8. Electricity: Electric Power Generation using Solar Energy and Other Non-conventional sources

8.1 Definition of the Sector

Electricity generation is chosen among the secondary sectors in this study. As defined by the National Industrial Classification (NIC-4 digit), NIC 3510: Electric power generation, transmission and distribution, this sector includes the sub-sectors focussed on the 'sunrise' aspects of this sector:

- NIC 35105: Electric power generation using solar energy
- NIC 35106: Electric power generation using other non-conventional sources

8.2 Value Chain

Electricity generation using renewable sources has gained importance amid the growing concerns of climate change. In line with the Paris Agreement of 2015, India's updated Nationally Determined Contribution (NDC) includes achieving 50 per cent cumulative electric power installed capacity from non-fossil fuel-based energy resources by 2030.[1]

In India, solar and wind energy offer potential for renewable electricity generation. Other non-conventional sources, initially considered for this study, included small-hydro power (SHP) and biogas. It was found through the initial stakeholder meetings that there is limited potential for expansion of SHP, and demand for workforce is low/limited and easily met with the existing supply—resulting in absence of skill shortages for SHP. On the other hand, biogas is neither being used nor is being viewed as a potential source of electricity generation, due to economic unviability. Also, unlike SHP and biogas, India's installed capacity for solar and wind energy has seen a rising trend over the years (MNRE[2]). Between April 2024 and January 2025, cumulative installed capacity for solar power increased by 18,516.2 MW (i.e., from 81.8 GW to 100.3 GW) and that for wind power increased by 2,478.8 MW (i.e., from 45.9 GW to 48.4 GW).[3]

It must be noted that the target was to reach 175 GW of renewable energy capacity by the year 2022, comprising 100 GW of solar and 60 GW of wind. This target is said to have been missed due to low-installation of solar roof-top and wind energy projects.[4] Now, by 2030, India aims to reach 500GW of installed capacity from non-fossil fuel sources. Attainment of these targets is possible if there is a corresponding

[1] India's updated NDCs: https://unfccc.int/sites/default/files/NDC/2022-08/India%20Updated%20First%20Nationally%20Determined%20Contrib.pdf; accessed on 25 July 2024. India achieved 43.8 per cent of electric power installed capacity from non-fossil fuel-based energy by October 2023: https://pib.gov.in/PressReleaseIframePage.aspx?PRID=1987752

[2] Year wise achievements: https://mnre.gov.in/year-wise-achievement/; accessed on 30 July 2024

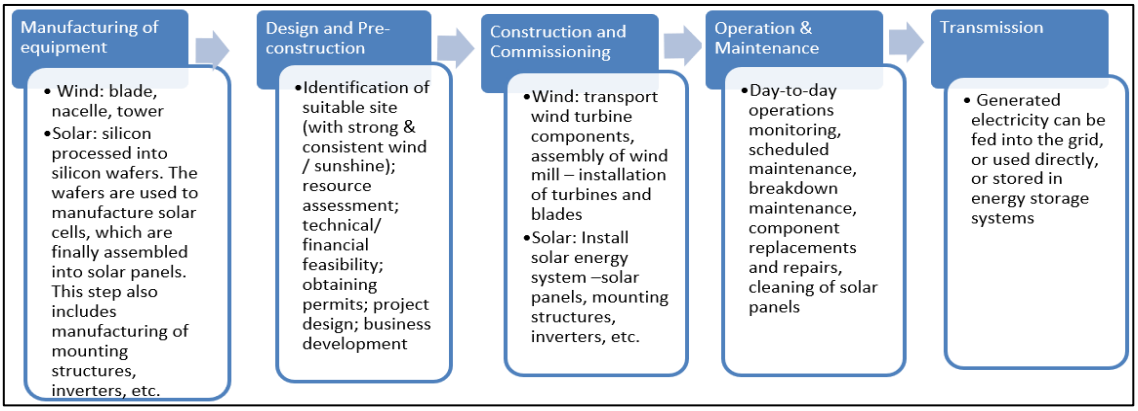
[3] Monthly physical progress: https://mnre.gov.in/physical-progress/; accessed on 6 March 2025

[4] https://www.thehindu.com/sci-tech/energy-and-environment/india-misses-re-capacity-target-due-to-low-solar-rooftop-wind-energy-project-installations-parliamentary-panel/article66646350.ece; accessed on 6 Sept 2024. Solar rooftop is now being promoted through the PM Surya Ghar Yojana (https://pmsuryaghar.org.in/), which is expected to increase the need for solar installers and O&M personnel.

growth of skilled personnel to fulfil the various job roles in the industry. According to an estimate by a recent study[5], over 3 million new jobs can be created in the solar and wind energy sectors by 2030. Therefore, to capture the in-demand job roles, and the skill shortage thereof, only the sectors of solar and wind electricity have been focused upon.

While limiting the scope to solar and wind electricity generation, the values chains of electric power generated through solar and wind energy are presented below. Manufacturing of solar panels and wind turbines 'precede' generation of electricity, and transmission 'follows'—both of which are outside the scope of the present study. Though technological changes are occurring within the manufacturing and transmission stages of the value chain, with regard to higher efficiency solar modules and wind turbines, and use of the electricity generated to produce green hydrogen.[6]

Figure 8.1: Electric power generation using solar and wind energy



Source: NCAER compilation, adapted from Ghosh et al. 2016[7] and SCGJ 2016.[8]

[5] CEEW, NRDC and SCGJ (2022). India's Expanding Clean Energy Workforce: Opportunities in the Solar and Wind Energy Sectors. Available at: https://www.ceew.in/publications/indias-expanding-clean-energy-workforce; accessed on 8 July 2024

[6] Given the Governments' Green Hydrogen Mission and the associated need for skills in the sector, Skill Council for Green Jobs has introduced several qualification packs for green Hydrogen, including Green Hydrogen Plant Entrepreneur, Green Hydrogen Plant Technician, Green Hydrogen Plant Junior Technician—Desalination, Green Hydrogen Plant Junior Technician- Electrolyser, Green Hydrogen Plant Junior Technician—Power Sources, and Green Hydrogen Plant Junior Technician—Storage.

[7] Design and pre-construction: design of the project. Direct employment includes jobs for designers, planners, architects, engineers (non-installers), resource analysts, and legal personnel. Construction and commissioning: actual installation of the project and setting up a connection to the national power grid. Direct jobs created for construction workers, electricians, technicians, engineers, meteorologists, and technicians working for equipment vendors (such as inverter suppliers). Both skilled and unskilled workers are required during this phase. Operations and maintenance create direct jobs for technicians, electricians, maintenance and security staff, and operations managers. Both skilled and unskilled workers are required to carry out O&M in the plant. Business development involves steps taken to develop a specific project, as well as ongoing efforts to promote business. Direct employment generated includes jobs in sales, marketing, legal, financial, and government/regulatory affairs (Ghosh et al. 2016. *Filling the Skill Gap in India's Clean Energy Market-Solar Energy Focus*. New Delhi; New York: Council on Energy, Environment and Water and Natural Resources Defense Council).

[8] SCGJ 2016. Skill Gap Report for Solar, Wind and Small Hydro Sector. Skill Council for Green Jobs, September 2016.

With electricity generation being the focus of this study, it covers activities involving engineering–procurement–construction, i.e., EPC (involving design and pre-construction, construction and commissioning), operation and maintenance, and business development (Figure 8.1). With technological changes, personnel involved in EPC and O&M will be required to install, and operate and maintain higher efficiency solar modules and wind turbines, but also keep up with automated O&M and cleaning of solar panels (instead of manual cleaning), data analytics for interpreting and predicting wind turbine performance, software to read and forecast solar and wind data, and setting up off-shore wind power plants in India.[9]

8.3 Workforce Characteristics

a. ***Females***: 17 per cent of the workforce are females in the sector 'electric power generation using solar energy'. This 17 per cent belongs to two States—Karnataka and Maharashtra. In the former, 40.4 per cent of the workers are females and in Maharashtra the corresponding number is 30.4 per cent. Female Labour Force Participation (LFP) is zero in case of electric power generation using other non-conventional sources.[10]

b. ***States:*** Figure 8.2 shows employment generated in renewable electricity generation, across the different States of India. According to the PLFS data (2022–23):

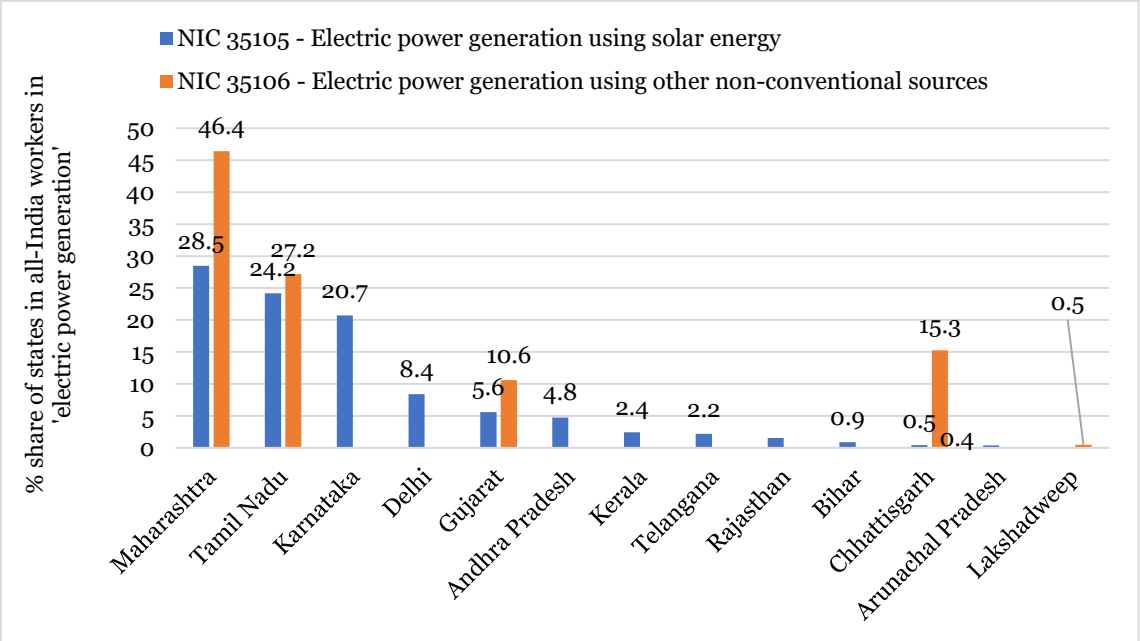
   - Maximum share of workers employed in Electric power generation using solar energy are located in Maharashtra, Tamil Nadu, and Karnataka. 73.4 per cent of workers in this sector are only from these three States.
   - Maximum share of workers in electric power generation using other non-conventional sources, are located in Maharashtra, Tamil Nadu, and Chhattisgarh. 73.6 per cent of workers in this sector are concentrated in Maharashtra and Tamil Nadu.

[9] Goswami, S. 2023. "India only has on-shore wind projects. Off-shore wind energy is currently being explored". Moneycontrol.com https://www.moneycontrol.com/news/business/indias-first-offshore-wind-projects-to-come-up-across-tamil-nadu-coast-11446851.html. September 28.

National Institute of Wind Energy website.
https://niwe.res.in/department_wra%26o_offshore_fowind.php ; accessed on 6 July 2024

[10] The finding of no women workers is based on PLFS data for 2022-23 (which was the latest available data at the time the secondary analysis was being conducted). Now with the release of PLFS data for 2023–24, it is noticed that there are some women employed in the sector 'electric power generation using other non-conventional sources', comprising 10 per cent of the sector's workforce, in the state of Himachal Pradesh.

