Skill Gap Report for Solar, Wind and Small Hydro Sector

Skill Council for Green Jobs

September, 2016

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Executive Summary

The Renewable Energy Industry Research Analysis Report, 2016 presents the results of the industry survey undertaken by Skill Council for Green Jobs to profile the renewable energy sector and map the key skill requirements across various sub sectors with the growth targets of the sector.

This survey report consists of exhaustive analysis of renewable energy sector's profile, growth trends and skill trends across its 4 major sub sectors as follows:

1. Solar Photovoltaic
2. Solar Thermal Applications
3. Wind Power
4. Small Hydro Power

This study is conducted taking into account the trends and factors prevalent across India. Extensive stakeholder consultations have been done to assess the manpower employment pattern across key renewable technology based power plants (solar and wind, small hydro), solar thermal based applications (Water heating (Industrial and Domestic), Solar Cooking, etc.) as well as manufacturing of wind components.

The skill gap analysis has been done taking into account the MNRE targets in respective segments and estimating the capacity addition till 2025 and 2030 extrapolating the historical growth. The snapshot of overall skill gap number across various sub-sectors is shown below:

1. **Solar PV Sector**

Sub - Sector	Current Capacity	Cumulative Capacity till FY 2022	Cumulative Capacity till FY 2025	Cumulative Capacity till FY 2030
Solar PV – Ground Mount (MW)	7065	62265	87765	~125000
Solar PV – Rooftop (MW)	740	40540	67540	~125000
Solar PV Pump sector (units)	1.47 lakhs	14.70 lakhs	46.69 lakhs	309 lakhs[1]
Solar off grid (units)	23 lakhs	200 lakhs	584 lakhs	3497 lakhs[2]

[1] CAGR of 46% taken based on historical growth
[2] CAGR of 43% taken based on historical growth

Sub - Sector	Current Manpower	Skill gap till FY 2022	Skill gap till FY 2025	Skill gap till FY 2030
Solar PV - EPC	37,097	4,00,257	4,00,257	6,40,320
Solar PV – O&M	24,572	2,34,951	2,81,693	4,24,055
Solar off grid	10,409	36,628	1,00,087	3,99,854

2. Solar Thermal Sector

Sub - Sector	Current Capacity	Cumulative Capacity till FY 2022	Cumulative Capacity till FY 2025	Cumulative Capacity till FY 2030
Solar domestic water heating sector (million sq. m.)	9.12	18.00	25.29	44.47[3]
Concentrated solar heating sector (000 sq. m.)	55.8	202.85	386.75	1133.8[4]

Sub - Sector	Current Manpower	Skill gap till FY 2022	Skill gap till FY 2025	Skill gap till FY 2030
Solar thermal applications	13508	16,167	29,369	65,490[5]

3. Wind Power Sector

Sub - Sector	Current Capacity	Cumulative Capacity till FY 2022	Cumulative Capacity till FY 2025	Cumulative Capacity till FY 2030
Wind Energy Installed Projects (MW)	26,932	60,000	92,208	~102022
Wind Energy Installed Manufacturing Capacity (MW)	9500	9500	12305	~12305

[3] CAGR of 11% assumed

[4] CAGR of 24% assumed

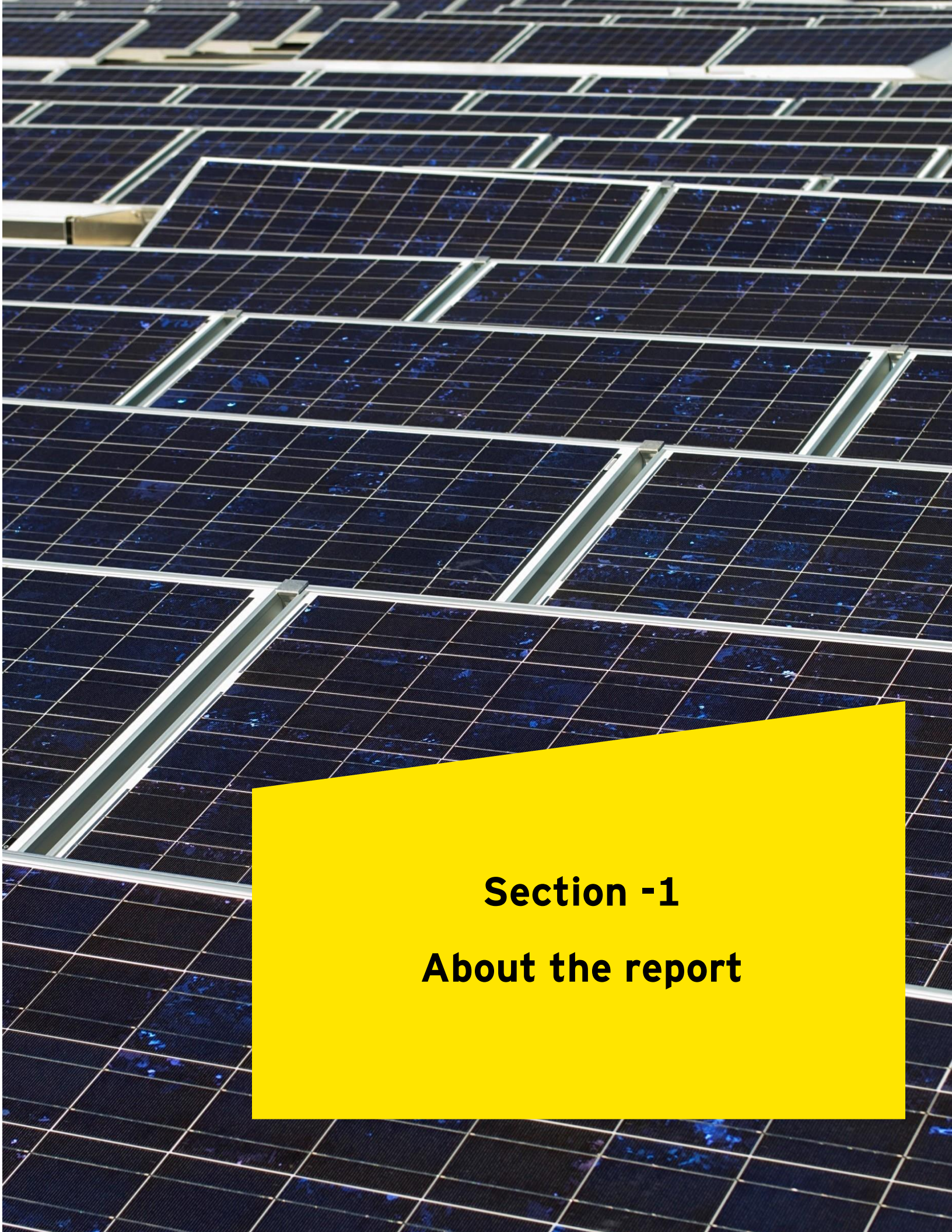
[5] To estimate skill gap till 2030, the CAGR of 12.8% has been taken basis the trend till 2025

Sector	Current Manpower	Skill gap till FY 2022	Skill Gap till FY 2025	Skill Gap till FY 2030
Engineering, Procurement and Commissioning	13,691	62,999	91,952	91,952
Operation and Maintenance	16,159	19,841	39,166	60,448
Manufacturing	8,215	-	2,426	2,4266
Total	**39,317**	**82,840**	**1,33,544**	**1,76,666**

4. Small Hydro Power Sector

Sub - Sector	Current Capacity*	Cumulative Capacity till FY 2022	Cumulative Capacity till FY 2025	Cumulative Capacity till FY 2030
Small hydro installed project (MW)	4,274	5,774	6,524	~7,774

Sector	Current Manpower	Skill gap till FY 2022	Skill Gap till FY 2025	Skilled manpower required till FY 2025	Skill Gap till FY 2030
Engineering, Procurement and Commissioning	13,104	-	-	13,104	-
Operation and Maintenance	45,947	18,200	26,000	71, 947	36,400
Total	**59,051**	**18,200**	**26,000**	**85,051**	**36,400**



Section -1

About the report

1. About the Report

This report presents the skill gap analysis conducted across 4 sub-sectors in the renewable energy sector namely: Solar PV, Solar Thermal, Wind and Small Hydro. The skill gap analysis has been done to assess the job role specific manpower requirement, primarily at entry level (also covering other important roles). Based on the skill gaps, select job roles shall be finalized for development of Qualification Packs (QPs) and National Occupational Standards (NOS) documents.

National Occupational Standards: National Occupational Standards (NOS) specify the standard of performance, knowledge and understanding when carrying out a particular activity in the workplace. Each NOS defines one key function in a job role[6].

Qualification Packs: A set of NOSs, aligned to a job role, called Qualification Packs (QPs), would be available for every job role in each industry sector. These drive both the creation of curriculum, and assessments. These job roles would be at various proficiency levels, and aligned to the NSQF.[7]

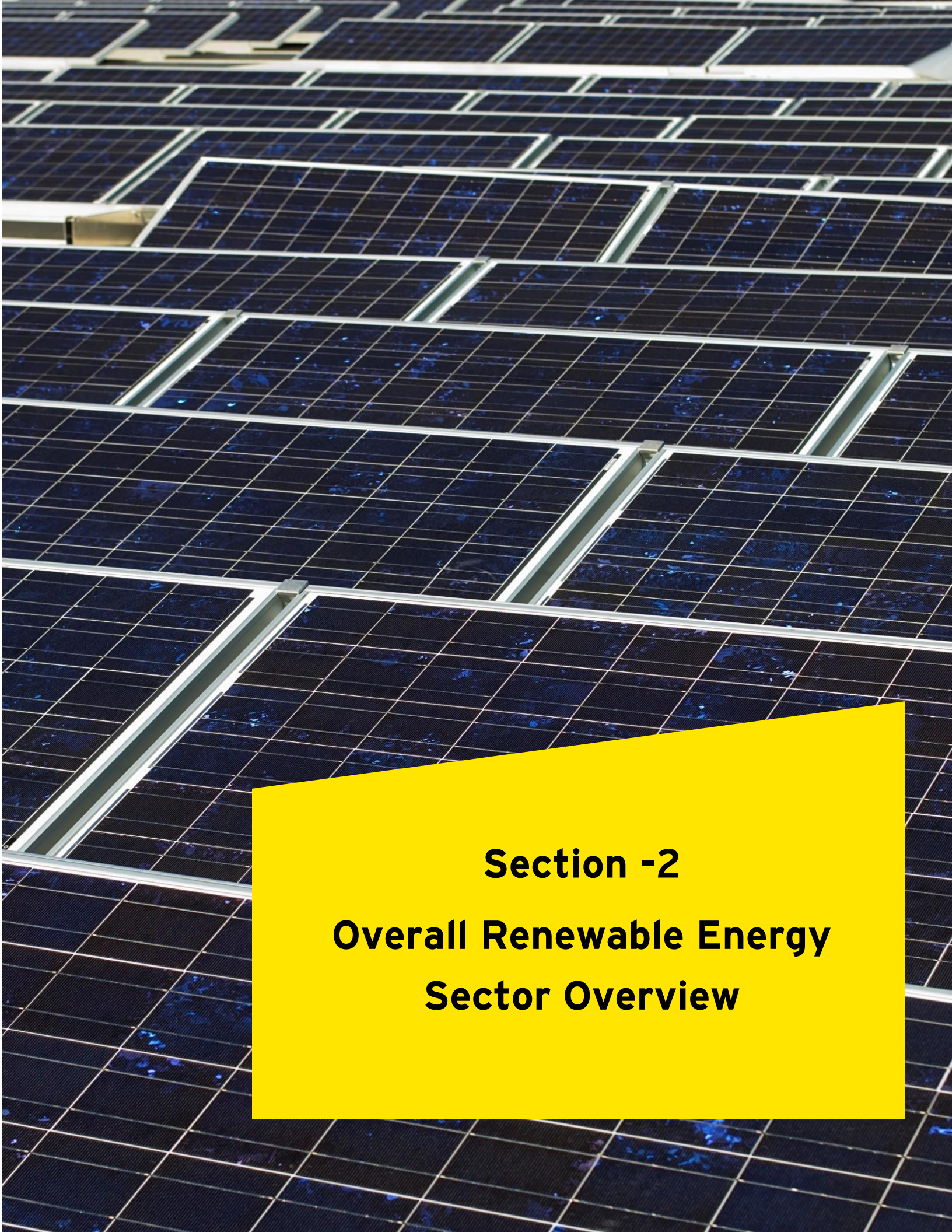
1.1. Report structure

The report has been divided into following chapters

- Industry overview
- Our approach to skill gap analysis
- Subsector analysis:
- Solar PV sector skill gap
- Solar thermal sector skill gap
- Wind sector skill gap
- Small hydro sector skill gap
- Supply side Manpower
- Conclusions: Job roles identified based on skill requirement in each sub-sector

[6] http://www.skilldevelopment.gov.in/qp&nos.html

[7] http://www.skilldevelopment.gov.in/qp&nos.html



Section -2

Overall Renewable Energy Sector Overview

2.Overall Industry Overview

2.1. Introduction

India contributes to 18% of the world's population, uses only 6% of the world's primary energy. However, as per the statistics, India's energy consumption has almost doubled since 2000 and it possesses the enormous potential for further growth. Indian economy, already the world's third-largest, is growing rapidly and policy makers are committing themselves to focus on energy efficiency as well as sustainability. "Make in India" puts manufacturing at the heart of India's growth model and that essentially means a large rise in the energy needed to fuel India's development. Further, India requires a cumulative $2.8 trillion in investment in energy supply in our main scenario, three-quarters of which goes to the power sector, and a further $0.8 trillion to improve energy efficiency. India's power system needs to almost quadruple in size by 2040 to catch up and keep pace with electricity demand that – boosted by rising incomes and new connections to the grid – increasing at almost 5% per year.[8]

Therefore, this has led to a stronger focus as well as ambitious target towards harnessing of energy from renewable sources led by solar and wind power. Currently, India has 4324 MW of Small Hydro power installed and close to 28[9] GW of wind power capacity, but has barely tapped its huge potential for renewable energy. India is, however, aiming high in this area, with a target to reach 175 GW of installed renewables capacity by 2022 (excluding large hydropower), which is a steep increase from today's level of ~47 GW.

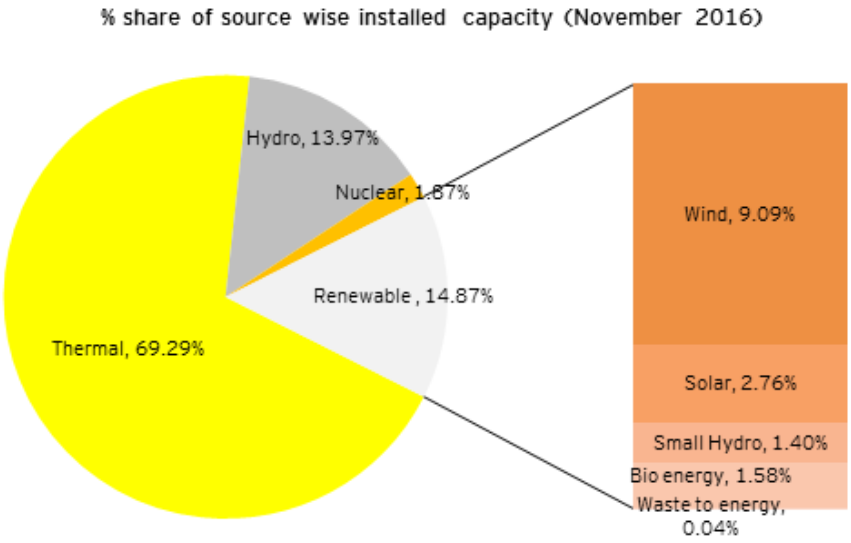


Figure 1: Percentage share of source wise installed capacity of power (Values in MW) [10]

[8] India Energy Outlook- 2015, International Energy Agency

[9] http://mnre.gov.in/mission-and-vision-2/achievements/

[10] http://www.cea.nic.in/reports/monthly/installedcapacity/2016/installed_capacity-11.pdf

Extensive stakeholder consultations have been done to assess the manpower employment pattern across key renewable technology based power plants (solar and wind, small hydro), solar thermal based applications (Water heating (Industrial and Domestic), Solar Cooking, etc.) as well as manufacturing of wind components. Subsequently, the skill gap in the sector is being assessed based on the proposed capacity addition plans and stakeholder input on the manpower requirements.

