Bharat Cleantech Manufacturing Platform: Talent and Workforce

Accelerating an Aatmanirbhar, Green and Viksit Bharat

bharat CLIMATE FORUM

Council for International Economic Understanding

Dalberg

As India rapidly moves towards meeting its NDCs, indigenisation of cleantech manufacturing is critical for an *Aatmanirbhar* and *Viksit Bharat*

India has national targets and projections across renewable energy and e-mobility for 2030…

300 GW Solar *installed capacity*[1]

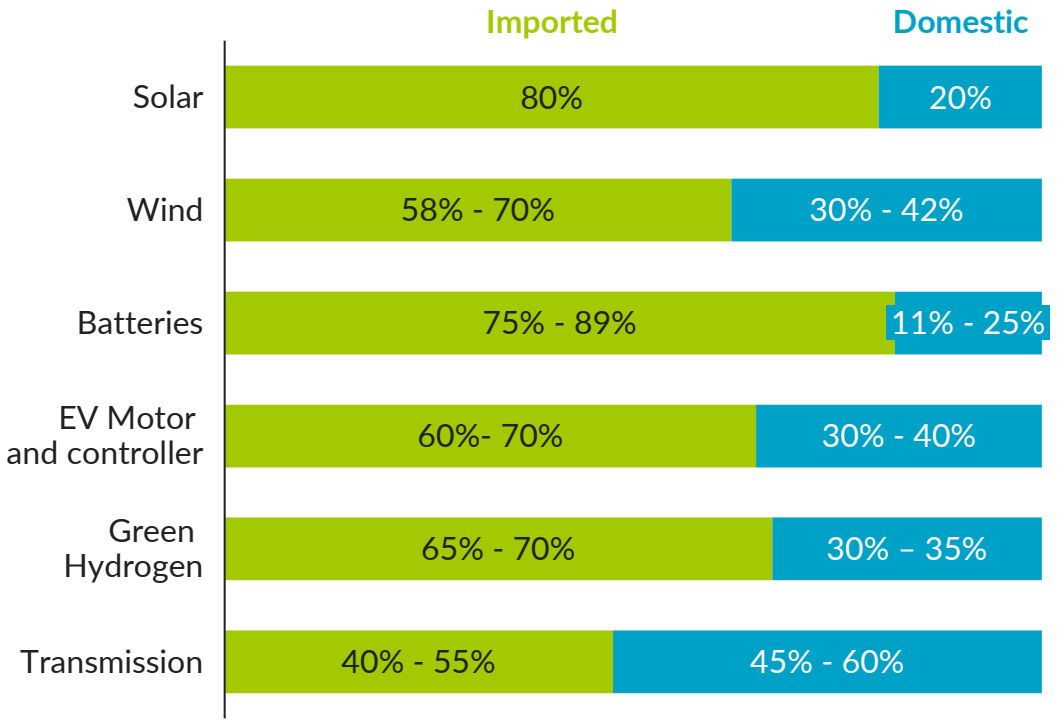
30% EV *sales penetration*[2]

100 GW Wind *installed capacity*[3]

5 MTPA Green Hydrogen *production*[4]

… but cleantech supply chains are heavily import-dependent and need to be indigenised for an Aatmanirbhar Bharat

Cleantech manufacturing import dependence across the value chain, 2023



Source: (1) MNRE; Solar capacity projection extrapolated from CEA's 2032 Solar capacity projections, assuming linear growth in capacity; (2) NITI Aayog ; (3) ET ; (4) MNRE - NGHM; MNRE, Ministry of Power; Economics Times; BNEF's installed and announced capacity; IEA, India – World Energy Investment 2024 – Analysis; NITI, India's Power Sector | Capacity & Generation Mix; PIB, India's Ethanol Push: A Path to Energy Security, CEEW, Strengthen India's Clean supply chain, 2024; Bain, India Electric Vehicle Report, 2023; Policy circle; Economist Impact, Scaling clean energy: financing and transition strategies for India's sustainable future

The Platform could support the National Manufacturing Mission to target at least 50% indigenisation of cleantech manufacturing value chains by 2030 enabling net-zero ambition with indigenous production

The Platform's potential to accelerate development of incremental indigenous capacity can be observed across sectors

Sector-wise goals

	Solar	Wind	BESS	E-mobility	Green Hydrogen	Transmission
Installed capacity						
2030 targets	300 GW[1]	100 GW[2]	230-240 GWh[3]	30@30[4]	5 MTPA[6]	648,190[7] ckm
% value chain indigenisation*						
Current levels (est.)	~20%	~35%	~20%	~35%[5]	~35%	~55%
2030 target (Proposed)	~50%	~60%	~45%	~50%	~60%	~70%

May decline due to shifting and unstable demand of domestic components amid intensified global competition

Note: *Indigenisation is domestic value contribution across cleantech value chain from raw materials to end production for all components; : (1) MNRE; (2) ET; (3) Estimated requirements under National Electricity Plan (NEP) 2023 of CEA; (4) NITI Aayog ; (5) For EV Motors and controllers; (6) MNRE - NGHM (7) 2032 target from National Electricity Plan Volume II – Transmission of CEA

Source: MNRE, Ministry of Power; Economics Times; BNEF's installed and announced capacity; IEA, India – World Energy Investment 2024 – Analysis; NITI, India's Power Sector | Capacity & Generation Mix; PIB, India's Ethanol Push: A Path to Energy Security, NEP 2023 of CEA; EV Reporter, India's electric vehicle supply chain landscape | An overview, 2024

A detailed strategy and action plan for the focus sectors would be developed to achieve these goals and objectives and build the cleantech indigenisation pathways for these sectors

Sector-wise gaps would be identified and addressed with all stakeholders across each cross-cutting theme in alignment with the National Manufacturing Mission

Enablers:
Policy recommendations; Trade partnerships; Public and private stakeholder recommendations; Demand and supply drivers; Leveraging AI for Climate and cleantech manufacturing

Sectors

- Solar
- Wind
- BESS
- E-mobility
- Green Hydrogen
- Transmission

Cross-cutting themes

Demand & Market Architecture	*Drive demand and adoption of output, incl.* ***Quality Control Orders (QCOs)***
R&D & Product Innovation	*Drive technology sharing, adoption and indigenous R&D*
Upstream Raw Materials & Critical Inputs	*Streamline raw material sourcing (e.g. critical rare earth elements; bio-energy feedstock etc.)*
Capital Equipment & Infrastructure	*Address machinery sourcing & infrastructure requirements (e.g., grid connectivity)*
Talent & Workforce	*Bridge skilling gaps for specialised and non-specialised workforce*
Financing & Taxation	*Identify financial instruments and mechanisms to reduce the funding gap Identify levers to improve* ***Ease of Doing Business*** *to attract investments*

Detailed ahead

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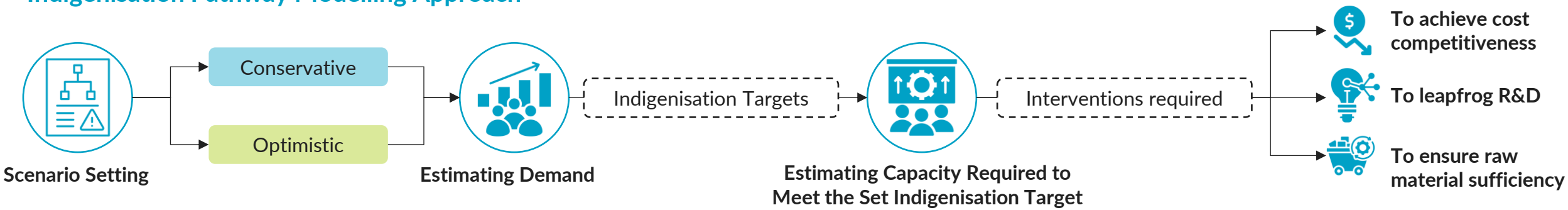
SECTION ONE

SKILLED WORKFORCE DEVELOPMENT PATHWAYS

The cleantech indigenisation pathways have been built on two demand scenarios – conservative and optimistic – to identify potential pathways and key enablers to achieve sectoral indigenisation targets (1/2)

Indigenisation Pathway Modelling Approach

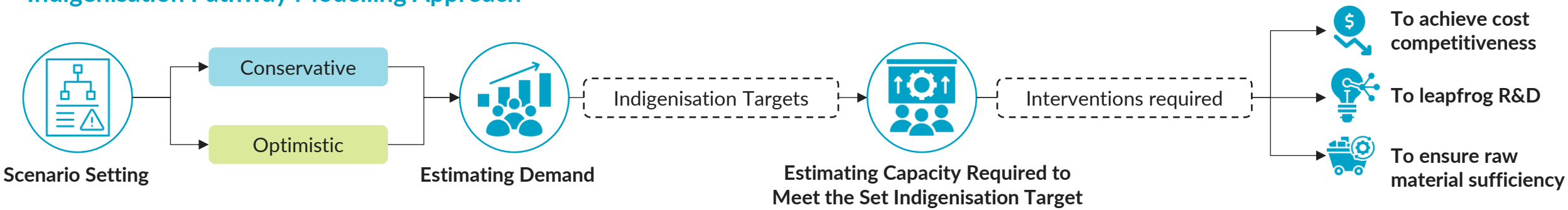


Scenario criteria	CONSERVATIVE SCENARIO			OPTIMISTIC SCENARIO		
	Solar	Wind	Battery	Solar	Wind	Battery
1 Government policy landscape		Upswing in tender activity, top states to meet RAP targets	Extension of ACC PLI and support for implementation		All states meet RAP targets; augmentation of grid at current pace	Extended support to battery manufacturers across value chain
2 Adoption Trajectory	Solar & hybrids meet **70%** of green H_2 energy demand **50%** off-grid & C&I adopt domestic modules	C&I levels expected to increase from current levels	**40 GWh** BESS by 2030 + additional for grid stability; **EV 30@30** to be achieved	Solar & hybrids meet **100%** of green H_2 energy demand **70%** of off-grid & C&I adopt domestic modules	Corporate shift to hybrid power accelerates to meet RE100 by 2030	Coverage of all additional VRE under 2-hour BESS; adoption of E2W/E3W beyond 30@30 goals
3 Export growth	**Africa**: Offer credit to 4 countries on use of Indian modules **US**: Deployment grows at 8% CAGR	**US/Europe/ME & Africa**: Existing share of 15% in global exports to these countries to be maintained		**Africa**: Offer credit to all countries on use of Indian modules **US**: Deployment grows at 10% CAGR	**US/Europe**: Existing share of 15% in global exports to be maintained **ME & Africa**: Increase in total share considered	

