potential capacity can be developed because of constraints such as land availability, transmission access and project costs.
- Wind sector companies do not generally share detailed workforce data, as it is considered commercially sensitive in terms of migration of people in the otherwise competitive wind industry and can be difficult to compile across different departments and project phases. As a result, the workforce estimates are presented as indicative ranges rather than exact figures.

3.5 Skill gap assessment framework

Skill gaps in the wind industry can occur at three different levels (Section 3.3.3). Each requires a different solution. This assessment separates these gaps to ensure that recommendations address the actual problem.

- Level 1 - Shortage of workers: There are not enough people available for a particular job, regardless of their skill level. This can be addressed by increasing recruitment and training more people.
- Level 2 - Shortage of skills: Enough workers may be available, but they may lack the technical knowledge, practical experience or safety skills required by the industry. This can be addressed by improving training programmes, providing more hands-on experience and introducing relevant certifications.
- Level 3 - Skills needed for new technologies and roles: Existing training programmes may not cover the skills required for new technologies and emerging areas such as digital operations and maintenance, predictive maintenance, condition monitoring, advanced turbine technologies, repowering, hybrid systems and offshore wind. This requires new or updated training content and qualifications.

3.5.1 Assessment Parameters

Each job role is assessed using the following parameters to identify where the gaps exist and what action is needed.

Table 9: Assessment Parameters

Parameter	What is assessed
Recruitment difficulty	How long employers take to fill vacancies and how difficult it is to find suitable candidates
Competency gap	Whether new recruits have the skills needed to perform their jobs
Time to competence	How long employees take to become capable of working independently
Training availability	Whether suitable training programmes and qualifications are available
Certification requirements	What safety and technical certifications are needed and whether they are available in India
Geographic regional availability	Whether qualified workers are available near project locations

Note: Parameters are assessed through employer responses in the industry survey and stakeholder consultations, supplemented by mapping against published qualification frameworks

3.5.2 Mapping Qualifications

The skills required for each job role are developed complying to the underlying methodology of MSDE/ NCVET within the National Skills Qualifications Framework (NSQF) and existing Qualification Packs developed by the Skill Council for Green Jobs (SCGJ) and the National Institute of Wind Energy (NIWE).

This helps to classify job roles into three categories:

- Roles for which suitable and up-to-date qualifications already exist.
- Roles for which qualifications exist but need to be updated to reflect current technologies and industry practices.
- Roles for which no suitable qualification is currently available.

Note: The mapping also identifies qualifications that are outdated, where occupational standards have not been updated to keep pace with changes in turbine technology, operating practices and digital systems.

3.5.3 Technology-Specific and Transferable Skills

Industry consultations highlighted that turbine control and diagnostic systems are often specific to individual manufacturers and industry recruitments are based on references or experience preferably. As a result, technical training is largely provided by employers and focuses on the turbine technologies they use.

Stakeholders noted that experience with one turbine platform does not always transfer easily to another. Companies servicing a particular turbine brand often prefer candidates with experience of that technology rather than training workers to operate across different platforms. This challenge is particularly relevant as third-party service providers increasingly manage wind turbines from multiple manufacturers. One big plus point is that every Level employee gets assured career growth with added experience in the wind sector provided the person's interest to relocate or changing technology needs or even a new learning possibility. Hence skilling, reskilling, upskilling, all the three are very significant in continuous scope for skill training.

The assessment therefore distinguishes between two types of skills:

- Transferable skills: Skills that can be taught through standardised training programmes, evaluations and certifications. These include safety practices, basic electrical and mechanical skills, wind resource assessment and data interpretation.
- Platform-specific skills: Skills related to particular turbine models, control systems and diagnostic tools, which generally require specialised training (OJT) provided by employers.

Stakeholder consultations highlighted that training institutes or authorized training partners often have limited access to turbine systems and operational data due to manufacturer restrictions. This makes it difficult to provide standardised technical training outside company-led programmes. The assessment therefore looks at which general skills, such as understanding turbine design, sensor systems and data interpretation, can be taught without relying on reference to specific manufacturers' technology.

This distinction helps identify which skill gaps can be addressed by updating training programmes and certifications, and which require companies to provide specialised, technology-specific training to their employees.

3.6 Readiness of training institutes

Training ecosystem readiness is assessed across five dimensions, each selected to identify constraints that would limit the sector's capacity to meet projected workforce requirements.

- Curriculum alignment - Coverage of current industry technology and practice, assessed against the competency requirements identified in Chapter 4. This includes digital operations and maintenance, condition monitoring, larger turbine platforms, repowering and life extension, and offshore competencies.
- Trainer capacity - Availability of qualified trainers, the extent of their direct industry exposure, and the existence of trainer development, certification and refresher pathways.
- Practical training infrastructure - Availability of turbine access for hands-on training, nacelle and drivetrain mock-ups, simulators, electrical and SCADA laboratories, working-at-height and rescue facilities, and, for offshore, sea survival and helicopter underwater escape training facilities.
- Certification and accreditation status - Recognition under NSQF, NCVET and MSDE frameworks, alignment with existing Qualification Packs, and certification against international standards including those of the Global Wind Organisation.
- Capacity and geographic positioning - Annual training throughput, location relative to wind clusters and ports, and employment outcomes of trainees.

3.6.1 Institutions Covered

The assessment covers the following categories of training provider:

- The National Institute of Wind Energy and its network of training partners
- Industrial training institutes and polytechnics located in wind states
- Engineering institutions offering wind or renewable energy programmes
- Original equipment manufacturer training centres
- Private sector training academies

3.6.2 Basis of Assessment

The assessment uses inputs from training institutions, published programme details, qualification pack specifications, training records and site visits wherever possible.

Employers are consulted separately to understand how well training programmes prepare candidates for industry requirements. These discussions cover employers' experience of hiring trained candidates, the additional training new recruits need before they can work independently, and the extent to which companies depend on in-house training rather than external training providers.

3.6.3 Geographic Positioning of Training Provision

The assessment looks at the location of training centres in relation to wind clusters. Stakeholder consultations indicated that people trained in cities are often reluctant to relocate to remote wind-farm sites for the long term. Training and hiring people from communities near wind farms can help meet local workforce needs more effectively and sustainably. This approach is also followed in existing national skill-development programmes, where training partners are selected based on their proximity to wind-resource areas.

3.7 Selection of States

States were selected based on their installed wind capacity, upcoming projects, manufacturing activity, offshore wind potential and the availability of existing training infrastructure.

3.7.1 Primary Wind States

The assessment covers Gujarat, Tamil Nadu, Karnataka, Maharashtra, Rajasthan, Andhra Pradesh and Madhya Pradesh. As of 30th September 2026, these seven states accounted for most of India's installed wind capacity, as shown below.

Table 10: Installed capacity

State	Installed capacity as on 30.09.2026 (MW)
Gujarat	17,044
Tamil Nadu	12,335
Karnataka	8,974
Maharashtra	6,485
Rajasthan	5,815
Andhra Pradesh	4,605
Madhya Pradesh	3,739
Telangana	128
Kerala	72
Others	4
Total	59,201

Wind sector activities vary across these states, which also affects the type of workforce required:

- States with a large number of operating wind farms: These require workforce for operations and maintenance (O&M), extending the life of older turbines and repowering existing wind farms.
- States with upcoming projects: These require workers for construction, installation and commissioning.
- States with manufacturing facilities: Workforce demand depends on production levels and the number of components being manufactured.

3.7.2 Emerging Wind States

Telangana and Odisha have limited or no operating wind capacity but are being considered for future development. These states are included to understand their potential workforce needs and whether the required training infrastructure and skilled workforce are available.

3.7.3 Offshore Focus States

Gujarat and Tamil Nadu are also assessed for offshore wind development, as they have been identified for initial projects and port infrastructure upgrades under the offshore wind viability gap funding scheme. The assessment also looks at training facilities near ports and maritime institutions that could support offshore wind development.

3.7.4 Rationale

Wind sector jobs are concentrated in specific states and locations. The availability of skilled workers at the national level does not necessarily mean that they are available where projects are located. This is particularly important for operations and maintenance, as workers need to be based near wind farms, which are often far from major cities and technical institutions.

Stakeholder consultations indicated that workers are often reluctant to relocate between states and prefer to remain in their home regions. Therefore, workforce availability needs to be assessed at the state and district levels, rather than only at the national level. Training facilities must also be assessed based on where workers are needed.

The state-level assessment helps distinguish between workforce demand arising from new projects, which depends on where new capacity is being added, and demand from existing wind farms, which depends on the location and size of the operating fleet.



4. WORKFORCE AND SKILL GAP ANALYSIS

4.1. Overview

The workforce and skill-gap assessment examines the extent to which India's existing human-resource base is equipped to support the present and future requirements of the wind energy industry. The assessment covers workforce availability, occupational structure, technical competencies, recruitment challenges, emerging technology requirements, training needs and geographic variations.

The analysis draws on two principal sources of evidence:

1. Primary research: Industry survey, stakeholder consultations and expert interactions undertaken as part of the present study; and
2. Secondary research: Employment, capacity, technology and skills information published by MNRE, NIWE, IRENA, ILO, GWEC, GWO and other recognized institutions.

The findings are interpreted within the context of the rapid expansion and technological transformation of India's wind sector.

International workforce projections provide a broader context for the Indian assessment. The Global Wind Workforce Outlook 2025-2030, published by GWO and GWEC, estimates that global demand for technicians in construction, installation, and operations and maintenance will reach around 6,28,000 by 2030.

The report also identifies India as one of six key markets and projects that demand for workers in onshore wind will grow more than 2.5 times between 2023 and 2035.

Different organizations use different methods to estimate workforce requirements, so their figures may not be directly comparable. Some estimates measure the total employment effort in job-years, while others forecast the workforce needed or estimate jobs under different scenarios. Since these estimates use different definitions and assumptions, they should not be combined into a single figure.

Stakeholder consultations so far have included testing and certification bodies, independent power producers, EPC contractors, O&M service providers, multi-brand asset management companies, national training institutions and industry associations.

Table 11 : Stakeholders Classification

Parameter	Classification
Organization type	OEM / Developer / EPC / O&M / Manufacturer / Consultant
Organization size	Small / Medium / Large
Geographic coverage	State / Multi-state / National
Value chain activity	Manufacturing / EPC / O&M / Other
Workforce size	Survey-derived categories
Respondent level	Management / HR / Technical / Operations

4.2 Current Workforce and Skills

Table 12: Current workforce and skills

Nearest . Existing . Qualification Pack	NSQF Level	Department	Job Role	Educational Qualification	Key Responsibilities / Skills
O&M Mechanical Technician - Wind Power Plant SGJ/Q1502	4	Wind O&M	Engineer - Wind O&M	Diploma/Degree - Mechanical Engineering	Preventive maintenance of WTGs, mechanical maintenance, equipment upgrades, review of drawings / SOPs / schematics, WTG health audits, dismantling and assembly, material planning, SAP documentation, corrective actions and EHS compliance
O&M Electrical & Instrumentation Technician - Wind Power Plant SGJ/Q1503	4	Wind O&M	Junior Engineer - Wind O&M	Diploma/ B.Tech - Electrical Engineering	Preventive and corrective WTG maintenance, gearbox / yaw / pitch / coupling inspection, alignment, torquing, lubrication, structural inspection, LOTO, work-at-height compliance and troubleshooting
CMS Engineer-Wind Power Plant SGJ/Q1501	5	Wind O&M / Reliability	Senior Engineer - Wind O&M	B.E. Electrical / Diploma Electrical	WTG troubleshooting, electrical/mechanical systems, component-health inspection, quality checks, retrofits, SCADA desktop analysis, OEM software, RCA, CAPA, ISO documentation and risk identification
O&M Electrical & Instrumentation Technician - Wind Power Plant SGJ/Q1503	4	Wind O&M	Senior Engineer - Wind O&M	Diploma/B.E./ B.Tech - Electrical Engineering	24×7 WTG operation, preventive / scheduled / unscheduled maintenance, breakdown response, online monitoring, electrical inspection, turbine fault analysis, safety, documentation and material management

Nearest . Existing . Qualification Pack	NSQF Level	Department	Job Role	Educational Qualification	Key Responsibilities / Skills
O&M Electrical & Instrumentation Technician - Wind Power Plant SGJ/Q1503	5	SCADA & Power Plant Solutions	Engineer - SCADA	Bachelor's degree - Electrical/Electronic Engineering	SCADA and PPC detailed engineering, OFC networks, installation, configuration and commissioning, PLC programming, industrial communication protocols, network troubleshooting, preventive/corrective maintenance and remote technical support
CMS Engineer-Wind Power Plant SGJ/Q1501	5	Remote Operations	Remote Operations Engineer	Bachelor's degree in Engineering or equivalent industry qualification	Remote monitoring and operation of wind-power plants, advanced turbine remote support, technical troubleshooting, fault diagnosis, performance optimisation and coordination with customers and internal teams
CMS Engineer-Wind Power Plant SGJ/Q1501	5	Condition Monitoring / Predictive Maintenance	Condition Monitoring Engineer	Relevant engineering qualification	Turbine vibration-data analysis, multi-sensor condition monitoring, lubrication/temperature/SCADA data interpretation, predictive-maintenance analysis and conversion of diagnostic findings into maintenance recommendations
SGJ/Q1501 - CMS Engineer	5	Remote Operations Centre	Engineer / Senior Engineer / Assistant Lead Engineer - ROC	Relevant engineering qualification	Remote turbine monitoring, operational support, fault identification, troubleshooting and coordination with service/field operations
O&M Electrical & Instrumentation Technician - Wind Power Plant SGJ/Q1503	4	Power Controls	Converter Control - Assistant Lead Engineer	Relevant Electrical/Electronics/ Control Engineering qualification	Converter controls, turbine-control engineering, power-electronic systems, control optimization and technical problem solving

Nearest . Existing . Qualification Pack	NSQF Level	Department	Job Role	Educational Qualification	Key Responsibilities / Skills
O&M Electrical & Instrumentation Technician - Wind Power Plant SGJ/Q1503	4	Electrical Engineering / Service Support	Specialist / Lead Engineer - Electrical Support	Relevant Electrical/Electronic Engineering qualification	Electrical turbine systems, control systems, technical troubleshooting, service support, reliability improvement and advanced electrical diagnostics
		Mechanical / Lifecycle Engineering	Lead Mechanical Engineer - Wind Turbines	Mechanical Engineering / relevant engineering qualification	Mechanical turbine engineering, operational issue resolution, reliability improvement, asset optimization and technical support to wind-service operations
NA	-	Digital / AI	ML Engineer	Relevant Computer Science/ Engineering/ Data/AI qualification	Machine learning, development of digital solutions, data-driven wind applications and integration of AI into engineering/operational processes

The previous table maps job roles currently advertised in the Indian wind sector against existing Qualification Packs and NSQF levels. The qualification packs are to follow NCVET guidelines as given by MSDE from time to time; and need to be validated to be considered as a active QP. The current verified status of the listed QPs are not available during the study. The mapping identifies roles for which aligned qualifications exist, and roles for which no wind-specific qualification is currently available. As per SCGJ now NIWE has been recognized in India as a Skill Certification Awarding Body for the QPs which are active. As per the available details there is 1 QP with 540 hours of training following NSQF norms which is named as Wind farm Engineer is offered by NIWE.