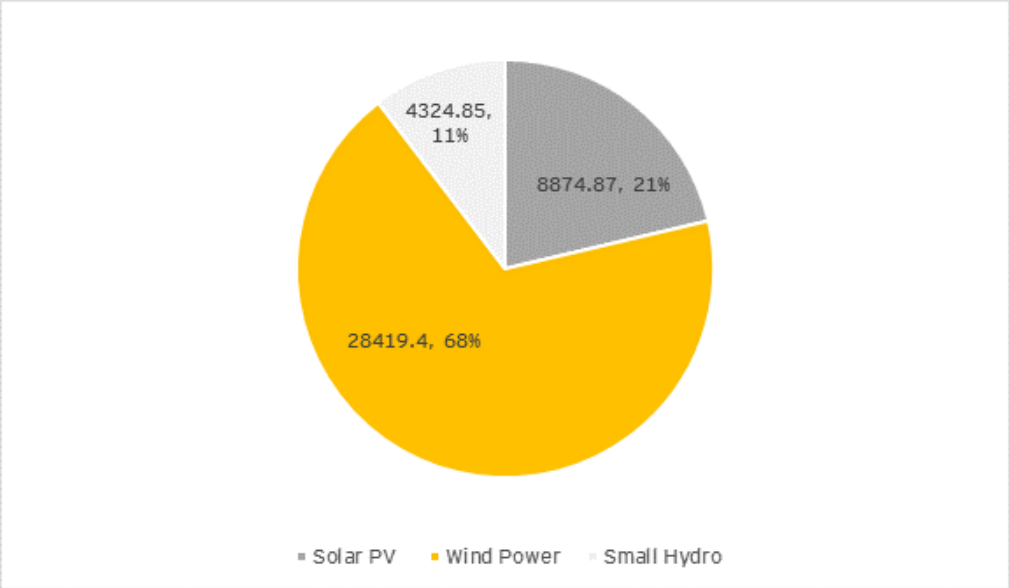


Figure 2: Current installed capacity in the sub-sectors being studied in this report (MW) except solar thermal applications[11]

Currently the total installed area of solar water heating systems is 9.12 million sq. m. and that of Concentrated Solar Thermal Systems is 55,880 sq. m. [12]

2.2. Renewable energy sector targets – specific to sub-sectors covered in the study

As depicted above, currently, wind power constitutes approx. 28 GW and the largest share in renewable energy currently. However, solar power is taken up as a key element of the government's expansion plans with a target of 100 GW of to be achieved by 2022 depicted as in the figure. [13]

[11] http://mnre.gov.in/mission-and-vision-2/achievements/

[12] MNRE Annual Report 2015-16

[13] http://mnre.gov.in/file-manager/annual-report/2015-2016/EN/Chapter%201/chapter_1.htm

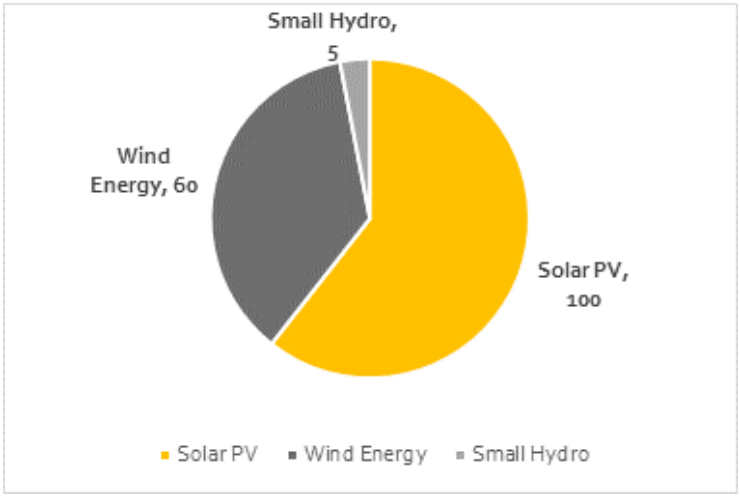


Figure 3: Target capacity to be achieved in the sub-sectors being studied in the report (GW) (10 GW is bio-mass not covered here)

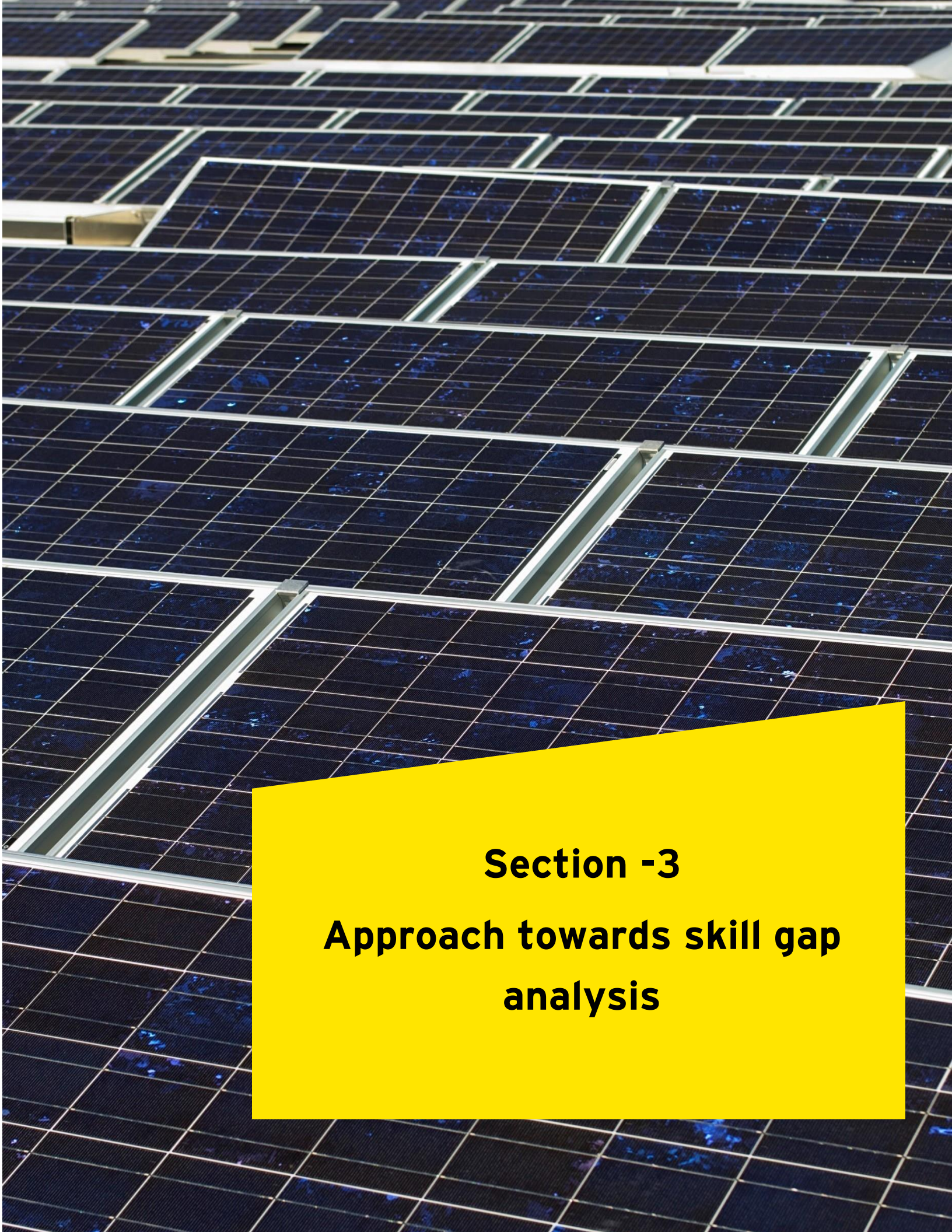
2.3. Industry Structure

The renewable energy sector is divided into[14] :

- **Grid –interactive power:** Solar power , Small Hydro power, Wind power, Bio Power (Biomass and Gasification and Bagasse Co-generation), Waste to power
- **Off- Grid / Captive power :** Waste to Energy, Biomass (non- bagasse) Co-generation, Biomass Gasifiers, Aero generators, SPV Systems, Water mills/micro hydel
- **Other renewable energy systems:** Family Biogas Plants, Solar Street Lighting Systems, Solar Lanterns and Solar Home Lighting Systems, Solar Water Heating Systems, Solar Cookers, Standalone solar/ biomass based power generators, Akshay Urja / Aditya Solar Shops, Wind pumps and Micro – Hydal Plants

This report focuses **ONLY on Solar Power including decentralised solar PV systems and off-grid solar PV systems, Wind Power, Small Hydro power, and solar thermal applications namely solar water heating systems, solar cookers and concentrated solar thermal**

[14] MNRE- http://mnre.gov.in/mission-and-vision-2/achievements/



Section -3

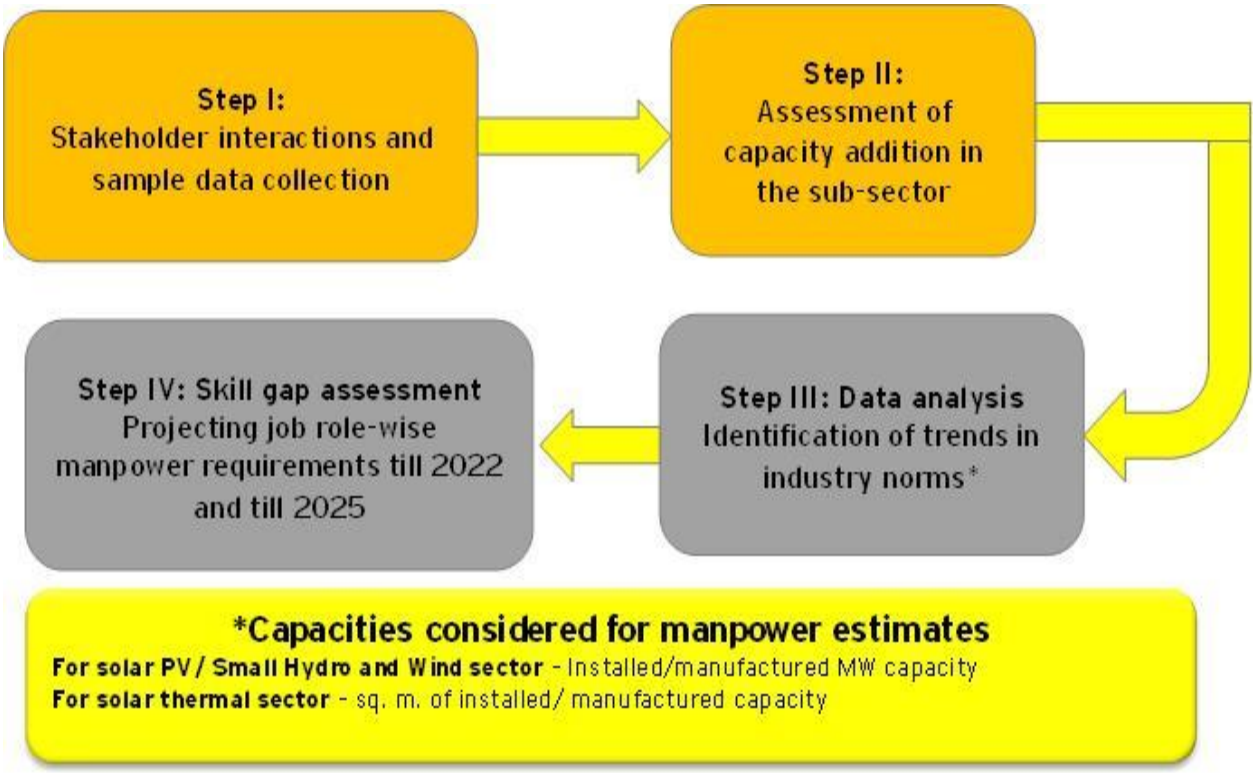
Approach towards skill gap analysis

3.Skill Gap analysis

This section analyses the total target capacity for each of the sub sectors and the corresponding skill requirements.

The data has been collected based on the broad value chain of each sub-sector and the occupational map which was developed based on the discussion with stakeholders.

The overall approach adopted to arrive at the skill requirements for various job roles across core functions is as follows:



The key steps followed are as follows:

- **Step 1:** In this step, extensive stakeholder discussions have been carried out to understand the key trends and man power deployment pattern in the industry. Subsequently, the present entry level man power deployed (sanctioned strength) for the different sub-sectors and different functions were collected.
- **Step 2:** The capacity to be added till 2022 and 2025 is assessed based on government targets where mentioned and using CAGR projections.
- **Step 3:** Based on the cumulative job role wise man power deployed and corresponding capacities, trends in the industry norms are identified
- **Step 4:** The previously calculated manpower deployment per unit capacity is used to assess the skill gap in the industry by projecting it with the future capacity additions in the sector till 2022 and till 2025

The detailed steps followed in each of the aforementioned phase/step are discussed in subsequent chapters for different sub-sectors covered in this report. The skill requirement has been assessed for activities in each sub-sector for Engineering, Procurement and Commissioning and Operation & Maintenance related activities for Solar PV power, Wind Power, Small Hydro Power and Solar thermal applications. Skill requirement has also been assessed for off-grid solar PV systems and wind component manufacturing.

The leadership roles have not been considered for this skill gap report as training for these roles will be focused later. The current focus is from NSQF level 1 - level 7.

Section - 4.1

Sub- Sector Analysis - Solar PV Sector

4. Sub- Sector Analysis

4.1. Solar PV

4.1.1. Introduction

Solar power works on the principle of converting sunlight directly into electricity. Photovoltaic (PV) gets its name from the process of absorbing photons – particles of light that act as individual units of energy and converting part of energy into which is called the Photovoltaic effect[15]. The process of conversion of photons into electricity is done through solar cells, which are made of layers of semiconductor material, which absorb the energy of sunlight and knock some electrons loose from their atoms which in-turn produce electricity.

Electricity generation as mentioned above (Solar PV system) can be installed across the following:

1. Rooftop
2. Ground Mount/Utility Scale

4.1.2. Background

Jawaharlal Nehru National Solar Mission was launched on 11th January, 2010. The Mission targets include (i) deployment of 20,000 MW of grid connected solar power by 2022, (ii) 2,000 MW of off-grid solar applications including 20 million solar lights by 2022, (iii) 20 million sq. m. solar thermal collector area.

For the first phase of the Mission, the Cabinet had approved a target to set up 1,100 MW grid connected solar plants including 100 MW capacity as rooftop and other small solar power plants till March 2013.