Figure 8.2: Green energy workers (aged 15+) are concentrated in 13 States, 2022–23(%)

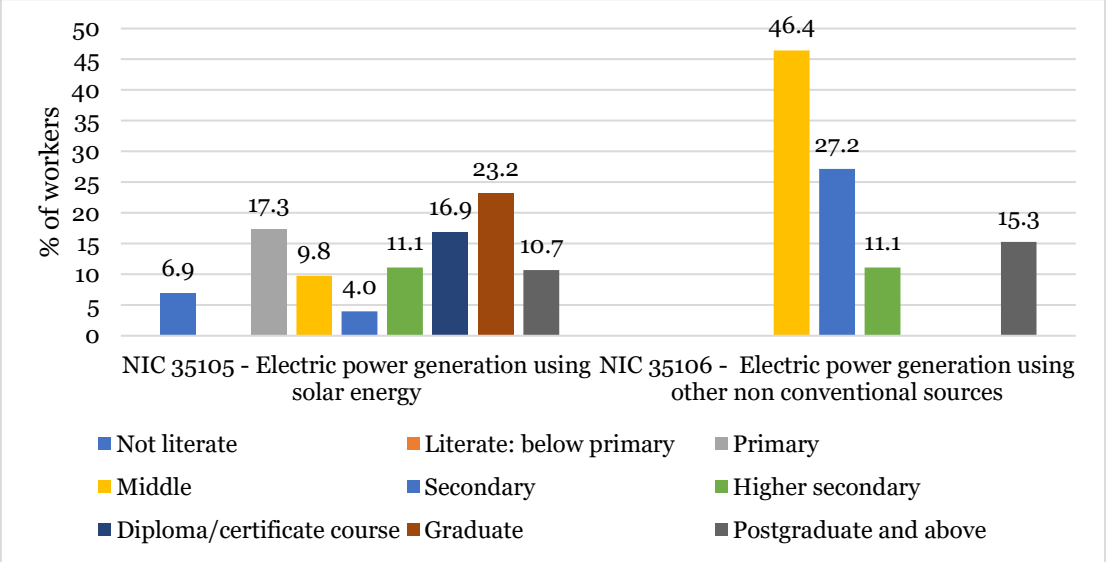


Source: NCAER analysis using PLFS data 2022–23.

c. ***Education:*** When analysed across levels of education (Figure 8.3), majority of workers involved in:

- Electric power generation using solar energy are graduates
- Electric power generation using other non-conventional sources are educated until middle school. But 27 per cent of workers have also attained secondary school education and 15 per cent of workers are post-graduates.
- Technical Education
  - 75 per cent of workers in electric power generation using solar energy do not have technical education. 8.1 per cent of workers have technical degree in: engineering/ technology, 6.7 per cent of workers have diploma or certificate (below graduate level): engineering/technology and 10.2 per cent of workers have diploma or certificate (below graduate level): other subjects.
  - 100 per cent of workers do not have technical education in the sub-sector, 'electric power generation using other non-conventional sources'.
- Vocational Education
  - 3.6 per cent of workers in electric power generation using solar energy have received formal vocational education and 20.5 per cent non-formal vocational education.
  - 100 per cent of workers have not received any formal vocational education in the sub-sector, 'electric power generation using other non-conventional sources' but 72.3 per cent of workers have received non-formal vocational education.

Figure 8.3: General education of workers (aged 15+) engaged in electric power generation using solar energy, and electric power generation using other non-conventional sources, 2022–23 (%)

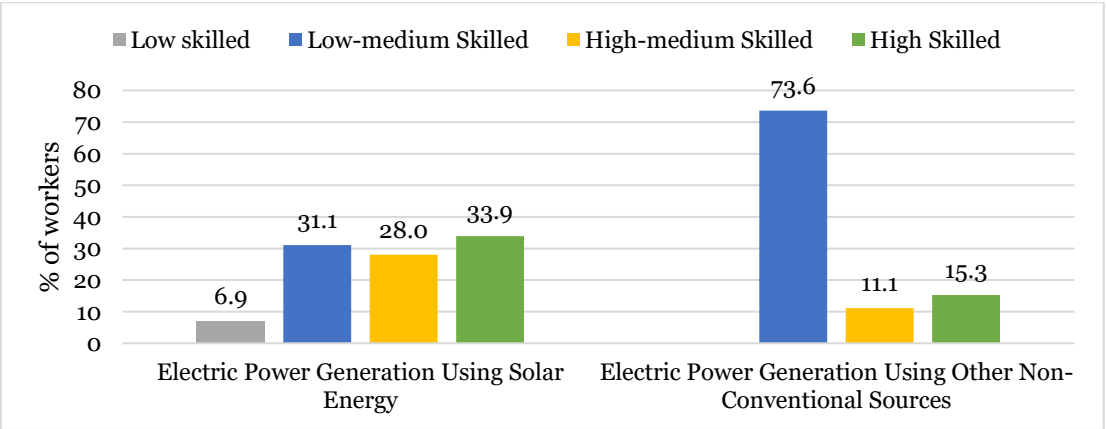


Source: NCAER analysis using PLFS data 2022–23.

d. ***Skills:*** Aligned with the levels of education, majority of workers involved in (Figure 8.4).

- Electric power generation using solar energy are high skilled.
- Electric power generation using other non-conventional sources are low-medium skilled.

Figure 8.4: Skill-level of workers (aged 15+) engaged in electric power generation using solar energy, and electric power generation using other non-conventional sources, 2022–23 (%)



Source: NCAER analysis using PLFS data 2022–23 (see Annexure 4.2 for definition of skills).

e. ***Across Occupations:*** In renewable electricity generation, workers are involved in several occupations. Certain occupations however stand-out, give the relatively large number of workers engaged in them (Table 8.1). For instance:

- Majority of workers in Electric power generation using solar energy (NIC 35105) are Protective Service Workers (30 per cent) and Electrical Equipment Installers and Repairers and keyboard Operators (both 12 per cent).
- Majority of workers in Electric power generation using other non-conventional sources (NIC 35106) are Manufacturing Labourers (46 per cent).

Table 8.1: Green energy workers by their occupations, 2022–23 (%)

Occupation Description	*Number of Workers (Males + Females)*		*% Share of each job role in the industry*	
	35105	*35106*	*35105*	*35106*
Business Services and Administration Managers	6,203	0	8	0
Engineering Professionals (excluding Electro-technology)	3,263	0	4	0
Finance Professionals	2,951	0	4	0
Sales, Marketing and Public Relations Professionals	4,179	0	6	0
Mining, Manufacturing and Construction Supervisors	1,651	2245	2	15
Administrative and Specialised Secretaries	1,792	0	2	0
General Office Clerks	2,948	3995	4	27
Keyboard Operators	8,934	0	12	0
Numerical Clerks	50	0	0	0
Other Clerical Support Workers	3,154	0	4	0
Other Sales Workers	6,200	0	8	0
Protective Service Workers	22,588	0	30	0
Electrical Equipment Installers and Repairers	8,611	0	12	0
Car, Van and Motorcycle Drivers	0	1561	0	11
Manufacturing Labourers	1,618	6824	2	46
Other Elementary Workers	0	74	0	1
Grand Total	74,143	14,698	100	100

Source: NCAER analysis using PLFS data 2022–23.

f. ***Engagement Status:*** In the sector electrical power generation using solar energy, 99 per cent of workers are regular-wage employees. In the sector electric power generation using other non-conventional sources, 100 per cent of the workers are regular wage employees (Table 8.2).

Table 8.2: Engagement status of workers (%)

	All Workers (aged 15+)					
	Self-employed					
	Own account worker	***Employer***	***Worked as helper in h.h. enterprise (unpaid family worker)***	***Regular salaried/ wage employee***	***Casual Wage Labour***	***Total***
Electric power generation using solar energy	0.9	0.0	0.0	99.1	0.0	100.0
Electric power generation using other non-conventional sources	0.0	0.0	0.0	100.0	0.0	100.0
	All Male Workers (aged 15+)					
Electric power generation using solar energy	1.1	0.0	0.0	98.9	0.0	100.0
Electric power generation using other non-conventional sources	0.0	0.0	0.0	100.0	0.0	100.0
	All Female Workers (aged 15+)					
Electric power generation using solar energy	0.0	0.0	0.0	100.0	0.0	100.0
Electric power generation using other non-conventional sources	0.0	0.0	0.0	0.0	0.0	0.0

Source: NCAER analysis from PLFS 2022–23.

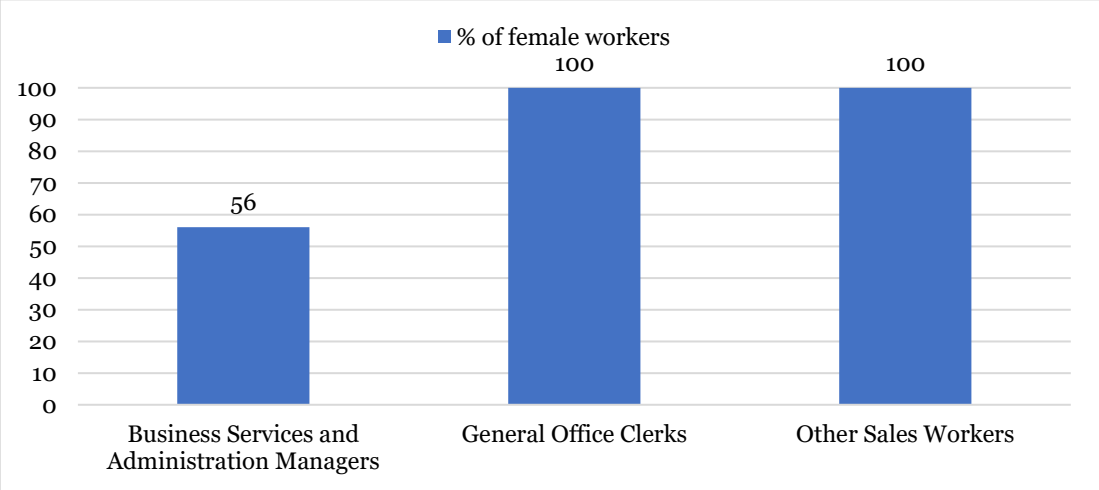
g. ***Concentration of Females in Specific Job Roles:*** There are no women workers captured in the PLFS data who are employed in Electric power generation using other non-conventional sources. Therefore, all occupations within this sector only employ men. This finding of no women workers is based on PLFS data for 2022–23 (which was the latest available data at the time the secondary analysis was being conducted). Now with the release of PLFS data for 2023–24, it is noticed that there are some women employed in the sector 'electric power generation using other non-conventional sources', comprising 10 per cent of the sector's workforce. Although these women are found to be engaged in only one occupation within this sector, that of 'General Office Clerks'. Rather all general office clerks are women.

While there are very few women employed in the solar electricity generation, these too are concentrated in specific job roles, in particular occupations such as General Office Clerks and Other Sales Workers only have women. Among all Business Services and Administration Managers, more than 56 per cent are women (Figure 8.5).

According to the PLFS data, there are no women employed in any other occupation in this sector. It is therefore evident that women are employed in

job roles which 'support' the core activities of solar electricity generation, considering that the 'core' occupations, which have the largest share of workers, i.e., Protective Service Workers and Electrical Equipment Installers and Repairers, only have men engaged in them. Keyboard Operators—a support occupation which too employs a large share of workers — has no women worked engaged in it.

Figure 8.5: Percentage of female workers (aged 15+) across job roles in green energy (%), 2022–23



Source: NCAER analysis using PLFS 2022–23 data.

8.4 Geographical Clusters

In the electricity sector, the study's focus is on electricity generation using solar and wind energy. Clusters of plants dedicated to generating electricity using either of the renewable sources is governed by the renewable energy potential of the geographic region. For instance, potential for solar and wind electricity will be higher in regions with greater duration and intensity of sunlight and wind. Solar and wind plants will be set up only in places where there is ample sunshine and wind to generate energy.

Firms will bid for tenders for setting plants of a particular installed capacity. Size of firms cannot be linked with size of plant.