Three key observations emerge from this mapping:

- The Qualification Packs which were active in India earlier, mainly covered field-based operations and maintenance roles. The available wind specific qualifications focus on mechanical and electrical O&M technicians and condition monitoring, at NSQF levels 4 and 5.
- There are no wind-specific Qualification Packs for digital and data-related roles. Roles involving machine learning, data analytics and digital asset management are now increasingly appearing in the sector, but these are not covered by the current qualification framework.
- Qualification Packs need to be updated regularly. Stakeholder consultations indicated that some earlier wind-sector Qualification Packs had expired and were not revised. It has been understood during stakeholder consultations, the QPs are formed by an expert committee set up by MSDE/NCVET and have a validity of 3 years, beyond which time the QP should be re-activated or updated. The training content has also not always kept pace with changes in turbine technology, such as the shift from fixed-speed to variable-speed turbines.

Stakeholder consultations indicated that formal qualification does not equate to operational readiness. Employers reported that recruits entering the sector, including those holding relevant engineering or diploma qualifications, typically require six months to one year of structured in-house training and supervised field experience before working independently on core technical tasks.

** No directly verified wind-specific SCGJ QP*

4.3. Evolution of Wind Project Development and O&M Business Models

The wind energy sector in India has undergone a significant transformation in its project development, ownership and operations models. Historically, wind turbine Original Equipment Manufacturers (OEMs) played an integrated role in the value chain, undertaking project development, turbine supply, installation, commissioning and long-term operations and maintenance (O&M). This model enabled OEMs to retain responsibility for both equipment performance and associated technical services.

Over time, the sector has increasingly transitioned towards a more specialized and fragmented business model, wherein OEMs primarily focus on equipment supply and technology support, while project development, engineering, procurement, construction, installation and O&M are undertaken by independent power producers (IPPs), EPC contractors and specialized service providers. Although OEM-led turnkey projects and O&M contracts continue to exist, the growing involvement of independent service providers and third-party asset managers has diversified the industry's operational structure.

This shift has important implications for the wind-sector workforce. Technical staff increasingly need to work with different turbine models and technologies rather than just one manufacturer's systems. However, stakeholder consultations indicated that companies servicing a particular turbine brand generally prefer to hire people who already have experience with that technology, instead of training them to work across different platforms. This makes it harder for workers to move between employers.

4.4 Emerging Technologies

The wind energy industry is experiencing a fundamental technological transformation. Over the past two decades, improvements in turbine design, materials, power electronics, sensing, digital control and manufacturing have substantially increased turbine size, energy capture and operational sophistication. The next phase of technological development is expected to be characterized by larger and smarter turbines, advanced condition monitoring, artificial intelligence (AI), digital twins, automated-drone based on robotic inspection, intelligent manufacturing, hybrid renewable-energy systems, offshore wind and improved lifecycle management.

Technology development is increasingly taking place across the complete wind energy system rather than within individual turbine components. A modern wind farm is no longer simply a collection of electro-mechanical generating machines. It is becoming a digitally connected power-generation system in which turbines, sensors, communication networks, substations, forecasting systems and remote-control platforms continuously exchange information.

Stakeholder consultations highlighted a gap in digital skills among the existing workforce. Employers reported that it is difficult to find people with skills in data analytics, drone-based inspections and AI-based fault detection. They also noted that these skills are not adequately covered in current training programmes.

Training institutions also identified areas such as remote monitoring, condition monitoring, simulation-based training and digital twin technologies that need to be included in existing courses.

Turbine scaling is one of the principal technological pathways through which the wind industry has improved energy capture and project economics. Modern turbine development involves simultaneous increases in rated capacity, rotor diameter and hub height, supported by advances in aerodynamics, materials, structural engineering and control technology[15]

The amount of power that can theoretically be extracted from wind is strongly influenced by the area swept by the turbine rotor. Consequently, increasing blade length and rotor diameter allows turbines to capture energy from a larger air stream. Higher towers can also access wind regimes that may be stronger and less affected by surface roughness.

[15] https://www.iea.org/reports/innovation-gaps/renewable-power

However, turbine scaling is not simply a matter of increasing physical dimensions. Larger machines require improvements throughout the turbine system. Blade structures must remain sufficiently light while resisting cyclic loading over millions of operating cycles. Towers and foundations must accommodate higher structural loads. Generators and power converters must handle higher power ratings, while pitch and yaw systems require increasingly sophisticated controls [16].

The technological direction is therefore towards highly integrated turbine platforms in which mechanical design, advanced materials, power electronics, sensors and software are developed together.

Stakeholder consultations highlighted that turbine control and diagnostic systems are largely specific to individual manufacturers and are not accessible outside their service teams. Training institutions noted that this makes it difficult to provide practical technical training. They suggested focusing on general concepts such as how these systems work, how sensor signals are accessed and how data is interpreted, rather than relying on manufacturer-specific systems.

India has progressively moved towards larger turbine platforms. MNRE reports turbine models of up to approximately 5.3 MW within the domestic manufacturing ecosystem. This represents a substantial technological progression from earlier generations of comparatively small wind turbines.

Higher hub heights are particularly important in the Indian context. As noted in Section 1.2.1, NIWE's estimate of gross onshore potential rises from approximately 695.5 GW at 120 m to approximately 1,163.9 GW at 150 m, illustrating how advances in turbine and tower design can expand the commercially relevant resource base. For the workforce, this technology requires greater capability in structural engineering, advanced composites, precision manufacturing, high-capacity lifting, electrical systems and turbine controls.

Stakeholder consultations also highlighted that the use of digital and AI-based tools varies across the wind sector. While remote monitoring and data analysis are widely used to monitor wind farms, field maintenance still relies heavily on the experience of technicians to identify faults. Service providers noted that current methods are not accurate enough to predict failures and justify component replacement on cost grounds. As a result, companies generally prefer to repair components and extend their service life rather than replace them at fixed intervals.

Consultations with manufacturers indicated that automation and artificial intelligence (AI) are likely to affect different job roles in different ways. At the shop-floor level, AI is expected to support data analysis, preventive maintenance and process optimisation, rather than replace production workers. Although fully automated tower manufacturing is technically possible, manufacturers noted that it is not currently cost-effective. They also indicated that administrative tasks, stores management and materials handling offer greater scope for automation than production and O&M / asset management activities.

4.4.1 Technology Adoption

The technological transformation of the wind sector is particularly evident in mature wind markets, where emerging technologies are progressing from research and demonstration towards commercial-scale deployment. Countries such as Denmark, Norway, the United Kingdom, Germany and other leading wind markets provide useful examples of how larger turbines, floating offshore wind, digital twins, drone-based inspection and recyclable components are being incorporated into the wind energy value chain. These developments are relevant to India because they indicate the technologies that could progressively influence turbine manufacturing, project development, O&M and workforce requirements.

[16] https://mnre.gov.in/en/wind-manufacturing/

- Large-Capacity Wind Turbines - Denmark

  Denmark continues to play an important role in the development and testing of next-generation large wind turbines[17], large blade testing, the entire drive train simulation and testing along with power electronics control panels etc.

  For India, such international developments are relevant because domestic turbine platforms are also increasing in size. The global transition towards very large machines indicates that future Indian manufacturing and O&M personnel may require progressively stronger competencies in large-component manufacturing, composites, high-capacity lifting, structural inspection and advanced turbine controls.

- Floating Offshore Wind - Norway

  Norway provides one of the unique examples of the commercial progression of floating offshore wind technology. Hywind Tampen, developed by Equinor in the Norwegian North Sea, consists of 11 floating wind turbines with a combined capacity of 94.6 MW. The turbines are installed on floating concrete spar structures in water depths of approximately 260-300 meters.[18]

- Recyclable Wind-Turbine Blades - Denmark and Germany

  Wind-turbine blade technology is also evolving towards improved recyclability. Siemens Gamesa developed its Recyclable Blade technology to enable blade materials to be separated more effectively at the end of the operating lifecycle.

  This development is important because conventional wind-turbine blades use composite materials that are difficult to separate and recycle. Recyclable resin systems represent a technological shift from designing primarily for aerodynamic and structural performance towards considering the complete material lifecycle.[19]

4.5 Future Workforce and Skills (2030)

India's wind energy sector is expected to undergo significant changes in workforce composition and competency requirements by 2030, driven by the expansion of onshore wind capacity, repowering of ageing wind farms, development of larger and more technologically advanced wind turbine platforms, integration of wind-solar-storage hybrid systems and the gradual development of offshore wind projects. Alongside capacity expansion, the increasing adoption of digital technologies, automation and performance-based asset management is expected to reshape occupational requirements across the wind energy value chain.

4.5.1 Projected Workforce Requirement:

This assessment adopts the Government of India's target of 100 GW of installed wind capacity by 2030 as its reference scenario, requiring an additional 40.8 GW from the September 2026 position, as set out in Section 3.4.6. For comparison, the Global Wind Energy Council projects 107 GW by 2030, with a conservative case of 85 GW.

Applying the employment coefficients to this additional capacity gives an estimate of the direct employment required for manufacturing and project deployment.

[17]https://www.vestas.com/en/media/company-news/2022/vestas--v236-15-0-mw-prototype-wind-turbine-produces-fi-c3691167
[18]https://www.equinor.com/energy/hywind-tampen
[19]https://www.siemensgamesa.com/global/en/home/press-releases/launch-world-first-recyclable-wind-turbine-blade.html

Table 13: Projected Workforce Requirements for 100 GW by 2030

Employment component	Coefficient (FTE job-years/MW)	Cumulative FTE job-years
Wind turbine and component manufacturing	0.55-0.75	22,440-30,600
Project deployment, including construction	0.45-0.6	18,360-24,480
IPP Workforce	0.40-0.75	16,320-30,600
O and M	0.19-0.43	7,752-17,544
Total direct employment	1.59-2.53	64,872-103,224

The estimates indicate that manufacturing and deploying the additional capacity could require approximately 64,872-103,224 direct FTE job-years. A job-year represents the work of one full-time equivalent worker for one year. This figure excludes indirect as well as induced local employment across the supply chain.

Manufacturing estimates depend on factors such as the share of equipment produced in India, factory utilisation, export volumes and the timing of component production. The figures should therefore be treated as indicative planning estimates rather than a forecast of actual employment.

Stakeholder discussions highlighted a significant gender gap in the wind energy workforce. While an estimated 4.5 million jobs are projected globally. In India, women account for approximately one-fifth of total employment in the sector. Women's participation remains concentrated in administrative, human resources and other non-technical roles, while on-site and technical positions continue to be predominantly occupied by men.

4.5.2 Repowering Workforce Requirement

Workforce demand from new capacity addition is not the only source of employment in India's wind energy sector; repowering and life extension of existing wind farms also create employment opportunities. NIWE estimates a repowering potential of 25,406 MW, The Government of India's National Repowering Policy for Wind Power Projects, 2023 specifies a capacity-enhancement ratio of 1.5 times for repowering. Applying this ratio to the repowering[20] potential set out in Table 2:

Table 14: Repowering workforce requirement by state

State	Repowering potential (MW)	Additional Capacity after repowering at 1.5 *(MW)	FTE job-years(at 1.59/ MW)
Tamil Nadu	7,386	3,693.00	5,872
Gujarat	4,665	2,332.50	3,708
Maharashtra	3,431	1,715.50	2,728
Karnataka	3,023	1,511.50	2,403
Rajasthan	2,934	1,467.00	2,332
Andhra Pradesh	2,366	1,183.00	1,881
Madhya Pradesh	1,562	781	1,242
Kerala	28	14	22
Total	25,406	12,703	20,198

[20]NATIONAL REPOWERING & LIFE EXTENSION POLICY FOR WIND POWER PROJECT

Methodology: Additional capacity is calculated as 0.5 times the existing repowering potential, assuming the capacity after repowering reaches 1.5 times the existing capacity based on a realistic assumption of repowering ratio of 1.5. Employment is estimated using a conservative coefficient of 1.59 FTE job-years per MW. from Table 10, even though ownership of PPAs, micrositing in line with wind capacity and land aggregation, Grid power evacuation would be additional skill gap challenges of repowering.