The Cabinet in its meeting held on 17/6/2015 has approved revision of cumulative targets under NSM from 20 GW by 2021-22 to 100 GW by 2021-22 for Grid Connected Solar Power Projects. The revised target of 100 GW is planned to be achieved in 7 years period and broadly consist of 40 GW Grid connected Rooftop projects and 60 GW large and medium size land based solar power projects as shown in Table 1 below[16]:

[15] NREL- Solar Photovoltaic Technology Basics

[16] MNRE Annual report- 2015-16: http://mnre.gov.in/file-manager/annual-report/2015-2016/EN/Chapter%204/chapter_4.htm

Category-I	Proposed Capacity	Category-II	(Capacity in MW) Proposed Capacity)
Rooftop Solar	40,000	Projects by Unemployed graduates, Village Panchayats, Small Scale Industries (SSI) Units	10,000
		Public Sector Undertakings	10,000
		Large Private Sector	5,000
		SECI	5,000
		Under State Policies	20,000
		Ongoing programs	10,000
Total	**40,000**		**60,000**

Table 1: Source-wise distribution of Solar PV targets

4.1.3. Solar Photovoltaic Value Chain

Activity Value Chain for Solar Photovoltaic Sub sector can be depicted as follows:

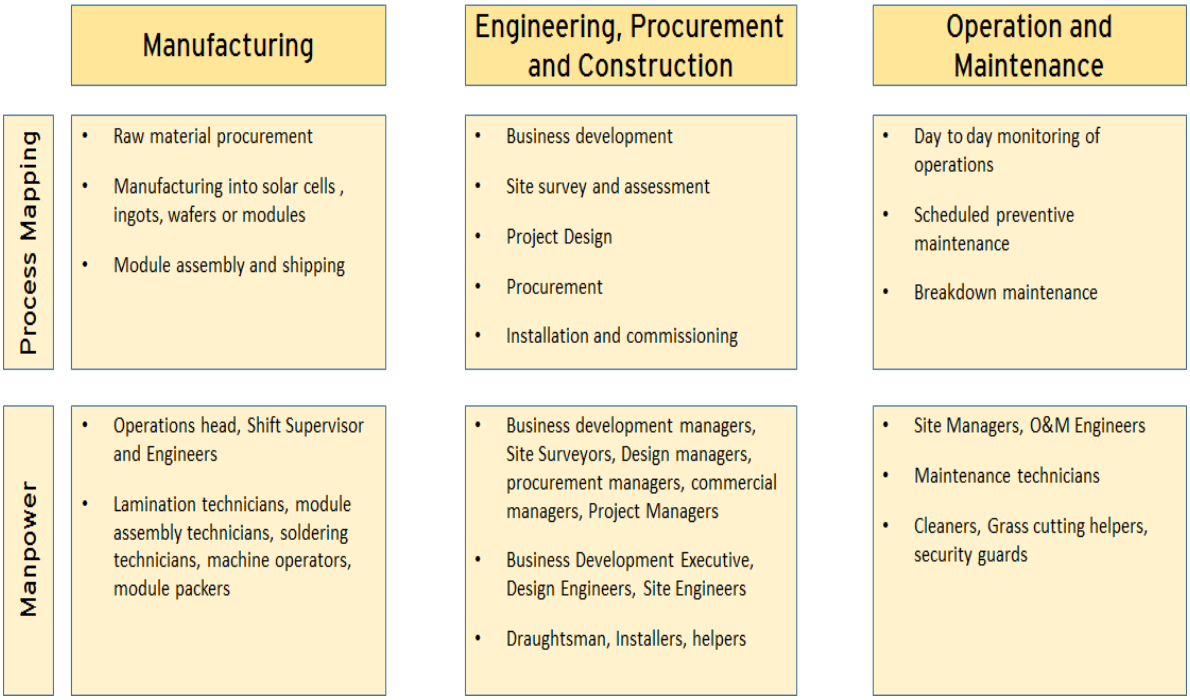


Figure 4: Value chain of activities in the solar PV sector

4.1.4. Current Industry status

4.1.4.1. Present Installed Capacity

Solar Photovoltaic sector currently constitutes approx. 8 GW of installed capacity. The break-up of current capacity installed across various states (as on October2016) is shown below[17]. The geographical clustering of the installed capacity is also represented in graphical form.

Sr. No.	State/UT	Total cumulative capacity till July 2016 (MW)
1	Andhra Pradesh	968.05
2	Arunachal Pradesh	0.27
3	Bihar	95.10
4	Chhattisgarh	128.56
5	Gujarat	1138.19
6	Haryana	17.39
7	Jharkhand	16.84
8	Karnataka	340.08
9	Kerala	13..05
10	Madhya Pradesh	811.38
11	Maharashtra	386.06
12	Odisha	66.92
13	Punjab	521.20
14	Rajasthan	1301.16
15.	Tamil Nadu	1555.41
16	Telangana	963.79
17	Tripura	5.00
18	Uttar Pradesh	143.50
19	Uttarakhand	41.15
20	West Bengal	11.77
21	Andaman & Nicobar	5.10
22	Delhi	23.87
23	Lakshadweep	0.75
24	Puducherry	0.03
25	Chandigarh	6.81
26	Daman & Diu	4.00
27	J&K	1.00
28	Himachal Pradesh	0.20
29	Mizoram	0.10
30	Others data from rooftop division cumulative	100.92
TOTAL		**8727.62**

Table 2: State wise distribution of solar PV installed projects

[17] http://mnre.gov.in/file-manager/UserFiles/grid-connected-solar-power-project-installed-capacity.pdf

Geographical clustering of Solar PV installed projects (MW)

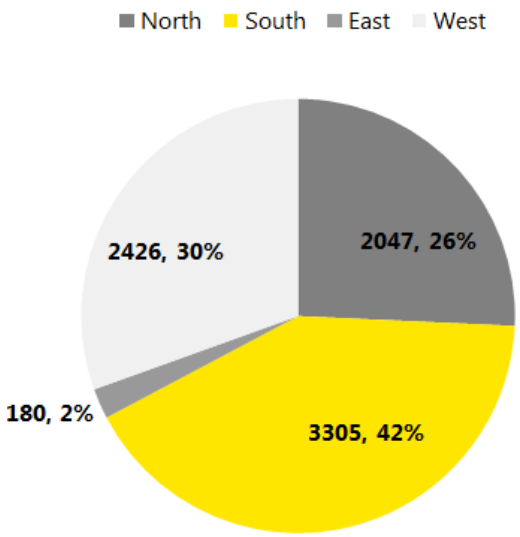


Figure 5: Geographical clustering of solar PV installed projects (in MW)

4.1.4.2. Solar PV Manufacturing

The solar PV manufacturing sector has two parts

a. End to end manufacturing
b. Assembly of solar panels

In order to support approximately 12 GW/ year of Solar PV addition, India requires adequate solar equipment manufacturing support. Currently, operating at 1.2 GW of cell manufacturing and 5.26 GW of module manufacturing[18], the industry will need to ramp up to achieve a target of additional 12 GW/ year of solar power to be installed each year in order to support the anticipated annual growth target. However, to further the objective of development of domestic solar manufacturing industry, recently the following MOUs have been signed:

1. Canadian Solar with Gurgaon based Sun Group (5GW of solar plants and manufacturing solar modules) across India

[18] http://mnre.gov.in/file-manager/UserFiles/information-sought-from-all-Solar-Cell-&-Module-manufacturers.pdf

2. Trina Solar with Welspun Energy - 2 GW solar manufacturing facility in Andhra Pradesh
3. JA Solar with Essel Group (solar cell and PV module manufacturing facility) in Andhra Pradesh

In the solar PV manufacturing segment, the current installed capacity is 5620 MW. However, sufficient data is not present regarding the operational capacity, ratio of imports and exports of solar PV modules. Hence, the future expansion plan has not been covered as part of this report.

4.1.4.3. MNRE targets for solar PV sector

4.1.4.3.1. Solar PV – Grid connected

The Indian government in 2010 launched the Jawaharlal Nehru National Solar Mission. Under this mission, the government has set an ambitious target to achieve 100 GW of installed solar capacity by 2022.

The envisaged plan to achieve the targeted 100 GW planned solar capacity is by multiple types and sizes of projects and under various schemes represented such as:

a. Solar ultra- mega parks of capacity more than 50 MW
b. Entrepreneurs scheme
c. Central Public Sector Undertakings
d. Viability Gap Funding
e. Defence schemes
f. Rooftop installations

The total target for solar capacity will be achieved through allocation of the same across different scale projects and over the years from 2015- 22. As per the MNRE guidelines, the year wise capacity targets across rooftop and ground mount are shown in table below.[19]

As per government estimates, an estimated 350 GW of power generation through renewable energy sources by 2030. This is also estimated in the context of Intended Nationally Determined Contributions (INDCs) for climate negotiations in Paris. [20][21][22]

[19] MNRE notification

[20] http://www.business-standard.com/article/economy-policy/india-s-energy-mix-to-have-40-renewable sources-by-2030-115092200057_1.html

[21] http://www.bridgetoindia.com/is-india-aiming-for-250-gw-of-solar-by-2030-2/

[22] www4.unfccc.int/submissions/INDC/Published%20Documents/India/1/INDIA%20INDC%20TO%20UNFCCC.pdf

	Current Installed - 31st May 2016	2017	2018	2019	2020	2021	2022	2025	2030
Installed Capacity - Ground Mount	7065	14265	24265	34265	44265	53765	62265	87765	125000*
Installed Capacity – Rooftop	740	5540	10540	16540	23540	31540	40540	67540	125000*
Per year capacity addition - Ground Mount		7200	10000	10000	10000	9500	8500	8500	~8500
Per year capacity Addition – Rooftop		4800	5000	6000	7000	8000	9000	9000	~14487
Total Installed capacity	**7805**	**19805**	**34805**	**50805**	**67805**	**85305**	**102805**	**155305**	**250000**

Table 3: Distribution of solar PV installed capacity year – wise across ground mount and rooftop

Note: To estimate the distribution of 250 GW between ground mount and rooftop projects, a distribution of 50: 50 has been assumed. This is done due to the decreasing ratio of ground mount and roof top projects. Also, more rooftop projects are foreseen to be installed in the future.

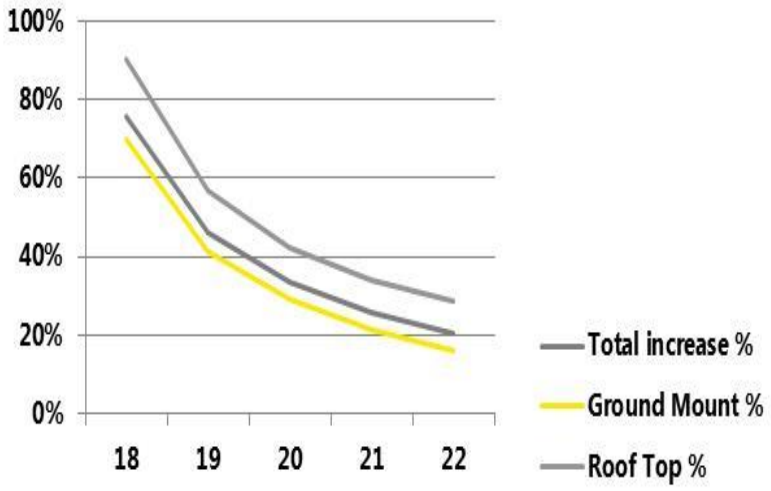
Key highlights of the targeted numbers till 2022 are as follows:

1. 40 GW will be contributed by Rooftop projects
2. 20 GW will be contributed by projects under new entrepreneurs, unemployed persons, etc[23].
3. Approvals have been accorded to 33 Solar Parks of aggregate capacity of 20 GW to be set up in 21 States
4. The state-run Solar Energy Corporation of India (SECI) plans to develop 2GW of solar projects (Ground Mount) ranging from 250-500 MW [24]
5. Remaining 18 GW will be taken care of by other Ground Mount utility scale projects being run by various states (i.e. 10 MW to 500 MW)[25]

[23] India's solar mission: Policies and Strategies

[24] Mercom Capita Group report-http://www.pv - tech.org/editorsblog/ 100gw_by_2022_behind_indias_big_solar_numbers

[25] (http://energyinfrapost.com/fact-sheet-solar-parks-ultra-mega-solar-power-projects/)



*- The capacity addition and installed capacity is basis the trend of growth observed. The per year capacity increase is assumed to stabilize at 17500 MW per year till 2022 basis the previous year's capacity addition. As in the graph, the year-wise percentage growth in solar installations is decreasing over the years and the solar industry is seen maturing by 2022.

Figure 6: Reducing growth of per-year capacity addition

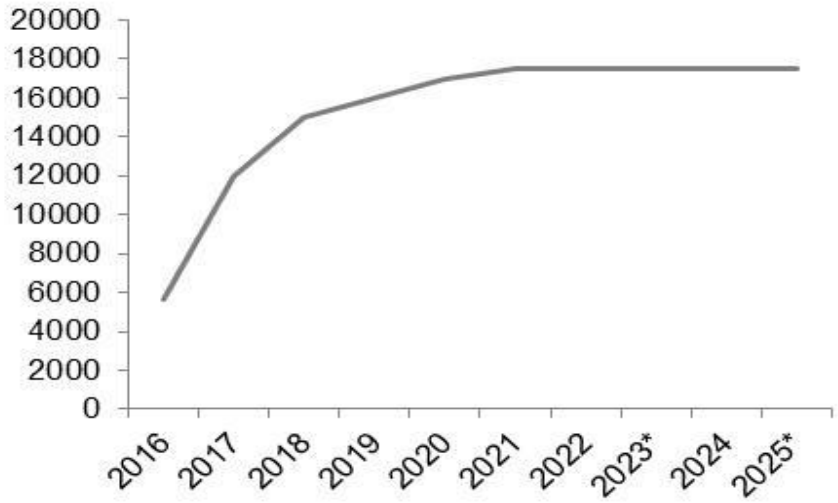


Figure 7: Maturing growth of solar PV sector as per MNRE projections till 2022

4.1.4.3.2. Solar PV – Off- Grid

The solar Off-Grid Sector is mainly divided into Solar PV pumps, Solar Home- Lighting system, solar lanterns, Solar street lights and Solar PV micro grids. As the name suggests, these are standalone solar systems which are used for captive purposes and not connected to the grid. As the grid connectivity of India is low, especially in rural areas, solar off-grid plays an important role in rural electrification.

For solar pumps, the government has set a target of 1, 00,000 solar pumps in the year 2014-15 and 10, 00,000 solar pumps till 2021[26]. Basis this CAGR has been calculated and year-wise targets have been estimated.

In the solar Off- Grid Lighting segment a total of 20 million units was set as a target by the JNNSM. The current cumulative solar off grid lighting systems sold is close to 10 lakhs.[27]

4.1.4.4. Growth Drivers for the increase in solar PV capacity

1. **Jawaharlal Nehru National Solar Mission (JNNSM):** The JNNSM defines the strategy for achieving 100 GW target through solar power (grid connected as well as off grid) and will drive the growth in the solar sector in the future. The JNNSM identifies strategies like:

   Bundling Scheme-to create price parity & encourage consumption

   Viability Gap Funding- There are many projects with high economic returns, but the financial returns may not be adequate for a profit-seeking investor. This would yield huge economic benefits by integrating these villages with the market economy, but because of low incomes it may not be possible to charge user fee. In such a situation, the project is unlikely to get private investment. In such cases, the government can pitch in and meet a portion of the cost, making the project viable. This method is known as viability gap funding

   JNNSM will be the main growth driver in the solar PV sector. It was launched on the 11th January, 2010 by then Prime Minister. The Mission has set the ambitious target of developing 100 GW of grid connected solar power by 2022 which is aimed at reducing the cost of solar power generation in the country by ;-

   - **long term policy**
   - **large scale deployment goals**
   - **aggressive R&D**
   - **domestic production of critical raw materials, components and products, as a result to achieve grid tariff parity by 2022**

[26] MNRE Notification - No. 42/25/2014-15/PVSE- Supplementary programme for implementation of "Solar Pumping Programme for irrigation and drinking water under off-grid and decentralised solar applications scheme"

[27] MNRE annual report -2015-16

Mission will create an enabling policy framework to achieve this objective and make India a global leader in solar energy.[28]

2. **Favourable Foreign Investment Policy-** The favourable FDI for wind sector has attracted many international players. For example, Hilliard Energy plans to invest Rs 3,600 crore (US$ 533.66 million) in Ananthapur district of Andhra Pradesh in the solar & wind power sector for the generation of 650 MW of power[29]

3. **Attractive long-term preferential tariff (feed in tariff):** 'Preferential tariff' means the generic or project specific tariff determined by the commission for the sale of electricity generated from a renewable source of energy. The developers sign a long-term PPA at fixed tariffs, which delivers a stable revenue stream.[30]

4. **Net Metering:** Net metering is a billing mechanism that credits solar energy system owners for the electricity they add to the grid. For example, if a residential customer has a PV system on the home's rooftop, it may generate more electricity than the home uses during daylight hours. If the home is net-metered, the electricity meter will run backwards to provide a credit against what electricity is consumed at night or other periods where the home's electricity use exceeds the system's output. Customers are only billed for their "net" energy use. On average, only 20-40% of a solar energy system's output ever goes into the grid. Exported solar electricity serves nearby customers' loads.[31]

5. **Smart cities & Solar Cities:** The Smart City guidelines commits that 10% of the Smart City's energy requirement would come from solar energy. A total of 100 smart cities have been shortlisted in the stage -1 of smart city challenge. Solar Cities aims to assist urban local bodies in assessing their present energy consumption & future demand and preparing Master Plans for energy savings & generation through RE installations & energy efficiency measure. Development of smart cities will see a movement from conventional source of power to solar power. 60 cities are being developed as solar cities. 34 of the targeted 60 solar cities fall under the category of smart cities. These cities may work in association with Smart Cities as all the Smart Cities to be taken under solar cities programme. Apart from 60 solar cities, 100 small townships/ campuses will be covered in this scheme. This will be a major growth driver for solar roof-top system.