Stakeholders (industry associations, SSC, training partners) connect geographical clusters, i.e., no. of projects, with State-level installed capacity (SCGJ 2016).[11] Therefore, departing from the standard Porter model, data on both on number of plants and installed capacity is used to assess rankings, and thereby clusters. The Central Electricity Authority (CEA) and Ministry of New and Renewable Energy (MNRE)[12] provide State-level data on installed capacity and generation of renewable electricity, helping identify the relevant States where there is focus on renewable electricity generation. Plant level information, though available with CEA,[13] is

[11] SCGJ 2016. Skill Gap Report for Solar, Wind and Small Hydro Sector. Skill Council for Green Jobs, September 2016

[12] MNRE Annual Reports: https://mnre.gov.in/annual-report/; accessed on 15 May 2024.

[13] Available at: https://cea.nic.in/renewable-generation-report/?lang=en; accessed on 15 May 2024.

incomplete as it includes only inter-state generating stations (ISGS) and central public sector units (CPSU).

An interactive portal, India Climate and Energy Dashboard,[14] developed by the NITI Aayog is a useful source to gather State and district-level information on all existing and proposed renewable and non-conventional energy plants (i.e., units), as well as their operational capacity. It may be noted that the data available from the NITI Aayog dashboard has been used after due cross-verification with other official government sources, particularly the Ministry of New and Renewable Energy (MNRE). In particular, state-level installed capacity of all renewable energy sources (which was arrived at by summing the installed capacity of NITI Aayog's plant-level data, as on 31st March 2024), matches the State-wise installed capacity data released by MNRE.

District-level data is useful to identify the exact location of the energy plant, but it has not been useful in determining the concentration of plants by district, since most districts only have one or two plants. State-level data has therefore been used for identification of clusters of solar and wind energy plants (Table 8.3).

Table 8.3: Geographical concentration of solar and wind energy generation, as on 31 March 2024

Solar Electricity Generation				*Wind Electricity Generation*			
State	***Rank using Operational units (Numbers)***	***Rank using Operational Capacity (MW)***	***Average Rank***	***State***	***Rank using Operational units (Numbers)***	***Rank using Operational Capacity (MW)***	***Average Rank***
Gujarat	2	2	2	Gujarat	2	1	1.5
Karnataka	1	3	2	Tamil Nadu	1	2	1.5
Rajasthan	4	1	2.5	Karnataka	2	3	2.5
Tamil Nadu	2	4	3	Maharashtra	4	4	4
Andhra Pradesh	5	7	6	Rajasthan	5	5	5
Maharashtra	8	5	6.5	Madhya Pradesh	5	7	6
Madhya Pradesh	5	8	6.5	Andhra Pradesh	7	6	6.5
Uttar Pradesh	5	9	7	Kerala	8	9	8.5
Telangana	12	6	9	Telangana	9	8	8.5
Punjab	10	11	10.5	Others	10	10	10
Haryana	14	10	12				
Odisha	11	15	13				
Chhattisgarh	15	12	13.5				
Delhi	13	16	14.5				
Uttarakhand	17	14	15.5				
Kerala	19	13	16				
West Bengal	15	18	16.5				
Bihar	17	17	17				
Jharkhand	19	19	19				
Assam	21	20	20.5				
Arunachal Pradesh	9	32	20.5				
Himachal Pradesh	23	21	22				
Chandigarh	23	22	22.5				
Jammu and Kashmir	23	23	23				
Puducherry	23	24	23.5				
Goa	23	26	24.5				
Daman and Diu	23	27	25				
Mizoram	23	28	25.5				

[14] Data can be viewed and downloaded from: https://iced.niti.gov.in/energy/electricity/generation; accessed on 15 May 2024.

Solar Electricity Generation				Wind Electricity Generation			
State	***Rank using Operational units (Numbers)***	***Rank using Operational Capacity (MW)***	***Average Rank***	***State***	***Rank using Operational units (Numbers)***	***Rank using Operational Capacity (MW)***	***Average Rank***
Andaman and Nicobar Islands	22	29	25.5				
Tripura	23	30	26.5				
Manipur	23	31	27				
Across India	38	25	31.5				
Ladakh	32	33	32.5				
Sikkim	32	34	33				
Dadra and Nagar Haveli	32	35	33.5				
Lakshadweep	32	36	34				
Meghalaya	32	37	34.5				
Nagaland	32	38	35				

Sources: Ministry of New and Renewable energy (MNRE); India Climate and Energy Dashboard, NITI Aayog.

Note: 'Operational capacity' refers to installed capacity.

Gujarat, Karnataka, Rajasthan, and Tamil Nadu are the key clusters at the State-level. The mapping between shares of labour force and concentration of generation units is not reported here to due to mismatch. While generation of solar energy is taking place in almost all States to some extent, the PLFS data shows that the workers are concentrated in barely 12 States. Box 8.1 elaborates on the reasons behind the data mismatch.

Box 8.1: Note on data mismatch between solar and wind clusters and associated presence of workers

Renewable electricity generation is a sunrise sector, which is expanding at a fast pace. Within the last decade (March 2014 – March 2024), the installed capacity of wind power increased by 24 GW, and that of solar power by 80 GW (MNRE).

The geographic clusters of solar and wind power have been identified using State-wise data on number of plants and installed capacity. However, the data with regard to availability State-level renewable power plants and installed capacity, i.e., the identified clusters, does not match with the PLFS data on State-wise number of workers employed in renewable electricity generation. There can be several reasons to explain this discrepancy.

1. *Relocation or Migration of Workers in the Industry*

Renewable energy projects are located in remote areas, where the early stages of plant development —including design, pre-construction, construction, installation, commissioning—involve short term relocation / migration of workers and employees of a developer firm or a contractor to the site location. Once the plant has been set up, workers are employed in operation and maintenance (O&M), which provides long-term employment at plant location. Through our stakeholder interactions it has been learned that local people are hired for O&M related jobs, but involvement of migrant workers is also likely.

PLFS is a household survey and it selects the households randomly within the sample areas. If in an industry located in the same sample area hires migrant workers from other areas, and they are accommodated within the plant, they will not be captured in the survey. Therefore, the presence of renewable power units and capacity in a State, but evidence of no workers involved in renewable power industry, becomes a possibility.

Another factor is 'daily migrants' working in an industry in a sample area. In the industries present in inter-state border areas, workers may be residing in one State, but working in another State. Data for such workers will be captured in states in which they are residing rather than in the States where they are working.

2. *Time Period of Data Availability*

The identification of clusters using plant and installed capacity data is as of 31 March 2024. However, the PLFS data is for 2022–23. It is important to note that just between 2022–23 and 2023–24, operational capacity of solar power increased by 2249.44 MW and of wind power by 977.83 MW (MNRE).

3. *Definition of Industry*

Given the scope of renewable electricity generation for this study, PLFS captures data for workers involved in 'electric power generation using solar energy' and 'electric power generation using other non-conventional sources'. While keeping in view the sources of discrepancy highlighted earlier, another discrepancy for wind power also emerges from the fact that PLFS data does not specifically capture the number of workers associated with electric power generation using wind energy. Rather, it is clubbed along with data for other non-conventional sources, and can hence be misleading.

Alternative methods

An alternative way of analysing workers in a particular industry is studying the plant level data captured by the Annual Survey of Industries (ASI) and the Enterprise Survey (ES), for organised and unorganised industries respectively. In this case, workers will be included in the sample area where the plant is located and not where they are residing. Here presence of workers in an industry should be commensurate with where 'clusters' for that industry are located. This may hold for the established sectors where frequent changes/revolutions are not taking place. However, in the sectors which is seeing frequent and fast transitions, just as the renewable power sector, even ASI and ES may not be able to capture presence of clusters and related workers in a sample area—primarily because the data is dated.

While this data could be valid for some amount of time (like 5 years) in normal circumstances, but in the fast changing sunrise sectors this may not be the case. In the case of green energy (solar and wind), latest years' generation/installed capacity figures for a sample area may not match with information on workers in that sample area—because ASI/ES data will be for a period that is already two to three years in the past.

This makes the need of adopting multiple approaches for studying the presence of clusters and associated workers for an industry, be it at the State or district level. To have the latest view of the industry at the State/ district level, expert consultations and primary scoping surveys should also be considered to supplement the industrial data available through secondary sources.

8.5 Occupational Maps

The National Classification of Occupations (NCO) are occupations in which workers are employed within the respective green electricity generation sector, according to the periodic labour force survey (PLFS) data. There are no stand-alone NCOs for wind electricity generation, and hence these are covered under the NCOs for electricity generation using 'other non-conventional' sources. NCAER has mapped and supplemented these occupations with the job roles from Skill Council for Green Jobs (SCGJ) for a complete occupational mapping of the sector (Annexures 8.1 and 8.2). The latter has been useful for incorporation of new job roles which have emerged over the years, since NCO occupations (2015) are dated.

8.6 Stakeholders' Survey

The scope of the electricity generation sector included the generation of electricity using solar power and other non-conventional sources. To assess skill shortages in the sector, a variety of stakeholders were contacted, including the sector skill council, industry associations, skilling institutions, firms, and experts and other stakeholders.[15] This section provides the methodology adopted to assess skill shortage in the sector, determine specific job roles in which firms are faced with a shortage at present and are likely to face a shortage in next three years, and the reasons thereof. Based on the findings, suggestions to carry forward the exercise have been provided.

8.6.1 Sampling

Data from the Ministry of New and Renewable Energy (MNRE) and NITI Aayog helped identify solar and wind energy clusters, i.e., States where there are a large number of plants and high installed capacity, and where both are fewer. Given that the present stage of the study only involved reaching out to a small sample of firms, it was considered useful to have a spatial spread of renewable energy plants in the choice of firms (a firm can have several solar and wind plants)—to capture any regional variation in skill shortage.

In the solar electricity sector, it was attempted to interview firms with solar plants in Rajasthan and Gujarat (given the high installed capacity and number of solar plants), and Madhya Pradesh and Chhattisgarh (given the potential solar capacity and plants). In the wind electricity sector, it was decided to target firms with wind farms in Tamil Nadu and Gujarat (given the high installed capacity and number of wind plants), and Karnataka and Maharashtra (given the potential wind capacity and plants). To understand if skill shortage varied by firm size, it was also attempted that firms operating across the selected regions are of different sizes.

[15] In line with the study's agenda, interviews involve meetings with 25 stakeholders, including the sector skill council (1 no.), industry association (1), training centres (2), firms (20), and a recruitment agency. Depending on the scope of the sector and stakeholder availability, these numbers have varied in practice. For instance, instead of one industry association, NCAER has met with two industry associations, to cover solar and wind electricity generation. Meeting industry experts, belonging to other national/regional associations and firms, has also been insightful to understand the issues of skill shortages. As of 8 Nov. 2024, NCAER has met with sector skill council (1), industry associations (2), training centres (2), firms and industry experts (20), recruitment agency (1) – taking the total stakeholder meetings to 26.

To achieve an ideal sample, it is necessary to have a comprehensive list of all the firms in solar and wind electricity generation in India[16] (independent power producers (IPP), developers, and firms offering design, installation and operations & maintenance (O&M) services such as original equipment manufacturers (OEM) and independent service providers), along with: details of their size, renewable energy focus, project types (e.g., solar rooftop/residential, utility scale, commercial and industrial), work phases they are engaged in, where their plants are located, as well as a guarantee that personnel at the chosen firms are willing to meet to discuss the issue of skill shortages. Amidst a glaring lack of such data, NCAER tried to seek help from the stakeholders (in particular the sector skill council and the industry associations), and also tried to reach out to any contacts available on the internet and known prior contacts.

A total of 63 firms were contacted over email and telephone, of which personnel from only 14 firms have met to discuss skill shortages, resulting in a response rate of 22.2 per cent. Response rate tends to be low in business surveys. Yet, NCAER has been successful in ascertaining a spatial spread in firms' plant locations for solar and wind projects, as well as in conducting interviews with firms of different sizes. In addition to the firms who have provided their insights to the questionnaire, expert consultations with personnel from some other firms and industry members have also been useful in supplementing the findings (Table 8.4).