Source: MNRE, Physical progress; MNRE, Press release; : ISA, India EXIM bank ; PV Magazine, Industry experts (industry associations; Source: GWEC, Global Wind Report, 2025 report; Ministry of Heavy Industries, PM E-Drive Portal; CEA, National Electricity Plan Vol I; Company announcements; Industry experts; mec+ analysis; Dalberg analysis

The cleantech indigenisation pathways have been built on two demand scenarios – conservative and optimistic – to identify potential pathways and key enablers to achieve sectoral indigenisation targets (2/2)

Indigenisation Pathway Modelling Approach



Scenario criteria	CONSERVATIVE SCENARIO		OPTIMISTIC SCENARIO		
	E-mobility	Green Hydrogen	E-mobility	Green Hydrogen	Transmission
1 Government policy landscape	No additional subsidies on EVs beyond existing subsidies under PM E-DRIVE		Extension of subsidy schemes beyond 2026, especially for 2W, 3W, Bus and Trucks		
2 Adoption Trajectory	Limited TCO[1] and product innovation – overall penetration[2] across vehicle segments expected to reach ~32% by 2030	Fertilizer sector – corresponds to tendered green ammonia capacity Refinery sector – 5% to 15% green H_2 blending in 2027-2030 for refiners with >50KTPA H2 consumption	Charging infra scale up, product innovation and financing mechanisms could enable ~48% penetration by 2030	Fertilizer sector - 100% import substitution of ammonia from 2027 Refinery sector – 5% to 30% green H_2 blending in 2027-2030 for refiners with >50KTPA H2 consumption	*Demand for Transmission sector is **primarily government driven** and estimated to reach **6.5 lakh ckm by 2032***
3 Export growth		**EU, Japan, Singapore, South Korea, UK**: India could capture 10% of this market by 2030		**EU, Japan, Singapore, South Korea, UK**: India could capture 20% of this market	

(1) Total Cost of Ownership; (2) Penetration refers to % share of EVs in total annual vehicle sales; Sources: VAHAN Dashboard ; RMI, Niti Ayog, Harnessing Green Hydrogen, 2022; SECI, Clarification for setting up Production facilities for Green Hydrogen under SIGHT scheme, 2024; Bain, RMI, From Promise to Purchase: Unlocking India's Green Hydrogen Demand, 2025; MoP CEA, National Electricity Plan, Volume II – Transmission, 2024; Company announcements; Industry experts; Dalberg analysis

Workforce requirements were modeled based on the demand and projected capacity additions across the three focus sectors, and segregated by worker skill levels

Approach followed to estimate workforce

1 *Demand Projection*

Projected demand till 2030 for Solar PV Modules, Wind Turbines, and Battery Packs based on conservative, optimistic scenarios

2 *Manufacturing Capacity Estimation*

Estimation of manufacturing capacity required to fulfil 2030 indigenisation targets across value chains

3 *Workforce Estimation*

Projection of workforce required for each skill level across the manufacturing value chain for solar, wind, and battery manufacturing

4 *Cost Calculation*

Estimation of cost requirements for training coursed and infrastructure based on workforce requirements

Skill levels and sources of talent for cleantech manufacturing

Ultra-Skilled

R&D and Innovation Experts

Source: Research labs, PhD/Postgrad programs, Tier-1 engineering institutes

High-Skilled

Engineers & Technical Specialists

Source: Tier-1 and Tier-2 engineering colleges

Low-Skilled

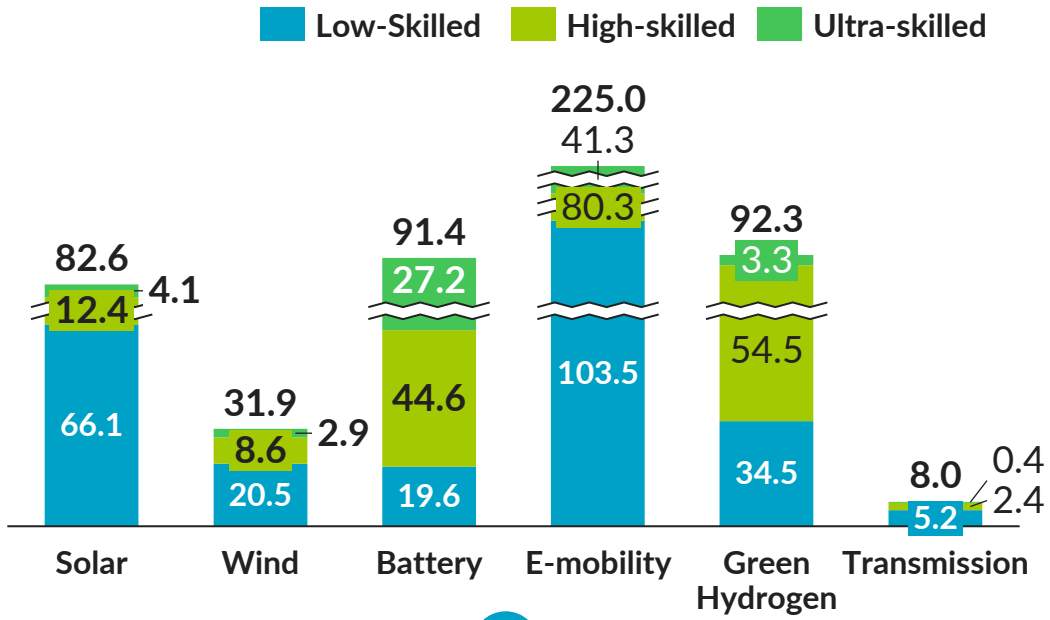
Production line workers

Source: ITIs, vocational training programs

Focused Cleantech sectors could create up to 5.3 lakh incremental jobs by 2030 but would require investments in course and training infrastructure and train the trainer programs

To build a ready workforce, targeted interventions would be required across four critical levers including trainers, course design, employability, finance; with skilling efforts focusing on strengthening industry linkages and global partnerships

Projected additional workforce requirement, '000, by 2030



Total proposed skilling budget[1]

INR 19,300-31,600 Cr

Government Share of Budget[2]

INR 13,000-20,300 Cr

Levers: Trainer · Course Design · Employability · Finance

Focus

1 Ultra-Skilled

- Launch a **National Cleantech Skills Consortium** under MSDE[3] to unify course design, build industry ties, lead cleantech training
- Leverage **NSTI[4] network** to develop and deploy **"Train the Trainer"** programs, for 200 – 300 trainers / academicians / professors from Top 100 engineering colleges[5]
- Leverage **India-EU TTC[6]** and strategic partnerships with Japan, South Korea etc. to enable **overseas immersion** for academicians, faculty and researchers in advanced cleantech manufacturing

2 High-Skilled

- Under MoE[7], **revamp course work** of top 100 engineering institutions, **integrating function-specific cleantech modules** to produce highly skilled talent for R&D and Innovation
- Ensure collaboration between **SSCs[8]** (Power, Electronics, Chemicals etc.) and **industry for curriculum, apprenticeships, demo facilities at ITIs, upskilling courses etc.**

3 Low skilled

- Allocate **15-20% of existing ₹60,000 Cr ITI upgradation budget** under PMKVY (2024-26) to develop industry-aligned cleantech training facilities and certified courses, co-delivered by industry and ITIs
- Launching a **Digital Cleantech Training Platform** – an online learning hub with courses, certification programs, and job-matching services

(1) Total budget covers training costs and demo facility investment; (2) Could be supplemented by Employment Linked Incentive Scheme – incentivizing additional hiring in the manufacturing sector; (3) Ministry of Skill Development and Entrepreneurship; (4) National Skills Training Institute; (5) Applicable for high-skill as well; (6) Trade and Technology Council; (7) Ministry of Education; (8) Sector Skills Councils; Source: PIB, Press Release, 2025;Industry experts (industry associations, key manufacturing players), Dalberg analysis

1 Up to 80,000 ultra-skilled workers could be needed across manufacturing for the 6 cleantech sectors by 2030, sourced from research labs, and Tier 1 engineering and research institutions

Promoting global collaborations via 'train the trainer' programs and attracting global sector experts, launching dedicated master's programs, and developing 'on-the-job' training could help build the ultra-skilled segment of the workforce

Recommendations	Responsible Ministry/Agency
Develop 'Train the Trainer'[1] program to train 200–300 trainers/academicians per cleantech sector from top 100 engineering colleges, with help of leading global trainers via G2G partnerships with academia/industry in EU, Japan, China, Germany, others **Develop Quality Improvement Programs** to facilitate industry aligned skill development for teachers at **Tier 2** and **Tier 3** institutes, especially for sectors with overlaps with conventional technologies – e.g., **EV motors**, **power electronics**	MoE[2], MSDE[3], DGT[4]
Establish COEs in Tier 1 institutes in collaboration with global institutes and industry, especially focused on improving cost-efficiency and accessibility of key cleantech components (**Batteries**, **Transmission systems**, **Wind Turbines**, etc.)	MoE, CSIR
Launch dedicated master's programs for cleantech fields in Tier-1 engineering colleges, along setting up R&D Labs	MoE
Attract cleantech experts from EU, Korea, Japan, China to **train academicians** at Tier 1 engineering institutes (top 25-30)	MSDE, MoE
Establish research fellowships and industry-linked PhD programs with institutions abroad (Germany, China, Korea, Japan etc.) to promote global collaboration and co-development of R&D	MoE, Council of Scientific and Industrial Research
Develop jointly funded industry-government on-the-job training initiatives with global exposure to retain ultra-skilled talent in sectors such as **EVs** and **Battery**	MoE, DGT
Establish a unified national certification framework for the **Transmission sector**, aligned with global transmission skilling standards[5]	Power Sector Skills Council, DGT, MSDE