Based on the lower employment estimate of 1.59 FTE job-years per MW, repowering the identified wind capacity could generate approximately 20,198 FTE job-years. These would be additional to the employment opportunities arising from greenfield wind projects, highlighting the potential of repowering to contribute to India's wind energy workforce requirements while increasing capacity from existing sites.

4.5.3 Comparison with Published Projections

Published estimates of wind-sector employment in India use different methods and measure employment in different ways. They are therefore not directly comparable with the estimates presented above.

The Global Wind Workforce Outlook 2025-2030 projects that India's wind workforce will reach approximately 32,439 workers by 2030. This estimate covers construction, installation and operations and maintenance roles and represents the number of workers, rather than cumulative job-years.

GWEC's India market assessment presents two scenarios for faster wind development. Annual installations scenario of 8 GW could support approximately 116,000 jobs, while annual installations optimistic scenario of 15 GW could support around 154,000 jobs. These estimates cover direct and indirect employment across the wider value chain under different annual installation scenarios.

Since these estimates use different methods, assumptions and measures of employment, they should be interpreted separately and should not be combined into a single workforce estimate.

Key Skill Priorities after 100 GW by 2030

1. Advanced Wind Turbine Technologies
   - Installation, operation and maintenance of larger-capacity turbines.
   - Advanced blade materials, power electronics and turbine control systems.
   - Specialized mechanical, electrical and structural diagnostics.
   - Digital twins in Manufacturing, testing, and O&M
2. Digital Operations and Predictive Maintenance
   - SCADA-based monitoring and performance analysis.
   - AI-assisted fault detection, digital twins and predictive maintenance.
   - Remote operations, condition monitoring and data-driven decision-making.
3. Multi-Brand O&M and Independent Asset Management
   - Maintenance and troubleshooting across different OEM turbine platforms.
   - Reliability engineering, lifecycle optimization and performance benchmarking.
   - Digital maintenance management, spare-parts planning and service contract management.
4. Offshore Wind Competencies
   - Marine surveys, offshore structural engineering and subsea cable systems.
   - Specialized installation vessels, offshore lifting and commissioning.
   - Marine safety, emergency response and offshore maintenance.

5. Wind-Solar-Storage Hybrid Integration
   - Hybrid power plant design and energy management systems.
   - BESS integration, grid stability and power-quality management.
   - Advanced forecasting, grid compliance and plant-level controls.
6. Advanced Manufacturing and Automation
   - Robotics, CNC machining, composite fabrication and automated inspection.
   - Sensor-based quality monitoring and industrial data analytics.
   - Advanced material testing, process optimization and digital manufacturing.

Table 15: Key Skills beyond 100 GW by 2030

Wind Energy Segment	Anticipated Workforce Requirements by 2030	Emerging Skills
Wind Resource Assessment & Project Development	Wind resource analysts, GIS and geospatial specialists, project development engineers, energy-yield assessment professionals, environmental and permitting specialists	Advanced LiDAR/SoDAR-based resource assessment, wind-flow and wake modelling, micro-siting optimisation, GIS and remote sensing, energy-yield forecasting, techno-economic feasibility and environmental risk assessment
Wind Turbine & Component Manufacturing	Production and manufacturing engineers, composite material specialists, automation and robotics technicians, quality assurance engineers, advanced manufacturing professionals	Advanced blade composites and fabrication, precision machining, automated production systems, robotics, non-destructive testing (NDT), digital quality control, predictive equipment maintenance and sustainable manufacturing practices
Construction, Installation & Commissioning	Civil and electrical engineers, structural specialists, heavy-lift crane operators, rigging professionals, turbine installation technicians and commissioning engineers	Large-capacity turbine erection, specialised heavy lifting and rigging, precision alignment and bolting, digital surveying, foundation engineering, electrical testing, automated commissioning and advanced HSE compliance
Grid Integration & Hybrid Renewable Systems	Power-system engineers, grid integration specialists, protection and control engineers, BESS engineers, hybrid plant operators and energy management professionals	Grid-code compliance, power-system modelling, advanced power electronics, battery energy storage integration, power-quality management, renewable energy forecasting, plant-level controls and grid stability assessment

Wind Energy Segment	Anticipated Workforce Requirements by 2030	Emerging Skills
Operations & Maintenance (O&M)	Multi-brand O&M engineers and technicians, reliability engineers, maintenance planners, mechanical and electrical specialists, asset performance professionals	Multi-OEM turbine trouble-shooting, condition-based and predictive maintenance, vibration and oil analysis, reliability-centred maintenance, root cause analysis, advanced fault diagnostics, digital maintenance planning and lifecycle cost optimization
Digital Operations & Asset Management	SCADA engineers, remote operations centre specialists, data analysts, condition monitoring engineers, digital asset managers, industrial cybersecurity professionals	AI-enabled fault detection, digital twins, SCADA and sensor-data analytics, remote turbine monitoring, automated performance benchmarking, predictive diagnostics, industrial communication protocols and cybersecurity
Repowering, Decommissioning & Lifecycle Management	Repowering project engineers, structural assessment specialists, dismantling and heavy-lift professionals, asset lifecycle managers, recycling and waste management specialists	Turbine life-extension assessment, structural integrity evaluation, advanced component replacement, repowering feasibility analysis, safe dismantling, blade recycling, circular economy practices and end-of-life asset management
Offshore Wind Development & Operations	Marine surveyors, offshore structural and electrical engineers, subsea cable specialists, marine logistics professionals, offshore installation technicians and marine O&M engineers	Hydrographic and geotechnical surveys, offshore foundation engineering, subsea cable installation and diagnostics, vessel-based lifting operations, corrosion protection, offshore commissioning, marine logistics, GWO-aligned safety training and offshore emergency response

Projected workforce requirements represent the net increase in workforce demand. Stakeholder consultations highlighted high employee attrition in the wind sector, with some organisations reporting rates above 35%, compared with a benchmark of 10-12%. Employers also noted that poaching of trained workers between companies often shifts the same pool of talent between employers without increasing the overall availability of skilled workers in the sector.

As a result, the total number of workers that companies need to recruit and train is higher than the net increase in workforce size. Workforce planning must therefore account for both the demand created by sector growth and the need to replace workers who leave. Increasing the number of new workers entering the sector and strengthening their practical skills will be important to address this gap, rather than relying mainly on the movement of existing workers between employers.

4.6 State-Wise Findings

Wind sector employment in India is geographically concentrated, with workforce demand distributed unevenly across states according to installed capacity, project pipeline and manufacturing presence. The distribution of installed capacity across states is set out in Section 3.7.1.

4.6.1 State-Wise Workforce Focus

Table 16: States and Areas of workforce demand

State	Principal areas of workforce demand
Gujarat	Manufacturing, project construction, transmission, and future offshore wind supply chains
Tamil Nadu	Operations and maintenance, blade services, manufacturing, electrical works and repowering
Karnataka	Wind farm operations, electrical maintenance and project development
Maharashtra	Project development, industrial supply, EPC and grid integration
Rajasthan	Project construction, site services, transmission and operations and maintenance
Madhya Pradesh	Project development, construction and supporting services
Andhra Pradesh	Operations and maintenance and project development
Telangana, Odisha	Emerging project development and supporting services

These are indicative areas of workforce focus rather than quantified state-level employment estimates.

4.6.2 Geographic Distribution of Workforce Demand

Workforce demand within each state can be divided into two categories. Deployment related demand, covering construction, installation and commissioning, depends on the pipeline of new projects and is concentrated in areas where new wind capacity is being added. Asset related demand, covering operations and maintenance (O&M), depends on the existing wind fleet and continues throughout the operating life of wind farms.

Stakeholder consultations indicated that workers move between wind states only to a limited extent. Service providers reported that technical personnel increasingly prefer to work within a particular region rather than relocate to other states. They also noted that hiring and retaining workers at remote project sites is often easier when recruiting from communities near wind clusters than when relocating workers from urban centres.

Consultations also highlighted the challenges of providing services across geographically dispersed wind farms. Independent service providers reported withdrawing from states far from their operating base because of high logistics costs and difficulties in retaining local teams. As a result, service capacity is unevenly distributed across wind states.

4.7 Recruitment and Skill Challenges

4.7.1 Workforce Retention and Attrition

Stakeholder consultations identified retention as a major challenge. Attrition rates above 35 per cent were reported by organisations across developers, independent power producers and service providers, against a level of 10 to 12 per cent described as sustainable. Technical staff frequently change jobs within the first one to two years, and companies commonly recruit workers already trained elsewhere rather than bringing new entrants into the sector. This raises recruitment costs without increasing the overall pool of skilled workers, and discourages employers from investing in training. The problem

intensifies during periods of rapid capacity addition, when companies with large project pipelines draw experienced staff from service providers. Retention is a recognised global challenge, identified in the Global Wind Workforce Outlook 2025-2030 alongside technician shortages and training capacity.

Replacement demand is estimated separately from the projections in Table 11. Those projections are expressed in cumulative job-years, which measure total work effort across the period rather than the number of people employed at any one time. Attrition applies to people, so replacement demand is estimated against projected workforce headcount. The Global Wind Workforce Outlook 2025-2030 projects India's wind workforce at approximately 32,439 workers by 2030, measured as headcount, covering construction, installation and operations and maintenance roles.

Estimated Workforce by 2030 (GWWO, headcount) = 32,439 [21]

Accordingly, Annual replacement requirement will be:

Table 17: Estimated Wind Workforce Training Requirements to Address Attrition by 2030

Attrition scenario	Rate	Annual replacement requirement
At reported attrition	35%	11,350 / year
At sustainable benchmark	10-12%	3,240 - 3,890 / year

Workers moving between companies does not reduce the need for training. When a worker leaves one company for another, the first company still has a vacancy to fill, and it is usually filled by someone new to the sector who needs full training. Workers who change companies often need training as well, because skills learned on one manufacturer's turbines transfer only partly to another's.

Retention therefore affects training demand directly. At current attrition levels the sector must replace around 11,350 workers a year. At the sustainable benchmark this would fall to around 3,200 to 3,900. The difference is training capacity that could be used to grow the workforce instead of replacing it. The MNRE programme of Vayumitra envisaged training of 5000-6000 at all levels in Phase-1 and Phase-2. Even though target are there to have TPs (Training Partners Pan-India), ToTs (Trainer of Trainers), identification of Master Trainers in the scheme VSDP, there is 100% increase in expected skill trained workforce demand YoY at all levels of competence.

4.7.2 Recruitment for Site-Based Roles

Stakeholder consultations highlighted difficulties in recruiting and retaining workers for operations and maintenance (O&M) roles at remote wind farm locations. Employers reported that engineering staff recruited from cities are often reluctant to stay at remote sites for long periods. They also noted that technical workers generally prefer to work within a particular region rather than move between wind states.

Stakeholders suggested that recruiting and training people from communities near wind farms could be a more sustainable way to meet local workforce needs. This approach is also reflected in existing national skill-development programmes for the sector.

4.7.3 Time to Operational Competence

Employers reported that having a formal qualification does not necessarily mean a person is ready to perform a job independently. New recruits, including those with relevant engineering or diploma qualifications, typically need six months to one year of in-house training, training on specific tools and supervised field experience before they can carry out key technical tasks on their own. Those without prior experience in the wind sector need more time to develop these skills and are generally not assigned specialised analysis or fault diagnosis work during the initial period of employment.

This training period adds to employers' costs and slows workforce expansion, as newly recruited workers take time to become fully capable of performing their roles independently.

4.7.4 Proprietary Technology and Skill Transferability

The wind energy industry is characterized by a high degree of technological specialization, with Original Equipment Manufacturers (OEMs) retaining proprietary control over critical aspects of turbine design, control systems, operational software, diagnostic platforms and technical documentation. Unlike conventional electrical and mechanical equipment, modern wind turbines incorporate sophisticated control algorithms, embedded software, power-electronic converters, sensor networks and integrated condition-monitoring systems that are often specific to individual manufacturers. Access to these technologies is generally governed by intellectual property protections, licensing arrangements, contractual obligations, unless the Indian establishment is given complete technology transfer rights and OEM-defined service protocols.

Historically, this technological dependency was less pronounced from a workforce development perspective, as OEMs frequently undertook project development, turbine installation and long-term operations and maintenance (O&M). Technical expertise was largely developed and retained within OEM-led service organizations through internal training, manufacturer-specific certification and direct exposure to proprietary systems. However, the gradual transition towards independent power producers (IPPs), third-party O&M contractors and multi-brand asset management companies has fundamentally altered the industry's operational structure.

The implications extend beyond maintenance activities to the broader skill development ecosystem. Engineering institutions, vocational training centers and skill development organizations may encounter difficulties in obtaining access to representative turbine technologies, proprietary software, operational datasets and specialized diagnostic equipment. Consequently, training programs may focus predominantly on general mechanical, electrical and safety competencies, with comparatively limited exposure to advanced turbine-specific troubleshooting, control-system diagnostics and digitally enabled asset management. As focused R&D in wind energy technology innovations as well as the much needed minimum research infrastructure are at present not being in place in India, there is always a lag in getting the latest technologies at an affordable cost.