[16] As was learnt during the stakeholder interactions, there are three types of players: IPP, OEM, and Developer. i) IPP is on the commercial and fundraising side (primarily finance and business development); ii) OEM is technology-oriented and manufactures the equipment (E.g., Vesta, GE, Suzlon): O&M too is usually by the OEM; iii) The developer facilitates the IPP and OEM: It finds potential land to build solar and wind plant, ensuring nearest grid connectivity, involving stages of design and pre-construction and construction. While the above may be broadly applicable, the distinctions on the extent to which each type of firm is involved in a project is not as clear-cut. For instance, IPPs will tend to have O&M Supervisors / Managers on plant location and have increased their capabilities over the years to also develop and maintain their plants. An OEM may only be manufacturing and not engaging with O&M at all. Smaller IPPs (for which developing and maintaining is costly) may bring in an OEM to do everything.

Table 8.4: Stakeholder consultations

Stakeholders (No.)			***Location of Firms (No.)***		***Ownership Type (No. of Firms)***		***Designation of Interviewees (No. of Interviewees *)***	
Ministry		No response	Delhi	2	Public Sector	0	Human Resource/Learning & Development Managers/Director (Training)	6
Sector Skill Council		1	Karnataka	3	Public Limited	3	Managing Director/CEO	4
National-level Industry Association		2	Madhya Pradesh	1	Private Limited	10	General Manager/Senior Manager	9
No. of Firms	Micro/ Small	3	Maharashtra	3	Individual Ownership/Partnership	0	Vice-President	1
	Medium	4	Tamil Nadu	3	MNC	1		
	Large	7	Telangana	1	Limited Liability Partnership	0		
	Total	14	Uttar Pradesh	1	Cooperatives	0		
No. of Placement Cells/TVET Institutions		2			Others	0		
Recruitment Agencies		1						
Other Stakeholders		6						
Firms plus Other Stakeholders		20						
Total		26						

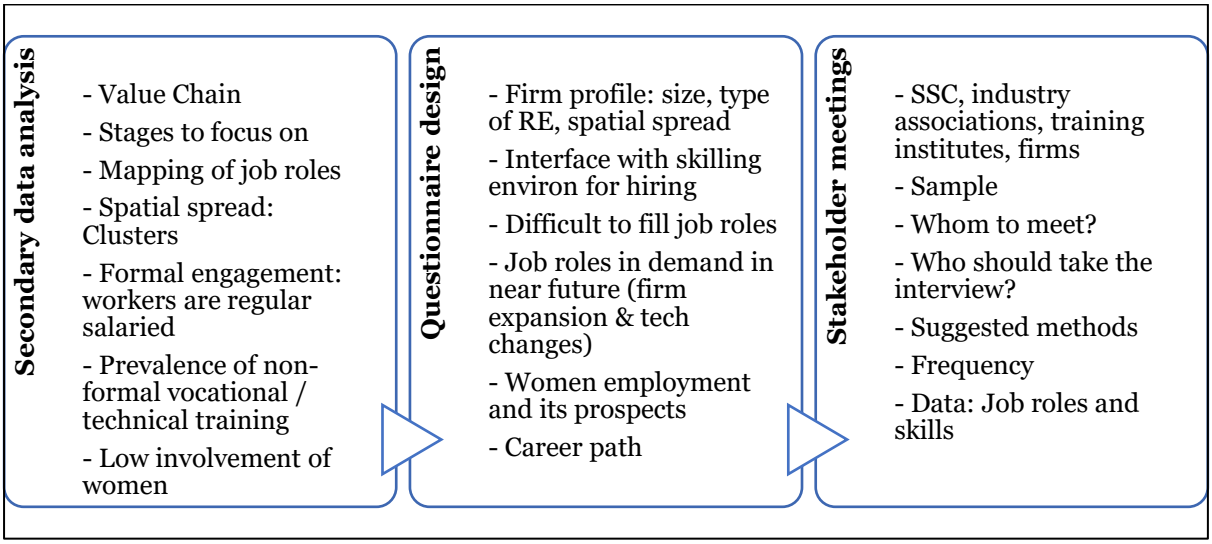
Source: NCAER Survey
Note: * NCAER team attempted to speak with multiple personnel at the firms.

8.6.2 Methodology

NCAER recommends to approach the assessment of skill shortages from the lens of 'data triangulation' by utilising different sources of data (secondary and primary), accessing multiple personnel at firms to speak with, and collating data through a team of investigators.

NCAER undertook detailed secondary analysis to understand the sector, developed the key instrument for data collection (i.e., the questionnaire), and undertook stakeholders' meetings to gather detailed insights on the sector and test the questionnaire and methodology of data collection on skill shortages. This process is summarised in Figure 8.6.

Figure 8.6: Methodology



Source: NCAER's Conceptualisation

8.6.3 How to Assess Skill Gaps?

A firm is faced with a skill shortage when they find difficulty in, or are unable to fill an advertised job role.

To get the stakeholders familiar with the various job roles, NCAER put together a list of occupations where personnel in the sector are employed (from the PLFS data) and mapped it onto the different job roles for which qualification packs have been designed by the sector skill council.

To collate specific job roles in which there is a skill shortage, questionnaires were structured to profile the firm on its size (small/medium/large), types of renewable electricity generation projects, spatial spread of projects, and the interface with the skilling environment for hiring purposes. They were designed particularly to help the respondents think through:

- Given the firm profile, what are the different job roles at the company
- For which job roles has there been a difficulty in finding the 'right' candidates
- For such 'difficult to fill job roles', what are the qualifications and skills that the company is looking out for in the 'right' candidate
- In near future, given the firm-level/technological changes, which job roles (and corresponding skills) will be required at the company, and how easy or difficult would it possibly be to find the appropriately skilled people
- Also, if difficulty in finding the appropriate skill sets are across India, or only in particular States/geographic regions
- Women employment at the firm—overall, specific job roles where there are more / no women, and prospects of increasing women employment in particular job roles
- Availability of factors supporting employee retention and gender diversity at workplace—career path, crèche facility, policies to hire female employees, and

policy and procedures for prevention of sexual harassment at workplace (POSH).

The questionnaire is an important instrument facilitating the collation of detailed information on job roles, and it has worked well on-field. The questionnaire and supporting documents have been designed for firms involved in generation of green electricity. Questionnaire for surveying firms engaged in generation of green electricity is attached at the end of the report (Questionnaire No. 8).

The questionnaire has been designed keeping in mind that the occupational map and in-demand job roles can vary between firms involved with different types and scales of renewable electricity generation projects, as well as depending on the project phases that the firms may be involved in. These intricacies and distinctions—particularly the in-demand job roles and skill requirements of different sets of firms, as per their project engagement—can be captured through analysing the data collected from a comprehensive industry survey.

- Based on the job roles identified during stakeholder meetings, Questionnaire has been updated to segregate the job roles, where: i) workers are employed according to PLFS (at NCO-3 digit), ii) those which do not show workers employed in PLFS but the NCOs are aligned with a qualification pack of Skill Council for Green Jobs (SCGJ), and iii) those which neither show PLFS worker data nor are aligned with any SCGJ QP. This has been useful to highlight the job roles which do not get captured in the PLFS survey, but are in-demand in the sector —with the skill council running training programs for some of these.[17]
- Salary is an important component, and appears to be a key deciding factor, whether an individual takes up a job in the sector. Therefore, it is recommended to collect information on the 'salary offered' by the firm for the in-demand job roles, within the supporting document of the questionnaires.

8.6.4 Who to Talk to?

The first task is to find the right person to speak with at the firm. A firm is a black box, where individual contact details are difficult to find.

Tasks related to preparing job descriptions, advertising job roles and facilitating interviews and onboarding, fall under the purview of the firms' human resource (HR) departments. Given the present aim to find details of 'difficult to fill' job roles, it is quite natural to consider the HR personnel as the key points of contact. However, the HR personnel are usually at the corporate/head office and responding to the demands of the operation managers, learning and development divisions, and senior directors while advertising job roles. While the HR may be able to check the data concerning number of jobs advertised and those which took longer or were not filled, further details on the skills of the applicants and how well they meet/do not meet the requirement of the company can be better gauged by the individuals overseeing the operations and on-the-job training (OJT). Also, in large firms, the HR personnel are a group of people, managing different departments, and therefore one person is unlikely

[17]Some of the other job roles mentioned by stakeholders included asset managers, resource assessors and site surveyors (for solar), site/construction manager, engineers (for wind energy), and even legal professionals, business development executives (for wind), and health, safety and environment officers. Incidentally, these are found to be missing among the job roles covered by PLFS 2022–23 and the sector skill council QPs.

to have all the information. In addition, before sharing any information with an outside party, consent from the corporate bosses is likely to be needed.

In NCAER's experience of talking to or trying to reach out to senior HR personnel, many were only able to give a broad overview with no specific details. Typically, they needed to consult their teams and operation heads for providing any information relating to skill shortages. At several firms, the contacted personnel directed NCAER's email request straight to the HR, none of whom have been responsive.

It may be noted that instead of bypassing the HR, the above pointers highlight the need to keep the individuals in the position of Managing Directors, CEOs, Manager-Plant and Operations, and those heading the learning and skill development divisions, among the key points of contact. Reaching out to these personnel at the firm should be ideal to get a full understanding of skill shortages. Unlike the usual manufacturing sector, the renewable electricity generation plants, once set up, are only employing personnel for O&M and site supervision. Since all activities are being managed from the corporate office, the senior corporate personnel are in a position to share the necessary details on difficult to fill job roles. The Managing Directors, CEOs, and General Managers have been rather resourceful and knowledgeable in providing specific details on all the questions.

Therefore, if the task is to carry out a large-scale survey of all firms in solar and wind electricity generation, the following steps may be followed:

- **Organise an awareness creation workshop/webinar**
  - At the outset, an awareness creation workshop or webinar must be organised, in partnership with the national and regional / State-level industry associations, with invitations going to the CEOs and all senior personnel at the corporate office of the firms.
  - Once all senior members of the corporate office have been explained the agenda and they find the usefulness of the labour market information system, they should be able to help connect with the HR heads, plant managers, and learning and skill development personnel at the firm. After all, the firms' organisational chart is known best by those at the top.
- **Compile a database of firm-level contacts, which should be periodically updated**
  - A comprehensive database should be created from the above exercise, which should also be updated on at least a semi-annual basis if the aim is to have a dynamic labour market information system, since:
    - Firms may be starting new plants, or even closing some
    - Individuals may be shifting between companies, and those who are the key points of contact at one point in time, may have shifted to another company when the survey is repeated.
- **Frequency of conducting the survey**
  - While the exercise is extensive, data on skill shortages should be collated from the firms on an annual basis—keeping in mind that the industry is growing at a rather fast pace and requires skilled personnel to help keep up the momentum.

8.6.5 Who Should Take the Interview?

Given the novel nature of this exercise, it is important that the interviews are conducted in-person—either online or offline. On average, each interview takes about

one hour and hence the respondents should be requested to spare at least an hour to ensure completeness of information.

Taking the interviews requires a team of interviewers who should be talking to the firms' key points of contact (discussed in the previous section), to gather holistic data on skill shortages.