[28] http://www.mnre.gov.in/solar-mission/jnnsm/introduction-2/
[29] http://indiainbusiness.nic.in/newdesign/index.php?param=industryservices_landing/365/2
[30] http://mnre.gov.in/file-manager/Compendium/Final/KERALA%203.pdf
[31] http://www.seia.org/policy/distributed-solar/net-metering

6. **Atal Mission for Rejuvenation and Urban Transformation (AMRUT)** [32]**-** in context of Solar power states to formulate a policy and action plan for having a solar rooftop in all buildings having an area greater than 500 square meters and all public buildings. The total outlay for AMRUT is Rs. 50,000 crore for five years from FY 2015-16 to FY 2019-20 and the Mission will be operated as a Centrally Sponsored Scheme. 500 cities will be taken up under AMRUT.

7. **Renewable Purchase Obligation (RPO):** This is a mechanism by which the State Electricity Regulatory Commissions are obliged to purchase a certain percentage of power from renewable energy sources. RPO is being implemented throughout the country to create demand for renewable energy.

8. **RPO** is of two categories – (a) Non Solar & (b) Solar. Under the solar obligation, every State in the country has announced a solar specific percentage as part of overall RPO. RPOs are enforced on three categories of consumers – (a) Distribution Licensees, (b) Open Access Consumers & (c) Captive Consumers[33]

9. **Renewable Energy Certification (REC) -** RECs are aimed at addressing the mismatch of renewable energy resources in the States and their RPO requirements. Obliged entities can fulfil their RPOs by purchasing RECs. RECs are traded on the Indian Energy Exchange (IEX) and the Power Exchange of India Ltd (PXIL). In line with RPOs there are two categories of RECs – Solar & Non-Solar.

   Solar RECs include both PV and CSP technologies. Non-solar RECs include renewable energy technologies such as biomass, wind, biofuel, cogeneration & small hydro. Solar RECs are traded once a month – last Wednesday of every month.

   In order to provide a minimum of certainty on REC prices, Central Electricity Regulatory Commission (CERC) has fixed a floor and forbearance price for the period up to 2017 between which the REC can be traded.[34]

   There are three categories of solar projects that are eligible for RECs:

   - Projects for captive consumption (Self use) – Eligible for REC only if concessions are not availed in transmission and wheeling charges, banking charges and electricity duty

[32] http://amrut.gov.in/

[33] http://www.shansolar.com/rpo/

[34] http://www.shansolar.com/rpo/

- PPA with distribution licensee – PPA with local distribution company at average power purchase cost (APPC) as determined by SERC. **Note: PPA at preferential tariff are not eligible**
- Sale to open access consumers – Sale at mutually agreed market determined price with all the transmission & wheeling and other charges payable to the Transco / DISCOM duly paid

10. **Deen Dayal Upadhyaya Gram Jyoti Yojana** is a scheme designed to provide continuous power supply to rural India. The government plans to invest 756 billion (US$11 billion) for rural electrification under this scheme. The scheme has replaced the existing Rajiv Gandhi Grameen Vidyutikaran Yojana (RGGVY). The DDUGJY scheme will enable to initiate much awaited reforms in the rural areas as ;-

    - It focuses on feeder separation (rural households & agricultural)
    - It focuses on strengthening of sub-transmission & distribution infrastructure including metering at all levels in rural areas.

11. **Make in India-** Government's focus on Make – in India initiatives like Domestic Content Requirements, etc. will be key to increasing domestic solar PV manufacturing capacity

12. **Taxation:** The government has imposed an import duty of 7.5% which will encourage domestic manufacturing. Also, additional tax on coal generation has been increased to INR 400 per ton for the National Clean Energy Fund (NCEF) in the budget for FY 2015-16

13. **Re Invest 2015 -** To achieve the Government's target to increase India's renewable energy capacity to 175 GW by 2022, the Secretary, Ministry of New and Renewable Energy (MNRE) invited public and private sector companies and proprietorship firms to invest in the country's renewable energy sector in the five year period from 2015 - 2019. Companies were asked to voluntarily commit any quantum of generation, even 1 MW, in any renewable energy sector: solar, wind, biomass and small-hydro. It was assured to the industry players that MNRE will assist the industry in every step of the process. The conclusion of the conference resulted in [35]

    - 283.30GW in total committed by major private players & public sector companies out of which

[35] http://re-invest.in/about-re-investment/green-energy-commitments/

- PSUs such as NTPC, Coal India, NHPC etc. commit 8,000 MW
- SBI to finance 15,000 MW, other financing bodies - 11,500 MW
- Manufacturing draws 41 GW of investment for both solar cells and wind turbines
- Noted names from all sectors, power & non-power, ready to be part of green bandwagon Foreign players join the fray with largest investment among all[36]

14. **Generation based Incentive:** GBI provided support to small grid solar power projects connected to the distribution grid (below 33 KV). This was an important driver to the growth of grid connected solar rooftop projects

15. **Inclusion of renewable energy in priority sector lending:** Loans given for renewable **energy** projects have been included in the priority sector from 2015.

16. **Carbon trading as a Source of Revenue-** Solar power generation emits lesser amount of CO2 compared to conventional sources of energy such as coal. Trading this reduction in the emissions trading market can be another source of income for the Solar Energy manufacturers. This will partially help in offsetting the high cost of solar production

17. **Selective Implementation of On-Grid Application-** From today's technology standpoint, solar power generation works at 15-20% efficiency. Under this scenario, large-scale on-grid applications are more feasible in areas where there is plenty of barren land and high rate of irradiance such as Gujarat and Rajasthan. It is very important to concentrate the efforts in these areas to realize solar potential there before moving onto other parts where the irradiance is low or there is scarcity of barren land. The RE produced in these regions can be transferred to other states through RECs, enabling uniform distribution

18. **Development of Off-Grid Application-** More than 80, 000 villages in India suffer major electricity supply shortages throughout the year, which provides tremendous opportunity for off-grid solar applications deployment. Some of the possible applications are lighting and electrification systems, solar powered cellular towers, irrigation pumps and street lighting.

19. **Energy Access Scheme:** Access to Electricity in Rural Areas mainly through deployment of off-grid electricity generation systems using any kind of renewable energy source. This scheme also provides for standalone solar lighting systems for willing households in a village as an alternative.

[36] http://www.business-standard.com/article/economy-policy/re-invest-2015-companies-commit-200-billion-to-clean-energy-115021400027_1.html

20. **Establishment of Localized Mini-Grids-** Localized mini-grids based on Photo Voltaic (PV) cells can be set up in regions that lack grid connectivity due to physical or financial barriers. The main advantages of mini-grids are lesser initial setup costs and power tariff comparable to that of conventional grid power

21. **Draft Renewable Energy Act, 2015-** The draft renewable energy act seeks to create an institutional structure and a support structure to encourage renewable energy in India. Some key highlights are National Renewable Energy Policy, National Renewable Energy Fund, State Green Fund, etc.

4.1.5. Occupational Map (Industry Delivery Structure)

The mapping of solar photovoltaic sub sector would further involve a bifurcation basis the following types:

- Rooftop Projects
- Ground Mount Projects
- Solar Equipment Manufacturing
- Solar Off- Grip sector