Total training cost INR 2,300-4,500 Cr + **Total demo facility investment** INR 1,000-1,800 Cr = **Total budget** INR 3,300-6,300 Cr

(1) "Train the Trainer" program is applicable to the high-skilled workforce as well (2) Ministry of Education; (3) Ministry of Skill Development and Entrepreneurship; (4) Directorate General of Training; (5) applicable across skill levels for Transmission sector

2 Up to 2 Lakh high-skilled workers could be needed across manufacturing for the 6 cleantech sectors by 2030, sourced primarily from Tier-1 and Tier-2 engineering institutions and lateral hiring from adjacent industries

A ready high-skilled workforce could be developed through global 'train the trainer' collaborations, launching specialized courses, and strengthening industry-academia links through co-delivery of modules and internships

Recommendations	Responsible Ministry/Agency
Develop 'Train the Trainer'[1] program to train 200–300 trainers/academicians per cleantech sector, from top 100 engineering colleges with help of leading global trainers via (G2G) partnerships with academia, industry in EU, Korea, Japan, China, others	MoE[2], MSDE[3], DGT[4]
Introduce 6-month certification courses or **1-year function-specific specialization courses** for cleantech manufacturing (e.g., EV motors, Cleanroom discipline, HV transmission systems) for Top 100 engineering colleges with setting up of R&D Labs, and integrate standardized clean tech modules (e.g., Green Hydrogen curriculum) in existing BTech/diploma courses **Upgrade existing university-level transmission curriculum** in partnerships with industry (e.g., PowerGrid Corporation of India Litd. (PGCIL), Bharat Heavy Electricals Ltd. (BHEL)) and international institutes (e.g., KTH[2], SuperGrid Institute)	MoE, Industry partners
Strengthen industry-academia collaboration by co-delivery of cleantech manufacturing modules, internships/apprenticeships at manufacturing plants for engineering students – may be government incentivized	MoE, AICTE[5], DGT, Industry Associations and key PSUs[6]
Deploy demonstration and training facilities (e.g., 5-10 kW electrolyser, cell testing, switch gear manufacturing, demonstration facilities co-developed with industry) in top engineering institutions for classrooms and applied learning	MSDE, Tier 1 & 2 Engineering Colleges, Industry Partners, MoE
Upskill high-skilled workers in Wind and Green Hydrogen sectors in quality control, lean manufacturing, and supply chain management	Sector Skill Councils (e.g., Capital Goods, Green Jobs)
Conduct a national skill gap assessment for the **transmission sector**, in partnership with utilities, OEMs and Engineering, Procurement and Construction players (EPCs), and aligned with transmission planning and manufacturing goals	NSDC[7], Power Sector Skill Council

Total training cost INR 1,400-2,600 Cr + **Total demo facility investment** INR 2,600-4,700 Cr = **Total budget** INR 4,000-7,300 Cr

(1) "Train the Trainer" program is applicable to the ultra-skilled workforce as well (2) Ministry of Education; (3) Ministry of Skill Development and Entrepreneurship; (4) Directorate General of Training; (5) All India Council for Technical Education; (6) Public Sector Undertakings; (7) National Skill Development Corporation

Up to 2.5 Lakh low-skilled workers could be needed across manufacturing for the 6 cleantech sectors by 2030, sourced from ITIs, vocational training institutes, and lateral hiring from adjacent industries e.g. automobiles

Development of standardised courses, internships at manufacturing plants, and developing training infrastructure could be key interventions to upskill the low-skill segment of the cleantech manufacturing workforce

Recommendations	Responsible Ministry/Agency
Develop standardized qualification packs, courses and certifications that reflect a superset of competency requirements defined by private sector manufacturers, including short-term 3-6 months skilling programs in manufacturing basics, safety and component assembly through ITIs and NSDC	NCVET[1], DGT[2], Skill Council for Green Jobs, State Skill Missions, MSDE[3], NSDC[4]
Develop demonstration and training facilities at ITIs to enable practical training and familiarization with industry production processes such as **Electrolyzers**[8], **Battery testing facilities**, **smart grid infrastructure**, **HVDC**[9] **infrastructure**, etc.	MSDE, ITIs
Launch a Digital Cleantech Training Platform – an online learning hub with courses, certification programs, and job-matching services	MSDE, ITIs
Promote public-private skilling partnerships (apprenticeship programs using NAPS[7], joint trainings by ITIs and manufacturers, etc.) across cleantech manufacturers and ITIs in proximity	MSDE, DGT, ITIs
Develop modules for retraining workers from adjacent industries – **automobile** (for solar ingots/wafers, EV drivetrains, gear machining), **electronics** (for battery packs, EV Power electronics) or **chemicals** (for CAM/AAM[5])	NCVET, DGT, SCGJ[6], ESSCI[10], ITIs
Establish transmission focused, shared training centers for SMEs under MSME cluster development programs	Ministry of MSMEs, Power Sector Skills Council

Total training cost
INR 4,100-6,600 Cr **+**

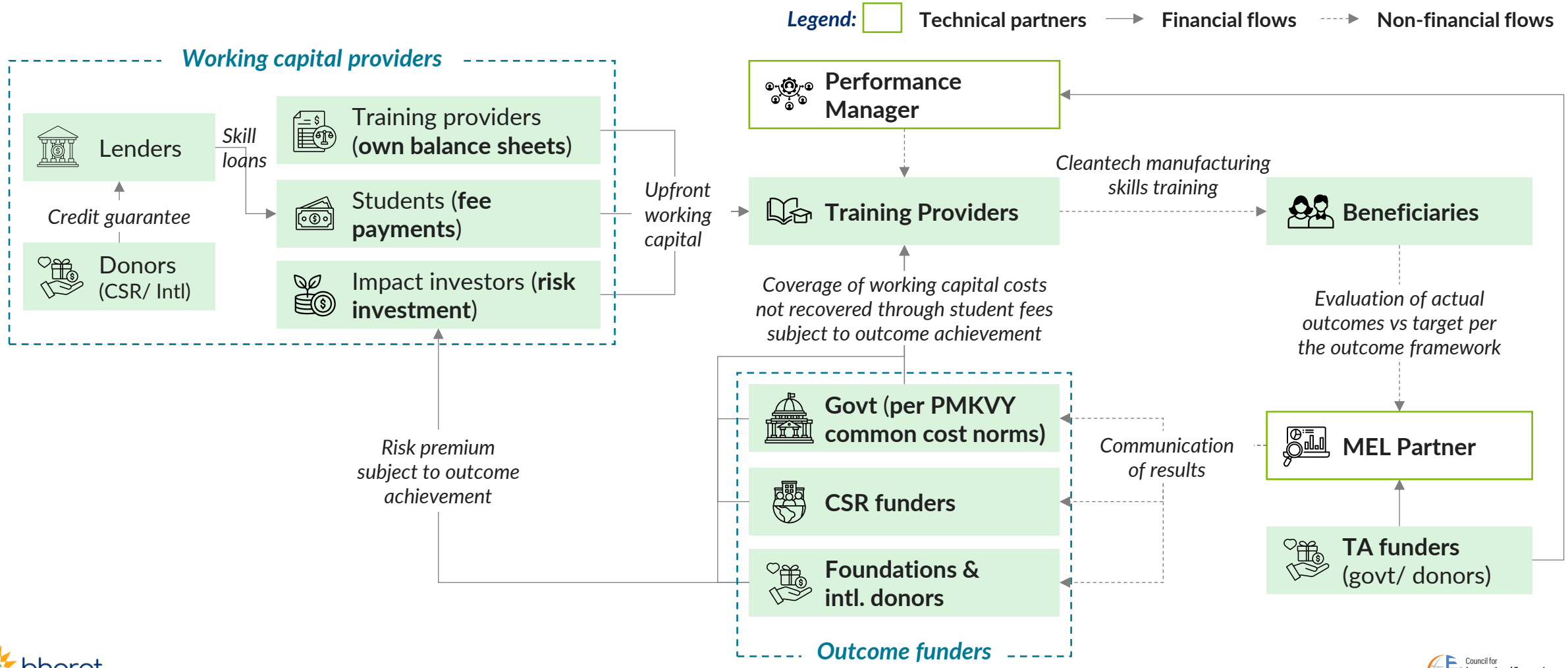
Total demo facility investment
INR 8,000-11,500 Cr **=**

Total budget estimated share of ITI upgradation budget)
INR 12,100-18,100 Cr (20-30%)

(1) National Council for Vocational Education and Training; (2) Directorate General of Training; (3) Ministry of Skill Development and Entrepreneurship; (4) National Skill Development Corporation; (5) Cathode Active Material, Anode Active Material; (6) Skill Council for Green Jobs; (7) National Apprenticeship Promotion Scheme; (8) Applicable across both High and Low Skills for Green Hydrogen, Battery, E-mobility and Transmission sectors; High Voltage Direct Current; (10) Electronics Sector Skills Council

As an additional pathway to support and finance cleantech skilling, aligning incentives through outcome-linked financing could lead to better training quality, industry alignment, and effective use of resources

A Clean Tech Impact Bond and Guarantee backed Income Share Agreement are potential innovative financing structures that may be well suited for promoting Clean Tech Skilling



System wide coordination is critical for long term success of the cleantech skilling ecosystem; a multi-stakeholder consortium under the Platform could institutionalize these efforts at the national level