Considering the seriousness of this exercise and the benefit it promises, even the individuals who should be communicating with the key points of contact (i.e., the respondents)—either through written or verbal means—should be 'skilled interviewers', with the following traits:

- *Clarity of thought*: The interviewer should be able to impart the importance and essence of the exercise to the respondents in a clear and concise manner, and have a keen understanding of all components of the questionnaire to be able to explain it well to the respondents.
- *Focused, polite and persistent*: It must be remembered that the senior personnel being contacted for the survey are busy, and a single email or tele-call cannot guarantee an interview. One has to remain focused on the task and be polite and persistent with regular follow-ups. Of course, if one proceeds with gathering contact details using the steps mentioned in the previous section (i.e., via the corporate headquarters), the chances of easily getting an interview, without much persistence, are higher.
- *Organised, detail-oriented and honest*: They should be able to keep a log of all data—who was contacted, when were they contacted, and what were the responses, to be able to undertake follow-ups and organise meetings in a professional manner. The task would also be useful in helping with constant updation of the firm level data and key points of contact. All of this should be done with full transparency and honesty, if the real benefit of the exercise has to be achieved. That is, the interviewers should neither fudge data, nor talk to just about 'anybody' and claim they have collated accurate data. Just fulfilling hollow 'numbers' (i.e., 'this' many firms and respondents were contacted), instead of striving for good quality information, will lead to a failure of this extensive exercise.
- *Confident, curious, transparent*: The interviewer should be able to engage in a discussion with confidence, keep the discussion on track, and ask questions as necessary to ensure completeness of information. It is also a good idea if the interviewer is transparent with sharing the questionnaire with the respondent, and noting the answers in consultation with respondents as it helps enhance trust and in turn allows the respondent to be confident in sharing data. It also helps ensure data accuracy and replicability of the method by overcoming the bias / inaccuracy that may arise in translating respondents' answers to the skills framework in the questionnaire. In an online meeting, screen-sharing while filling answers is a good idea, which has also worked well in practice.
- *Advanced communication skills and knowledge of language*: To confidently deliver on each of the above, the interviewer needs to have advanced communication skills, with a superior knowledge of grammar and sentence structure to be able to communicate with respect and clarity in written (e.g., emails, filling questionnaire) and verbal (e.g., tele-calls, in-person meetings) formats. In a diverse country like ours, in addition to knowledge of English and Hindi, having interviewers who are conversant (or even proficient) in the local

language will be extremely useful in helping the respondents be at ease in sharing the requisite details.

- *Teamwork and cultural sensitivity*: Considering that firms in the sector are spread across the country, with plants in diverse geographies, it would be useful to have a team of interviewers, who can take on conducting interviews for the same sector, while focusing on different geographies depending on their knowledge of language and culture. Given the vastness of India, and the renewable energy sector, a culturally diverse team will make the task at hand more efficient in terms of time and cost, and effective in assimilating the requisite information.
- *Computer skills*: Along with a knowledge of MS Office and email communication, the interviewers should also be skilled at conducting online interviews through software such as Zoom, MS Teams, Webex, etc. Online interviews tend to be more convenient and time and cost effective, from the side of the respondents and interviewers, and the screen-sharing feature helps maintain transparency—in what is being asked of the respondent, and the answers being noted by the interviewer.
- *Ability to reflect towards the bigger picture*: Firms are profit oriented, and in many instances, it is likely that the respondent will ask: "what benefit do I get?", "will you train those people for me?", "what if you take information from me on what the industry needs, but the skilled people join another firm?". The interviewers should be ready for such questions, and be able to explain how the contribution of each firm helps build an information system to benefit the industry and each of its players.
- *Education and knowledge*: While the above traits are necessary, it is more likely that an advanced degree in economics or a related field, with an interest / work / research experience in the particular sector and the skilling literature, will be helpful. Not only would it allow the interviewer to always have the bigger picture at the back of their mind (as economists are taught how to connect the micro with the macro), but an interest in the sector will be a constant source of curiosity.

8.6.6 Key Findings from the Stakeholders' Survey

Skill shortage is found to be an issue in the solar and wind energy sectors, across the different stages of project development due to peculiar issues emanating from the side of the skilling ecosystem (supply-side). This is especially true of job roles involving on-site plant installation and O&M, where the bulk of the workforce is required.

1. There are no renewable energy specific courses in India. People lack in-depth knowledge of renewable energy: both theoretical and practical knowledge. The industry relies upon the general pool of ITI and engineering candidates (in mechanical, electrical, and electronics streams), who then have to be trained to the needs of the renewable energy industry. While the need for such industry-aligned courses is at the ITI and graduate level, it has been learnt from industry stakeholders that courses in renewable energy are being introduced at the master's level—indicating a clear mismatch between the industry needs and the skilling ecosystem.
2. Practical training, to be familiar with solar and wind modules and site-work, is absent. It has been learnt from stakeholders that while practical training is still possible for job roles in the solar sector, practical training for the wind sector is

only possible on a wind farm. To ensure practical knowledge, the industry looks out for individuals with at least 1–2 years of experience.

3. Solar and wind farms are in remote locations, but there is a lack of locally trained workforce to work on-site and manage site operations, including O&M. It has been learnt that those on-site need to be familiar with the local language and culture to maintain friendly relations with neighbouring villages. It implies that people need to be mobilised from the villages in sunny and windy locales and provided hostel facilities at training centres (to overcome issues regarding daily commute).
    - Shortages may also be experienced at company head offices for desk-based job roles—such as design, scheduling and forecasting engineers, and finance—when people do not wish to re-locate to a non-capital city (as was evinced by firms in Tamil Nadu and Maharashtra).

The *Suryamitra* programme, a top-up course for ITI/diploma graduates (in Electrical, Electronics, Civil, Mechanical, Fitter, Instrumentation, Welder) to be employed for installation and O&M of solar panels, was taken up with much fanfare. The stakeholders have highlighted how the obsession with 'numbers trained' rather than the quality of training—particularly practical training—resulted in poor placement record.[18]

Additionally, despite the fact that a local workforce with knowledge of local language and culture is needed in regions where there is scope for development of solar farms, Suryamitra was conducted across all States of India. A stakeholder on the training side did not appear sensitive to the possibility of a spatial mismatch, and felt it was quite easy for those trained (in say Assam) to be able to take up jobs and adjust to life in another part of the country (say a remote village in Rajasthan). Another stakeholder felt that the rise in roof-top solar installations all across the Indian States should help overcome this spatial mismatch in training and jobs.

The *Vayumitra* programme, a top-up course for ITI/diploma graduates (in Electrical, Electronics, Civil, Mechanical, Fitter, Instrumentation, Welder) to be employed on the wind farm as O&M technician (electrical and instrumentation), O&M technician (mechanical) or Wind Resource Assessors and Site Surveyor, is faced with its own set of challenges—in finding the training institutions to impart the training, and mobilising candidates.[19]

To avoid repeating the mistakes of the *Suryamitra* Programme, the *Vayumitra* programme is directed towards rural-folk, with the aim to develop a local skilled workforce available to work where wind farms are already operating. To be eligible to impart training on the curriculum, the training partners: i) Need to have training centres in the windy areas, at a certain distance from the wind farm to enable practical training and experience for local youth; ii) Should have an MoU with the

[18] According to the numbers on National Institute of Solar Energy (NISE) website, which is the nodal agency for MNRE's *Suryamitra* programme, the overall placement rate across all States and years is 47 per cent: https://nise.res.in/wp-content/uploads/2024/07/2015-2024-Suryamitra-Programme.pdf; accessed on 14 Aug 2024. A stakeholder also indicated how the obsession with numbers resulted in many training centres recording 'bogus' candidates, and that the training quality suffered despite the fact that the training curriculum was developed by the sector skill council in all sincerity.

[19] National Institute of Wind Energy (NIWE), is the nodal agency implementing MNRE's Vayumitra programme. Interestingly, the on-the-job training components in the qualification packs for the Vayumitra job roles are 'optional': https://vsdp.niwe.res.in/VSDP/TP/Participant/; accessed on 27 Aug 2024.

industry for on-the-job training and employability; iii) Need to have all training facilities, including trained faculty and infrastructure such as classrooms, labs, and hostels. It, however, has been difficult to find training partners and centres which meet the criteria, particularly in Telangana and Kerala.

At the same time, mobilising candidates for training has been difficult due to the remote job location and low salaries for O&M (which are in the range of INR 15,000 – 20,000 per month, though salaries are slightly higher for the relatively more skilled role of Wind Resource Assessor). As pointed out by a stakeholder, other work avenues, such as the job of a delivery worker in a major city (which requires no educational qualifications) may appear more lucrative to the youth, than working as an O&M professional at remote plant locations (see Box 8.2). Additionally, instrumentation engineers are in demand in other technical industries too, and wind industry has to compete with such other industries to attract this workforce.

Box 8.2: Which job is more attractive?

Availability of alternative, better-paying, work avenues has made it difficult to mobilize youth for on-site job roles at solar and wind power plants. Salaries may lie in the range of INR 10,000-20,000 for junior level positions, and INR 20,000 – 25,000 for senior level positions for wind-site O&M. A comparison of recent job offerings in Tamil Nadu, from companies in the Wind energy and Food Delivery sectors, indicates why the former may potentially be faced with a shortage of its much-needed workforce.

Comparator	***Technician / Trainee Engineer (Tiruppur, Tamil Nadu)***	***Delivery Boy (Chennai, Tamil Nadu)***
Education required	Diploma / B.E.	12th pass
Skills required	• Good communication skills • Technical knowledge • Team work	• Deliver packages from one place to another safely and on time • Collect payments where needed • Good communication with customers (English and local language) • Physical fitness for riding and lifting
Entry conditions	• Diploma or B.E. in Mechanical and Electrical and Electronics • Ability to commute/relocate	• Driving license and 2-wheeler (can join as cyclist if don't have bike and license) • Smartphone • Age: 18+ years • Bag and uniform kit for Rs.2
Work Experience	1 year	Freshers (0 - 6 months)
Type of contract	Not specified	Not specified
Benefits	• Day shift (full time) • Food, accommodation, travel, training • health insurance, provident fund • Yearly bonus • Employer-provided relocation package	• Health insurance • Flexible hours, including evening and weekend shifts (part time or full time) • Life insurance • Joining bonus up to Rs. 10,000 • Performance bonus • Opportunity for career growth
Place of work	Tiruppur, Tamil Nadu	Chennai, Tamil Nadu
Gender	Not specified (though it is learnt that women do not usually apply for site-jobs)	Not specified (though job title says 'boy')
No. of vacancies	Not specified	Not specified
Salary per month	Rs. 10,000 – Rs. 15,000	Rs. 35,000 – Rs. 40,000

Source: NCAER analysis, using information from advertised positions on online job-portals.

Note: The Technician / Trainee Engineer details are taken from a Wind company's advertisement for their plant in Tiruppur, Tamil Nadu, available at: https://www.glassdoor.co.in/job-listing/technican-trainee-engineer-wind-care-india-pvt-ltd-JV_IC2836484_KO0,26_KE27,50.htm?jl=1009440390077&utm_campaign=google_jobs_apply&utm_source=google_jobs_apply&utm_medium=organic
The Delivery Boy details are taken from Swiggy advertisement, for work in Chennai, available at: https://www.simplyhired.co.in/job/zZPEKAHuwnKEcjDEswDEFkohnq2UWjn-wvGz55Q9HbQbyet5Fy5vgw

The above reasons have rendered a shortage in the availability of a trained workforce on wind farms, which has also been evinced by the stakeholders from the side of the industry and those on the side of skilling.