Key Implications for Recruitment and Skill Development

1. Concentration of Advanced Technical Expertise within OEMs: Advanced competencies related to turbine control systems, converter diagnostics, embedded software, specialized fault analysis and major component troubleshooting may remain concentrated among OEM-trained professionals. This can constrain the availability of experienced personnel for independent O&M companies and increase competition for specialized technical talent.

2. Limited Transferability of OEM-Specific Competencies: Wind turbine manufacturers employ different equipment configurations, control architectures, communication interfaces and maintenance procedures. Professionals trained on one turbine platform may therefore require additional training before independently servicing equipment from another manufacturer. This can restrict workforce mobility and increase the time and cost associated with developing multi-brand technical capabilities.

3. Constraints on Industry-Oriented Training Infrastructure: The limited availability of turbine-specific software, technical documentation, diagnostic platforms and operational equipment can affect the ability of training institutions to replicate actual maintenance conditions. Without appropriate industry partnerships, trainees may have insufficient exposure to advanced troubleshooting, fault simulation, condition monitoring and control-system diagnostics.

4. Dependence on OEMs for Specialized Maintenance and Technical Support: Independent service providers may continue to depend on OEMs for software updates, specialized troubleshooting, proprietary component replacement and certain control-system interventions. This dependency can limit the scope of independent executable maintenance

[21] Global Wind Workforce Outlook 2025–2030

activities and create demand for professionals capable of coordinating technical interfaces between OEMs, asset owners and third-party service organizations.

5. Challenges in Standardizing Multi-Brand Occupational Competencies: The proprietary nature of turbine technologies makes it difficult to establish a uniform technical curriculum covering all manufacturer-specific systems. While common mechanical, electrical, hydraulic and safety competencies can be standardized, advanced diagnostic procedures and software-based interventions may require platform-specific training and authorization.

4.7.5 Safety Competency

Safety was identified across multiple consultations as the most consistent competency gap among field personnel. Personnel working without basic personal protective equipment were reported as still observed at operating sites, although practice was described as improving relative to earlier periods. The training requirements identified were working at height, rescue, fire awareness and manual handling.

A specific gap was identified in renewable energy safety officer roles. Safety personnel are currently drawn predominantly from industrial safety qualifications designed for chemical and process industries, which have limited applicability to wind operations.

International safety frameworks were identified as the applicable benchmark, with some markets additionally applying national safety standards and individual competency record systems that record initial training, refresher training and current qualifications.

4.7.6 Owner and Asset Manager Capability

Industry association consultations identified the ability of wind turbine owners to operate their assets and develop new projects as a distinct skill area. Owners fall into four groups, each with different skill gaps:

- Legacy and small owners: Textile mills, spinning mills, sugar and cement units, and individuals who bought 225 kW to 1.5 MW turbines in the 1990s and 2000s, often for tax benefits. Skill gap is higher in such arrangements.
- Captive and group-captive commercial and industrial owners: Use wind power for their own consumption through open access. Skill gap is relatively higher in such arrangements.
- Independent Power Producers (IPPs): Operate utility-scale assets under SECI or state power purchase agreements. Their gaps mainly concern in-house O&M capabilities.
- Public Sector Undertakings and Utilities: Organisations that are new to wind power.

The most serious gap is data access and analytics. Many owners cannot independently access raw SCADA data, verify OEM-reported availability, or compare actual turbine power curves with certified curves. This prevents them from enforcing availability guarantees in O&M contracts, while generation losses of 5-15% may go unnoticed. Owners of unsupported turbines also face long downtimes, sometimes lasting months, due to a lack of spares and reverse-engineering capabilities.

Repowering decisions are a major skill gap for legacy owners. Many owners of sub-megawatt turbines at prime sites annot assess whether to continue operating until failure, extend turbine life, repower on a one-to-one basis with a turbine of similar capacity, or join an aggregation of wind turbines for better returns. Sub-megawatt turbine options are increasingly limited as those technologies are withdrawn from the market. Several unrelated owners often hold adjoining plots, making land aggregation a barrier even where repowering is economically viable. Decommissioning and blade disposal are emerging areas with very limited practical experience in India.

Wind generation is increasingly managed like conventional power, with scheduling, deviation penalties and grid code requirements. Small owners usually leave these tasks to aggregators or OEMs and do not understand the charges on their bills. As transmission utilities enforce standards more strictly, grid code non-compliance is becoming a commercial risk.

On safety, owners often assume the OEM or contractor is fully responsible. However, Indian law places significant obligations on owners as occupiers and holders of electrical installations. Ageing turbines also pose structural risks, non-availability of components and supply spares for sustaining operations, which is one prime reason for the repowering policy.

Six underlying causes of the skill gaps were identified

- Historical ownership model: Much of India's early wind capacity was purchased as a financial investment rather than an operating business. Owners outsourced operations to OEMs through comprehensive O&M contracts and did not develop in-house teams.
- OEM lock-in: Proprietary controllers, restricted SCADA access and OEM-only spares prevented owners from verifying performance or switching providers, as discussed in Section 4.7.4. When OEMs restructured or stopped supporting older models, owners were left with unsupported turbines.
- Limited training ecosystem: Technician training is available, but structured training for owners and asset managers is limited, particularly in contracts, data, regulation and investment decisions.
- Fragmented ownership: Small, scattered holdings make in-house capabilities uneconomical for individual owners, while shared-service models are limited.
- Changing regulations: Scheduling, deviation settlement, open access, grid codes and repowering rules have changed repeatedly, making it difficult for small owners to keep up.
- Technology changes: The shift from 225 kW to 3 to 5.3 MW capacity of turbines requires new skills in converters, pitch systems, condition monitoring and digital controls/remote centralized asset performance management.



5. TRAINING ECOSYSTEM ASSESSMENT

India's wind energy training ecosystem comprises government-supported skill programs specialized training by the National Institute of Wind Energy (NIWE), NSQF-aligned occupational training, universities and technical institutions, industry-led academies and internationally recognized safety and technical training frameworks. The ecosystem has established a foundation for wind-resource assessment, turbine installation, commissioning and O&M. However, continued technological development, particularly larger turbines, digital O&M, predictive maintenance, automation, hybrid systems and offshore wind is expanding the range of competencies that the training ecosystem will need to address.

The assessment therefore considers three dimensions: the existing training ecosystem, its alignment with current industry requirements, and infrastructure gaps that could constrain preparation of the future wind workforce.

5.1. Existing Training Ecosystem

No supply side capacity figures set for each training institutions in India because each wind turbine technology is IP protected and confidentiality is to be maintained. Most of the industry partners recruit based on demand and provide on the job training. Hence, supply side numbers could not be obtained. Most of the training institutions such as NIWE, SCGJ, ITIs and polytechnics or even industry aligned private training institutions all of them provide training based on demand from the industry without any annual supply side targets for skilling / reskilling / upskilling.

5.1.1 National Institute of Wind Energy

NIWE, under the Ministry of New and Renewable Energy (MNRE), is one of the principal institutions supporting wind energy capacity building in India. NIWE conducts national and international training programs covering wind technology, resource assessment, installation, commissioning, O&M, financial aspects and policy. Its national training program has continued through 2026, including the 30th National Training Course on Wind Energy Technology held in July 2026. NIWE has been one of the major wind energy (educated, awareness created, end-to-end state of art of job needs in every phase of wind energy development) human resource supplier ready to be on the job (technology specific) trained and employed in the industry. NIWE has given rise to start-ups, Country Heads in corporates, and several employees of significant portion of wind industry at all levels. In 2011, NIWE and IWTMA supported postgraduate diploma and certification courses to develop skilled professionals ready to be employed. Given the significant growth expected in wind capacity, this kind of industry sponsored academia executed training programmes should be reconsidered to help meet future workforce needs.

A major component of the formal skill-development ecosystem is the VayuMitra Skill Development Program (VSDP). Phase I focused on three NSQF-aligned job roles: O&M Electrical & Instrumentation Technician - Wind Power Plant, O&M Mechanical Technician - Wind Power Plant, and Site Surveyor - Wind Power Plant. Phase I envisaged training 5,734 personnel in total, comprising 5,010 participants under the Training of Participants programme, 690 trainers under the Training of Trainers programme, and 34 assessors[22].

Consultations indicated that the qualification packs which were framed with industry consultation by SCGJ and NIWE used in Phase I subsequently lapsed without revision, and that the institution NIWE itself has now been recognised as an awarding body similar to SCGJ and assessment agency under the national vocational educational training framework. A consolidated qualification as Wind farm Engineer (540 hours of training) has been developed by NIWE covering the competencies previously addressed across the three separate packs, and is being used for Phase II delivery. A third phase is at proposal stage, with training volumes to be determined in consultation with industry.

[22] VSDP - About Vayumitra Skill Development Programme(VSDP)

NIWE's VSDP training-partner model is geographically significant. Training partners are selected near wind farms and wind-potential areas and include universities, technical institutes and specialized training organizations [23].

Another important feature is the participation of industry personnel in trainer development. NIWE reports participation from organizations including Suzlon, Vestas, ReNew, Greenko, Envision, ZF Wind Power and other wind and renewable-energy companies in Phase II Training-of-Trainer activities. Academic participants included institutions such as IIT Delhi, Anna University, MNIT Bhopal, NPTI and government polytechnics.

This industry-academia participation provides an important foundation for ensuring that training content remains connected to operational requirements [24].

Strengthening the institution's sanctioned scientific capacity would enable it to expand direct delivery nationally. The training-partner and train-the-trainer model, drawing on experts from industry and academia, has meanwhile enabled the programme to reach wind states beyond what could be covered from a single location.

Consultations also indicated scope for more independent and industry supported research and development.

The institution has a wind turbine test station, a research station, meteorological measurement facilities and operational turbines for practical training. However, stakeholders noted that the turbines available for training have lower rated capacities (sub-megawatt) than those the trend of multi MW machines currently being installed in India.

5.1.2 GWO Training centers in India

GWO training is available in India through certified training providers, particularly in states associated with wind energy development and operations. These providers offer practical safety and technical training for wind turbine technicians, engineers, installation personnel and maintenance professionals [25].

Table 18: GWO-listed wind training providers in India[26]

No.	Training provider	City / location	Key training capabilities listed
1	Advanced Bolting Solutions Private Limited	Jamnagar, Gujarat	First Aid, Manual Handling, Fire Awareness, Working at Heights
2	Auchare Aerostructures Private Limited	Pune, Maharashtra	First Aid, Manual Handling, Fire Awareness, Working at Heights, Advanced Rescue Training (ART), Blade Repair, Onsite Training Facility
3	Backbone Skytech Private Limited	Jasdan, Gujarat	First Aid, Manual Handling, Fire Awareness, Working at Heights, Onsite Training Facility
4	Capital Equipment Services Limited	Poonamallee, Tamil Nadu	First Aid, Manual Handling, Fire Awareness, Working at Heights, Onsite Training Facility
5	CORE India LLP	Pune, Maharashtra	First Aid, Manual Handling, Fire Awareness, Working at Heights

[23] https://mnre.gov.in/en/skill-development-programme/(10/6/2026)
[24] https://vsdp.niwe.res.in/about-vsdp/
[25] https://winda.globalwindsafety.org/training-providers-map/?#!
[26] Global Wind Organisation (GWO). Training Providers Directory (WINDA)

No.	Training provider	City / location	Key training capabilities listed
6	Derrick Lifters India Private Limited	Tenkasi, Tamil Nadu	First Aid, Manual Handling, Fire Awareness, Working at Heights, ART, Onsite Training Facility
7	Eduforce	Vasind-Thane, Maharashtra	First Aid, Manual Handling, Fire Awareness, Working at Heights, Sea Survival, Wind Limited Access (WLA), Electrical, Hydraulics, Mechanical, Bolt Tightening, Hazardous Energies, ART, Enhanced First Aid (EFA), Blade Repair, Slinger Signaller, Service Lift, Crane and Hoist, Onsite Training Facility
8	Emsafe Fire Safety Solutions Private Limited	Bengaluru, Karnataka	First Aid, Manual Handling, Fire Awareness, Working at Heights, Sea Survival, Electrical, Hydraulics, Mechanical, Bolt Tightening, ART, Blade Repair, Slinger Signaller, Service Lift, Control of Hazardous Energies (CoHE), Crane and Hoist, High Voltage, Onsite Training Facility, Digital Learning
9	Emsafe Fire Safety Solutions Pvt. Ltd.	Rajkot, Gujarat	First Aid, Manual Handling, Fire Awareness, Working at Heights, Electrical, Hydraulics, Mechanical, Bolt Tightening, ART
10	Emsafe Fire Safety Solutions Pvt. Ltd.	Navi Mumbai, Maharashtra	First Aid, Manual Handling, Fire Awareness, Working at Heights, Sea Survival, Electrical, Hydraulics, Mechanical, Bolt Tightening, ART, Blade Repair
11	Emsafe Fire Safety Solutions Pvt. Ltd.	Tiruchirappalli, Tamil Nadu	First Aid, Manual Handling, Fire Awareness, Working at Heights, Electrical, Hydraulics, Mechanical, Bolt Tightening, ART
12	Force Tech Security (India) Pvt. Ltd.	Noida, Uttar Pradesh	Manual Handling, Fire Awareness, Working at Heights
13	Jai Haran Energy Services	Tiruppur, Tamil Nadu	First Aid, Manual Handling, Fire Awareness, Working at Heights, Electrical, Hydraulics, Mechanical, Bolt Tightening, Onsite Training Facility
14	Karam Safety Private Limited	Noida, Uttar Pradesh	First Aid, Manual Handling, Fire Awareness, Working at Heights, Onsite Training Facility
15	NTC Training Academy LLP	Namakkal, Tamil Nadu	First Aid, Manual Handling, Fire Awareness, Working at Heights