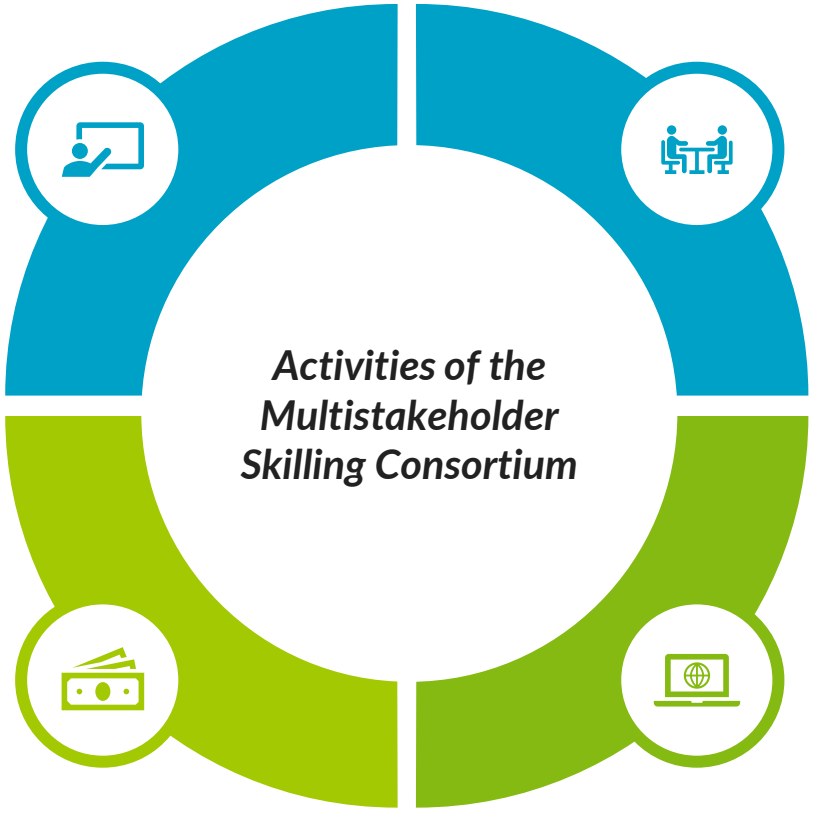
A multi-stakeholder consortium could help align stakeholders on shared priorities, ensure resources are deployed where most needed, and embed feedback loops between employers, training providers, and policymakers

Curriculum & Training

- *Recommending curriculum updates, additions aligned with demand*
- *Strengthening trainer capacity for updated courses*
- *Setting up dedicated labs and workshops for advanced technologies (e.g., green hydrogen)*

Financing

- *Identifying innovative financing model(s) to crowd in co-funding building on the template created through the Skill Impact Bond*
- *Unlocking student co-funding through skill loans unlocked via the Credit Guarantee Facility Scheme for Skill Development (CGFSD)*



Industry Demand Alignment

- *Active engagement with industry partners through SSCs*
- *Integrating Formal On Job Training (OJT) into course design leveraging NAPS*
- *Establishing linkages with long-term placement opportunities post apprenticeship/ OJT via NAPS*

Governance and Infrastructure

- *Developing unified end-to-end data dashboards building on the Skill India Digital Hub (SIDH) and JobX platforms developed by NSDC*
- *Guide national and state-level policy integration with cleantech workforce priorities*

SECTION TWO

ANNEX: SECTORAL SKILLED WORKFORCE DEEP DIVES

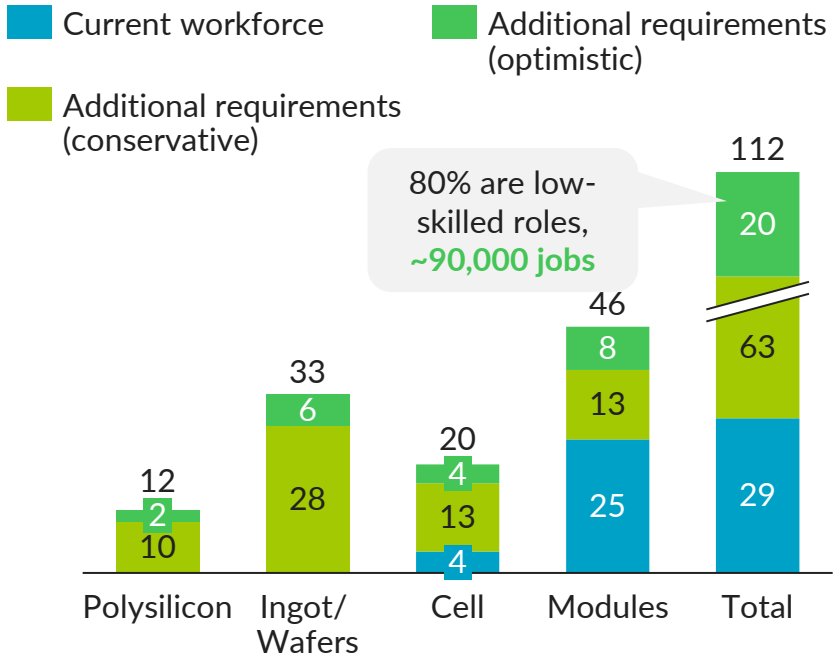
SECTION FIVE, SUB-SECTION A

SOLAR INDIGENISATION PATHWAYS

India would require up to 90,000 low-skilled workers across solar manufacturing by 2030, who could be trained with 8-12% of ITI upgradation budget

Workforce for cell manufacturing will be priority to prepare for upcoming production. Further, a higher focus would be required for training ultra-skilled R&D talent as majority of lower-skill workforce could also be hired from adjacent industries[1]

Current and projected (2030) workforce requirement for solar manufacturing value chain, in '000



Skill levels and sources of talent for solar manufacturing

Focus

Ultra-skilled — **R&D and Innovation Experts**
Research labs, PhD/Postgrad programs, Tier-1 engineering institutes

High-skilled — **Engineers & Technical Specialists**
Tier-1 and Tier-2 engineering colleges

Low-Skilled — **Production line workers**
ITIs, vocational training programs

Industry insight[3]

Cells:
- **Shortage of high-skilled workers** who can meet cleanroom and process discipline and **ultra-skilled workforce** for R&D in cell technology

Ingots/Wafers:
- Potential to hire from adjacent industries like **automotive and mechanical** industries

Polysilicon:
- Potential to hire from adjacent industries like **petrochemical** industry

Total training cost[2]
INR 2,000-2,700 Cr

+

Total demo facility investment[3]
INR 3,000-4,500 Cr

=

Total budget (estimated share of ITI upgradation budget[4])
INR 5,000-7,200 Cr (~8-12%)

(1) Assumption: Current workforce for polysilicon, ingot, and wafer assumed to be zero as no domestic capacity yet; (2). Training cost for additional low-skill workers required; (3) Assumption: 2–3 ITIs tagged to each manufacturing plant (total 25 plants today; assuming 20% new plants will come up by 2030 to total of 30 plants); (4) Solar glass industry could benefit from ITI skilling programs but could also cross-hire from broader glass workforce, thus, excluded from current investment estimation

Source: Industry experts (industry associations, key manufacturing players), Dalberg analysis

To successfully build this workforce, action would be required across four critical levers: reducing foreign trainer dependency, standardizing training, improving employability and securing financing

LEVERS	CURRENT STATUS	RECOMMENDATIONS
Trainers	Dependent on foreign trainers for capital machinery set up, especially for upstream manufacturing	• **Launch a 'Train the Trainer' program** for professors and academicians at Tier-1 engineering colleges, with overseas immersion in advanced solar manufacturing hubs like EU, Korea, Japan, China
Course Design	Varied training approaches and modules across different industry players	• **Standardise qualification packs and courses** through collaboration with industry, academia • **Expand initiatives like Suryamitra** to include manufacturing training • **Utilize R&D infrastructure**[1] to train ultra-skilled workforce
Employability	Employability impacted due to limited manufacturing job-ready skills for graduates from ITIs, engineering colleges	• **Co-delivery of cleantech manufacturing modules by academia and industry** • **Internships and apprenticeships** at manufacturing facilities for engineering students, can help reduce retraining costs for manufacturers
Finance	Disaggregated investment in manufacturing skills – either directly at ITI level or manufacturer-led on-the-job training	• Invest INR 4,800-7,000 Cr for training and demonstration facility set up through **innovative financing instruments** (e.g., skill bonds) • Catalyze private sector investments in skilling, **CSR and private foundation** funding for ultra-skilled talent development and ITI investments

(1) As per recommendations for R&D infrastructure upgrade in R&D section, leveraging the upgraded infrastructure for training is imperative

Source: Industry experts (industry associations, key manufacturing players)

Skilling efforts for solar manufacturing across skill levels could focus on strengthening industry linkages and global partnerships, along with offering specialized courses in engineering colleges and ITIs

Skill level	Recommendations	Responsible Ministry/Agency
Ultra-Skilled	• **Develop 'Train the Trainer'[1] program** to train 200–300 trainers/academicians/professors from Top 100 engineering colleges with the help of 25 leading global trainers through government-to-government (G2G) partnerships with academia and industry in countries such as EU, Korea, Japan, China	Ministry of Education, Ministry of Skill Development and Entrepreneurship (MSDE), Directorate General of Training (DGT)
	• **Attract solar/cleantech experts** from the EU, Korea, Japan, China to **train academicians and professors** at Tier 1 Engineering colleges (top 25-30)	MSDE, Ministry of Education
	• **Establish research fellowships and industry-linked PhD programs with institutions abroad** (Germany, China, Korea, Japan etc.) on solar R&D for 500-600 researchers per year	Ministry of Education
High-Skilled	• **Introduce specialized courses specifically for clean tech manufacturing** for Top 100 engineering colleges	Ministry of Education
	• **Strengthen industry-academia** by co-delivery of cleantech manufacturing modules, and internships at manufacturing plants for engineering students	Ministry of Education
Low-skilled	• **Develop standardized qualification packs and courses** that reflect a superset of competency requirements defined by private sector manufacturers	National Council for Vocational Education and Training, DGT, Skill Council for Green Jobs
	• **Repurpose 8-12% of the ITI upgradation scheme** to promote public-private skilling partnerships (apprenticeship programs using NAPS, joint trainings by ITIs and manufacturers) between 15 solar manufacturers and ITIs in proximity (total of 60-90 ITIs)	MSDE, DGT, ITIs
	• **Launch a Digital Cleantech Training Platform** – an online learning hub with courses, certification programs, and job-matching services	MSDE, ITIs

(1) The "Train and Trainer" program is applicable to the high-skilled workforce as well