4. Questions have also arisen on 'who is training'. Renewable energy industry is new, and personnel knowledgeable enough to train are few. Those with industry experience are the ideal individuals in a position to train. However, lack of industry-academia collaborations / tie-ups / partnerships are hampering the creation of an industry-ready workforce.
5. Increasing the generation of solar and wind power through development of solar and wind plants requires an increase in equipment manufacturing, i.e., solar panels and wind turbines and towers. Certain stakeholders highlighted how the original equipment manufacturers (OEMs) are themselves faced with a shortage of technicians for manufacturing and assembly operations, which hampers the OEMs' expansion plans and in turn, the renewable project developers are unable to find adequate equipment for their sites.
6. There are specialised personnel required at the wind farm during construction, such as the erection specialists and crane operators, which too are in short supply. After all, it makes sense to have more trained personnel for such short-term contractual construction jobs only when the industry offers a consistent demand, which has not quite been the case in the recent past.[20]

The fluctuating growth of the renewable energy industry over the past several years, and the wavering importance attributed to it from the side of policy, is blamed for the present state of lagging-affairs on the side of skilling. Better industry-academia alignment, with involvement of industry trainers, is therefore the need of the hour – such that skilling can take place to the desired requirement of the industry, with a focus on 'local' skill development. It will help: i) the industry reduce its cost of training a workforce that is unfamiliar with renewable energy (as is found to be a common practice across all firms), ii) the training centres to have an industry partner for imparting practical experience,[21] and iii) Have a locally skilled workforce which can communicate in the local language at the remote site location. Through such an arrangement, the quality and quantity of an industry-ready skilled workforce is bound to increase. A stakeholder talked about their firm having MoUs with engineering and non-engineering colleges to offer internships to students, who can then potentially be hired at the firm, or even at other firms, with minimal on-the-job training. Another industry stakeholder also pointed out that for Wind industry in particular, a skill gap in Andhra Pradesh, Madhya Pradesh and Rajasthan exists because of poor interaction between industry and skilling institutions, and that supply of skills is better where such interaction is present.

Job roles on-site are considered non-aspirational, such that despite undergoing training, students may choose another work avenue that offers a better salary. Women employment on-site is next to nil (see Box 8.3). An involved engagement of the

[20] Several stakeholders, both from the side of the industry and skilling, pointed out that the wind industry has not done well in the last few years and grown rather slowly in comparison to solar. While it peaked in the early 2000s, it slowed afterwards and picked up again in 2017-18 after which COVID-19 struck. Now the momentum is slowly getting back. Such fluctuation directly impacts employment, and the slow growth in the last few years automatically led to the lack of a pre-trained workforce in the present day.

[21] Setting up labs and equipment to provide practical training at academic institutions is considered difficult and costly.

industry may help in mentoring and counselling students, help setting expectations, better matching of interest and skills with job roles, and prevent attrition. That a career path and other incentives exist at the firm, where a technician can rise to higher level managerial positions, must also be highlighted during the training.

Box 8.3: Prospect for women employment in the green electricity sector

There are few women in the solar and wind industry, and those in the sector are concentrated in job roles based at the corporate offices. These include:

- Administration related roles, including accounts, project finance, secretaries, human resource
- Engineers (across domains), Engineering Pre-Design (EPD)
- Project Coordination, Management Information System
- Resource assessment, Forecasting, Monitoring and Scheduling
- Policy and Regulatory

All stakeholders unanimously mentioned an absence of women for on-site work, particularly where long periods of stay on-site are required – such as O&M. While the firms have expressed their willingness to have gender diversity in the core on-site job roles, most are unable to fulfil the same due to:

- Lack of women at ITI, which offer training in trades preferable to the renewable industry (Electrical, Electronics, Civil, Mechanical, Fitter, Instrumentation, Welder).
- Lack of women applicants for O&M jobs due to remote site locations.
- Pre-conception among stakeholders about women being unable to perform physically taxing tasks. This has been particularly true of O&M roles in the wind sector, given the need for climbing wind mills.

While pre-conceptions, and ensuring women security in India, may take time to change, a positive finding has been the emphasis placed by several firms on treating applications from male and female candidates at par, enacting POSH policies and committees, and providing crèche facilities at corporate office premises (firms have not felt a need to have crèche facilities at plant locations, as there are no women involved there). A firm even talked about policies that provide incentives to their employment agencies if a woman candidate is hired and there being a 'technical committee' to encourage women participation in technical job roles.

In times to come, prospects of increasing women employment are perceived to be higher in:

- Resource assessment, forecasting
- Design: power system design, plant engineering and design, project management
- O&M: for solar (Wind O&M is a possibility once there are lifts provided for climbing), and for both solar and wind as and when O&M gets automated (i.e., remote diagnostics is possible)

Source: NCAER stakeholders' survey

The existence of skill shortage in the green energy industry is not new. In a study[22] undertaken in 2016, the Skill Council for Green Jobs (SCGJ) has conducted an occupational mapping and estimated the expected jobs which will be created by the renewable energy industry. It was on the basis of this study that different qualification packs were introduced for imparting training. It was learnt during the meetings that qualification packs / curriculum for different job roles are finalised after consultation with 30 industry players. Yet, persistence of skill shortage to this date requires digging deeper into the reasons for the same, as came out during NCAER's stakeholder meetings. More importantly, it highlights the need to conduct thorough industry surveys on a frequent basis, as the findings from 2016 and a small sub-set of players are unlikely to be applicable in 2024 and beyond for the entire industry, in such a fast-evolving sector. Additionally, more than just the projected numbers, the focus must be

[22] SCGJ 2016. Skill Gap Report for Solar, Wind and Small Hydro Sectors. Available at: https://sscgj.in/wp-content/uploads/2016/06/SCGJ-skill-gap-report.pdf; accessed on 1 July 2024

to qualitatively understand the detailed skill needs of the sector (i.e., detailed job descriptors for each in-demand job role) and how the industry views the demand for certain difficult to fill job roles evolving. The present study by NCAER is an attempt to help bridge this gap in skill shortage assessment.

Based on NCAER's limited stakeholder interactions, details on the job roles where there is a skill shortage are discussed in the following section.

Job Roles in Demand

Having had detailed discussions with the firms, training institutes, and sector skill council, several job roles came into view, where:

- There is a skill shortage at present (i.e., there are not enough people, but the skills are high in demand by industry).
- There is likely to be a skill shortage in near future, three years from now (i.e., which will be in demand in future, but finding skilled personnel for the same may be difficult too).

Although the study's aim has been to develop a methodology and results from a small sample of firms cannot determine all possible job roles in shortage; yet there is an overlap between the views of the different stakeholders. Job roles mentioned by the stakeholders are detailed in Table 8.5.

Incidentally, from the firms' perspective, all job roles in shortage at present are also perceived to remain in shortage in near future. This is because of the expected growth of the solar and wind energy sectors.

All stakeholders agreed that along with technical training, soft-skills are equally important and are in-demand for the stated job roles. Interviews with stakeholders have been successful at collating details on job descriptors, including the different cognitive, socio-emotional, and physical skills needs for the job role, at different levels of proficiency. Considering that cognitive and socio-emotional skills start developing at the school level, the importance of good quality school education has also been reiterated in stakeholder meetings.

Along with a list of qualifications and skills, the questionnaire has also helped capture the number of personnel required by firms in the stated job roles – both at present and in near future to help anticipate demand, along with the geographic regions where the skilled personnel are required.

Additionally, any attempt to project the number of people required in the sector in the future using the existing PLFS database (as performed using the input-out analysis) is likely to be misleading. There are several job roles in-demand now and in the near future, but there are no individuals employed in their corresponding NCOs according to the PLFS database. It implies that while people may be working in those job roles now and increasingly in near future, any labour demand projections using PLFS will exclude such workers. This includes job roles relating to installers, technicians, resource assessors, engineers, site surveyors, site / project / asset managers– which were mentioned by the stakeholders, and the sector skill council (SCGJ) has even developed some QPs for training personnel in these in-demand roles – particularly for the *Suryamitras* and *Vayumitras*[23] (Table 8.5).

[23] The issue is detailed in an article Dayal, I. and Bhandari, B. 2025. "Expansion in renewable energy implies an employment growth in the sector too — are we undercounting green jobs?" *Down To*

Therefore, an annual national survey of solar and wind firms is recommended to ascertain the demand for job roles and associated skills in times to time, while working alongside to improve the skilling ecosystem and industry-academia collaborations in line with the sector's evolution.

Based on stakeholder interactions, the list of key job roles and their brief descriptions are de-lineated here.

1. Solar Project Manager; Solar Installer; Solar PV Installer and O&M Technician[24]: Solar Panel Installation Technician is also known as 'Panel Installer', the Solar Panel Installation Technician is responsible for installing solar panels at the customers' premises. The individual at work checks the installation site, understands the layout requirement as per design, assesses precautionary measures to be taken, installs the solar panel as per customer's requirement and ensures effective functioning of the system post installation.

2. O&M Technicians (Wind)—Mechanical and Electrical

    - O&M Mechanical Technician-Wind Power Plant[25]: Carry out operation of mechanical components of wind power plant, carry out maintenance of mechanical components of wind power plant, perform basic health and safety practices at project site (Ground and Height), work effectively with others.
    - O&M Electrical & Instrumentation Technician- Wind Power Plant[26]: carry out operation of electrical & instrumentation systems of wind power plant, carry out maintenance of electrical & instrumentation systems of wind power plant, perform basic health and safety practices at project site (Ground and Height), work effectively with others

3. Engineers; Electrical engineers—Power Systems Design; Civil and Electrical Engineers; Project Engineers

    - Engineers (Design engineers/Site Engineers/Forecasting and Scheduling engineers (O&M)): Perform efficient plant design for optimal electricity generation; oversee proper installation and material use, aligned with plant design; planning, forecasting, and scheduling the production and delivery of products and services; coordinate with different teams and stakeholders to ensure timely and efficient execution of projects and tasks; Knowledge of renewable energy systems and practical operations, and safety parameters
    - Electrical engineers- Power Systems Design: Optimising power transmission while reducing losses; knowledge of RE power transmission systems
    - Civil and Electrical Engineers: Perform RE project execution and O&M.

Earth. https://www.downtoearth.org.in/renewable-energy/expansion-in-renewable-energy-implies-an-employment-expansion-in-the-sector-too-are-we-undercounting-green-jobs. March 18.

[24] National Career Services. 2016. National Classification of Occupations 2015. https://www.ncs.gov.in/Documents/National%20Classification%20of%20Occupations%20_Vol%20I-%202015.pdf. Directorate General of Employment, Ministry of Labour and Employment, Government of India, New Delhi.

[25] Skill Council for Green Jobs and National Skills Development Corporation. Undated. "O&M Mechanical Technician – Wind Power Plant". https://sscgj.in/wp-content/uploads/2019/03/SGJ_Q1502-O_M-Mechanical-Technician-Wind-Power-Plant.pdf.

[26] Skill Council for Green Jobs and National Skills Development Corporation. Undated. "O&M Electrical & Instrumentation Technician – Wind Power Plant". https://sscgj.in/wp-content/uploads/2019/03/SGJ_Q1503-O_M-Electrical-Technician-Wind-Power-Plant.pdf.

- Project engineers: Implement the project as per the designs and specifications, within the stipulated timelines.

4. Resource Assessment; Site Surveyor; Resource Analysis:[27] Conduct site survey at power plant, perform basic health and safety practices at project site (Ground and Height) and work effectively with others

5. Site Managers / in-charge /supervisor; Construction / Project Managers: Keeping projects up and running, without technical fault or challenge from locals; Manage and supervise site/construction functions and staff on site, including the installation and O&M vendors; regularly reporting on plant performance; practical experience in wind and solar projects along with the theoretical RE knowledge; Knowledge of machine and managing O&M at wind plant site; awareness of safety considerations. Project manager/Manager project design also needs to perform project design and optimisation of project cost with respect to RE (solar/wind).

6. Asset Management; Quality and Vendor Management Engineers: Optimally and sustainably manage assets relating to their performance, risks and expenditures over their lifetime; efficient asset management for better machine availability and more output; basic managerial skill for asset management along with good communication—ensure quality of the outsourced activities, developing vendors, and managing the vendors.

[27] Skill Council for Green Jobs and National Skills Development Corporation. Undated. "Wind Resource Assessor and Site Surveyor – Wind Power Plant". https://sscgj.in/wp-content/uploads/2019/03/SGJ_Q1202-Site-Surveyor-Wind-Power-Plant.pdf; https://vsdp.niwe.res.in/static/img/Wind%20Resource%20Assessor%20and%20Site%20-%20WPP.pdf.