Note- Detailed Occupational Maps in Annexure

4.1.5.1. Solar PV Ground Mount- Engineering, Procurement, Commissioning and Operation & Maintenance

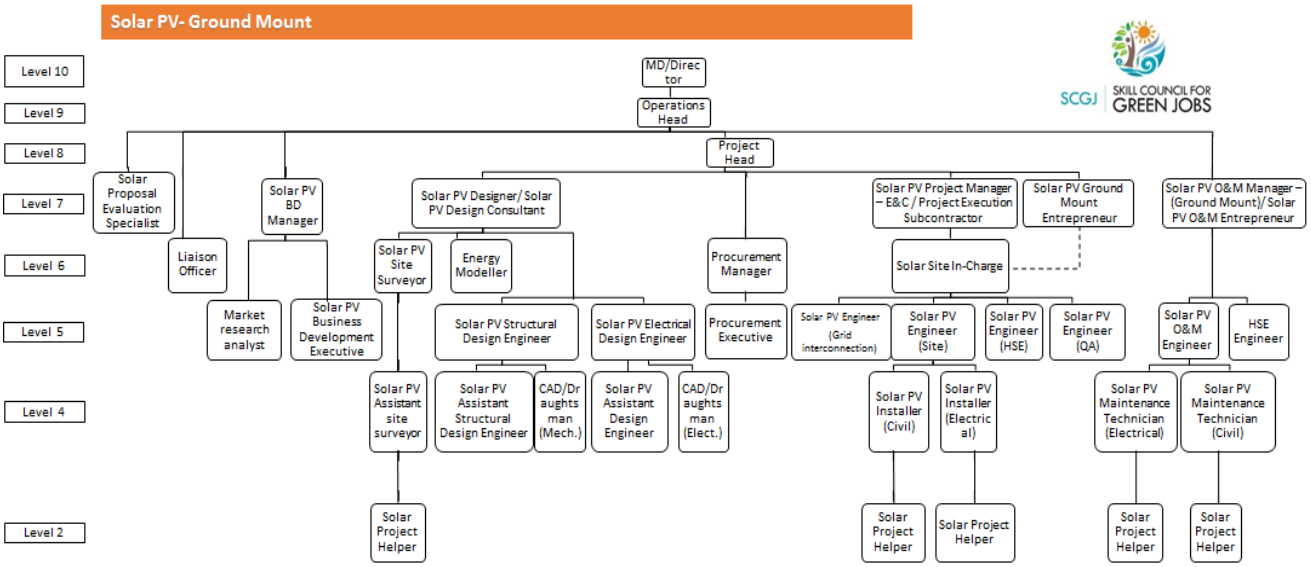


Figure 8: Solar PV – Ground Mount Occupational Map

4.1.5.2. Solar PV Rooftop- Engineering, Procurement, Commissioning and Operation & Maintenance

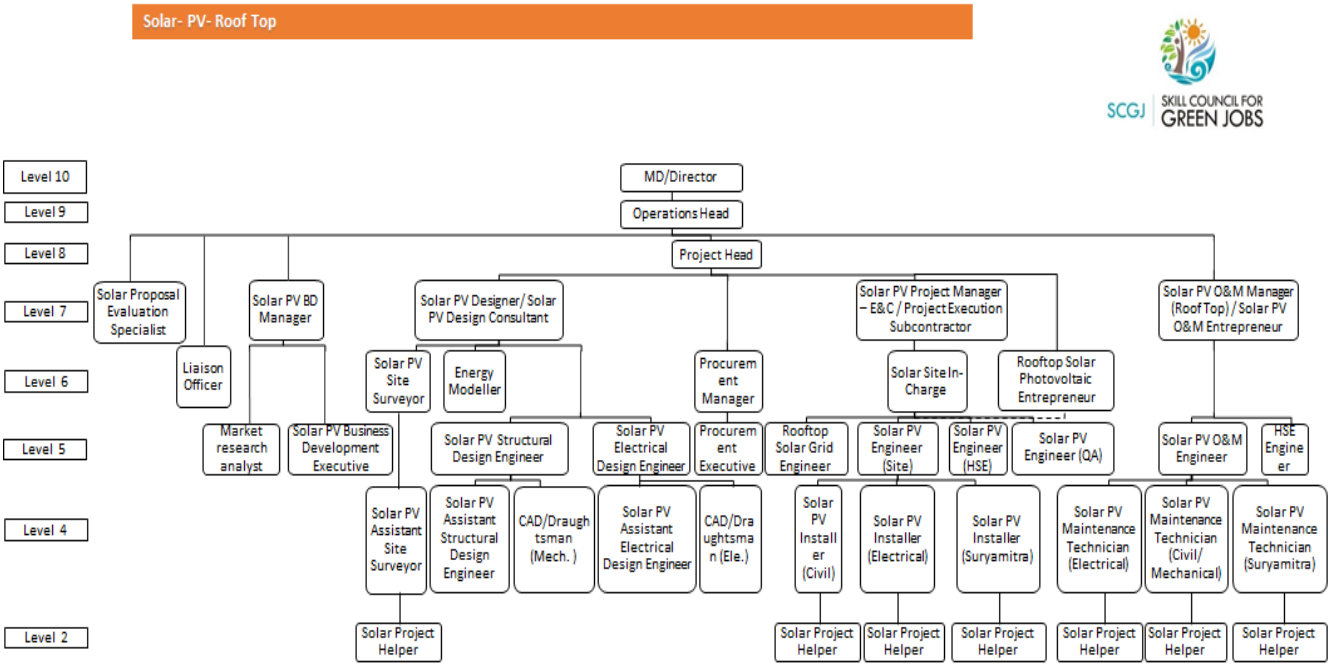


Figure 9: Solar PV Rooftop – Occupational Map

4.1.5.3. Solar PV Manufacturing

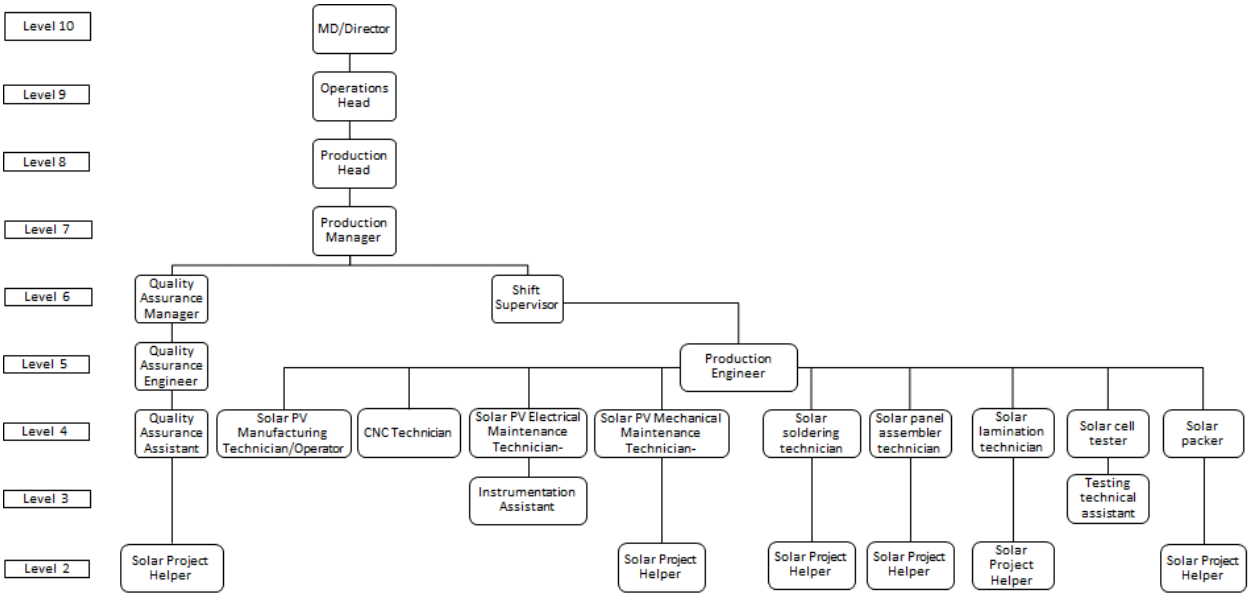


Figure 10: Solar PV Manufacturing – Occupational Map

4.1.5.4. Solar Off-Grid

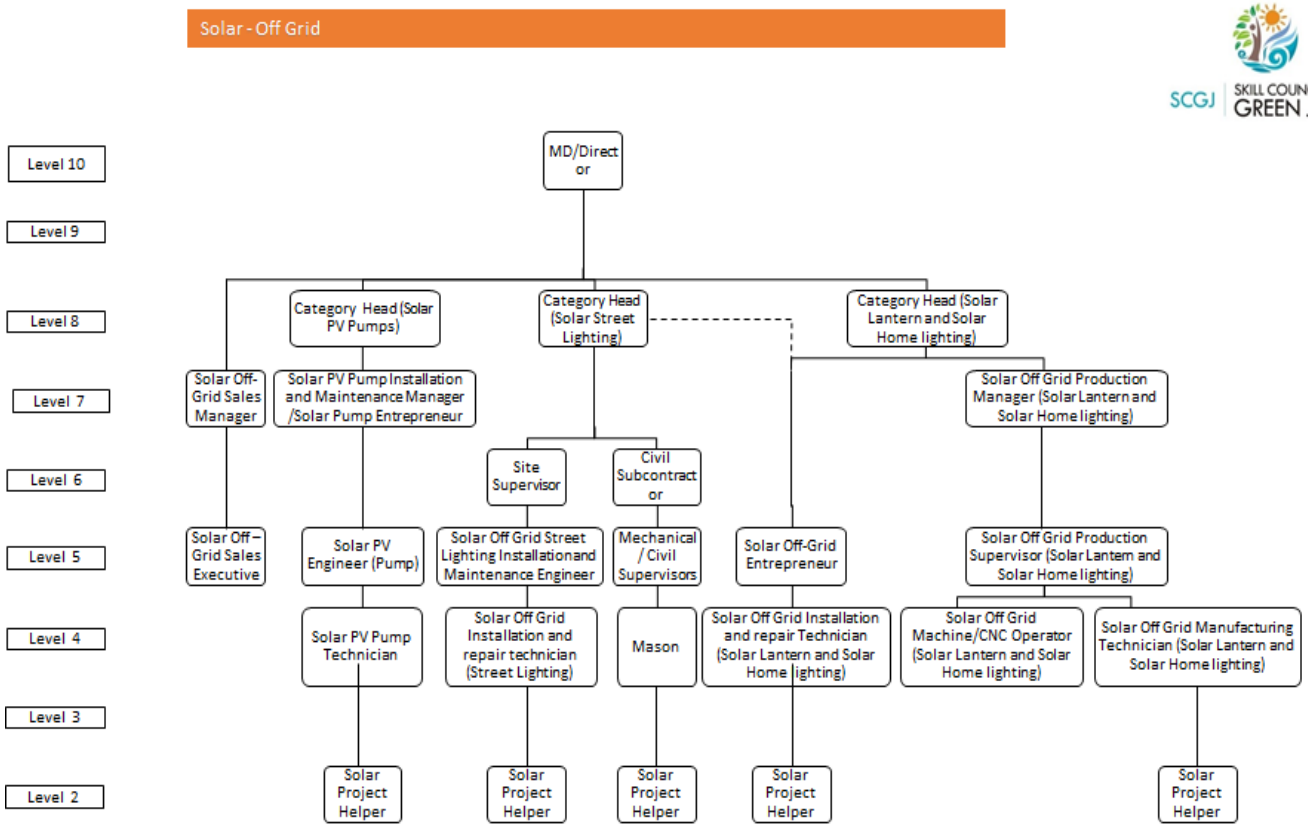


Figure 11: Solar Off-Grid – Occupational Map

4.1.6. Solar PV Sector – Assumptions

4.1.6.1. Solar PV – Ground Mount

- To carry out the skill gap assessment, the respondents in the solar ground mount were categorised according to the sizes into three categories:
  1. 1-5 MW category
  2. 5 MW- 50 MW category
  3. Greater than 50 MW category
- The manpower requirement for different project sizes varies largely. For lower size projects, there is a minimum number of manpower required per project. However, as the size of the project increases, due to economies of scale, the manpower requirement per MW reduces
- The distribution of the project sizes is assumed as follows basis the secondary and primary data collected. The same distribution has been assumed for each year till 2022

Project Size	Assumed distribution
>50 MW	**5%**
5 MW- 50 MW	**60%**
1-5 MW	**35%**

Table 4: Assumed distribution of solar PV ground mount projects

- **The total number of days has been taken as 240 in a year**
- For estimating the number of people required in the sector, a deployment of 80% in projects in a year has been assumed for the manpower in all phases except Operation and Maintenance
- The manpower already present in the sector is taken into consideration while estimating the skill gap for EPC phase. Hence, only the skill gap arising due to increase in per – year capacity addition has been taken
- For Operation and maintenance, the skill gap has been calculated as per MW requirement
- Ground Mount and Rooftop Entrepreneur- 20 GW scheme of new entrepreneurs. Considered an 80:20 ratio, where 80% of the 20 GW will be through rooftop schemes and 20% through ground mount schemes

- To estimate capacity addition till 2030, the target of 250 GW for the solar PV sector has been assumed. Further, a distribution of 50: 50 from ground mount and rooftop has been assumed

- **Solar PV Ground Mount Entrepreneur:** 80% of the 20 GW will be to cater to rooftop schemes and 20% of the 20GW scheme will be through Ground Mount solar PV power plant of size 1 MW. It is observed that solar PV ground mount entrepreneurs who is at NSQF level will owners of companies undertaking end to end EPC of a ground mount solar PV power plant

- Current maximum installation of solar PV ground mount projects done in an year: 3700 MW

- Distribution of projects within the range of 1-5 MW

- Number of projects undertaken by a Solar PV Ground Mount Entrepreneur ~ 10

Project Size	Assumed distribution	Project Sizes
1 MW	**20%**	**259 MW**
>1 MW	**80%**	**1036 MW**

- Maximum per year capacity addition in Ground Mount Sector = 10,000 MW
- Number of project sizes of 1-5 MW = 0.35*10,000= 3500 MW per year
- Number of projects of 1 MW added per year till 2022 and 2025 = 700
- Solar Proposal evaluation specialist has been estimated basis discussions with bankers, developers and developer associations:

Project Size	Number of people required	Number of days deployed	Average number of projects in an year
1-5 MW	1	5	40
5- 50 MW	1	15	10
>50 MW	1	15	10

Table 5: Norm for Solar Proposal Evaluation Specialist

- Solar PV Engineer (Grid Interconnection) data was taken from companies separately

Project Size	Team composition	Deployment	Number of projects
1- 5MW	2 Solar PV Engineers (Grid Interconnection) 2 Helpers	10 days	20
5- 50 MW	3 Solar PV Engineers (Grid Interconnection) 2 Helpers	15 days	12
More than 50 MW	3 Solar PV Engineers (Grid Interconnection) 2 Helpers	15 days	12

Table 6: Norm for Solar PV Engineer (Grid Interconnection)

Note: The helpers shown in the above table have not been taken separately to calculated the skill gap numbers of solar project helpers

- Current maximum installation of solar PV ground mount projects done in an year: 3700 MW
- Current Manpower numbers assuming a maximum of 3700 MW added in a single year is

Project Size	Project distribution (MW)	Average Project Size assumed	Number of projects (Approx.	Current Manpower
1- 5MW	1295	2 MW	~ 647	64
5- 50 MW	2220	20 MW	~ 111	30
More than 50 MW	185	50 MW	~ 4	3
Total				**~ 97**

Table 7: Project distributions for calculation of solar PV Engineer (Grid Interconnection)

4.1.6.2. Solar Photovoltaic Rooftop

- To carry out the skill gap assessment, the respondents in the solar rooftop were categorised according to the sizes into two categories:
  1. Less than 50 KW – Residential and Small Commercial Category
  2. 50-500 KW – Large Commercial and Industrial Category
- The following distribution has been assumed basis secondary and primary data collected

Project Size	Distribution of rooftop projects for current year[37]	Assumed distribution of rooftop projects for future
< 50 KW	**30 %**	**50%** (Increase in small installations due to government focus)
50 – 500 KW	**70 %**	**50%**

Table 8: Assumed distribution of solar PV rooftop projects

- **The total number of days has been taken as 240 in a year**
- For estimating the number of people required in the sector, a deployment of 80% in projects in a year has been assumed for the manpower in all phases
- The manpower already present in the sector is taken into consideration while estimating the skill gap for EPC and O&M phase. Hence, only the skill gap arising due to increase in per – year capacity addition has been taken
- To estimate capacity addition till 2030, the target of 250 GW for the solar PV sector has been assumed. Further, a distribution of 50: 50 from ground mount and rooftop has been assumed
- Rooftop Solar Grid Engineer data was taken from companies and discoms:

Team composition	Deployment	Number of projects (assuming 80% deployment)
1 Rooftop Solar Grid Engineer 1 helper	5 days	40

Table 9: Norms observed in the solar Rooftop Solar Grid Engineer

Note: solar project helpers in the above table have not been taken separately to calculated the skill gap numbers

[37] Bridge to India - Solar Rooftop Map 2016

4.1.6.3. Solar Off- grid

4.1.6.3.1. Solar PV Pumps

According to the government sanctioned targets[38] we have estimated the capacity addition in the solar pumps segment till 2025 as follows.

Basis MNRE target, a CAGR of 46% till 2021 has been derived. The CAGR has been extrapolated to estimate capacity addition till 2030

(Numbers in lakhs)

	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025
Current Sanctioned Numbers	1.47	2.16	3.17	4.66	6.86	10	14.70	21.60	31.76	46.69
Capacity addition required @ 46% CAGR	0.47	0.69	1.01	1.49	2.19	3.13	4.60	6.77	9.96	14.64

Table 10: Assessment of capacity addition in solar pump sectors

4.1.6.3.2. Solar off grid home-lighting/ street lighting/ lanterns

- For the manpower estimation in the solar off grid sector, the following numbers have used:
  1. The total number of channel partners for the off-grid segment = 549 [39]
  2. Targeted total number of units to be sold by 2022 is 20 million.[40] [41]
- Basis the MNRE target to sell 20 million units by 2022, we calculated the following:

	Target	Current
Cumulative installed capacity (units)	20 million	2.3 million
CAGR required (%)	**43%**	
Increase in capacity (growth) of current channel partners (%)	**30%**	

Table 11: assessment of capacity addition in the solar off- grid sector

- It is assumed that 70% of this growth will be through increase in the numbers of channel partners, while 30% of this growth will be through increase in individual level sales.

[38] MNRE Notification - No. 42/25/2014-15/PVSE- Supplementary programme for implementation of "Solar Pumping Programme for irrigation and drinking water under off-grid and decentralised solar applications scheme"

[39] MNRE- Final List of channel partners for Off Grid and Decentralised Solar Applications Programme accessed on 29/08/2016

[40] MNRE- Policy document JNNSM phase 2

[41] Business Case for off-grid energy in India- The Climate Group, GoldmanSachs

4.1.7. Solar PV Sector Manpower norms

4.1.7.1. Solar PV - Ground Mount

Basis our interactions with multiple industry stakeholders, we have observed the following norm for Solar PV ground mount projects:

Project Size	>50 MW	5- 50 MW	1-5 MW
Engineering and Design			
Average time required	90 days	70 days	20 days
MD/ Director	1	1	1
Operations Head	1	1	-
Project Head	1	1	1
Solar Proposal Evaluation Specialist*	1	1	1
Liaison Officer	1	1	-
Solar PV Business Development Manager	2	2	1
Market Research Analyst	1	1	1
Solar PV Business Development Executive	4	4	3
Solar PV Designer/ Solar PV Design Consultant	2	1	1
Solar PV Site Surveyor	2	2	1
Assistant Site Surveyor	1	1	-
Energy Modeller	1	1	-
Solar PV Plant Structural Design Engineer	2	1	1
Solar PV Plant Assistant Structural Design Engineer	3	1	0
CAD/ Draughtsman (Mechanical)	1	1	1
Solar PV Electrical Design Engineer	2	1	1
Solar PV Assistant Electrical Design Engineer	3	1	0
Procurement Manager	1	1	1
Procurement Executive	3	3	2
Erection and Commissioning			
Average time required	300	120	90
Solar PV Project Manager- E&C	1	1	1
Solar PV Ground Mount Entrepreneur	-	-	1
Project execution sub-contractor	2	2	1
Site In-charge (Solar PV)/ Solar Site Supervisor	4	3	2
Solar PV Engineer (Grid Interconnection)**	3	3	2
Solar PV Engineer (Site)	6	6	4
Solar PV Engineer (HSE)	1	1	0
Solar PV Engineer (Quality assurance)	2	2	-
Solar PV Installer (Civil)	10	10	4
Solar PV Installer (Electrical)	10	10	5
Solar Project Helper	70	40	20
Operation and Maintenance			
Solar PV O&M Manager	2	1	0
Solar PV O&M Engineer	6	3	1
Solar PV Maintenance Technician (Electrical)	15	6	4
Solar PV Maintenance Technician (Civil/Mechanical)	3	3	1
Solar Project Helper	10	6	4
HSE Engineer	-	-	-

Table 12: Norms in Solar PV Ground Mount sub-sector

*- Solar Proposal evaluation specialist was estimated basis discussions with bankers, developers and developer associations:

A Solar proposal evaluation specialist is a person from the BD team, with a financial background who gets inputs from the design team.

Basis our discussions we developed the following norm:

Project Size	Number of people required	Number of days deployed	Average number of projects in an year
1-5 MW	1	5	40
5- 50 MW	1	15	10
>50 MW	1	15	10

Table 13: Norms for Solar Proposal Evaluation Specialist

**- Solar PV Engineer (Grid Interconnection) data was taken from companies and discoms:

Project Size	Team composition	Deployment	Number of projects
1- 5MW	2 Solar PV Engineers (Grid Interconnection) 2 Helpers	10 days	20
5- 50 MW	3 Solar PV Engineers (Grid Interconnection) 2 Helpers	15 days	12
More than 50 MW	3 Solar PV Engineers (Grid Interconnection) 2 Helpers	15 days	12

Table 14: Norm for Solar Proposal Evaluation Specialist

Note: The helpers shown in the above table have not been taken separately to calculated the skill gap numbers of solar project helpers

4.1.7.2. Solar PV Rooftop

Basis our interactions with multiple industry stakeholders, we have observed the following norm for Solar PV rooftop projects:

Project Size	< 50 KW	50-500 KW
Engineering and Design		
Average time required	**2 days**	**7 days**
MD/Director	1	1
Operations Head	-	-
Project Head	1	1
Solar Proposal Evaluation Specialist	1	1
Liaison Officer	-	-
Solar PV Business Development Manager	1	1
Market Research analyst	-	-
Solar PV Business Development Executive	1	2
Solar PV Designer/ Solar PV Design Consultant	1	1
Solar PV Site Surveyor	-	-
Assistant Site Surveyor	-	-
Solar Project Helper	-	-
Energy Modeller	-	-
Solar PV Structural Design Engineer	1	1
Solar PV Rooftop Assistant Structural Design Engineer	-	-
CAD / Draughtsman (Mech.)	-	1
Solar PV Electrical Design Engineer	1	1
Solar PV Assistant Electrical Design Engineer	-	1
CAD / Draughtsman (Electrical)	-	-
Procurement Manager	0	2
Procurement Executive	1	2
Erection and commissioning		
Average time required	**10 days**	**30 days**
Solar PV Project Manager - E&C/ Project Execution Subcontractor	1	1
Rooftop Solar Photovoltaic Entrepreneur	1	1
Solar Site Supervisor		1
Rooftop Solar Grid Engineer*	1	1
Solar PV Engineer (Site)	2	2
Solar PV Engineer (HSE)	-	-
Solar PV Engineer (Quality Assurance)	-	-
Solar PV Installer (Civil)	3	3
Solar PV Installer (Electrical)	2	3
Solar PV Installer (Suryamitra)	-	-
Solar Project Helper	3	3
Operation and Maintenance		
Solar PV O&M Manager (Rooftop) / Solar PV O&M Entrepreneur	-	0
Solar PV O&M Engineer	-	1
Solar PV HSE Engineer	-	-
Solar PV Maintenance Technician (Electrical)	1	2
Solar PV Maintenance Technician (Civil/ Mechanical)	0	1
Solar PV Maintenance Technician (Suryamitra)	-	-
Solar Project Helper – O& M	2	2

Table 15: Norms observed in the solar PV rooftop projects

*- Rooftop Solar Grid Engineer data was taken from companies and discoms:

Team composition	Deployment	Number of projects (assuming 80% deployment)
1 Rooftop Solar Grid Engineer 1 helpers	5 days	40

Table 16: Norms observed in the solar PV rooftop projects

Note: The helpers shown in the above table have not been taken separately to calculated the skill gap numbers of solar project helpers

4.1.7.3. Solar PV Pump Sector

	Manpower norms for a 0-10 HP pump
Solar Project Helper	2
Solar Pump Technician	1
Solar PV pump Installation and Maintenance Engineer	1
Solar PV Pump Installation and Maintenance Manager /Solar Pump Entrepreneur	1
Category Head (Solar PV Pumps)	1

Table 17: Norms observed in the solar PV pumps sector

4.1.8. Solar PV sector skill gap

4.1.8.1. Solar PV sector ground mount – skill gap assumptions

To carry out the skill gap assessment, the respondents in the solar ground mount were categorised according to the sizes into three categories:

1. 1-5 MW category
2. 5 MW- 50 MW category
3. Greater than 50 MW category

The manpower requirement for different project sizes varies largely. For lower size projects, there is a minimum number of manpower required per project. However, as the size of the project increases, due to economies of scale, the manpower requirement per MW reduces.