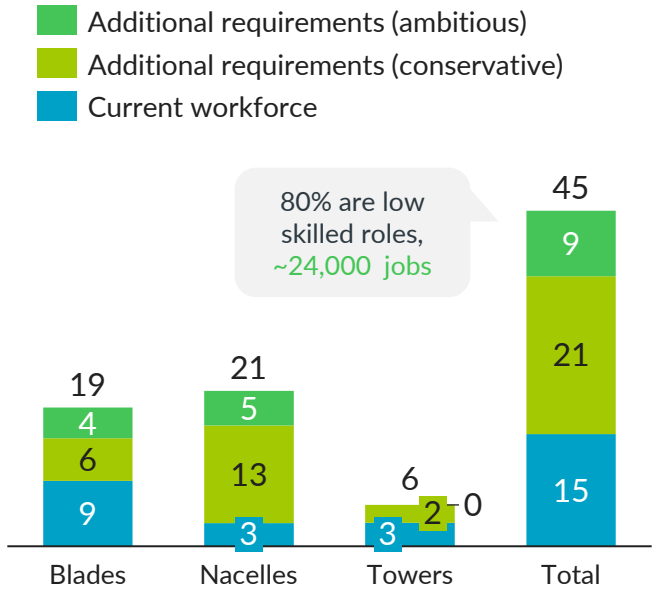
SECTION FIVE, SUB-SECTION B

WIND INDIGENISATION PATHWAYS

India would require an additional 24,000 low skilled workers across wind manufacturing by 2030, who could be trained with ~4-5% of ITI upgradation budget

Workforce efforts should target nacelle components—gearboxes, generators, control systems and other nacelle components—where local content lags blades (85% local content) and towers (100% local content)

Current and projected (2030) workforce requirement for wind manufacturing value chain, in '000



Skill level and sources of talent for wind manufacturing

Focus

Ultra-skilled

R&D and digital Innovation experts

Research labs, PhD/Postgrad, programs, Tier-1 engineering and technical institutes

High-skilled

Engineers & component specialists

Tier-1 and Tier-2 engineering colleges, lateral hires from automotive/aerospace sector

Low-skilled

Production line workers

ITIs, vocational training programs

Industry insight

Nacelles components- power electronics

- **Shortage of ultra-skilled workers** for R&D to developing IP-protected converters and controllers. India lacks manufacturing capability for these critical components

Shortage of skilled workers

- Manufacturers report a **severe worker shortage (skilled engineers, technicians)**, forcing them to overspend on talent and reducing overall operational efficiency

Lack of training in institutes

- India's training institutes **lack the capacity and quality** to prepare skilled workers for the wind energy sector. Subpar programs and limited subsidies deepen the shortage of workforce

Total training cost[1]
INR 480-880 Cr

+

Total demo facility investment[2]
INR 2,100-2,220 Cr

Total budget (estimated share of ITI upgradation budget)[3]
INR 2,580-3,100 Cr (~4-5%)

Note- (1). Training cost for additional low-skill workers required; (2) Assumption: 2–3 ITIs tagged to each manufacturing plant (total 16 plants today; assuming 20% new plants will come up by 2030 to total of 18 plants); (3) Wind turbine industry could benefit from ITI skilling programs but could also cross-hire from competitive industry, thus, excluded from current investment estimation

Source: CEEW; Global Wind Workforce outlook; NRDC; IRENA; EU Workforce skill gap; GE 2006; MEC+ Analysis

To successfully build this workforce, action would be required across four key levers; education and training system, industry participation, policy and incentives and research and certification

LEVERS	CURRENT STATUS	RECOMMENDATIONS
Education & Training System	• Limited programs focused on renewable energy manufacturing • Lack of applied research in turbine tech • Limited industry exposure in engineering and vocational programs	• Develop wind-specific curriculum with industry partnerships; Integrate wind tech modules in engineering, diploma and ITI programs • **Incentivize joint R&D projects in partnerships with industry**; establish wind energy centers of excellence in technical universities • Launch a "Train the trainer" program for professors and academicians at Tier 1 Engineering colleges and ITI centres with wind manufacturing specific programs
Industry Participation	• Inconsistent engagement of OEMs in skilling efforts • Few structured apprenticeship or upskilling models.	• **Co-develop training curricula** with OEMs and suppliers • Create government-incentivized apprenticeships and in-factory training programs
Policy & Incentives	• Skill policies exist but lack focus on green manufacturing • Weak enforcement of local employment/training mandates	• Align industrial and skill policies to support local wind manufacturing • **Link subsidies and clearances to local workforce development targets**
Research & Certification	• Minimal R&D for advanced turbine tech locally • Lack of standardized certification pathways for wind-related roles.	• **Fund R&D through national centers of excellence in wind tech** • Establish national certification frameworks aligned with global wind industry standards.

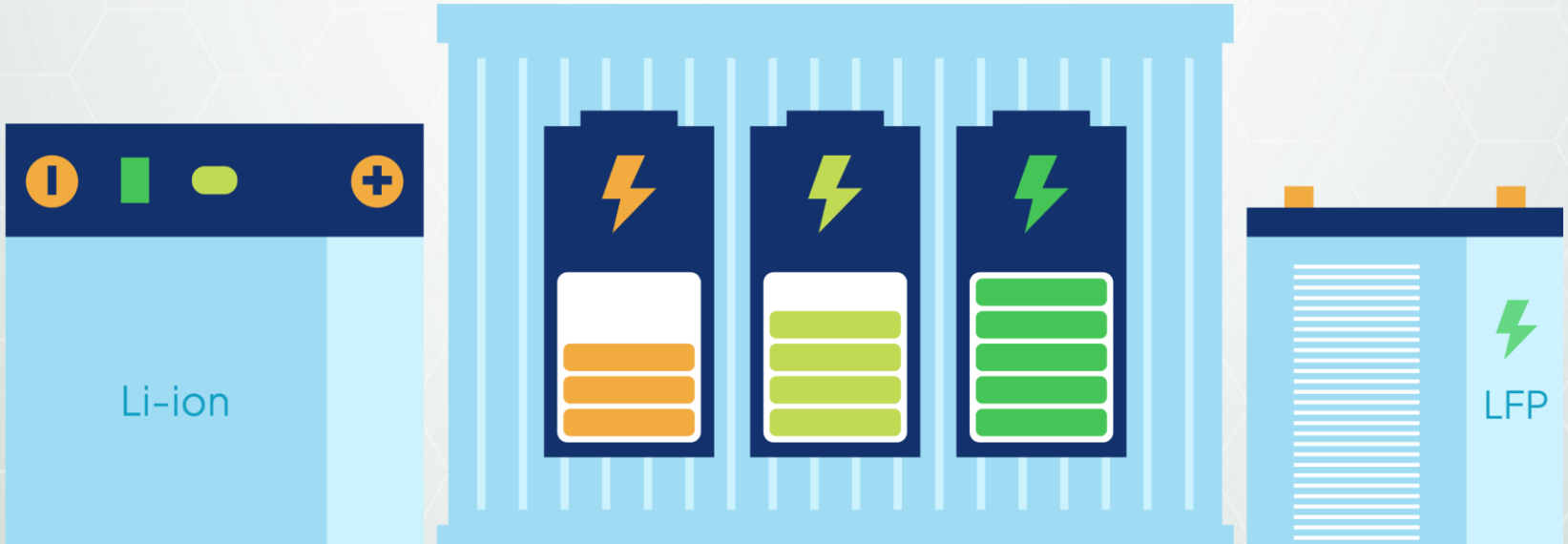
Source: CEEW; Global Wind Workforce outlook; NRDC; IRENA; EU Workforce skill gap; GE 2006; MEC+ Analysis

Skilling efforts for wind manufacturing across skill levels could focus on strengthening industry linkages and global partnerships, along with offering specialized courses in engineering colleges and ITI's

Skill level	Recommendations	Responsible Ministry/Agency
Ultra-skilled	• **Fund PhD/Postdoc research in advanced materials, blade design, and control systems** to make wind turbines more efficient	Ministry of New and Renewable Energy (MNRE)
	• **Promote global research collaboration**, for more comprehensive research. This could be done by relax visa restrictions on foreign technicians	Council of Scientific and Industrial Research (CSIR)
	• **Establish Centers of Excellence in wind tech**, especially focused on making wind turbines more cost-efficient and accessible	Ministry of Education (MoE)
High-skilled	• **Develop wind energy modules in BTech/diploma courses** or add a course for specialization in Renewable Energy	Ministry of Skill Development & Entrepreneurship (MSDE)
	• **Promote industry internships** and project-based learning	All India Council for Technical Education (AICTE)
	• **Upskill in quality control**, lean manufacturing, and supply chain	Sector Skill Councils (e.g., Capital Goods, Green Jobs SSC)
Low-skilled	• **Run short-term skilling programs (3–6 months) in manufacturing basics**, safety, and turbine assembly	MSDE, National Skill Development Corporation (NSDC)
	• **Enable on-the-job training with local OEMs**, to speed up manufacturing/ commissioning process	Directorate General of Training (DGT)
	• **Offer certifications through ITIs and NSDC programs**	State Skill Missions

SECTION FIVE, SUB-SECTION C

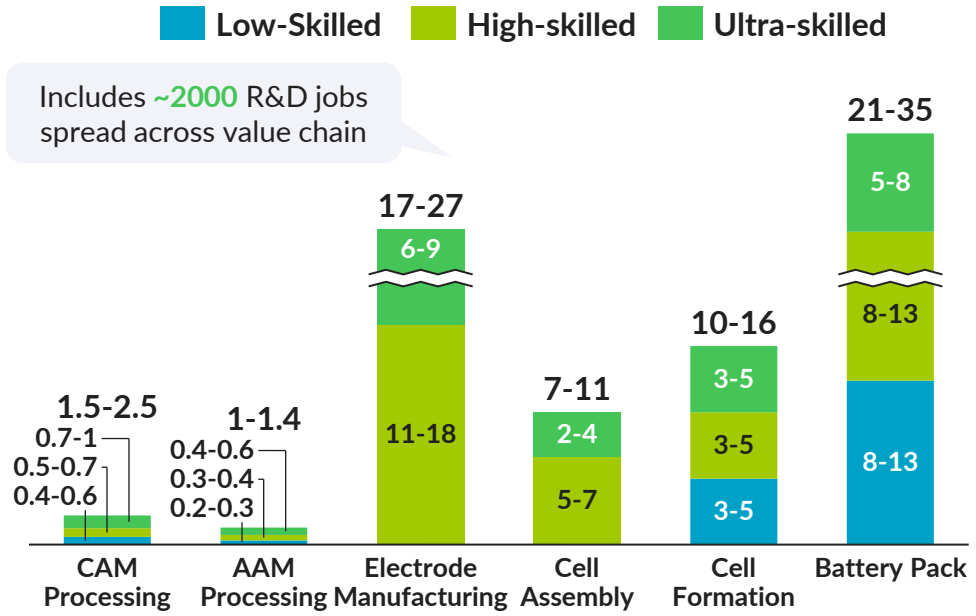
BATTERY INDIGENISATION PATHWAYS



India would require 58,000-91,000 additional ultra, high, and low-skilled workers across battery manufacturing value chain by 2030; low skilled workers could be trained with <1% of ITI upgradation budget