Table 8.5: Details of in-demand job roles

Job roles	***1) Solar Project Manager; Solar Installer; Solar PV Installer and O&M Technician (Surya Mitra)***	***2) O&M Technicians (Wind)—Mechanical and Electrical***	***3) Engineers; Electrical engineers—Power Systems Design; Civil and Electrical Engineers; Project Engineers***	***4) Resource Assessment; Site Surveyor; Resource Analysis***	***5) Site Managers / in-charge /supervisor; Construction / Project Managers***	***6) Asset Management; Quality & Vendor Management Engineers***
NCO 3/8–digit code	7421.1401: Solar Panel Installation Technician	3113.0102: Maintenance Technician Electrical 3115.0102: Maintenance Technician – Mechanical	214: Engineering Professionals (Excluding Electrotechnology) 215: Electrotechnology Engineers	2165.9900: Cartographers and Surveyors, Other	1323.0100: Manager, Construction/Manager Construction Projects	1324.0100: Manager, Material Control/Manager Materials
NCO 8-digit (QP code)	SGJ/Q0102: Solar PV Installer – Electrical; SGJ/Q0101: Solar PV Installer (Suryamitra)	SGJ/Q1503: O&M Electrical & Instrumentation Technician—Wind Power Plant SGJ/Q1502: O&M Mechanical Technician—Wind Power Plant	SGJ/Q0110: Solar PV Designer SGJ/Q0109: Solar PV Structural Assistant Design Engineer SGJ/Q0106: Rooftop Solar Grid Engineer	SGJ/Q1202: Wind Resource Assessor and Site Surveyor-Wind Power Plant	SGJ/Q0114: Solar PV Project Manager (E&C)	
No. of stakeholders which mentioned this	6	5	4	4	7	3
Match from Job Projections (541, 413, 741, 932, 411) @	No	No	No	No	No	No
Extent of the need (sum of the numbers from stakeholder consultations)	50,000 (NISE), additional 20,000 (till March 2025)	3,660 (NIWE target until March 2025)	40+ (now) and 80+ (three-five years from now)	~ 25 (now) and ~50 (three-five years from now)	~ 35 (now) and 50+ (three years from now)	~ 21 (now) and ~45 (three-five years from now)
Geography (where?)	MP; Across India (with solar rooftop)	Windy States, such as: KL; TL; TN (Tirunelveli, Nagercoil, Udumalpet, Thenkasi); AP (Tadipatri); GJ (Kutch); KA (Shimoga)	Corporate office: MH (Pune) Solar now: KA (Pavagada); TL (Mahabubnagar, Gadwal, (Veltoor, Tandur, Nirmal); RJ (Jaisalmer, Jodhpur, Barmer, Jaisalmer, Dedasari), MH (Dhule) Wind now: TN (Tirupur, Theni); GJ (Jamnagar, Mahidad,	Corp ofc: MH (Mumbai) Solar now: RJ (Barmer, Jodhpur, Jaisalmer) Wind now: AP (Anantpur, Kurnool) Hybrid future: AP Prospective future: TL, MP	Corp ofc: TN (Coimbatore) Solar: TN, MH, GJ; KA (Pavagada); TL (Mahabubnagar, Gadwal); RJ (Jaisalmer, Jodhpur) Wind: AP, TN (Tirupur); GJ (Jamnagar, Bhuj) ; KA (Chitradurga, Harapanahalli, Harihar), MH (Satara, Nandurbar), RJ (Jaisalmer, Jodhpur); MP (Devas)	Corp ofc: MH (Mumbai) Solar: TN, MH, GJ Wind: GJ, TN; RJ (Jaisalmer, Jodhpur); MP (Devas) Solar Future: AP, MH, GJ, TN, RJ Wind future: TN, GJ

Job roles	*1) Solar Project Manager; Solar Installer; Solar PV Installer and O&M Technician (Surya Mitra)*	*2) O&M Technicians (Wind)—Mechanical and Electrical*	*3) Engineers; Electrical engineers—Power Systems Design; Civil and Electrical Engineers; Project Engineers*	*4) Resource Assessment; Site Surveyor; Resource Analysis*	*5) Site Managers / in-charge /supervisor; Construction / Project Managers*	*6) Asset Management; Quality & Vendor Management Engineers*
			Samana, Sidhpur), AP (Anantpur, Kurnool), RJ (Bhakrani, Sipla, Tejuva); MP (Chandgarh); MH (Andhra Lake, Jath, Khandke); KA (Hara, Saundatti) Solar future: RJ (Barmer); GJ (Banaskantha) Wind future: MP Hybrid future: RJ+MP (Jaisalmer + Dhar); GJ+MP (Bansakantha + Dhar); RJ+MP+TN (Jaisalmer+ Dhar + Dindigul); AP		Hybrid: KA (Kopal) Solar future: AP, MH, TN, RJ (Barmer); GJ (Banaskantha) Wind future: TN, GJ, MP Hybrid future: KA (Gudadur); RJ+MP (Jaisalmer + Dhar); GJ+MP (Bansakantha + Dhar); RJ+MP+TN (Jaisalmer+ Dhar + Dindigul)	
Monthly income (₹)	12,000 – 15,000	15,000 – 20,000	Varies by experience: ~ 40,000 – 60,000	Entry-mid level: ~ 35,000 – 45,000	Mid-Senior level positions: 1,30,000 – 1,90,000	Managerial position: ~ 80,000 – 1,00,000
Educational Qualifications	ITI/Diploma/B Tech (Electrical/Mechanical/ Electronics/ Civil/ Fitter/ Instrumentation / Welder)	ITI / diploma (Mechanical / electrical/ electronics/ Civil/ Fitter/ Instrumentation/ Welder)	B.E. / Diploma / B.Tech / M.E. (Electrical / Mechanical / Electronics/ Civil)	B.E. / B. Tech / Diploma / M.Tech (Environmental sciences/ electrical/ computers/ Mechanical/ Civil/ Electronics and Communication / Control & Instrumentation)	ITI / diploma / B.E./B Tech / M Tech (electrical/ mechanical/electronics)	Diploma / B.E. (Electrical/ mechanical/ civil)
Skills required at the competency level (3)	**Cognitive skills**: Speaking; communication; digital skills; active listening; problem solving; time management; **Socio-emotional skills**: Conscientiousness; agreeable (teamwork); emotional stability;	**Cognitive skills**: Reading; writing; speaking; communication; language (business plus local languages); numeracy/math; digital skills; active listening; science; problem solving; critical	**Cognitive skills**: Reading; writing; speaking; communication; language (local, English); numeracy/math; ICT skills; active listening/learning; science; problem solving; critical thinking; creativity; judgement; systems	**Cognitive skills**: Reading; writing; speaking; communication; language (local, English); numeracy/math; ICT skills; active listening/learning; science; problem solving; critical thinking;	**Cognitive skills**: Reading; writing; speaking; communication; language (local, English); numeracy/math; ICT skills; active listening/learning; science; problem solving; critical thinking;	**Cognitive skills**: Reading; writing; speaking; communication; language (local, English); numeracy/math; ICT skills; active listening/learning; science; problem solving; critical thinking;

Job roles	***1) Solar Project Manager; Solar Installer; Solar PV Installer and O&M Technician (Surya Mitra)***	***2) O&M Technicians (Wind)—Mechanical and Electrical***	***3) Engineers; Electrical engineers—Power Systems Design; Civil and Electrical Engineers; Project Engineers***	***4) Resource Assessment; Site Surveyor; Resource Analysis***	***5) Site Managers / in-charge /supervisor; Construction / Project Managers***	***6) Asset Management; Quality & Vendor Management Engineers***
	Physical skills: ability to work at heights, e.g., solar rooftop; or in confined spaces Global competence **TVET**: Fundamentals of electricity, electric components, necessary tools, measuring instruments and Solar PV; how to install, test, commission Solar PV systems efficiently, and operate, maintain, and troubleshoot solar PV systems; industrial safety; Solar field experience; knowledge of software (Sketchup, PVSyst), SCADA; working on computer (Word, excel, outlook etc.); need to work with drones in future for O&M/security (*overlap with drone operators in agriculture sector*) **Entrepreneurial skills** (Managing projects, installations, and manage technicians)	thinking; creativity; systems analysis; resource/time management; diversity **Socio-emotional skills**: Open to experience; conscientiousness; agreeable; emotional stability; **Physical skills:** climb windmills; ability to work at height and in confined spaces; actively access interspersed windmills; physically adjusting to different work shifts **TVET**: Wind energy knowledge and its electrical and mechanical aspects; O&M of the electrical and mechanical equipment—monitoring parameters and attending to breakdowns due to faults in machine parts; knowledge of working at height and in confined spaces with high voltages, and of working with wirings, gearboxes, bearings,	analysis/evaluation; resource/time management; diversity; **Socio-emotional skills**: Open to experience; conscientiousness; agreeable; emotional stability; instructing; negotiation; persuasion; Physical skills ,particularly for on-site work; Global competence **TVET**: *Engineers (Design engineers/Site Engineers/Forecasting and Scheduling engineers (O&M)):* efficient plant design for optimal generation; oversee proper installation and material use, aligned with plant design; planning, forecasting, and scheduling the production and delivery of products and services; coordinate with different teams and stakeholders to ensure timely and efficient execution of projects and tasks; Knowledge of RE systems and practical operations, and safety parameters; knowledge of MS Office; CAD/CAM; SCADA; PVSyst.	creativity; judgement; systems analysis/evaluation; resource/time management; diversity; **Socio-emotional skills**: Open to experience; conscientiousness; agreeable; emotional stability; instructing; negotiation; persuasion; Physical skills (need to climb towers, work at heights); Global competence **TVET**: *Site surveyor*: Identifying the right land parcels and activities regarding survey of land- to acquire land systematically; knowledge of survey tactics and required equipment, operate equipment like Total Station / GPS / AutoCAD; MS office *Resource Assessment / analysis*: Layout design (wind / solar) along with energy assessment for individual sites, knowledge of RE energy assessment (study and analysis of wind and solar resources, in	resource/time management; cultural diversity; **Socio-emotional skills**: Open to experience; conscientiousness; agreeable; emotional stability; instructing; negotiation; persuasion; Physical skills (Actively access large wind sites, where each plant may be a km apart; climbing the tower for inspection); Global competence (especially concerning communication; can have people working for other global operations too; due to competition from global firms) **TVET**: Keeping projects up and running, without technical fault or challenge from locals; manage and supervise site / construction functions and staff on site including the installation and O&M vendors; regularly reporting on plant performance; practical experience in wind and solar projects along with the theoretical RE knowledge; knowledge of machine and managing O&M at wind plant	creativity; judgement; systems analysis/evaluation; resource/time management; diversity; **Socio-Emotional Skills**: Open to experience; conscientiousness; agreeable; emotional stability; instructing; negotiation; persuasion; Physical skills (site-work, climbing wind-mills); Global competence (especially concerning communication; competition from global firms) **TVET**: Optimally and sustainably manage assets relating to their performance, risks and expenditures over their lifetime; Efficient asset management for better machine availability and more output; basic managerial skill for asset management along with good communication—Ensure quality of the outsourced activities, developing vendors and managing the vendors; practical