The distribution of various project sizes is taken from NRDC report[42]:

Project Size	Assumed distribution
>50 MW	5%
5 MW- 50 MW	60%
1-5 MW	35%

- **For estimating the number of people required in the sector, we have assumed a deployment of 80% over the whole time**
- The manpower already present in the sector is taken into consideration while estimating the skill gap for EPC phase. Hence, only the skill gap arising due to increase in per – year capacity addition has been taken
- For Operation and maintenance, the skill gap has been calculated as per MW requirement
- Ground Mount and Rooftop Entrepreneur- 20 GW scheme of new entrepreneurs. Considered an 80:20 ratio, where 80% of the 20 GW will be through rooftop schemes and 20% through ground mount schemes
- To estimate capacity addition till 2030, the target of 250 GW for the solar PV sector has been assumed. Further, a distribution of 50: 50 from ground mount and rooftop has been assumed
- 80% of the 20 GW will be to cater to rooftop schemes and 20% of the 20GW scheme will be through Ground Mount solar PV power plant of size 1 MW as it is observed that

[42] Solar Power Jobs: Exploring the Employment Potential in India's Grid-Connected Solar Market CeeW, NRDC - 2014

solar PV ground mount entrepreneurs who are at NSQF level 7 will be owners of companies undertaking end to end EPC of a ground mount solar PV power plant

- Distribution of projects within the range of 1-5 MW:

Project Size	Assumed distribution	Project Sizes
1 MW	**20%**	**259 MW**
>1 MW	**80%**	**1036 MW**

- Number of projects undertaken by a Solar PV Ground Mount Entrepreneur ~ 10 projects

4.1.8.2. Solar PV rooftop skill gap assumptions

To carry out the skill gap assessment, the respondents in the solar rooftop were categorised according to the sizes into two categories:

1. **Less than 50 KW – Residential and Small Commercial Category**
2. **50-500 KW – Large Commercial and Industrial Category**

Basis this division, we categorized the proposed annual target into these categories based on the following distribution:

Project Size	Distribution of rooftop projects for current year[43]	Assumed distribution of rooftop projects for future
< 50 KW	**30 %**	**50%** (Increase in small installations due to government focus)
50 – 500 KW	**70 %**	**50%**

Table 18: Assumed distribution in solar PV rooftop

- **For estimating the number of people required in the sector, we have assumed a deployment of 80% over the whole time**
- The manpower already present in the sector is taken into consideration while estimating the skill gap for EPC and O&M phase. Hence, only the skill gap arising due to increase in per – year capacity addition has been taken

[43] Bridge to India - Solar Rooftop Map 2016

- To estimate capacity addition till 2030, the target of 250 GW for the solar PV sector has been assumed. Further, a distribution of 50: 50 from ground mount and rooftop has been assumed

Solar PV – Ground mount and rooftop sector skill gap

The total skill gap required in the solar PV sector across various job roles is shown below. The norms in the sub-sector are depicted in the annexure.

S. No.	Job role	Present Manpower	Skill gap till FY 2022	Skill gap till FY 2025
1.	Solar Project Helper	19550	184857	203051
2.	Solar PV Maintenance Technician (Electrical)- Ground Mount and Rooftop	8799	78689	98663
3.	Solar PV Installer (Civil)	6408	78013	78013
4.	Solar PV Installer (Electrical)	5360	57469	57469
5.	Solar PV Engineer (Site/ QA/ HSE)	4860	53011	53011
6.	Solar PV Installer (Suryamitra)*	0	50000	50000
7.	Solar PV O&M Engineer	2556	23371	27440
8.	Solar PV Maintenance Technician (Civil/ Mechanical)	2534	23183	27207
9.	Solar PV O&M Manager	810	8432	8912
10.	Solar Site Incharge	1865	8624	8624
11.	Rooftop Solar Photovoltaic Entrepreneur	1686	7516	7516
12.	Solar PV Project Manager - E&C/ Project Execution Subcontractor	1031	7204	7204
13.	Rooftop Solar Grid Engineer	576	6429	6429
14.	Solar PV Designer	474	5875	5875
15.	Solar PV Structural Design Engineer	474	5875	5875
16.	Solar PV Design Engineer (Electrical)	474	5875	5875
17.	Solar PV Business Development Executive	930	5859	5859
18.	Procurement Executive - Solar PV	795	5629	5629
19.	Solar Proposal Evaluation Specialist	374	4652	4652
20.	Business Development Manager	545	4116	4116
21.	Procurement Manager- Solar PV	365	2797	2797
22.	Solar PV Site Surveyor	323	1720	1720
23.	Market research analyst	208	354	354
24.	CAD/ Draughtsman- Solar PV	135	230	230
25.	Solar PV Assistant Design Engineer (Electrical)	76	130	130
26.	Solar PV Assistant Structural Design Engineer	76	130	130
27.	Energy Modeller- Solar PV	73	124	124
28.	Assistant Site Surveyor	73	124	124
29.	Solar PV Engineer (Grid Interconnection)	97	262	262
30.	Solar Ground Mount Entrepreneur	26	70	70

*- Suryamitra numbers based on MNRE scheme

Table 19: Skill gap in solar PV sector across job roles

Note: The manpower numbers in roles at level 8 and above are not captured in this report

4.1.8.3. Solar PV Off- Grid

In the solar off-grid sector, we studied the solar PV Pumps, Solar Home Lighting, Solar Lanterns and Solar Street Lighting.

4.1.8.3.1. Assessment of capacity addition for Solar PV Pump sector

According to the government sanctioned targets[44] we have estimated the capacity addition in the solar pumps segment till 2025 as follows. We have used the 46% CAGR till 2021 to estimate the capacity addition in the following years:

(Numbers in lakhs)

	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025
Current Sanctioned Numbers	1.47	2.16	3.17	4.66	6.86	10	14.70	21.60	31.76	46.69
Capacity addition required @ 46% CAGR	0.47	0.69	1.01	1.49	2.19	3.13	4.60	6.77	9.96	14.64

Table 20: Assessment of capacity addition in solar PV pump sector

4.1.8.3.2. Skill Gap for solar PV pump sector

Basis our interaction with key stakeholders and players in the solar PV pump segment, we have arrived at the following skill gap for the solar PV pump sector

	Current Manpower	Skill gap till FY-2022	Skill gap till FY-2025
Solar Project Helper	1470	4140	14173
Solar Pump Technician	735	2070	7086
Solar PV pump Installation and Maintenance Engineer	735	2070	7086
Solar PV Pump Installation and Maintenance Manager /Solar Pump Entrepreneur	184	517	1772
Category Head (Solar PV Pumps)	46	129	443

Table 21: Assessment of capacity addition in solar PV pump sector

[44] MNRE Notification - No. 42/25/2014-15/PVSE- Supplementary programme for implementation of "Solar Pumping Programme for irrigation and drinking water under off-grid and decentralised solar applications scheme"

4.1.8.4. Skill gap in the solar off- grid sector

For the manpower estimation in the solar off grid sector, we have made the following assumptions:

1. The total number of channel partners for the off-grid segment = 549 [45]
2. Targeted total number of units to be sold by 2022 is 20 million.[46] [47]

Basis the MNRE target to sell 20 million units by 2022, the following calculation has been made:

	Target (units)	Current (units)
Cumulative installed capacity	20 million	2.3 million
Estimated CAGR required	**43%**	
Increase in capacity (growth) of current channel partners	30%	

Table 22: Assessment of capacity addition in solar off grid sector

Note: It is assumed that 70% of this growth will be through increase in the numbers of channel partners, while 30% of this growth will be through increase in individual level sales.

Solar Lantern and Home Lighting	Current Manpower	Skill Gap till FY 2022	Skill Gap till FY 2025
Solar Off-Grid Entrepreneur	600	2296	5763
Solar Installation and repair Technician (Solar Lantern and Solar Home lighting)	600	2296	5763
Solar Off-Grid Machine/CNC Operator (Solar Lantern and Solar Home lighting)	1098	4202	10546
Solar Off-Grid Manufacturing Technician (Solar Lantern and Solar Home lighting)	1098	4202	10546
Solar Project Helper	1098	4202	10546
Solar Off-Grid Production Supervisor (Solar Lantern and Solar Home lighting)	549	2101	5273
Sales Function			
Solar Off Grid Sales Manager	549	2101	5273
Solar Off Grid Sales Executive	549	2101	5273

Table 23: Skill gap in the solar off-grid sector

[45] MNRE- Final List of channel partners for Off Grid and Decentralised Solar Applications Programme accessed on 29/08/2016
[46] MNRE- Policy document JNNSM phase 2
[47] Business Case for off-grid energy in India- The Climate Group, GoldmanSachs

4.1.9. Top Job roles in the Solar PV sector

The total skill gap required in the solar PV sector across various job roles is shown below. The norms in the sub-sector are depicted in the annexure.

Job role	Skill Gap till FY 2025
Solar Project Helper-EPC, Manufacturing, Off Grid	227770
Solar PV Maintenance Technician (Electrical)	98663
Solar PV Installer (Civil)	78013
Solar PV Engineer (Site/ QA/ HSE/Pump)	60097
Solar PV Installer (Electrical)	57469
Solar PV Installer (Suryamitra)*	50000
Solar PV O&M Engineer-Roof Top and Ground Mount	27440
Solar PV Maintenance Technician (Civil/ Mechanical)	27207
Solar Off-Grid Machine/CNC Operator (Solar Lantern and Solar Home lighting)	10546
Solar Off-Grid Manufacturing Technician (Solar Lantern and Solar Home lighting)	10546
Solar PV O&M Manager	8912
Solar Site Incharge	8624
Rooftop Solar Photovoltaic Entrepreneur	7516
Solar PV Project Manager - E&C/ Project Execution Subcontractor	7204
Solar Pump Technician	7086
Rooftop Solar Grid Engineer	6429
Solar PV Designer	5875
Solar PV Structural Design Engineer	5875
Solar PV Rooftop Design Engineer (Electrical)	5875
Solar PV Business Development Executive	5859
Solar Installation and repair Technician (Solar Lantern and Solar Home lighting)	5763
Solar Off-Grid Entrepreneur	5763
Procurement Executive - Solar PV	5629
Solar Off-Grid Production Supervisor (Solar Lantern and Solar Home lighting)	5273
Solar Off Grid Sales Manager	5273
Solar Off Grid Sales Executive	5273
Solar Proposal Evaluation Specialist	4652
Business Development Manager	4116
Procurement Manager	2797
Solar PV Pump Installation and Maintenance Manager /Solar Pump Entrepreneur	1772
Solar PV Site Surveyor	1720
Category Head (Solar PV Pumps)	443
Market research analyst	354
Solar PV Engineer (Grid Interconnection)	262
CAD/ Draughtsman- Solar PV	230
Solar PV Assistant Design Engineer (Electrical)	130
Solar PV Assistant Structural Design Engineer	130
Assistant Site Surveyor	124
Energy Modeller- Solar PV	124
Solar Ground Mount Entrepreneur	70

Table 24: Top job roles in the solar PV sector

4.1.10. Summary of capacity addition and skill gap in solar PV sector

The estimated capacity addition is shown in the table below. The estimated addition till 2022 have been taken in accordance with the MNRE guidelines. Post 2022, the value has been extrapolated till 2030 at the CAGR observed till 2022.

Sub - Sector	Current Capacity*	Cumulative Capacity till FY 2022	Cumulative Capacity till FY 2025	Cumulative Capacity till FY 2030
Solar PV – Ground Mount (MW)	7065	62265	87765	~125000
Solar PV – Rooftop (MW)	740	40540	67540	~125000
Solar PV Pump sector (units)	1.47 lakhs	14.70 lakhs	46.69 lakhs	309 lakhs[48]
Solar off grid (units)	23 lakhs	200 lakhs	584 lakhs	3497 lakhs[49]

Table 25: Summary of capacity addition in solar PV sector

*- As on august 2016

Sub - Sector	Current Manpower	Skill gap till FY 2022	Skill gap till FY 2025	Skill gap till FY 2030
Solar PV - EPC	37,097	4,00,257	4,00,257	6,40,320
Solar PV – O&M	24,572	2,34,951	2,81,693	4,24,055
Solar off grid	10,409	36,628	1,00,087	3,99,854

Table 26: Summary of skill gap in solar PV sector

[48] CAGR of 43% taken based on historical growth
[49] CAGR of 43% taken based on historical growth

Section - 4.2

Sub - Sector Analysis - Solar Thermal Sector

4.2. Solar Thermal Sector

4.2.1. Introduction

Solar thermal technology uses the sun's energy, rather than fossil fuels, to generate low-cost, environmentally friendly thermal energy. This energy is used to heat water or other fluids, and can also power solar cooling systems.[50]

Solar thermal applications have been used in India since the 1980s. Solar water heaters (the most prominent of the solar thermal applications) are available in the market for consumers to buy and use. They can be installed on any rooftop. Other uses of solar thermal are solar cooking and steam generation, Industrial process heating and Air Heating.

For the industrial process heating, this sector deploys systems which utilize solar energy to generate heat which in turn is used to for industrial level heating process

However, the application of solar thermal energy is two-fold as mentioned below:

1. **Power Generation (Concentrating Solar Thermal Power)** - Solar thermal power plants use the sun's rays to heat a fluid to high temperatures. The fluid is then circulated through pipes so that it can transfer its heat to water and produce steam. The steam is converted into mechanical energy in a turbine, which powers a generator to produce electricity.
2. **Solar Heat Applications**
    a. **Industrial Heat Application**- Solar energy can be used to generate heat for medium and high temperature applications using different types of Concentrating Solar Systems. The heat generated could be used for process heat allocations in industries in the form of steam/pressurized hot water /air, cooking in community kitchens, laundry in hospitals / hotels etc.
    b. **Water Heating-** A solar water heater (SWH) is a combination of an array of collectors, an energy transfer system and a thermal storage system. In active solar water heating systems, a pump is used to circulate the heat-transferring fluid through the solar collectors, whereas in passive thermo-siphon systems, the natural circulation of working fluid is used.
    c. **Solar Cooking-Solar** consists of a solar collector which is used for cooking applications. Solar cookers consist of three types. Dish type solar cooker, box type solar cooker and concentrated solar technology used to generate steam for community cooking. Steam generating systems of Concentrating Solar Thermal (CST), are of two types – fixed receiver E-W automatically tracked concentrating technology (Scheffler) and the other on fully tracked receiver on dish technology (Arun).