Training of Ultra and High-Skilled workforce critical for developing battery manufacturing ecosystem in India; lower-skill workforce primarily needed in pack manufacturing, which could also be hired from adjacent industries[1]

Projected (2030) additional workforce requirement for battery manufacturing value chain, in '000



Skill levels and sources of talent for battery manufacturing

Focus

Ultra-skilled — **R&D & Innovation Experts**
Research labs, PhD/Post-graduate programs, Tier-1 engineering institutes

High-skilled — **Engineers & Technical Specialists**
Tier-1 and Tier-2 engineering colleges

Low-Skilled — **Production line workers**
ITIs, vocational training programs

Industry insights

Battery Pack:
- Potential to hire from adjacent industries like **automotive and electronics** industries

Battery Cells:
- **No adjacent industries,** requirement for **high skilled workers** who meet clean room, process discipline for manufacturing

CAM/AAM Processing:
- Potential to hire from adjacent industries like **chemicals** industry

Total training cost[1] INR 1000-2000 Cr + **Total demo facility investment[2]** INR 3000-5500 Cr = **Total budget** INR 4000-7500 Cr

Includes **INR 100-200 Cr** for Low-skilled workers (<1% of ITI upgradation budget)

(1) Training cost for additional workers required across skill levels; (2) R&D and demonstration facilities across ITIs and top 100 engineering institutes
Source: Industry experts (industry associations, key manufacturing players), Dalberg analysis

Action would be required across four critical levers to successfully build this workforce: reducing foreign trainer dependency, standardizing course design, improving employability and securing financing

Applicability: Ultra-skilled, High-skilled, Low-skilled

LEVERS	CURRENT STATUS	APPLICABILITY	RECOMMENDATIONS
Trainers	Dependent on foreign trainers for capital machinery set up	Ultra-skilled, High-skilled, Low-skilled	• **Launch a 'Train the Trainer' program** for professors and academicians at Tier-1 engineering colleges, with overseas immersion in advanced battery manufacturing hubs like EU, Korea, Japan, China
Course Design	Varied training approaches and modules across different industry players	Ultra-skilled, High-skilled Low-skilled	• **Develop dedicated Masters programs** and **Certification and Specialization** courses for ultra and high-skilled workers respectively • **Standardise qualification packs, courses and training modules** through collaboration with industry, academia for low skill workers
Employability	Employability impacted due to limited manufacturing job-ready skills for graduates from ITIs, engineering colleges	Ultra-skilled, High-skilled Ultra-skilled, High-skilled Low-skilled	• **Setting up R&D infrastructure, live demo plants** and access to industry R&D facilities for engineering students • **Live internships** and **on-the-job training** through jointly funded industry-government partnerships • **Apprenticeships** at manufacturing facilities for low-skill workers
Finance	Disaggregated investment in manufacturing skills – either directly at ITI level or manufacturer-led on-the-job training	Ultra-skilled, High-skilled, Low-skilled Ultra-skilled, High-skilled, Low-skilled	• Invest INR 4000-7500 Cr for training programs and demonstration facilities and R&D labs across skill levels through **innovative financing instruments** (e.g., skill bonds) • Catalyze private sector investments in skilling, **CSR and private foundation** funding for ultra-skilled talent development and ITI investments

(1) As per recommendations for R&D infrastructure upgrade in R&D section, leveraging the upgraded infrastructure for training is imperative
Source: Industry experts (industry associations, key manufacturing players)

Skilling efforts for battery manufacturing across skill levels could focus on strengthening industry linkages and global partnerships, along with offering specialized courses in engineering colleges and ITIs

Skill level	Recommendations	Responsible Ministry/Agency
Ultra-Skilled	• **Develop 'Train the Trainer'[1] program** to train 200–300 trainers/academicians from top 100 engineering colleges with help of 25 leading global trainers via government-to-government (G2G) partnerships with academia, industry in EU, Korea, Japan, China, others	Ministry of Education, Ministry of Skill Development and Entrepreneurship (MSDE), Directorate General of Training (DGT)
	• **Attract battery/cleantech experts** from the EU, Korea, Japan, China to **train academicians and professors** at Tier 1 Engineering colleges (top 25-30)	MSDE, Ministry of Education
	• **Launch dedicated master's programs** on battery technology in tier 1 Engineering colleges along with setting up R&D Labs	Ministry of Education
	• Develop jointly funded **industry-government on-the-job training initiatives** with global exposure to retain talent in India	Ministry of Education, DGT
High-Skilled	• **Introduce 6-month certification courses** or **1-year specialization courses** for battery manufacturing for Top 100 engineering colleges with setting up of R&D Labs	Ministry of Education
	• **Strengthen industry-academia** by co-delivery of cleantech manufacturing modules, and internships at manufacturing plants for engineering students	Ministry of Education
Low-skilled	• **Develop standardized qualification packs and courses** that reflect a superset of competency requirements defined by private sector manufacturers	National Council for Vocational Education and Training, DGT, Skill Council for Green Jobs, Electronics Sector Skills Council of India
	• **Repurpose <1% of the ITI upgradation scheme** to promote public-private skilling partnerships (apprenticeship programs using NAPS, joint trainings by ITIs and manufacturers) between battery manufacturers and ITIs (total 40-50 ITIs)	MSDE, DGT, ITIs
	• **Develop modules for retraining** workers from adjacent industries like automobile, electronics (for pack), chemicals (for CAM/AAM)	NCVET, DGT, SCGJ, ESSCI, ITIs

(1) The "Train and Trainer" program is applicable to the high-skilled workforce as well

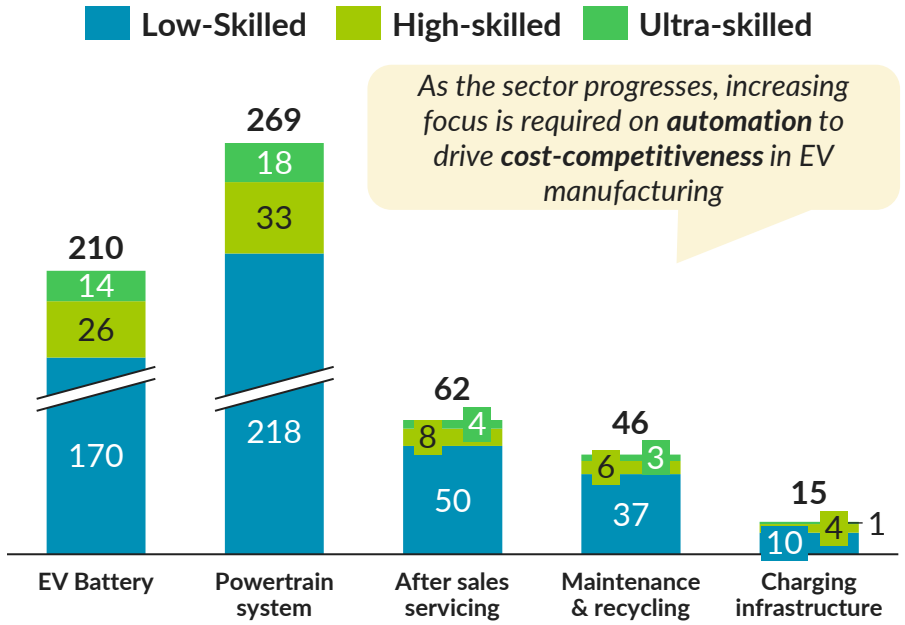
SECTION FIVE, SUB-SECTION D

E-MOBILITY INDIGENISATION PATHWAYS

India would require at least ~6 lakh additional ultra, high, and low-skilled workers[1] across EV manufacturing value chain by 2030

India would need ~25K permanent EV ready talent per year across Ultra, High and Low Skilled workforce by 2030 to achieve >50% indigenisation targets; separately 2/3rds of total workforce would be comprised of temporary low skilled workers

Projected (2030) additional workforce requirement for EV manufacturing value chain, in '000 workers



Skill levels and sources of talent for EV manufacturing

Focus

Ultra-skilled — **R&D & Innovation Experts**
Research labs, PhD/Post-graduate programs, Tier-1 engineering institutes

High-skilled — **Engineers & Technical Specialists**
Tier-1 and Tier-2 engineering colleges

Low-Skilled[2] — **Production line workers**
ITIs, vocational training programs

Industry insights

EV Battery:
- Significant need of technicians for assembly/testing and engineers for electrochemistry & thermal management

Powertrain:
- Requires mix of technicians for build and engineers for motor/inverter design
- Regen braking: Primarily engineer-heavy with skills focused on electronics and integration

Maintenance & recycling
- Primarily requires technicians for dismantling, engineers for recovery, plus ultra skills for circular systems.