No.	Training provider	City / location	Key training capabilities listed
16	Oxford Global Training Academy	Chennai, Tamil Nadu	First Aid, Manual Handling, Fire Awareness, Working at Heights
17	Renom Energy Services Pvt. Ltd.	Pune, Maharashtra	First Aid, Manual Handling, Fire Awareness, Working at Heights, Onsite Training Facility
18	RenServ Global Private Limited	Belgaum, Karnataka	Working at Heights
19	RS Windtech Engineers Pvt. Ltd.	Aralvaimozhi, Tamil Nadu	First Aid, Manual Handling, Fire Awareness, Working at Heights, WLA Onshore, Electrical, Hydraulics, Mechanical, Bolt Tightening, Hazardous Energies, ART, Blade Repair, Service Lift, CoHE, Mobile Training Facility, Onsite Training Facility, Digital Learning
20	Safeskill Safety Services	Pune, Maharashtra	First Aid, Manual Handling, Fire Awareness, Working at Heights, ART, Onsite Training Facility
21	Sangreen Future Renewables Private Limited	Pune, Maharashtra	First Aid, Manual Handling, Fire Awareness, Working at Heights, Onsite Training Facility
22	Shlaaghhy Sahlan Electro Infra Private Limited	Jaipur, Rajasthan	First Aid, Manual Handling, Fire Awareness, Working at Heights, Electrical, Hydraulics, Mechanical, Bolt Tightening, ART, Slinger Signaller, Service Lift, Onsite Training Facility
23	Siemens Gamesa Renewable Power Private Limited	Chennai, Tamil Nadu	First Aid, Manual Handling, Fire Awareness, Working at Heights, Electrical, Hydraulics, Mechanical, Hazardous Energies, ART, Blade Repair, Service Lift, CoHE, Mobile Training Facility, Onsite Training Facility
24	Speed Team Infra Private Limited	Tenkasi, Tamil Nadu	First Aid, Manual Handling, Fire Awareness, Working at Heights, Electrical, Hydraulics, Mechanical, ART
25	Suzlon Energy Limited	Satara, Maharashtra	First Aid, Manual Handling, Fire Awareness, Working at Heights, Onsite Training Facility
26	UGES Powermax Private Limited	Vadodara, Gujarat	First Aid, Manual Handling, Fire Awareness, Working at Heights, Electrical, Hydraulics, Mechanical, Bolt Tightening, ART, Onsite Training Facility

No.	Training provider	City / location	Key training capabilities listed
27	Usha Fire Safety Equipments Pvt. Ltd.	Chennai, Tamil Nadu	First Aid, Manual Handling, Fire Awareness, Working at Heights, Electrical, Hydraulics, Mechanical, Bolt Tightening, Onsite Training Facility, Digital Learning
28	Vestas Wind Technology India Private Limited	Nellikuppam / Chennai, Tamil Nadu	Working at Heights, Electrical, Hydraulics, Mechanical, Bolt Tightening, Service Lift, Onsite Training Facility, Digital Learning
29	Windcare India Private Limited	Gudimanga-lam, Tiruppur District, Tamil Nadu	First Aid, Manual Handling, Fire Awareness, Working at Heights, Electrical, Hydraulics, Mechanical, ART, Slinger Signaller, Service Lift, Onsite Training Facility
30	Wind World (India) Limited	Udvada, Val-sad, Gujarat	First Aid, Manual Handling, Fire Awareness, Working at Heights, Onsite Training Facility

Note: During stakeholder consultations some of the companies involved in multi-brand O&M along with asset management seem to offer GWO training and certification in collaboration with GWO.

Table 19: Training Standard [27]

Training Standard	Competencies Covered	Relevance to Wind Sector Work-force
Basic Safety Training (BST)	Working at height, first aid, fire awareness, manual handling and sea survival (offshore mod-ule)	Foundational occupational safety competencies for wind turbine installation, operations and maintenance, and offshore personnel
Basic Technical Training (BTT)	Fundamentals of mechani-cal, electrical and hydraulic systems, bolt-tightening tech-niques and installation activities	Development of essential technical competencies for entry-level wind turbine tech-nicians, installation personnel and maintenance professionals
Advanced Rescue Training (ART)	Advanced rescue procedures, casualty evacuation and emer-gency response within turbine structures, nacelles and re-stricted working environments	Strengthening emergency preparedness and specialised rescue capabilities among wind turbine service and mainte-nance teams
Enhanced First Aid (EFA)	Advanced first aid, emergency casualty assessment, stabili-sation and response in remote operational environments	Improving emergency medical preparedness for personnel working at remote onshore and offshore wind installations
Blade Repair (BR)	Composite blade inspection, damage assessment, surface preparation, composite repair techniques and quality verifica-tion	Development of specialised technical competencies for wind turbine blade inspection, maintenance and repair profes-sionals
Slinger Signaller (SLS)	Safe lifting operations, load handling, rigging communica-tion, signaling and lifting-related risk awareness	Enhancing safety and opera-tional competency during wind turbine component handling, assembly and installation
Control of Hazardous Energies (CoHE)	Hazardous-energy identifi-cation, isolation procedures, electrical safety, pressure-fluid safety and verification of safe working conditions	Supporting safe maintenance, troubleshooting and technical interventions involving electri-cal, hydraulic and other hazard-ous-energy systems

5.1.3 Manufacturer and Industry-led Training

Turbine manufacturers have their own training facilities for service personnel. Stakeholder consultations indicated that this training focuses on the manufacturer's specific turbine models and is generally not available to people outside the organisation. This is largely because turbine control and diagnostic systems are proprietary.

Independent service providers reported that they mainly develop technical skills through in-house training based on their operational experience, rather than through external training programmes. Consultations also indicated that these organisations hire few people with certifications from national skill-development programmes.

[27] Official GWO Wind Training Standards

Industry-led training academies have also emerged, offering structured training programmes to companies which makes a truly viable business case with win-win for industry and training academy. These programmes typically combine classroom learning, practical work at sites and simulator-based fault diagnosis over an extended period. Assessments are generally conducted by industry experts.

5.1.4 Academic and Vocational Provision

Wind energy is not yet widely offered as a separate specialisation in undergraduate engineering programmes. Stakeholder consultations indicated that wind energy is usually covered through electives in power systems or at the postgraduate level in a few private universities and institutions. As a result, students have limited opportunities to learn about the full wind energy value chain, and their priorities of entering the industry choosing the right stage of the value chain.

A postgraduate syllabus in wind energy has been developed and approved, but it needs to be updated to reflect current technologies. A two-year vocational course in wind energy has also been approved for delivery through Industrial Training Institutes (ITIs).

Consultations highlighted the emerging examples of industry-linked academic programmes. SRM Institute of Science and Technology has introduced wind energy as a minor specialisation within mechanical and electrical engineering degrees. The programme includes six wind-specific courses covering wind resource assessment, turbine design, operations and maintenance, offshore wind, electrical generators and control systems.

The programme also links students with internships at turbine manufacturers. Faculty visits to industry facilities are organised to help teachers gain practical industry exposure and strengthen their understanding of current technologies and industry requirements.

5.2 Alignment between Industry and Training Programs

Existing wind energy training program provides foundational competencies in mechanical and electrical systems, turbine maintenance, basic installation procedures, hydraulic systems, occupational safety and conventional power plant operations. Engineering and diploma program, SCGJ-aligned qualifications, vocational training and GWO training standards contribute to developing these capabilities. However, the evolving technological and operational requirements of the wind energy industry necessitate additional specialized competencies.

Stakeholder consultations revealed different views on how well existing training programmes prepare people for jobs in the wind sector. Training institutions reported that their trainees were finding jobs in wind-farm areas. While such certifications have weightage to some extent, several employers noted that candidates with prior experience with the relevant turbine technology are also preferred.

Stakeholders also questioned whether the duration and content of existing courses are sufficient to prepare candidates for work. They noted that short training programmes may provide basic knowledge but may not develop the practical skills needed to perform technical tasks independently. They also highlighted the need to track whether trainees find jobs after completing their courses, rather than relying only on the number of people trained.

These differences show that the number of people completing training or receiving certificates does not, by itself, indicate how effective a programme is. Employer feedback, practical skills assessments and systematic tracking of placements are needed to understand whether training programmes are meeting industry requirements

Table 20: Training Programmes

Training Programme / Qualification	Implementing Organisation	Existing Competencies Covered	Competencies Requiring Further Integration
Vayumitra Skill Development Programme (VSDP) - Phase I	MNRE / NIWE / SCGJ-aligned training	Wind farm site surveying, mechanical O&M, electrical and instrumentation maintenance, turbine fundamentals and occupational safety	Advanced turbine diagnostics, multi-OEM maintenance, SCADA analytics, predictive maintenance and digital troubleshooting
Vayumitra Skill Development Programme - Phase II (Wind Farm Engineer)	NIWE	Wind energy fundamentals, turbine components, aerodynamics, electrical systems, wind resource assessment and practical field exposure	Advanced wind farm engineering, integrated asset management, hybrid plant controls, multi-brand diagnostics and digital O&M
O&M Mechanical Technician - Wind Power Plant (SGJ/Q1502), NSQF Level 4	SCGJ qualification framework	Mechanical maintenance, turbine component inspection, servicing procedures and occupational safety	Advanced gearbox and drivetrain diagnostics, vibration analysis, reliability engineering and predictive maintenance
O&M Electrical & Instrumentation Technician - Wind Power Plant (SGJ/Q1503), NSQF Level 4	SCGJ qualification framework	Electrical and instrumentation maintenance, fault identification, control-system fundamentals and operational safety	Advanced converter diagnostics, SCADA analytics, industrial communication systems and multi-OEM electrical troubleshooting

Training Programme / Qualification	Implementing Organisation	Existing Competencies Covered	Competencies Requiring Further Integration
CMS Engineer - Wind Power Plant (SGJ/Q1501), NSQF Level 5	SCGJ qualification framework	Condition-monitoring systems, instrumentation, equipment monitoring and maintenance procedures	AI-assisted diagnostics, advanced vibration analytics, digital twins and predictive asset management
GWO Basic Safety Training (BST)	GWO-certified training providers	Working at height, first aid, fire awareness, manual handling and offshore sea survival	Wider access to specialised safety training, offshore preparedness and integration with workplace safety procedures
GWO Basic Technical Training (BTT)	GWO-certified training providers	Mechanical, electrical and hydraulic fundamentals, bolt tightening and installation-related competencies	Advanced OEM-specific troubleshooting, complex turbine controls and specialised technical applications
GWO Advanced Rescue Training (ART) and Blade Repair	GWO-certified training providers	Advanced turbine rescue procedures, emergency response and composite blade repair techniques	Expanded advanced rescue capabilities, large-blade repair applications and turbine-specific practical training

Note: Status of QPs of various training institutions.

Stakeholder consultations indicated that training programmes in the wind sector can be affected by changes in market conditions. An earlier postgraduate programme in wind resource assessment, supported by industry and delivered through academic institutions, provided stipends to participants through industry funding. However, the programme was discontinued.

This highlights the need for training programmes that depend on industry funding to have plans in place to ensure continuity during periods of slower project activity.

Another successful industry practice that was learnt in the industry consultations, has been selecting tier 2 or tier 3 colleges and choosing a set of students in their final year through a written aptitude test and providing them training to make them industry ready and absorb in the industry.

5.3. Gaps in Training Infrastructure

The comparative assessment highlights the need to strengthen India's wind energy training ecosystem through greater industry participation, competency-based standardization, practical training infrastructure and measurable employment outcomes. While the GWO framework provides a useful reference for quality assurance, safety training and credential recognition, its adoption should complement rather than replace existing initiatives such as Vayu Mitra, NIWE technical program, SCGJ qualifications and DGT vocational training.

Emphasis is required on improving training-to-employment conversion, ensuring that candidates acquire not only recognized certifications but also the practical competencies, industry exposure and employer-validated skills necessary for sustained employment in the wind energy sector.