[50] Sunwatersolar.com- http://sunwatersolar.com/solar-thermal/what-is-solar-thermal

The solar thermal can also be classified with regard to the type of the systems into distributed solar thermal and concentrating solar thermal as depicted below: [51]

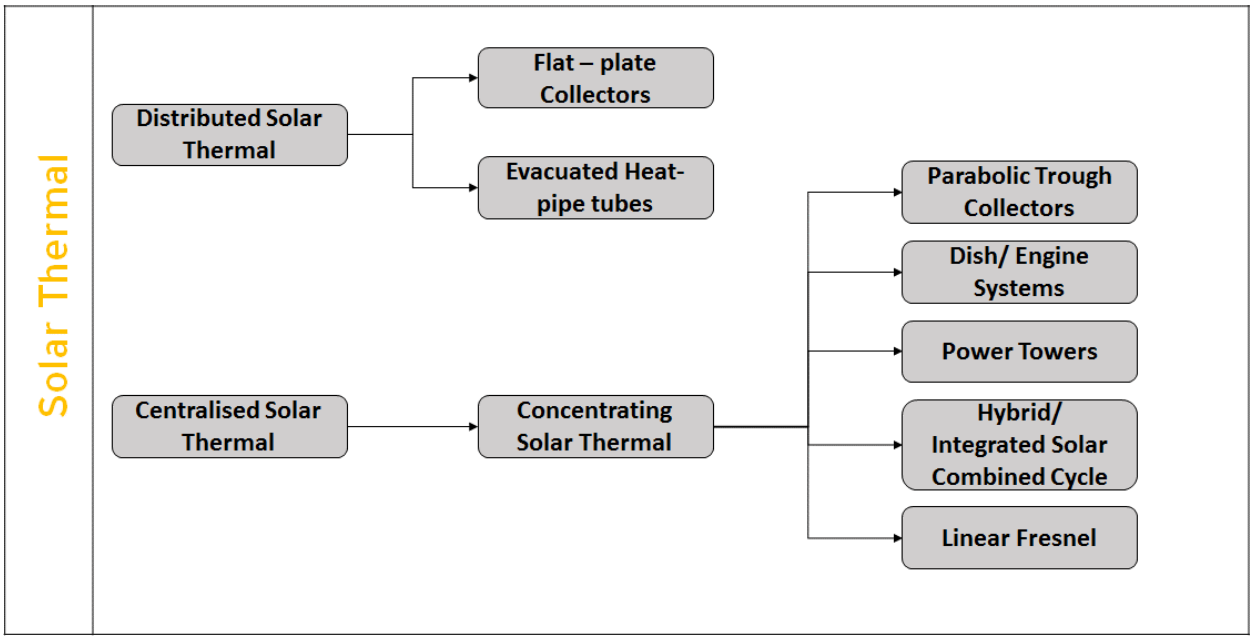


Figure 12: Broad classification of solar thermal sector

While concentrated solar power was a major focus in JNNSM phase 1 where 50% of the power target was to be achieved from solar thermal, going ahead, focus of producing power will be on solar PV though India has massive potential of CSP. 2014 CSP Today markets scorecard ranked India as the fifth most promising market for CSP compared to the first position the country held in the 2013 ranking.[52] However, there is some process side a delay due to this technology is yet to take off. For example, Low availability of DNI data, long gestation, variability in weather conditions, the absence of fossil back up, bankability, affordability of rate payers and limited experience in technology are the issues which is being faced by this sector.

However, off grid and decentralized solar thermal has a huge untapped market. Currently most of the set ups are involved in solar thermal energy applications wherein the energy is used for commercial/ industrial and residential purposes. Hence, this report will focus on mostly solar thermal applications where is there is significant growth potential.

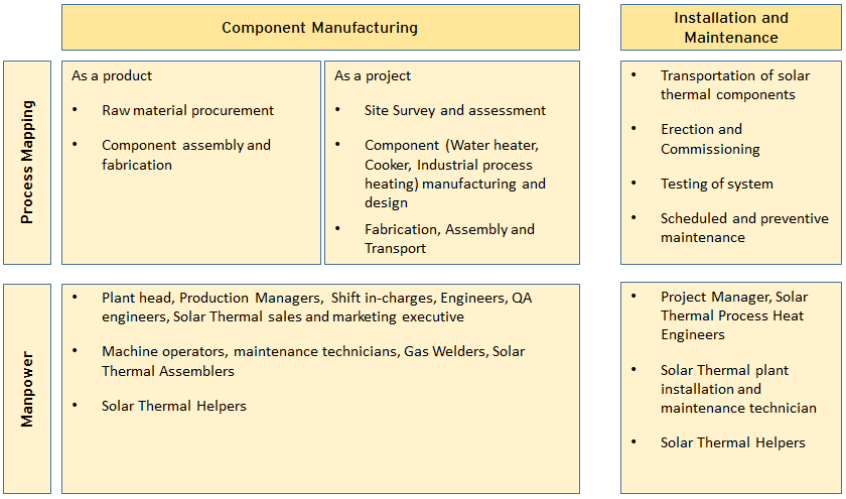
[51] Source: Key Suppliers in Solar Thermal Value Chain and Venture Capital Companies, Clixoo

[52] http://www.business-standard.com/content/manufacturing-industry/concentrating-solar-power-in-india-an-outlook-to-2024-114091500273_1.html

4.2.2. Background

In the year 2010, Jawaharlal Nehru National Solar Mission was launched. The Mission targets include (i) deployment of 20,000 MW of grid connected solar power by 2022[53], (ii) 2,000 MW of off-grid solar applications including 20 million solar lights by 2022, (iii) 20 million sq. m. solar thermal collector area. For the first phase of the Mission, the Cabinet had approved a target to set up 7 million square meter solar thermal collector area. As of march 2013, 7.01 million sq. m. had been achieved against this target. [54] Phase 2 of the mission has set a target of 8 million sq. m. addition in the years 2013 – 17 to take the cumulative installed solar thermal collector area to 15 million sq. m. In phase III, i.e. from years 2017-2022, additional 5 million sq. m. of collector area is to be installed.

4.2.3. Solar Thermal Value Chain



It is observed in the solar thermal sector, even though there are manufacturers of solar domestic water heating, the industry has not many stand - alone manufacturers and the manufacturing is done as per project requirement. Hence, solar thermal manufacturing is divided into two categories[55].

Figure 13: Solar thermal industry value chain

1. **Distributed solar thermal:** This includes solar thermal water heating systems namely flat plate collector systems and evacuated heat-plate water heating systems and box-type solar cookers.
2. **Concentrated solar thermal:** This includes a concentrating reflector which is used to produce heat at higher temperatures. The applications of these include large scale solar cooking (community cooking applications), steam generation and industrial process heating. CST systems include technologies like Arun, Scheffler, Parabolic Dish and linear Fresnel reflector.

These categories are depicted below along with the temperature ranges:

[53] Modified to 100GW of Solar PV power by 2022.
[54] MNRE annual report 2015-16: http://mnre.gov.in/file-manager/annual-report/2015-2016/EN/Chapter%204/chapter_4.htm
[55] Solar thermal energy technologies for industrial applications - India's experience- Shirish Garud, Fellow, TERI

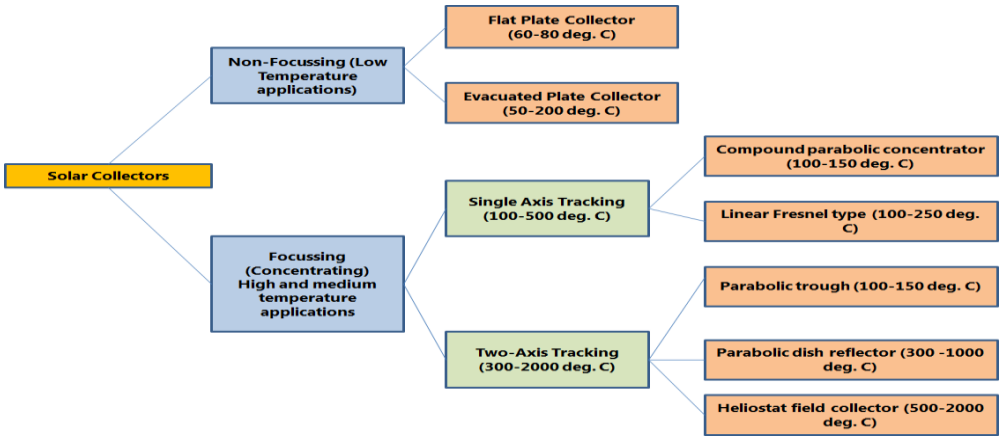


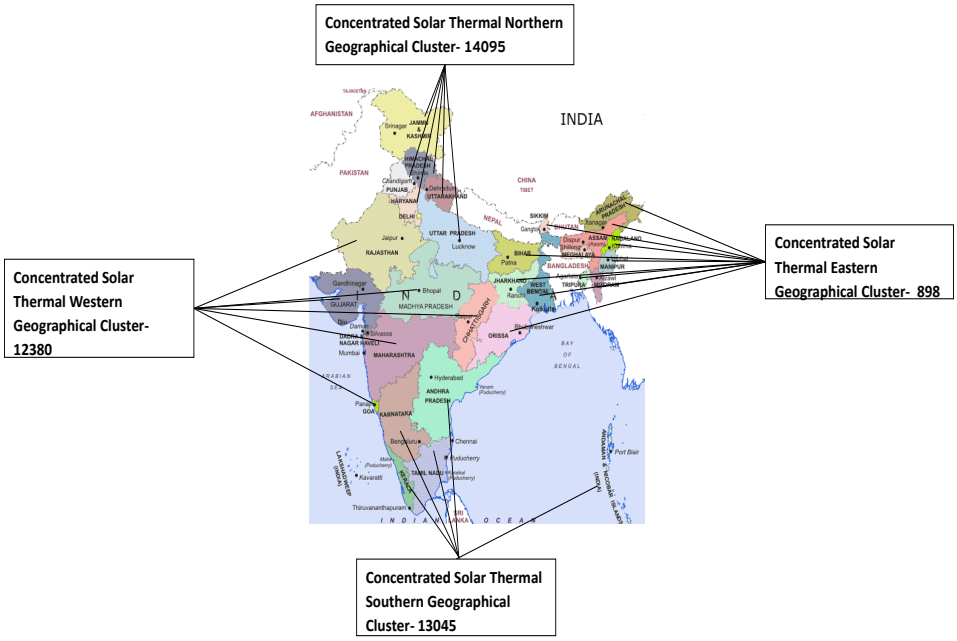
Figure 14: Classification of solar collectors according to temperature ranges

4.2.4. Geographical Clustering

Concentrated solar thermal:

The geographical clustering of concentrated solar thermal projects as per installed capacity is shown below:

(Values in 000 sq. m.)



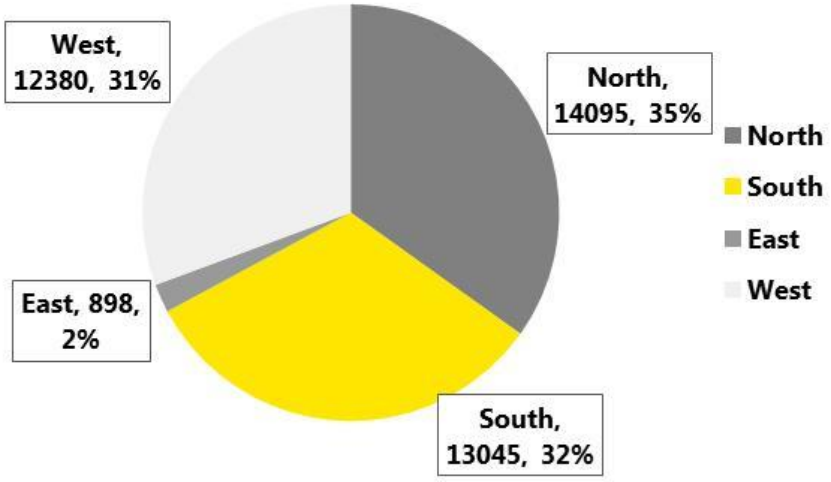
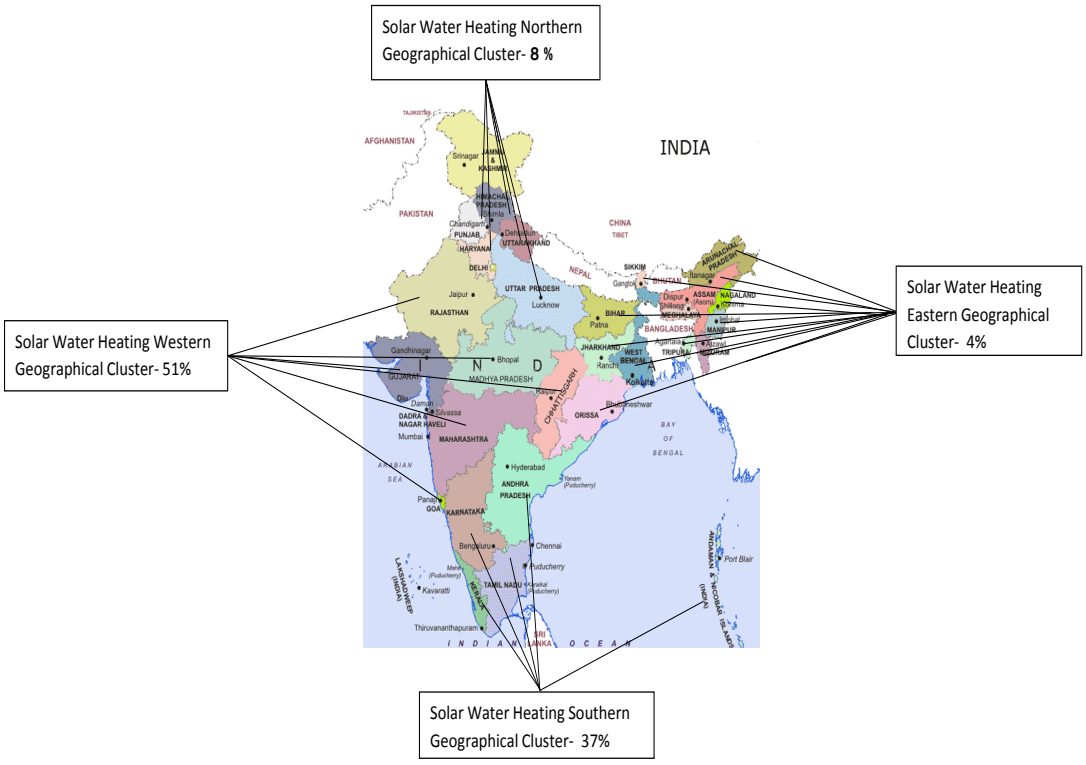


Figure 15: Geographical clustering of solar thermal projects as per installed capacity (values in 000 sq. km.)

Solar Domestic Water heating

The geographical clustering of solar water heating segment is done basis the list of channel partners provided by MNRE. As can be seen, majority of the solar water heating companies are clustered in the south and western regions (specifically Bangalore and Pune).



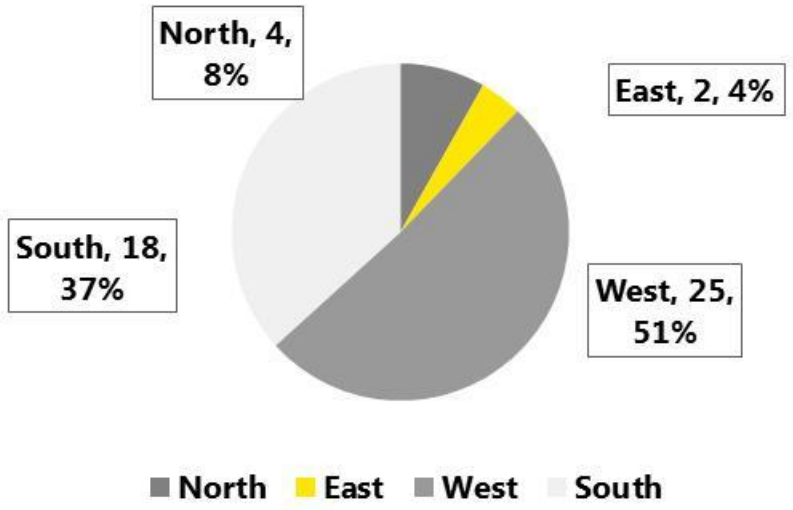


Figure 16: Geographical clustering of solar domestic water heating companies

4.2.5. Current Industry Status

4.2.5.1. Solar Thermal – Current Installed Capacity and MNRE targets

Solar thermal capacity is measured as total solar collector area. The solar collector targets as set under JNNSM are shown below. As envisaged under phase 1, the total achievement was 7.001 Sq. million.

Application segment	Target Phase 1 (2010-13)	Cumulative target phase 2 (2013- 17)	Cumulative Target phase 3 (2017 – 22)
Solar collectors	7 Sq. Million	15 Sq. Million	20 Sq. Million

Table 27: Solar thermal energy targets as per JNNSM

Under phase II, the solar collector targets are distributed in the following way: [56]

1. **Solar water heating systems:** The focus area of JNNSM Phase II would be to popularize solar water heaters across the country. Currently, most of the deployments of solar water heaters are concentrated in a few cities and urban centres like Pune and Bangalore. The Phase II would target addition around **8 million sq. m. collector** area by the end of 2017
2. **Solar Cookers and Steam Generating Systems** – According to the Mission document, "Phase II would target at-least 100 institutions for deployment of solar cookers and around 25,000 installations for solar cooking applications in schools for mid-day meals. An overall target of deployment of 50,000 solar cookers would be set in Phase II of JNNSM."