Total training cost[3]
INR 4,300-7,900 Cr

+

Total demo facility investment[4]
INR 3,000-5,000 Cr

=

Total budget
INR 7,300-12,900 Cr

Includes 1,000 ITI upgradation expenses

(1) Includes both direct and indirect workers; (2) Low skill workers includes temporary/contract workers; (3) Training cost for additional workers required across skill levels; (4) R&D and demonstration facilities across ITIs and top 100 engineering institutes
Source: SIAM, EV Talent Landscape in India: Bridging the Skill Gap for 2030, 2025; Industry experts (industry associations, key manufacturing players), Dalberg analysis

Nearly a third of the talent gap for EV would have a high overlap with ICE competencies & skills and therefore, won't require either fresh hiring or re-skilling and can be supplemented with on the job training/shadowing

Roles with partial skill overlap with ICE vehicle skills can be addressed through reskilling using virtual instructors and simulations, while roles with minimal overlap and will require fresh skilling programs and certifications

High overlap *Medium overlap* *Some overlap*

Area	Functional Focus	Overlap with ICE/other industries
Battery	Software – Design, product assembly and end of line, testing and validation	Only BMS, HV validation have no ICE equivalent.
	Mechanical design, process setup, simulation, integration, certification & sourcing	Some overlap with ICE in mechanical design and testing, but BMS integration and HV compliance are new.
	Cell assessment, systems & product selection, mechanical- product development, electrical simulation, electrical design, BMS hardware	New competencies in cell chemistry and battery control electronics.
Powertrain System	Powertrain mechanics, quality control & testing	Significant overlap with ICE (gear machining, assembly, QC).
	Systems design	Overlaps in drivetrain layout, but EV motor–inverter design is new.
	Power train electricals, power electronics, thermal design	Power electronics and HV thermal mgmt are new vs ICE.
Regenerative Braking	Drivetrain design	Overlap with ICE drivetrains, but energy recovery integration is new.
	Vehicle dynamics modeling, direct drive applications	EV torque-vectoring/direct drive systems have little ICE precedent.
	Power electronics	No direct ICE analogue; requires new skills.
After-sales Servicing	Servicing – mechanics, quality & inspection, testing and validation	Strong overlap with ICE workshops; EV adds HV safety.
	Servicing – electricals,, battery safety, operating digital interfaces	ICE experience in diagnostics overlaps partly; EV battery safety is new.
Maintenance & Recycling	Product assembly and end of line, mechanical – simulation	Overlap with ICE dismantling/testing, but HV/materials recovery new.
	Product management	General mgmt skills overlap, but EV lifecycle planning is distinct.
	Diagnostic battery management, electrical simulation	No ICE equivalent; unique to EVs.

Source: SIAM, EV Talent Landscape in India: Bridging the Skill Gap for 2030, 2025; Industry experts (industry associations, key manufacturing players), Dalberg analysis

Compared to EV manufacturing, charging infrastructure has far fewer overlaps with ICE, making the ecosystem far more dependent on fresh skilling.

While civil works, wiring, basic O&M skills can be adapted from existing trades, the majority will require fresh skilling in power electronics, grid integration, and compliance

◕ *High overlap* ◑ *Medium overlap* ◔ *Some overlap*

Area	Functional Focus	Overlap with ICE
Manufacturing & Assembly	Cabinet fabrication, connectors, enclosures; integration of power modules	◕ Mechanical fabrication overlaps with ICE suppliers, but EVSE-specific power electronics and safety standards are new.
Installation & Commissioning	Civil works, site prep, electrical wiring, meter integration, utility interfacing	◕ Civil/electrical work overlaps with ICE infra projects, but HV-DC wiring and smart metering are new.
Operations & Maintenance (O&M)	Preventive maintenance, field servicing, remote monitoring, firmware updates	◑ Basic O&M overlaps with ICE fueling infra; EVSE diagnostics and digital monitoring are new.
Testing & Certification	Safety compliance, EMI/EMC, interoperability testing, calibration	◑ ICE has emissions/mechanical testing, but EVSE requires new standards for interoperability and electrical safety.
Program & Ecosystem Management	Grid integration, load balancing, planning, policy & regulatory management	◔ Minimal ICE precedent; EV requires new skills in power systems, regulation, and utility coordination.

Source: TERI, EV Charging in India: Ecosystem Perspectives and Skilling Opportunities, 2025; Industry experts (industry associations, key manufacturing players), Dalberg analysis

Action would be required across four critical levers to successfully build this workforce: reducing foreign trainer dependency, standardizing course design, improving employability and securing financing

LEVERS	CURRENT STATUS	APPLICABILITY	RECOMMENDATIONS
			Applicability: Ultra-skilled High-skilled Low-skilled
Trainers	Limited pool of EV-ready trainers; some pilots (like DGT–Shell) are creating a nucleus of master trainers.		• **Build 'Train the Trainer' pipelines** with tiered specialization (technician, engineer, ultra-skill profiles) supported by standardized toolkits and regular industry immersion programs with OEMs (Tata, Mahindra, Ola Electric) and Tier-1 suppliers (Bosch, Continental)
Course Design	Initial EV modules (90–240h) exist in ITIs/ASDC curricula, but often lack depth and alignment with industry standards		• **Develop modular, stackable skilling pathways** — short-term certifications for technicians, diplomas for engineers, and advanced Master's programs for ultra-specialists in batteries, power electronics, and recycling • **Setting up R&D infrastructure, live demo plants** and access to industry R&D facilities for engineering students • **Embed hands-on labs/demo facilities** within curricula and align programs with ASDC/NSDC frameworks for national recognition and portability. • **Upgrade training labs and existing course structures** (at undergraduate and graduate levels) to align with latest industry developments
Employability	Placement linkages remain weak; many trained candidates are not absorbed due to skill mismatches.		• **Live internships** and **on-the-job training** through jointly funded industry-government partnerships • **Link skilling to apprenticeships and placement pipelines**, ensuring job-readiness through mandatory industry-based assessments.
Finance	Disaggregated investment in manufacturing skills – either directly at ITI level or manufacturer-led on-the-job training		• Invest **INR 6,500-11,500 Cr** for training programs and demonstration facilities and R&D labs across skill levels through **innovative financing instruments** (e.g., skill bonds) • Catalyze private sector investments in skilling, **CSR and private foundation** funding for ultra-skilled talent development and ITI investments

(1) As per recommendations for R&D infrastructure upgrade in R&D section, leveraging the upgraded infrastructure for training is imperative
Source: Industry experts (industry associations, key manufacturing players)

Skilling efforts for EV manufacturing across skill levels could focus on strengthening industry linkages and global partnerships, along with offering specialized courses in engineering colleges and ITIs

Skill level	Recommendations	Responsible Ministry/Agency
Ultra-Skilled	• **Develop 'Train the Trainer'[1] program** to train 200–300 trainers/academicians from top 100 engineering colleges with help global trainers via G2G partnerships and create domestic Centres of Excellence in batteries, power electronics, and recycling • **Develop Quality Improvement Programs** on similar lines to facilitate industry aligned skill development for teachers and trainers at **Tier 2** and **Tier 3 institutes**	Ministry of Education, Ministry of Skill Development and Entrepreneurship (MSDE), Directorate General of Training (DGT)
	• **Attract EV experts** from the Global OEMs (EU, Korea, Japan, China) to **train academicians and professors** at Tier 1 Engineering colleges (top 25-30)	MSDE, Ministry of Education
	• **Launch dedicated master's programs** that blend technical skills with policy & regulatory skilling (safety, interoperability, grid integration)in tier 1 Engineering colleges	Ministry of Education
	• Develop jointly funded **industry-government on-the-job training initiatives** with global exposure to retain talent in India	Ministry of Education, DGT
High-Skilled	• **Introduce 6-month certification courses** or **1-year function specific courses** (BMS, motor design, powertrain testing), backed by simulation-heavy learning (digital twins, HIL rigs) and joint faculty–industry projects	Ministry of Education
	• **Strengthen industry-academia** by co-delivery of cleantech manufacturing modules, and internships at manufacturing plants for engineering students	Ministry of Education
Low-skilled	• **Develop standardized qualification packs and courses** (HV-safe technician, battery service associate) that reflect a superset of competency requirements defined by private sector manufacturers	National Council for Vocational Education and Training, DGT, Skill Council for Green Jobs, Electronics Sector Skills Council of India
	• **Develop targeted reskilling modules to transition workers from adjacent** industries — e.g., automobile mechanics for EV servicing and powertrain assembly, electronics technicians for battery pack assembly and BMS, and chemical/process engineers for cathode/anode material manufacturing	NCVET, DGT, SCGJ, ESSCI, ITIs

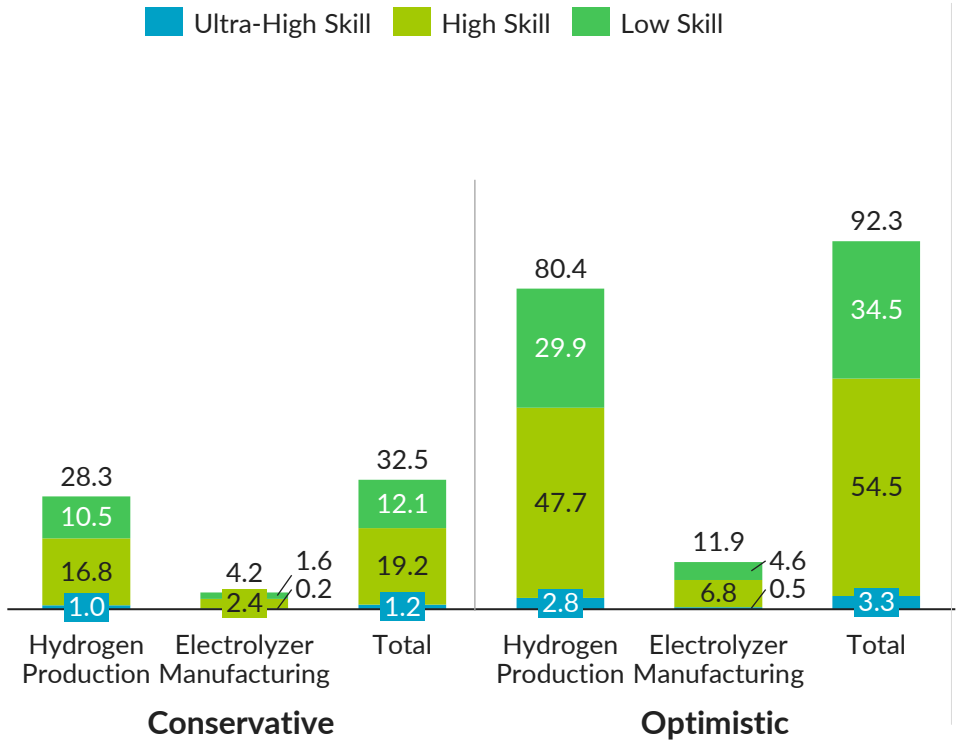
(1) The "Train and Trainer" program is applicable to the high-skilled workforce as well