Table 21: Assessment Parameters

Assessment Parameter	Key Challenges in India's Wind Training Ecosystem	GWO Training Framework	Recommended Measures for Strengthening the Domestic Ecosystem
1. Industry-Training Alignment	Variations in the alignment of existing curricula with evolving competency requirements across OEMs, IPPs, EPC contractors and independent O&M service providers	Industry-developed training standards incorporating defined safety and technical competency requirements	Institutionalize periodic industry-led curriculum reviews, occupational competency mapping and employer validation of training outcomes
2. Practical Training Infrastructure	Limited availability of operational turbine assemblies, nacelle simulators, specialised diagnostic equipment and facilities for realistic maintenance exercises	Certified training providers are required to maintain appropriate facilities, equipment and practical training environments in accordance with applicable standards	Establish industry-supported training centres equipped with turbine simulators, component-level laboratories and practical troubleshooting facilities
3. Competency Standardisation	Differences across vocational, academic and industry-led training pathways may result in inconsistent practical competencies and varying levels of employer recognition	Standardised learning objectives, defined performance criteria and competency-based assessments across certified training providers	Harmonise occupational competency requirements and introduce standardised practical assessments aligned with industry expectations
4. Training-to-Employment Conversion	Limited integration of training completion with structured apprenticeships, employer recruitment processes and measurable placement outcomes	Verifiable training records support employer assessment of completed training; however, GWO certification does not independently establish job readiness or guarantee employment	Develop structured training-to-employment pathways incorporating apprenticeships, placement partnerships and post-training employment tracking

Assessment Parameter	Key Challenges in India's Wind Training Ecosystem	GWO Training Framework	Recommended Measures for Strengthening the Domestic Ecosystem
5. Qualification Recognition and Workforce Mobility	Inconsistent recognition of training credentials across employers, turbine platforms and occupational categories may restrict workforce mobility	Internationally recognised training standards and verifiable records facilitate recognition among participating wind industry employers	Strengthen industry recognition of domestic qualifications and establish complementary pathways between NSQF-aligned programmes and relevant GWO standards
6. Trainer Competency and Industry Exposure	Uneven access to emerging turbine technologies, operational facilities and continuous industry exposure may constrain trainer development	Defined instructor competency requirements and training-provider certification processes support consistency in training delivery	Expand structured Training of Trainers initiatives, including Vayu-mitra-linked program, OEM attachments and periodic technical upskilling
7. Training Quality Assurance	Consistency in training delivery, practical evaluation and institutional monitoring requires strengthening across diverse training providers	Independent certification, periodic audits and defined quality management requirements support standardized training delivery	Introducing strengthened third-party assessments, practical competency verification and periodic institutional quality audits
8. Digital Training and Competency Records	Fragmented training records and limited integration of certification, competency assessment and employment information may affect workforce tracking	The Wind Industry Database (WINDA) enables centralized recording and verification of completed GWO training	Establish interoperable digital skill records enabling credential verification, competency tracking and employment outcome monitoring
9. Advanced Technical Specialization	Emerging competency requirements in SCADA analytics, predictive maintenance, converter diagnostics, digital asset management and multi-OEM troubleshooting may exceed conventional training coverage	Modular technical training standards address selected foundational and specialized competencies, while advanced OEM-specific capabilities generally require additional training	Integrate specialized digital, diagnostic and multi-brand maintenance modules into NIWE, SCGJ and OEM-supported training pathways
10. Regional Accessibility and Training Costs	High infrastructure investment, geographical concentration of specialized facilities and associated training expenses may constrain participation	An international network of independently certified providers supports geographically distributed delivery of standardized training	Develop regional centers of excellence, shared training infrastructure and targeted financial support for candidates and institutions

Assessment Parameter	Key Challenges in India's Wind Training Ecosystem	GWO Training Framework	Recommended Measures for Strengthening the Domestic Ecosystem
11. Offshore Wind Training Readiness	Limited availability of offshore wind-specific facilities for marine operations, subsea systems, installation activities and specialized emergency response	Relevant standards address offshore sea survival, rescue procedures and selected technical safety competencies	Establish offshore wind training partnerships with maritime institutions and develop specialized marine safety, installation and maintenance training infrastructure
12. Continuous Upskilling and Competency Renewal	Refresher training, technology-specific upskilling and structured occupational progression may not be consistently embedded across training pathways	Relevant GWO standards prescribe refresher requirements and enable verification of training validity	Introducing modular refresher programmes, periodic competency reassessment and structured career progression pathways linked to evolving technologies



6. OFFSHORE WIND: WORKFORCE AND SKILLS

6.1 Offshore Wind in India

The Facilitating Offshore Wind in India (FOWIND) initiative was led by Global Wind Energy Council (GWEC) and funded by European Union executed jointly by several leading certification companies of Europe along with few institutions in India. This provides an important foundation for understanding the technical, infrastructural, regulatory and institutional requirements for establishing an offshore wind industry in India. The series of desktop and simulated compilation studies, including the Gujarat and Tamil Nadu Pre-Feasibility Studies (2015), Supply Chain, Port Infrastructure and Logistics Study (2016), Grid Integration Study (2017), From Zero to Five GW - Offshore Wind Outlook for India (2017), and subsequent Gujarat and Tamil Nadu Feasibility Studies (2018), collectively highlight the need for coordinated planning across the offshore wind value chain.

Figure 21: Typical Offshore wind installation in Europe



While these reports primarily examine resource potential, project feasibility, port infrastructure, supply-chain capabilities, grid connectivity and regulatory preparedness, their findings have significant implications for workforce development. The specialized nature of offshore wind activities, including marine surveys, offshore foundation engineering, heavy-lift operations, subsea electrical infrastructure, vessel operations, installation and maintenance, indicates the need for technical competencies that extend beyond the existing onshore wind workforce.

A critical implication of the FOWIND studies is that India's offshore wind workforce development ecosystem needs to be systematically established from a relatively nascent base. Although transferable expertise exists within the onshore wind, maritime, shipbuilding, offshore oil and gas, and conventional power sectors, dedicated offshore wind occupational standards, structured training pathways, practical training infrastructure and industry-recognized competency frameworks require further development. Consequently, workforce planning cannot rely solely on adapting existing onshore wind training programs; it must incorporate offshore-specific technical, operational, safety and certification requirements.

Major findings across the reports [28]

The reports point to five recurring development requirements:

1. Resource and project readiness: Offshore wind potential must be supported by detailed wind measurements, seabed investigations, metocean studies and bankable project assessments.
2. Supply-chain localization: India's established manufacturing base offers opportunities, but offshore-specific fabrication, quality assurance, logistics and vessel capabilities require development.
3. Port and installation infrastructure: Offshore wind requires ports capable of handling exceptionally large components, heavy lifting, specialized vessels and complex marine logistics.
4. Grid and regulatory preparedness: Offshore transmission infrastructure, project approvals, regulatory certainty and coordinated development planning are critical.
5. Workforce and institutional capacity: Specialized technical expertise, practical experience and collaboration between domestic and international stakeholders are needed to support industry development.

Table 22: FOWIND reports in open domain

FOWIND Report	Major Findings
Inception Report (2014)	Identified the need for a structured offshore wind development framework, stakeholder coordination, resource assessment, and institutional preparedness.
Global Offshore Wind Policy Assessment (2014)	Highlighted the importance of stable policy frameworks, transparent regulatory mechanisms, financial incentives, and best international practices for offshore wind development.
Gujarat Pre-Feasibility Study (2015)	Identified eight potential offshore development zones and emphasized the need for detailed wind resource measurements, seabed investigations, and environmental assessments.
Tamil Nadu Pre-Feasibility Study (2015)	Identified promising offshore wind development areas while highlighting challenges related to marine conditions, water depth, environmental considerations, and infrastructure readiness.
Supply Chain, Port Infrastructure and Logistics Study (2016)	Highlighted the need to strengthen domestic manufacturing capabilities, upgrade port infrastructure, develop specialized marine logistics, and ensure the availability of offshore installation vessels.
Grid Integration Study (2017)	Identified the importance of transmission infrastructure upgrades, offshore power evacuation planning, grid stability assessments, and coordination with transmission utilities.

[28] https://mnre.gov.in/en/off-shore-wind/

FOWIND Report	Major Findings
From Zero to Five GW (2017)	Emphasized phased offshore wind development, clear policy direction, financial support mechanisms, infrastructure investment, and coordinated implementation planning.
Gujarat Feasibility Study (2018)	Examined offshore wind project feasibility, including turbine configurations, foundation requirements, energy-yield estimates, project costs, and technical risks.
Tamil Nadu Feasibility Study (2018)	Assessed project feasibility considering offshore wind conditions, turbine and foundation design, installation requirements, electrical infrastructure, and O&M considerations.

Initial NIWE assessments indicate approximately 36 GW of offshore wind potential off Gujarat and nearly 35 GW off Tamil Nadu[29].

To support market development, the Government approved a ₹7,453 crore Viability Gap Funding scheme for offshore wind projects[30]. This includes ₹6,853 crore towards installation and commissioning of 1 GW of offshore wind capacity, 500 MW each off Gujarat and Tamil Nadu, and ₹600 crore for upgrading two ports to support offshore wind logistics[31].

Manufacturers identified uncertainty about future demand as the main barrier to investment, rather than a lack of technical capability. They indicated that a single 1 GW project would not be enough to justify the investment and that they would need a clear view of expected demand over the next five years. One manufacturer reported discussions with an Indian shipbuilding facility over three years, during which land had been offered, but the investment was postponed due to uncertainty about the future project pipeline.

Stakeholders suggested a phased approach to developing domestic offshore manufacturing as an alternative to either importing all components or manufacturing everything in India. Under this approach, components that Indian manufacturers can already produce would be made domestically. Components that are beyond current manufacturing capabilities would be imported in an unfinished form, completed and painted at port facilities, and supplied alongside locally manufactured components. This would allow India to gradually build its offshore manufacturing capabilities.

[29] https://mnre.gov.in/en/off-shore-wind/
[30] https://www.pib.gov.in/PressReleaseIframePage.aspx?PRID=2026700&reg=48&lang=2
[31] https://www.pib.gov.in/PressReleasePage.aspx?PRID=2026699&reg=48&lang=2

6.2 Offshore Wind Value Chain

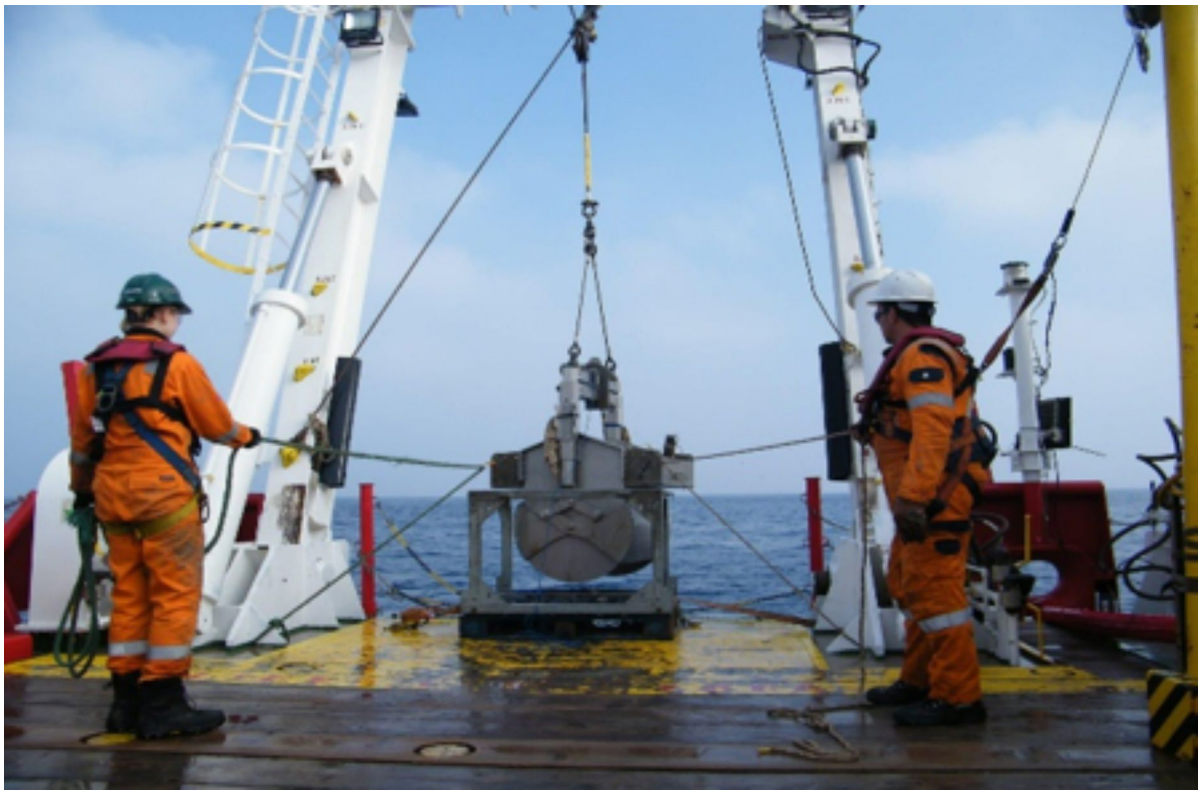
Offshore wind represents one of the most technologically advanced segments of the global wind industry

Its value chain extends beyond conventional turbine manufacturing into:

Marine Survey and environmental impact assessment in all stages → Foundation Manufacturing → Subsea Cable Manufacturing → Port Logistics → Offshore Installation → Offshore Substation → Commissioning → Marine O&M.