Job roles	***1) Solar Project Manager; Solar Installer; Solar PV Installer and O&M Technician (Surya Mitra)***	***2) O&M Technicians (Wind)—Mechanical and Electrical***	***3) Engineers; Electrical engineers—Power Systems Design; Civil and Electrical Engineers; Project Engineers***	***4) Resource Assessment; Site Surveyor; Resource Analysis***	***5) Site Managers / in-charge /supervisor; Construction / Project Managers***	***6) Asset Management; Quality & Vendor Management Engineers***
		and hydraulic systems; understand health & safety practices in wind industry, SCADA	*Electrical engineers—Power Systems Design*: Optimising power transmission while reducing losses; knowledge of RE power transmission systems, Conversant with MATLAB / ETAP; *Civil and Electrical Engineers:* knowledge of RE project execution and O&M. *Project engineers:* Implement the project as per the designs and specifications within the stipulated timelines. Future training for BESS and Green H2.	terms of geographical locations, historical trends, and quality); trained on software for resource assessment (e.g., WindPro); MS Office. Understand and perform health and safety practices at project site--Ground and Height	site; awareness of safety considerations; proficient in MS Office (Emails, Excel, PowerPoint). *Project manager/Manager project design*: Good communication, knowledge of CAD and other specific software (e.g., for solar: PVSyst software—to estimate generation from solar plant); project design and optimisation of project cost with respect to RE (solar/wind) Future skills relating to BESS; Green H2; bio-fuels	experience in wind and solar projects along with the theoretical RE knowledge; knowledge of MS Office and software for remote monitoring of solar and wind plants; safety awareness is important as work with electricity; future skills relating to Battery Energy Storage Systems; Green Hydrogen; bio-fuels
Skills Shortage	Yes	Yes	Yes	Yes	Yes	Yes
Skills Gap	Yes	Yes	Yes	Yes	Yes	Yes
Relevance of TVET System	- Field / site experience is necessary, but practical experience and training is lacking; communication skills are also lacking- how to talk to customers. - Programs are not imparting requisite knowledge (Trainees do not even know the difference between AC/DC, or between current and voltage). - People tend to learn from online videos on YouTube or social media--	- Those coming from colleges are not familiar with wind sites, and only have theoretical knowledge. Have to be imparted safety related training as well as practical (i.e. skill requirement on the field). - Need to train people who can attend to mechanical and electronic aspects	- *Electrical engineers—Power Systems Design*: no one training people in this field - *Ground Execution- Civil and Electrical Engineers*: people are not industry ready - People lack in-depth renewable energy (RE) knowledge: both theoretical and practical knowledge. A curriculum needs to be designed for RE sector.	- Lack of institutes training people in these fields - No structured training method - People lack RE knowledge: both theoretical and practical knowledge - For wind sector, resource assessor and site surveyor, the programme is being implemented by NIWE, but there is a lack of training	- Need to have engineering courses/B.E. in renewable energy (RE) (No RE courses for entry/mid management level). NTPC / NPTI / IIT /UPES have engineering courses related to power, but it is not enough to meet industry demand in terms of the numbers required. Courses should be run across States to overcome this spatial shortage. - Engineers: have theoretical knowledge, but application of	- Need to have B.E./diploma in renewable energy (RE) (No RE courses for entry/mid management level). A curriculum needs to be designed for RE sector. When electrical/ mechanical engineers join, they do not have RE knowledge - Engineers: have theoretical knowledge, but application of knowledge is missing;

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	These are not the right places, and impart wrong knowledge. - They also should have knowledge of drill machines and grinder and other tools – but it is lacking. - Trainers do not have field experience, and only have bookish knowledge. It is important that training is being provided by good quality, experienced trainers, who have industry knowledge.	(mechatronics). - Lack of training centres with requisite facilities to impart training and those meeting NIWE's selection criteria (i.e. training centre in proximity to wind farm, MoU with industry for OJT and employability, trained faculty and infrastructure—classroom, labs, hostels)		centres with requisite facilities to impart training, and those meeting NIWE's selection criteria (i.e. training centre in proximity to wind farm, MoU with industry for OJT and employability, trained faculty and infrastructure—classroom, labs, hostels)	knowledge is missing; - For site roles: practical knowledge needs to be imparted. People need to be exposed to firm's green electricity systems - Entire skill set is needed-managerial & technical skills. Difficult to find people with both (particularly local people with managerial bent of mind) - Education and skilling system should at least impart overall awareness of safety considerations and provide a complete understanding of the core area of work	- For site roles: practical knowledge needs to be imparted. People need to be exposed to firm's green electricity systems.
Gender (Challenges) *	Security and required physical skills to work at sites make these occupations non-aspirational both from demand and supply sides; Lack of women in relevant trades at ITI		There are some women in these job roles, and companies foresee an increase in women employment in these roles in next three years. Yet challenge comes from the fact that a ready-talent pool is not available (who have experience in renewable energy on the technical side).		Security and required physical skills work at sites make these occupations non-aspirational both from demand and supply sides; absence of crèche/childcare facilities on-site	
Challenges Faced by Industries in Meeting Skill Requirements	ITI graduates have little practical skills, which means that firms incur costs and time in training them		Incur costs in making the hired workforce (from general engineering pool) industry ready and trained to RE needs		Shortage of locally available capable people who can supervise construction and O&M on-site. These are senior/managerial level positions and it is difficult to shift with family to the remote site location, resulting in shortage as well as attrition.	
Industry-specific interventions that facilitate skill & capacity development (best practices)	Learning & Development (L&D) divisions; training on the job		L&D divisions; training on the job; Graduate Engineer Trainees		L&D divisions; training on the job (particularly practical knowledge for site roles)	
Policy Recommendations	**Skill Training Programmes:** Training programmes need to be expanded especially for training in the wind sector; Remote location adds to spatial mismatch and hence one needs locally skilled workforce—Local coordination		**Skill Training Programmes**: Training programmes need to be expanded to fulfil specific needs of the RE sector; Remote location adds to spatial mismatch and hence one needs locally skilled workforce— Local coordination		**Skill Training Programmes:** Need for upskilling/reskilling programmes, to enable those with experience in other managerial / supervisory site roles (E.g., in conventional power) to take up such senior roles in RE.	

Job roles	***1) Solar Project Manager; Solar Installer; Solar PV Installer and O&M Technician (Surya Mitra)***	***2) O&M Technicians (Wind)—Mechanical and Electrical***	***3) Engineers; Electrical engineers—Power Systems Design; Civil and Electrical Engineers; Project Engineers***	***4) Resource Assessment; Site Surveyor; Resource Analysis***	***5) Site Managers / in-charge /supervisor; Construction / Project Managers***	***6) Asset Management; Quality & Vendor Management Engineers***
	between industry and ITIs is critical. **Curriculum Development**: Practical experience at solar and wind sites, knowledge of latest equipment, data and analytical skills aligned with industry requirements; emphasis on development of local skilled workforce; engage more master trainers from the industry **Gender:** Security and reduced physical work at sites (lifts for climbing windmill; automated O&M); hostel facilities at ITI to encourage women in relevant trades; counselling and mentoring at high school level and encouraging women candidates by awareness on POSH, equal opportunity, etc. **Skill Initiatives:** Dual vocational skilling programmes; apprenticeships should be made mandatory; Compulsory OJT components during education/training; involvement of industry trainers for teaching and mentoring (aligning students interests and expectations for better matching and lowering attrition)		between industry and engineering colleges is critical. **Curriculum Development**: Develop specialised courses on RE technology (at present industry hires from general pool of engineering graduates, and trains them to RE needs); development of soft skills should be integral to the curriculum. **Gender**: Counselling and mentoring from high school level, encouraging women candidates in RE engineering trades, and generating awareness on renewable energy company practices (on POSH, equal opportunity, etc.) **Skill Initiatives**: Compulsory OJT components during education/training; involvement of industry trainers for teaching and mentoring (aligning students' interests and expectations for better matching and lowering attrition)		**Curriculum Development**: Curriculum should impart engineering (specific to RE) and managerial skills, along with practical experience at solar and wind sites; Emphasis on development of local skilled workforce; development of soft skills (especially excellent communication skills) and knowledge of safety considerations on-site should be integral to the curriculum **Gender:** Counselling and mentoring from high school level, encouraging women candidates in RE engineering trades, and generating awareness on renewable energy company practices (on POSH, equal opportunity, etc.) **Skill Initiatives:** Compulsory OJT components during education/training; involvement of industry trainers for teaching and mentoring (aligning students interests and expectations for better matching and lowering attrition); skill development at local level	

Source: NCAER survey.
Notes: @ Pink shade indicates no match between I-O quantitative top 5 occupation projections (Chapter 3) and survey-based top 6 occupation projections

8.7 Recommended Methodology

Based on the above, the recommended methodology to assess skills shortages and skill gaps for this sector is the following:

1. Map the sub-segments of the sector to the NIC code and specify them clearly. For example, the wind sub-sector is not clearly specified in the NIC.
2. Update mapping of NCO 2015 job roles with job roles identified by the Sector Skill Councils. This should be an annual exercise.
3. In coordination with the Ministry of Skill Development and Entrepreneurship, the Sector Skill Council needs to implement surveys on a regular (at least annual) basis, which captures vacancies of firms. The job roles should be mapped/matched with the ones previously identified. Ideally the Economic Census forms the frame for any survey. Given the lack of data, the Ministry of Corporate Affairs' database or Goods and Services Tax Network are the other sources of universal data, from where data may be used to derive the universe. That universe needs to be divided into the sub-sectors as previously identified. Then proper sampling strategy needs to be adopted to understand the validity of the results. Biases needs to be addressed. Response rates should also be collected.
4. Big Data analysis is highly recommended for SSCs using various job sites[28] They should also use/assess data from National Career Services and various employment exchanges around the country. The job roles should be mapped/matched with previously identified job roles.
5. The questionnaires asked respondents of the mediums used for hiring employees. While direct recruitment through job fairs at ITI and campus recruitments from engineering colleges were common, several firms also advertised positions on websites such as LinkedIn, Naukri.com, and Workindia.in and National Career Services. The job details from advertised positions on these portals can help create a good database to understand the kind of job roles which are in demand by the industry along with the corresponding educational qualifications, skill-sets, and salaries. Constant tracking of such data can also help keep the job-roles and skills database dynamic.
6. Stakeholder interactions needs to be carried out as an annual exercise based on templates designed by the MSDE. It will capture jobs which are difficult to fill but also get a holistic view of the sector in terms of emerging technological trends, emerging jobs, detailed qualitative needs for qualifications and skills, hiring practices, best practices of firms, migration trends, practices to encourage female labour force participation, etc.
7. Last but not the least, the MSDE, Ministry of Labour and Employment and Ministry of Statistics and Programme Implementation should design an occupation-wage-employment survey. It is absolutely important to identify the occupation codes mentioned in Step 2. Ideally the Economic Census forms the frame for any survey.

This chapter puts forth the methodology and the instrument which can be useful to gather insights on skill shortages in the green electricity sector, and how it may be captured on a dynamic basis. Through the challenges faced in testing out the methodology, the chapter also attempts to present practical solutions to the same.

[28] Big data should only be used as a 'supplement': As many job roles, especially the core manufacturing job roles which tend to be filled through campus placements from engineering colleges and ITI, may not to be advertised online. They will hence be missed in the big data analysis, despite being in-demand and faced with a skill shortage.

Given the novel nature of the exercise, in-person interviews are recommended at the start. Though, MSDE may consider moving to direct submission of details by the firms once the Labour Market Information System (LMIS) goes online, and the process of data collection has been regularised and popularised. This direct submission could involve uploading an electronic version of the questionnaire on the MSDE website, which can be accessed by the firms to submit their answers.

Moving forward, it would be a good idea to also consider the sector of manufacturing of solar panels and wind turbines and towers, as all technological advancements in the renewable energy industry – to manufacture more efficient solar and wind equipment – are happening in this stage. While this was outside the scope of the present study, several stakeholders highlighted the issue of shortage of workers for manufacturing, which stands to hold back the expansion of solar and wind electricity generation in India and the achievement of 2030 targets. It should not be a difficult task to do so, since the OEMs (i.e., original equipment manufacturers) are already mentioned among the stakeholders who should be contacted for the study (as they also tend to be involved in O&M activities).

Though the usefulness of a labour market information system was acknowledged by the respondents, the workforce will be able to fulfil the skill demands only when the education and skilling ecosystem can keep up with designing their curriculums in the desired manner as well. ITI and engineering colleges must look up to collaboration possibilities with the industry to prepare an industry ready workforce, particularly at the local village-level where renewable energy plants are located / are in the pipeline.