SECTION FIVE, SUB-SECTION E

GREEN HYDROGEN INDIGENISATION PATHWAYS

India would require a direct workforce of ~33,000 - 92,000 by 2030 who would need to be trained by through specialised green hydrogen courses and interventions

Projected (2030) direct workforce for green hydrogen production & manufacturing electrolyser value chain, '000



Skill levels and sources of talent for GH2 manufacturing

Ultra-skilled

Leadership & R&D Experts

PhD/Post-graduate programs, Tier-1 engineering institutes & labs, experienced professionals

High-skilled

Engineers & Technical Specialists

Tier-1 and Tier-2 engineering colleges

Low-Skilled

Technicians, O&M

ITIs, vocational training programs

Industry insights

- Hiring potential from **adjacent industries**
  - Thermal Power sector (O&M)
  - Chemicals / Fertilisers
  - Oil & Gas - refineries, gas transport (Safety, Process, etc.)
  - Heavy Engineering/Manufacturing
  - **Reskilling/upskilling** will be required for ~80-100% of the workforce needed (L3 – L8)
- **Indirect jobs** projections for green hydrogen production and electrolyser manufacturing range from 1.05 lakhs – 3.01 lakhs[3] (~3.3x indirect job multiplier)

Total training cost[1]
212 - 537 Cr

+

Total demo facility investment[2]
INR 7.8 Cr

=

Total budget
INR 219 - 545 Cr

Includes **INR 160 – 455 Cr** for Low-skilled workers (<1% of ITI upgradation budget)

Note: 1. Training cost includes NGHM skilling budget, skilling low-skill workers at ITIs and 6% of ultra-high skill workers through CSIR fellowships (Assumed a 6% acceptance rate for CSIR fellowships) TimesofIndia, 2. 5-10 kW demonstration facilities for skilling across 60 Hub ITIs (2 electrolyser facilities/state) + 20 top non – IIT engineering colleges, 3. Assuming 85% of the total capacity will be achieved through domestic electrolysers; 3.49x Multiplier (Hydrogen Production), 1.75x Multiplier (Electrolyser Manufacturing) Source: SSCGJ - Green Hydrogen Skills Gap Report; Hindustan Times; Skill Outlook; Industry experts; Dalberg analysis

Efforts across skill levels could focus on strengthening industry linkages and global partnerships, along with offering specialised courses in engineering colleges and ITIs

Levers: Trainer & Curriculum; Industry Participation; Infrastructure; R&D

Skill level	Recommendations	Responsible Ministry/Agency
Ultra-skilled	Develop 'Train the Trainer'[1] program to train trainers and professors from Tier-1 & 2 engineering institutes through local and global (Germany, Denmark, Netherlands) partnerships with academia and industry	Ministry of Education (MoE), Ministry of Skill Development and Entrepreneurship (MSDE), Directorate General of Training (DGT)
	Establish research fellowships and advanced labs (CoEs) in Tier-1 institutes with industry-led hydrogen projects and global institutes, enabling leadership in technology innovation	Council of Scientific and Industrial Research (CSIR), MoE
	Establish centralized, university-led or national platforms to map hydrogen technology Develop and create pipelines for transitioning research into start-ups for ultra-skilled	MSDE, CSIR
High-skilled	Deploy 5-10 kW electrolyser demonstration facilities co-developed with industry in top engineering institutions for classrooms and applied learning	MSDE, Tier 1 & 2 Engineering Colleges, Industry Partners, MoE
	Create government-incentivized apprenticeships and in-factory training programs with industry partners	MSDE, DGT, Industry Associations
	Introduce cleantech manufacturing curriculum and standardized green hydrogen curriculum with modules to ensure industry-readiness for innovations and skills	Ministry of Education, MSDE
Low-skilled	Introduce short certification programs and micro-credentials covering core hydrogen topics such as safety procedures, regulatory compliance, and emergency response	National Council for Vocational Education and Training, Skill Council for Green Jobs
	Deploy 5-10 kW electrolyser demonstration facilities for applied learning, focusing on modules for repair and maintenance skill development for diploma and ITI graduates	MSDE, ITIs, Industrial Skill Centers (e.g. Tata Power Skill Development Institute (TPSDI))
	Launch a Digital Cleantech Training Platform – an online learning hub with courses, certification programs, and job-matching services	MSDE, ITIs

Note: 1. The "Train and Trainer" program is applicable to the high-skilled workforce as well
Source: CEEW - Green Jobs Reports; SSCGJ - Green Hydrogen Skills Gap Report

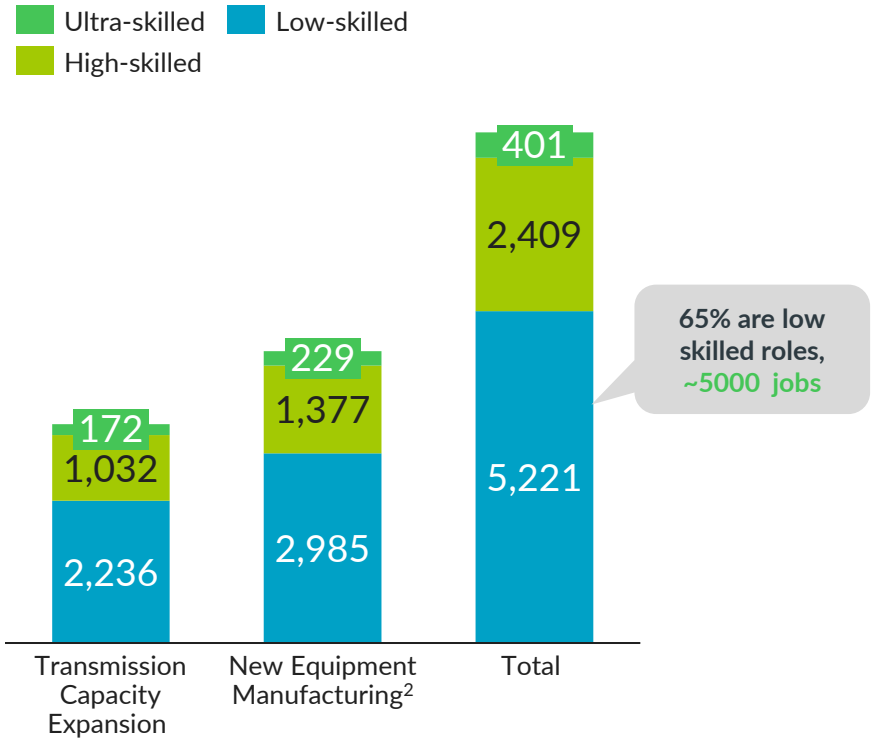
SECTION FIVE, SUB-SECTION F

TRANSMISSION EQUIPMENT INDIGENISATION PATHWAYS

India would require an additional ~8000 skilled workers across Transmission manufacturing by 2032, who could be trained with a ₹250-280 crore budget

Focus training workforce on substation components like converter transformers, AC/DC switchyards and control/protection systems since transmission lines are already highly indigenised

Current & projected (2032) workforce requirement for Transmission manufacturing, '000



Skill level and sources of talent for Transmission manufacturing

Ultra-skilled

R&D and system design Innovation experts

Research labs, PhD/Postgrad, programs, Tier-1 engineering and technical institutes

High-skilled

Engineers & component specialists

Tier-1 and Tier-2 engineering colleges, lateral hires from industrial automation sector

Low-skilled

Production line workers

ITIs, vocational training programs

Skilling Investment Required

Personnel training cost

₹ 175 - 200 Cr

+

Training centers investment[3]

₹ 75 - 80 Cr

=

Total budget

₹ 250 - 280 Cr

Note- (1) Additional workforce requirements aligned with the 15th National Electricity Plan (target year 2032); (2). Prioritized the indigenisation of DC switchyard manufacturing to import dependency (2) Includes 100% indigenisation of AC and DC switch gear for HVDC systems (3) Does not include lab equipment needed for ultra –high skilled workforce as it is included in R&D set up cost already

Source:; World Energy Employment Report; NITI:ITI Report (2024); Dalberg Analysis

To successfully build this workforce, concerted action is needed across education, industry and policy certification stakeholders

Skill Level — Ultra-high — High — Low

Current Challenges		Recommendations
Uneven and limited training capacity	• **Lack of targeted skilling program** for transmission sector, particularly HV focused, for low skilled workers	**Expand NPTI's current Diploma and short courses** into HV transmission systems, co-developed with PGCIL[1] and BHEL
	• **Absence of a national workforce planning** exercise to align human capital needs with transmission expansion goals	National Skill Development Council **(NSDC)** and the Power Sector Skill Council **(PSSC),** in partnership with utilities, OEMs and EPCs, to **conduct a national skill gap assessment** aligned with transmission planning and manufacturing goals
Curriculum–technology mismatch	• **Curricula in Tier I/II institutions lag** sector needs; minimal coverage of HVDC/VSC, smart grid infrastructure etc.	**Upgrade university-level transmission curriculum** in partnership with PGCIL, BHEL, and international institutes (e.g., KTH[2], SuperGrid Institute)
	• **ITIs have basic infrastructure**, but advanced labs/equipment and syllabi for modern transmission technologies do not exist	**Establish a Center of Excellence** under Ministry of Skill Development & Entrepreneurship (MSDE) for transmission system, developing training curriculum and cascading training capacity at a national level **Modernize ITI infrastructure** under National and State Skilling Missions, in partnership with utilities, EPCs and OEMs
Limited Industry–academia links and certification standards	• Large OEMs (e.g., L&T, Tata Power) run in-house programs, while **SMEs (accounting for ~90% of production) lack access** to any training programs	Establish **transmission focused shared training centers** for SMEs under the MSME[3] Cluster Development Programme
	• **Credentials are fragmented** (PSSC, NPTI, state licenses, OEM programs) with no unified registry, limiting employer visibility and comparability.	PSSC to **establish a unified national certification framework** aligned with global transmission skilling standards

(1) Power Grid Corporation of India Limited (2) KTH Royal Institute of Technology (Sweden) (3) Micro, Small and Medium Enterprises
Source: IEEMA: Electrical equipment mission plan ; IEA : World Energy Employment Report; NITI : ITI Report; Dalberg Analysis

Thank you!