1. Marine Survey
   - Hydrographic and geophysical surveys
   - Seabed mapping

Figure 22: Marine Survey



   - Geotechnical investigations
   - GIS and marine environmental assessment.
2. Foundation Manufacturing
   - Structural design
   - Steel fabrication
   - Precision welding
   - Corrosion protection
   - Non-destructive testing (NDT)
3. Subsea Cable Manufacturing
   - High-voltage cable manufacturing
   - Insulation

- Cable testing
- Jointing
- Termination
- Fiber-optic integration

4. Port Logistics
   - Heavy-lift handling
   - Component storage
   - Vessel coordination
   - Marine logistics planning
   - Port safety
5. Offshore Installation
   - Jack-up vessel operations
   - Heavy lifting and rigging
   - Foundation and turbine installation
   - Offshore electrical works
   - Safety compliance
6. Offshore Substation
   - High-voltage electrical systems
   - Transformers
   - Protection and control
   - SCADA
   - Automation and grid integration
7. Commissioning
   - Electrical and mechanical testing
   - Protection relay validation
   - Turbine performance verification
   - Grid-code compliance
   - HSE procedures
8. Marine Operations & Maintenance (O&M)
   - Offshore turbine maintenance
   - Subsea cable inspection
   - Corrosion monitoring
   - Remote diagnostics
   - Vessel operations
   - Marine safety

6.3 Current Offshore Capability in India

Consultations with manufacturers indicated that offshore wind capability in India remains at an early stage. Manufacturers estimated that around 90 %of the skills required for onshore tower manufacturing are available in India, compared with only about 10 per cent of the skills needed for offshore manufacturing.

Welding was identified as the main technical gap. Offshore towers and foundations require welding of thick materials to a higher level of precision than is generally required for onshore wind structures, and these skills are not currently available in India. Manufacturers noted that existing onshore workers could be trained to meet these requirements, but that this would depend on specialised training and technology transfer from countries with established offshore manufacturing capabilities. Gaps were also identified in portside operations, including barge handling and the floating and upending of large structures, none of which is yet well established in India.

Offshore manufacturing further carries specific location requirements. Facilities producing offshore foundations, transition pieces and towers need to be located at ports, as these components can weigh 400 to 500 tonnes each and require dimensional checks, assembly and loading onto vessels at the quayside. Inland facilities were reported as not viable. Setting up such a facility was estimated to require approximately 45 to 50 acres of port land, together with new machinery, worker training and the acquisition of technical knowledge and technology from Europe.

Of the ports identified for offshore wind development, Tuticorin in Tamil Nadu was considered closest to being ready for offshore manufacturing, while Pipavav in Gujarat would require further development. The principal infrastructure requirements are cranes, load-bearing platforms and covered facilities for assembly and inspection. Manufacturers indicated that they expect the central government to take the lead in developing this infrastructure.

6.4 Offshore Competency Requirements

The transition from onshore to offshore wind energy introduces additional technical complexities and specialised workforce requirements. While both segments share core mechanical, electrical and operational competencies, offshore wind demands "concept to commissioning", more rigorous reliability and environmental compliance in safe installation and O&M. Greater expertise in marine operations, subsea systems, logistics, digital technologies, marine worthiness of turbine & support systems for wind wave/current and safety management. The following skill-intensity matrix provides an indicative comparison of competency requirements across onshore and offshore wind operations, highlighting areas requiring specialised training and workforce development.

Table 23: Indicative Competency Matrix

Indicative competency intensity		
Competency	Onshore	Offshore
Mechanical	●●●	●●●
Electrical/HV	●●	●●●
Digital	●●	●●●
Marine	●	●●●
Safety	●●	●●●
Logistics	●●	●●●
Subsea systems	●	●●●
● Basic / ●● Moderate / ●●● High		

Table 24: Offshore transferable capability

Source sector	Transferable capability
Offshore oil and gas, including rig operations	Marine working practice, offshore safety culture, platform operations, vessel-based working
Offshore structural engineering and refineries	Foundation and substructure design, geotechnical and bathymetric assessment, wind wave current effects
Shipbuilding and heavy fabrication	Heavy-section welding, plate forming, dimensional control, port-based assembly
Shipping and merchant marine	Vessel operations, sea survival competency, marine coordination
Port operations	Heavy lifting, load-out, crane operation, marine logistics
Ocean technology and marine survey institutions	Metocean measurement, floating LiDAR, seabed survey

Internationally recognized training frameworks such as those developed by the Global Wind Organization (GWO) have become important benchmarks for safety and technical training in the wind industry [32].

India's offshore workforce strategy will need to consider alignment with international standards to facilitate safety, competency assurance and workforce mobility.

[32] https://www.globalwindsafety.org/statistics/annual-report-2025

6.5 Offshore Workforce Requirements

Stakeholders consulted indicated that offshore facilities are not yet operational in India, making it difficult to estimate workforce requirements reliably without practical experience. These estimates will need to be developed using international benchmarks and inputs from manufacturers and developers with established offshore experience.

Consultations identified several factors that will determine when offshore workforce demand arises. Offshore wind measurement at identified development sites has not yet been undertaken, with assessments currently relying on nearshore studies and global datasets. Developers reported requiring at least one year of site-specific measurement following seabed allocation before project assessment could be concluded. Project development timelines of seven to eight years, extending to ten, were indicated from initial assessment through to commissioning, including infrastructure development. Offshore project economics were identified as challenging, with capital expenditure in the order of three times onshore and coastal wind speeds below levels considered viable in established offshore markets.

For manufacturing investment, the principal constraint was identified as visibility of forward demand rather than technical capability.

The Global Wind Workforce Outlook 2025-2030 indicates that India's offshore workforce demand is not expected to become a reality until after 2030, and that this is heavily dependent on the successful allocation of offshore wind tenders.

6.6 Offshore Training Readiness

Stakeholder consultations indicated that Offshore-specific safety training, including sea survival and helicopter underwater escape training, is not currently available in India. Workers requiring these certifications must obtain them abroad. This is a key barrier to developing the workforce for offshore wind, as these certifications are mandatory for offshore wind technicians in international markets.

Availability of offshore wind-specific training facilities is limited more broadly, covering marine operations, subsea systems, installation activities and specialised emergency response. Internationally recognised standards do address offshore competencies: the Global Wind Organisation Basic Safety Training standard includes a sea survival module for offshore personnel, and relevant standards cover rescue procedures and selected technical safety competencies. These modules are not currently delivered in India.

Specialised capability relevant to offshore development exists outside the wind sector. Offshore wind measurement was reported as requiring specialised capability available within oil and gas and dedicated ocean technology institutions. Establishing offshore wind training partnerships with maritime institutions, and developing specialised marine safety, installation and maintenance training infrastructure, would allow this capability to be drawn into the wind sector.



7. IMPACTS OF ADDRESSING SKILL GAP

7.1 Benefits to Industry

The establishment of an industry-aligned, standardized training, assessment and certification framework is expected to strengthen workforce capabilities across the wind energy value chain. By developing a pool of technically competent and industry-recognized professionals, such a framework can reduce workforce deployment timelines, improve operational reliability and enhance the overall efficiency of project execution and asset management.

The key benefits to the industry include:

1. Enhanced Availability of Industry-Ready Workforce: Development of a readily deployable talent pool equipped with validated technical, operational and safety competencies, reducing dependence on extensive employer-led foundational training.
2. Reduced Workforce Mobilization and Deployment Lead Times: Standardized competency certification enables employers to assess candidate readiness more efficiently, accelerating recruitment, onboarding and deployment across project development, installation, commissioning and O&M activities.
3. Improved Asset Reliability and Operational Performance: Availability of appropriately trained personnel strengthens preventive maintenance, fault diagnosis and corrective interventions, contributing to reduced turbine downtime, improved asset availability and enhanced operational performance.
4. Common Training, Assessment and Certification Infrastructure: Establishment of shared, industry-recognized training standards and evaluation mechanisms promote consistency in workforce competencies while enabling efficient utilization of specialized training facilities and resources.
5. Optimization of Workforce Development Costs: Access to a common pool of certified professionals and shared training infrastructure can reduce duplication of training investments, minimize competency gaps during onboarding and improve the cost-effectiveness of workforce development.
6. Greater Workforce Flexibility and Cross-Industry Mobility: Standardized and verifiable competencies facilitate workforce mobility across OEMs, independent service providers, EPC contractors and project developers, supporting more efficient resource allocation across the wind energy value chain.
7. Strengthened Safety and Quality Assurance: Competency-based training and independent assessment support consistent adherence to occupational safety practices, technical procedures and quality requirements, reducing operational risks and improving service delivery.
8. Improved Scalability of Wind Energy Operations: A structured pipeline of qualified professionals supports workforce expansion in response to increasing project capacities, technological advancements and emerging requirements in repowering, hybrid systems and offshore wind.

Stakeholder consultations indicated that the cost of training workforce is not shared evenly across the wind sector. Companies that recruit and train new workers often lose them to employers offering higher salaries, making it difficult to recover their investment in training.

A common training and certification system, along with more new workforce entering the sector, could help address this challenge. It would reduce the sector's reliance on hiring workers already trained by other companies and help build a larger pool of skilled workers.

7.2 Benefits to Workforce

The establishment of a standardized, industry-recognized training and certification framework can significantly enhance workforce employability, professional recognition and long-term career development within the wind energy sector. By providing structured competency development, practical industry exposure and verifiable qualifications, such a framework can facilitate greater access to employment opportunities and clearly defined career progression pathways.

The key benefits for the workforce include:

1. Enhanced Employability and Industry Recognition: Industry-recognized certifications validate technical and safety competencies, strengthening professional credibility and improving access to employment opportunities across the wind energy value chain.
2. Structured Career Progression: Standardized competency frameworks establish transparent pathways for progression from entry-level technical positions to specialized, supervisory and managerial roles, supporting long-term professional development.
3. Improved Recognition of Skills and Experience: Formal assessment and certification enable workers to demonstrate acquired competencies, facilitating greater recognition of technical expertise, practical experience and professional capabilities.
4. Greater Workforce Mobility: Transferable and verifiable certifications enhance opportunities for employment across OEMs, EPC contractors, independent O&M service providers and wind project developers, including relevant international markets.
5. Access to Continuous Upskilling and Specialization: Modular training and certification pathways enable workers to develop advanced competencies in turbine diagnostics, SCADA, predictive maintenance, digital asset management and emerging wind technologies.
6. Improved Career Advancement Opportunities: Demonstrated competencies and recognized qualifications can strengthen eligibility for higher-responsibility positions, specialized technical roles and potential improvements in remuneration.
7. Enhanced Workplace Safety and Confidence: Practical safety training and competency-based assessments strengthen workers' ability to perform high-risk activities safely, improving operational confidence and reducing exposure to workplace hazards.
8. Recognition of Prior Learning and Occupational Experience: Competency assessment mechanisms can support formal recognition of skills acquired through practical experience, enabling experienced workers to pursue further qualifications and career advancement.

7.3 Benefits to Sector and Economy

Strengthening the wind energy skill development ecosystem is essential for supporting India's national renewable energy ambitions, particularly the target of achieving 500 GW of non-fossil fuel-based installed electricity capacity by 2030, and the long-term objective of achieving net-zero emissions by 2070.

The availability of technically competent, certified and industry-ready manpower can support these objectives by accelerating wind energy project development, reducing workforce-related commissioning delays, improving turbine availability and enabling effective integration of renewable energy into the national electricity system.

Strengthening skill development in the wind sector can deliver three broader benefits.

- Building domestic technical capability - Stakeholder consultations indicated that the sector still relies heavily on technology developed outside India. Building stronger engineering and design capabilities will require sustained collaboration between industry and technical institutions. Training that goes beyond operations and maintenance to include engineering and design can help India develop its own wind technologies and reduce dependence on imported technology.
- Preparing for offshore wind - Offshore wind requires specialised skills that are not yet widely available in India, including marine operations, offshore structural engineering, subsea systems and offshore safety. Developing these skills before projects begin can reduce reliance on overseas experts and support the growth of domestic offshore supply chains.
- Expanding exports of technical services - India already has a strong engineering base serving international wind markets. Further strengthening the domestic skills base can help expand the technical services delivered from India and support wind energy development in other countries.

7.4 Cost of Inaction

If the identified skill gaps are not addressed, the wind sector will continue to face challenges in hiring and developing workforce. Stakeholder consultations indicated that companies already face long recruitment and training periods, higher employment costs due to competition for a limited pool of experienced workers, and repeated training costs when employees leave for other organisations.

For offshore wind, the lack of offshore safety training facilities in India is a basic barrier to workforce development. Certifications that are mandatory for offshore technicians in international markets cannot currently be obtained in India. Without developing these training facilities in advance, the first offshore wind projects will have to rely on workers trained and certified abroad.

Consultations also indicated that training provision has reduced during periods of lower project activity in the past. This can leave the sector with limited training capacity when project development picks up again, making it harder to meet the workforce needs of a growing industry.



8. RECOMMENDATIONS

8.1 Recommendation for Industry

Establish an industry-led consortium comprising wind turbine OEMs, independent O&M service providers, project developers, EPC contractors, training institutions and industry associations to develop shared technical training infrastructure for specific wind turbine technology platforms. Drawing upon the standardized, industry-driven training framework adopted by the Global Wind Organization (GWO), the consortium could facilitate the establishment of specialized training centers equipped with turbine nacelle simulators, drivetrain assemblies, electrical and hydraulic systems, SCADA interfaces and advanced diagnostic tools. MNRE has industry relevant training infrastructure funding available for training Indians and absorbing them in the Industry after successful evaluation and certification.

The proposed consortium should focus on:

1. Shared Training Infrastructure: Pool industry resources to establish common technical training, assessment and certification facilities, reducing duplication of capital-intensive investments.
2. Technology -Specific Training: Develop practical training modules covering different turbine platforms, including mechanical systems, electrical controls, power converters, condition monitoring and fault diagnostics.
3. OEM Participation and Knowledge Transfer: Facilitate structured collaboration with turbine manufacturers for access to representative equipment, authorized diagnostic tools and technical expertise while protecting proprietary technologies.
4. Standardized Competency Assessment: Establish industry-recognized competency benchmarks and practical evaluation mechanisms, complementing existing NIWE, SCGJ, Vayu Mitra and GWO training frameworks.
5. Training-to-Employment Linkages: Integrate training programs, industry apprenticeships, employer-led assessments and recruitment pathways to improve the availability of certified, deployment-ready manpower.

8.2 Recommendation for Training Institutes

For the wind sector, specialized training programs proposed to be developed in eight priority areasDigital Technologies (AI and Digital Twins), Small Wind Energy Systems, Offshore Wind and Port Logistics, and Workforce Transition from Onshore Wind and Oil & Gas to Offshore Wind.

The proposed program should complement existing NIWE, Vayu Mitra, SCGJ and GWO-aligned training pathways, with emphasis on practical competencies, industry exposure and employability.

Table 25: Recommendations for Training Institutes

Priority Training Area	Proposed Occupational Role / Training Program	Indicative NSQF Level	Key Competencies to be Developed
1. Digital Technologies - AI, Digital Twins and Advanced Analytics	Wind SCADA Monitoring Technician	Level 4	SCADA monitoring, operational data collection, alarm interpretation and basic fault reporting
	Wind Condition Monitoring Specialist	Level 5	Vibration analysis, sensor diagnostics, condition monitoring and predictive maintenance
	Wind AI and Digital Twin Engineer	Level 6	Machine learning, digital twin modelling, advanced fault prediction and turbine performance optimization
2. Small Wind Energy Systems	Small Wind Turbine Installation Technician	Level 4	Turbine assembly, electrical connections, installation, commissioning and safety procedures
	Small Wind System Design and O&M Supervisor	Level 5	Site assessment, turbine sizing, wind-solar hybrid integration, system troubleshooting and maintenance supervision
3. Offshore Wind Technologies	Offshore Wind Turbine Technician	Level 4	Offshore turbine maintenance, mechanical and electrical systems, corrosion protection and offshore safety
	Offshore Wind Installation and Commissioning Specialist	Level 5	Turbine installation, foundation interfaces, commissioning, subsea electrical systems and technical inspections
	Offshore Wind Engineering and O&M Supervisor	Level 6	Offshore engineering coordination, maintenance planning, asset reliability and operational supervision

Priority Training Area	Proposed Occupational Role / Training Program	Indicative NSQF Level	Key Competencies to be Developed
4. Offshore Wind Port Infrastructure and Logistics	Offshore Wind Port Handling Technician	Level 4	Heavy-component handling, rigging fundamentals, material movement and port safety
	Offshore Wind Heavy-Lift and Logistics Supervisor	Level 5	Lifting-plan implementation, component transportation, load-out operations and vessel coordination
	Offshore Wind Port Logistics Manager	Level 6	Port logistics planning, supply-chain coordination, marine transport scheduling and operational risk management
5. Workforce Transition from Onshore to Offshore Wind	Offshore Wind O&M Technician - Bridging	Level 4	Offshore safety, vessel transfers, marine working conditions, turbine access and offshore maintenance procedures
	Offshore Wind Maintenance Specialist - Bridging	Level 5	Advanced offshore troubleshooting, corrosion management, maintenance planning and emergency response
	Offshore Wind Operations Supervisor - Bridging	Level 6	Offshore workforce coordination, operational risk management, maintenance supervision and emergency preparedness
6. Workforce Transition from Oil & Gas to Offshore Wind	Offshore Wind Technical Specialist - Conversion	Level 5	Wind turbine technologies, offshore electrical infrastructure, subsea power systems and wind-specific maintenance
	Offshore Wind Engineering and Operations Supervisor - Conversion	Level 6	Offshore wind installation, engineering supervision, asset management and operational planning
7. Repowering and life extension - onshore	Turbine Life extension Assessor	Level 5	Structural integrity assessment, remaining life evaluation, component condition assessment, recertification, requirements.
	Decommissioning and Recycling Supervisor	Level 5	Safe dismantling, heavy lifting, material segregation, composite blade handling and disposal

Priority Training Area	Proposed Occupational Role / Training Program	Indicative NSQF Level	Key Competencies to be Developed
8. Offshore Manufacturing	Offshore Structure Welder	Level 4	Heavy-thickness welding to offshore standards, offshore structural tolerances, dimensional control
	Port Assembly and Load- out supervisor	Level 5	Port-based assembly, dimensional checking, barge handling, upending operations

- Institutionalise alumni feedback into curriculum revision: Training institutions should conduct structured alumni surveys following course completion, hold annual alumni interaction with current students, and include alumni representation in syllabus review. Feedback from industry alumni after training provides direct evidence of which competencies employers actually use and which parts of a programme contribute most to employability.
- Make industrial internship a substantial credited component with institutional placement support: Internships should carry significant credit weight and be placed through institutional industry contacts rather than left to students to arrange, so that the internship becomes a route into employment rather than a formality.
- Establish dedicated wind energy laboratories with industry-standard software: Institutions in wind states should establish wind energy laboratory facilities with exposure to the resource assessment and plant performance software used in industry, including WAsP, WindPRO, WindSIM and Meteodyn, alongside wind-solar hybrid and storage system modelling.

8.3 Recommendation for Government and Skill Councils

Strengthening India's wind energy workforce requires a coordinated approach involving government agencies, sector skill councils, training institutions, industry stakeholders, and technology providers. With increasing deployment of larger wind turbines, repowering of existing wind farms, expansion of domestic manufacturing, integration of digital technologies, and the emergence of offshore wind, existing skill-development frameworks need to evolve in line with changing industry requirements. The following recommendations aim to address current competency gaps, strengthen institutional capacity, and establish a structured, industry-responsive workforce-development ecosystem.

1. Strengthening NSQF-Aligned Qualification Frameworks
   - Review and update existing wind-sector Qualification Packs (QPs) to reflect emerging technologies, equipment configurations, and industry requirements.
   - Prioritize occupational pathways at NSQF Levels 4, 5, and 6, covering skilled technicians, advanced technical and supervisory personnel, and specialized technical roles, subject to formal qualification mapping.
2. Expansion of Industry-Oriented Training Programs
   - Strengthening existing wind energy skill-development initiatives, including the Vayu Mitra Skill Development Program, through updated curricula, practical training, and industry participation.
   - Expand training coverage across wind-resource-rich states, particularly Gujarat, Tamil Nadu, Karnataka, Maharashtra, Rajasthan, and Andhra Pradesh, Telangana, Madhya Pradesh.

3. Standardization of Training Certification

   - Establish standardized competency assessment mechanisms to ensure consistency in wind-sector training outcomes.
   - Strengthen trainer certification and Training of Trainers (ToT) programs for emerging wind energy occupations.

4. Develop Offshore Safety Training in India

   - Develop offshore safety training facilities in India, including training in sea survival and helicopter underwater escape. These certifications are mandatory for offshore technicians in international markets but are not currently available in India. Partnerships with maritime training institutions should be explored, as some already provide related sea survival training.

5. Provide Clear Plans for Offshore Wind Projects

   - Manufacturers indicated that they need a clear view of expected demand over the next five years before investing in offshore wind manufacturing facilities. Such investments also affect the development of the required workforce. Clear timelines for tenders and project capacity announcements would help companies plan their investments and training needs.

6. Assess Gaps in Offshore Manufacturing

   - Assess India's current offshore wind manufacturing capabilities to identify which components can be produced domestically and which require new technology or expertise. The assessment should also identify the investment and training needed to develop these capabilities.

7. Link Port Development with Workforce Planning

   - Offshore wind manufacturing requires suitable port facilities. As ports are developed under the offshore wind Viability Gap Funding (VGF) scheme, plans should also be made to establish training facilities at or near these locations. This would help prepare local workers for upcoming offshore wind projects.

8. Curriculum integration at degree level

   - Wind energy as a minor specialisation within mechanical and electrical engineering degrees, linked to industry internships and supported by faculty industry exposure, was identified as a working model. Extension to additional institutions in wind states could be supported through industry partnership.

9. Dedicated postgraduate programme in wind energy

   - Consultations indicated that the existing approved postgraduate syllabus requires revision, and that a dedicated programme would be appropriate given the sector's scale.

10. Establish a Dedicated Offshore Wind Training Programme

    - Develop a specialised training programme of one to one-and-a-half years to prepare professionals for jobs in offshore wind. The programme should be developed jointly by technical institutions with expertise in marine engineering, ocean technology and ocean information services, along with companies involved in offshore manufacturing and marine construction.

11. Develop a Renewable Energy Specific Safety Officer Qualification

    - Safety personnel in the wind sector are currently drawn predominantly from industrial safety qualifications designed for chemical and process industries, which have limited applicability to wind operations. A qualification addressing wind sector operating

conditions would address the gap identified in consultations.

12. Develop Structured Training for Wind Asset Owners and Asset Managers

Technician training exists, but there is little structured training for owners and asset managers, who need to understand contracts, data, regulation and investment decisions rather than perform maintenance. Suggested training areas are:

- Reading SCADA and verifying OEM performance claims
- O&M contracts: what to demand and how to enforce
- Forecasting, scheduling, deviation settlement and grid code
- Repowering and life extension: economics and policy
- Condition monitoring and failure analysis
- Blade inspection and repair supervision
- Safety leadership for wind farm owners
- GWO Basic Safety Training
- Hybrid and BESS integration

Annexure I - Stakeholder Outreach

Organisations were selected to represent the major segments of the wind energy value chain. Together they account for over 80 per cent of the market in India.

Table 26: Stakeholder Outreach

Stakeholder category	Approached	Responded
Wind turbine OEMs	16	4
Independent power producers	9	3
Component manufacturers	3	1
Technical consultancy and training institutions	3	3
Industry associations	4	3
Total	35	14

In addition to organisation-level outreach, survey questionnaires were circulated to 107 individuals in the wind sector

Annexure II – Questionnaire

Skill Gap Studies for Solar PV and Wind Energy Sector in India

Survey Form- Wind Sector

SECTION A: Interview/Interviewer Profile

Organization Name:
Coordinator Name:
Designation: E Mail ID:
Mobile Number:
Sub coordinator Details:

Sl. No.	Name of Sub Coordinator	Designation	Email ID	Mobile no	Data Shared
1					
2					
3					
4					
5					
6					

CII Coordinator: E Mail ID:

Designation: Mobile number:

SECTION B: Organization Profile (Select whichever is applicable)

Sl. No.	Particulars	Details
1	Organization Name	
2	Type of Activity	☐ Component Manufacturing ☐ Turbine Assembly/ OEM ☐ Logistics/ Transportation ☐ Project Development ☐ Turbine Installation & Commissioning ☐ Operation & Maintenance ☐ Decommissioning & End-of-life Management ☐ Skill Training and Certification
3	Main Wind Products	☐ Blade ☐ Hub ☐ Nacelle (Gear box & Generator) ☐ Foundation Components ☐ Safety equipment ☐ Weather Monitoring ☐ Transformer ☐ other special products or special materials
4	Head Office Location	
5	Plant Locations	

SECTION C: Operations Data (Select whichever is applicable)

Sl. No.	Particulars	Details
1	Total Capacity of Wind Plants Deployed (MW)	
2	Total no. of plants and capacity of Wind Plants for which O&M services are provided (MW)	
3	Total no. of employees • No. of employees on payroll • No. of contract employees	
4	Expansion Plans (Till 2030)	

SECTION D: Current Workforce Availability

Sl. No.	Job Role	Existing No.	Required No. by 2030	Required Qualification	Skills Required/ Experience	Skill Gap/ Upskilling required*
1						
2						
3						
4						
5						
6						
7						
8						

*For more details refer to predefined skill sets required

New Roles Expected in next 5 Years

Designation	Qualifications	Skill Required	Numbers

SECTION E: Key Challenges Regarding Manpower

☐ Lack of skilled manpower with or without GWO-standards (Global Wind Organisation)

☐ High attrition

☐ Shortcomings in certain skillsets (Specify)

☐ Lack of availability of industry recognized courses for bridging skill gaps

☐ Lack of availability of Experts for Training / Training of Trainers

☐ Others: _____

SECTION F: Recommendations from Industry

***Predefined Skill Set :**

Job Role	Technical Skills	Digital Skills	Safety Skills	Soft Skills
Wind Turbine Design Engineer	Aerodynamics, structural design, gearbox, generator, blade design	ANSYS, SolidWorks, MATLAB	IEC 61400	Innovation
Wind Project Engineer	Foundation, erection, crane planning, commissioning	Primavera, AutoCAD	Lifting safety	Coordination
Wind O&M Engineer	Turbine maintenance, gearbox, pitch system, yaw system, hydraulics	SCADA, CMS	Working at Height, Rescue	Problem-solving
Wind Performance Engineer	Power curve analysis, wake analysis, AEP calculation	WindPRO, OpenWind, SCADA	Grid compliance	Data analytics
Wind SCADA Engineer	PLC, RTU, communication, networking	SCADA, IEC 61400-25	Cybersecurity	Troubleshooting
Blade Repair Engineer	Composite repair, NDT, coating systems	Inspection software	Rope Access, Working at Height	Precision

Job Role	Technical Skills	Digital Skills	Safety Skills	Soft Skills
Condition Monitoring Engineer	Vibration analysis, oil analysis, thermography	CMS software	Machine safety	Analytical skills
Electrical Maintenance Engineer	HT systems, transformers, switchgear, protection relays	Relay software	Electrical Safety	Decision making
Control Room Engineer	Grid operations, dispatch, forecasting	SCADA, EMS	Grid Code	Communication

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