[56] Source – JNNSM phase – II, policy document

3. **Industrial Process Heat Applications** - Phase II would target at least 400 systems, 250 sq.m. each on an average **(100,000 sq. m.)** of concentrating Solar Thermal (CSTs) for heating applications in industries
4. **Air Conditioning / Refrigeration** – More than 200 systems, 30 Tons of Refrigeration (TR) each on an average (60,000 sq. m.) for air conditioning / refrigeration systems are targeted in Phase II

The current installed capacity of solar collector is shown in the graph below[57]. The current growth in installed capacity stands at 7% year on year. Basis this growth trend, we estimate that the phase two target of 15 million sq. m. will not be achieved with this growth rate. Basis our calculation we estimate that to achieve the solar thermal target of 20 million sq. m. by 2022, the industry growth rate needs to increase to 11%.

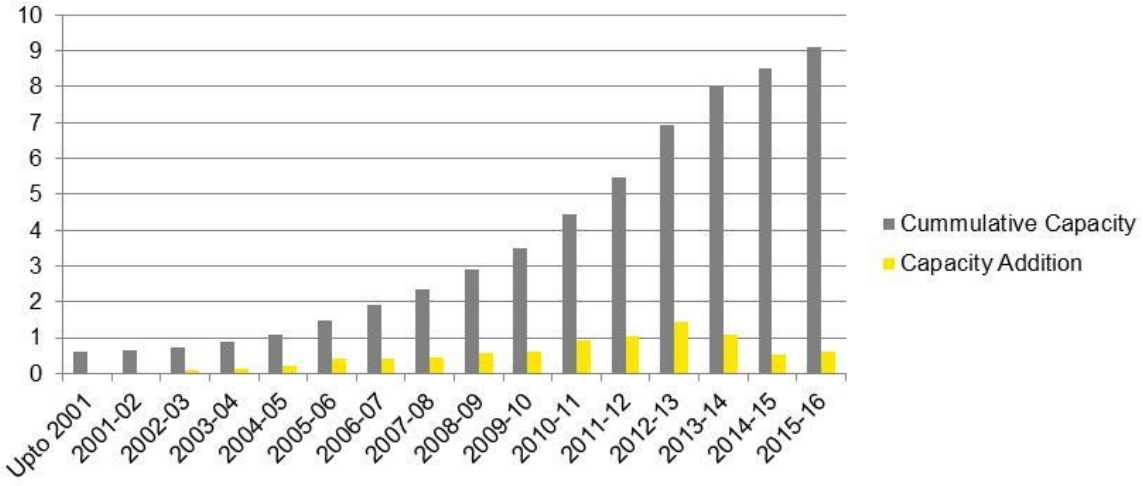


Figure 17: Historical growth of solar thermal sector (values in million sq. m.)

It is estimated the 11% CAGR will continue till 2025 and the solar water heating installed targets would be as shown in the table below. Post 2025 we estimate the industry to grow at the same CAGR to reach a value of 44.57 million sq. m. by 2030

	Cumulative Capacity (million sq. m.)	Per year capacity addition (million. Sq. m.)
2016-17	10.21	1.09
2017-18	11.44	1.23
2018-19	12.81	1.37

[57] MNRE annual report 2015-16

2019-20	14.35	1.54
2020-21	16.07	1.72
2021-22	18.00	1.93
2022-23	20.16	2.16
2023-24	22.58	2.42
2024-25	25.29	2.71
2025-26*	28.32	3.03
2026-27	31.72	3.40
2027-28	35.53	3.81
2028-29	39.79	4.26
2029-30	44.57	4.77

Table 28: Assessment of capacity addition in solar domestic water heating sector

For concentrated solar thermal (CST), the growth of CST be as per phase II policy document is 100000 sq. m. by FY 2017. However, as per 2015-16 MNRE annual report, current installed capacity is 45000 sq. m. with 5266 sq. m. added in the year 2015-16. Basis the JNNSM target, to achieve the 2017 target the industry would need to grow at close to 50% annually.

We have made an assumption that the target of 100000 sq. m. through CST would be set for phase 2 also making CST cumulatively 200000 sq. m. With this we see a growth rate of 24% year on year. The same CAGR is used to estimate the capacity till 2030. Basis this assumption the per-year growth is observed to be:

Concentrated Solar Thermal	Cumulative Capacity (sq. m.)	Per Year capacity addition (sq. m.)
2015	45000	5266
2016	55800	10800
2017	69192	13392
2018	85798	16606
2019	106390	20592
2020	131923	25534
2021	163585	31662
2022	202845	39260
2023	251528	48683

2024	311894	60367
2025	386749	74855
2026	479569	92820
2027	594665	115097
2028	737385	142720
2029	914358	176972
2030	1133803	219446

Table 29: Assessment of capacity addition in concentrated solar thermal sector

4.2.5.2. Solar Thermal growth drivers

1. **Jawaharlal Nehru National Solar Mission (JNNSM):** The JNNSM defines the strategy for achieving 100 GW target through solar power. Further, it lays down target to be achieved through solar thermal applications for water heating as well as CST. This will drive growth in the solar thermal sector

2. **Solar and Smart cities:** The Smart City guidelines commits that 10% of the Smart City's energy requirement would come from solar energy. A total of 100 smart cities have been shortlisted in the stage -1 of smart city challenge. Solar Cities aims to assist urban local bodies in assessing their present energy consumption & future demand and preparing Master Plans for energy savings & generation through RE installations & energy efficiency measure. Development of smart cities will see a movement from conventional source of power to solar power. 60 cities are being developed as solar cities. 34 of the targeted 60 solar cities fall under the category of smart cities. These cities may work in association with Smart Cities as all the Smart Cities to be taken under solar cities programme. Apart from 60 solar cities, 100 small townships/ campuses will be covered in this scheme. This will be a major growth driver for solar domestic water heating systems

3. **Government subsidies –** The government set subsidies for solar water heating was a major growth driver in the increase of solar water heater usage in India. The interest subsidy scheme was implemented through financial institutions and banks and IREDA. 31 banks participated in this scheme. Further, close to 80% accelerated depreciation was available to profit making commercial and industrial establishments which did not avail soft loans.

4. **Make in India-** Government's focus on Make – in India initiatives will see more domestic manufacturing of solar water heaters.

5. **UNDP- GEF support:** 20% of benchmark cost is provided through UNDP for CST systems. This will attract more players in the coming years and will lead to growth in CST in the coming years

6. **Draft Renewable Energy Act, 2015-** The draft renewable energy act seeks to create an institutional structure and a support structure to encourage renewable energy in India. Some key highlights are National Renewable Energy Policy, National Renewable Energy Fund, State Green Fund, etc.

4.2.6. Solar Thermal Occupational Map (Industry Delivery Structure)

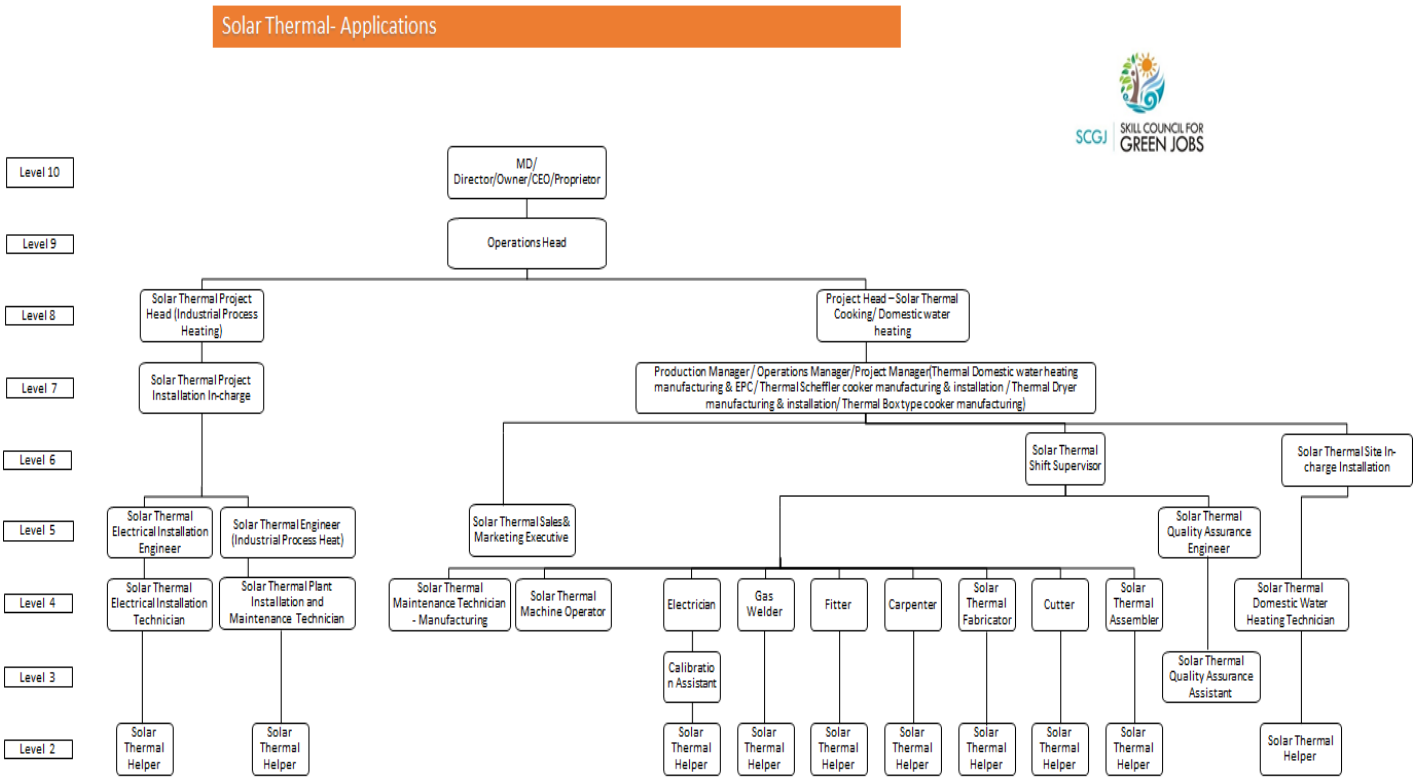


Figure 18: Solar thermal applications sector occupational map

4.2.7. Solar Thermal sector assumptions

- Solar thermal capacity is measured as total solar collector area. The solar collector targets as set under JNNSM are shown below. As envisaged under phase 1, the total achievement was 7.001 Sq. million

Application segment	Target Phase 1 (2010-13)	Cumulative target phase 2 (2013- 17)	Cumulative Target phase 3 (2017 – 22)
Solar collectors	~7 Sq. Million	15 Sq. Million	20 Sq. Million

Table 30: Assessment of capacity addition in the solar thermal sector

- The current growth in installed capacity stands at 7% year on year. Basis this growth trend, we estimate that the phase two target of 15 million sq. m. will not be achieved with this growth rate. Basis our calculation we estimate that to achieve the solar thermal target of 20 million sq. m. by 2022, the industry growth rate needs to increase to 11%.
- It is assumed that 11% CAGR will continue till 2025 and has been extrapolated till 2030
- For concentrated solar thermal, we have taken a growth rate of 24% annually basis historical trends and sector targets
- For the end to end installation of a solar water heating system of 100 -150 sq. m. would require the deployment of the following roles for duration of 7 days:
    a. 1 Overall MD/CEO of the organisation
    b. 1 Project head (Solar Thermal) looking after multiple projects
    c. 5 Solar thermal domestic water heating technician
    d. 5 Solar thermal helpers/ semi –skilled technicians
- Total number of projects which can be undertaken = 80% of (251/ 7) ~ 30 projects in a year
- For manufacturing and installation of solar thermal water heating the current installed capacity is catering to close to 1.07 million sq. m. per year. By 2022, to achieve the target of 20 million sq. m. of solar water heaters, the -per year capacity addition needs to increase to 2.16 million sq. m. per year. By 2025, this needs to increase to 3.02 million sq. m. per year
- According to JNNSM phase -2, a target of 50,000 solar cookers has been set till 2022. Basis the MNRE annual report 2015-16, we observe that currently 6, 80, 669 of box type solar cookers and 15,000 of dish type of solar cookers were sold by 2015-1658. A total of 29 channel partners have been associated with MNRE. It is assumed that the current manpower can cater to the future capacity increase by targets.
- For Industrial water heating applications the manpower deployment for a 100-200 sq. m. project is:

[58] MNRE- Annual Report – 2015-16

a. 15 solar thermal plant installation/ maintenance technicians
b. 10 Solar thermal helpers
c. 4 Fitters
d. 4 Cutters
e. 4 Solar thermal process heat engineers
f. 3 Solar thermal maintenance technician- Manufacturing
g. 3 Solar thermal electricians
h. 3 Solar thermal gas welders
i. 1 Project head (Solar Thermal)
j. 1 Project installation in-charge
k. 1 Solar thermal Fabricator
l. 1 Carpenter

- The time taken for a concentrated solar thermal- for industrial water heating is as follows:
  - 1 Week – Engineering and Assessment
  - 3 Weeks – Manufacturing and Transportation
  - 2 Weeks - Erection and Commissioning + 1 week for testing
- Total projects which can be undertaken in a year = 4 at 80% deployment
- In CST projects, the same manpower deployed for the erection and commissioning of the system will take care of the operation and maintenance also. Hence, with increase in capacity, more manpower needs to be trained. For calculation we have assumed the current capacity as the capacity added in the previous year i.e. 5266 sq. m. of CST[59]

4.2.8. Solar Thermal sector manpower norms

4.2.8.1. Solar water heating and solar cooking – installation and manufacturing – Norms

1. For the end to end installation of a solar water heating system of 100 -150 sq. m. would require the deployment of the following roles for duration of 7 days:
   - 1 Overall MD/CEO of the organisation
   - 1 Project head (Solar Thermal) looking after multiple projects
   - 5 Solar thermal domestic water heating technician
   - 5 Solar thermal helpers/ semi –skilled technicians

[59] MNNRE- Annual report – 2015-16

2. Total number of projects which can be undertaken = 80% of (251/ 7) ~ 30 projects in a year
3. For manufacturing and installation of solar thermal water heating we observed that the current installed capacity is catering to close to 1.07 million sq. m. per year. By 2022, to achieve the target of 20 million sq. m. of solar water heaters, the -per year capacity addition needs to increase to 2.16 million sq. m. per year. By 2025, this needs to increase to 3.02 million sq. m. per year. Hence we have calculated the manpower numbers basis this assumption
4. According to JNNSM phase -2, a target of 50,000 solar cookers has been set till 2022. Basis the MNRE annual report 2015-16, we observe that currently 6, 80, 669 of box type solar cookers and 15,000 of dish type of solar cookers were sold by 2015-1660. A total of 29 channel partners have been associated with MNRE. The current manpower can cater to the future capacity increase by targets

4.2.8.2. Solar Thermal CST (Industrial Process Heating)- Norms

1. For Industrial water heating applications the manpower deployment for a 100-200 sq. m. project is:
    - 15 solar thermal plant installation/ maintenance technicians
    - 10 Solar thermal helpers
    - 4 Fitters
    - 4 Cutters
    - 4 Solar thermal process heat engineers
    - 3 Solar thermal maintenance technician- Manufacturing
    - 3 Solar thermal electricians
    - 3 Solar thermal gas welders
    - 1 Project head (Solar Thermal)
    - 1 Project installation in-charge
    - 1 Solar thermal Fabricator
    - 1 Carpenter
2. The time taken for a concentrated solar thermal- for industrial water heating is:
    - 1 Week – Engineering and Assessment
    - 3 Weeks – Manufacturing and Transportation
    - 2 Weeks - Erection and Commissioning + 1 week for testing
3. Total projects which can be undertaken in a year = 4 at 80% deployment
4. In CST projects, the same manpower deployed for the erection and commissioning of the system will take care of the operation and maintenance also. Hence, with increase in

[60] MNRE- Annual Report – 2015-16

capacity, more manpower needs to be trained. For calculation the current capacity is taken as the capacity added in the previous year i.e. 5266 sq. m. of CST[61]

4.2.9. Solar Thermal Skill Gap

Solar Thermal is divided into three major segments, solar water heating (Domestic), Soar Industrial process heating and Solar Cooking. The broad value chain of Solar thermal as depicted is divided into manufacturing and installation.

4.2.9.1. Assessment of capacity addition

The targets for the solar thermal sector as set by the government are: [62]

Application segment	Target Phase 1 (2010-13)	Target phase 2 (2013- 17)	Target phase 3 (2017 – 22)
Solar collectors	7 Million Sq. m.	15 Million Sq. m.	20 Million Sq. m.

Table 31: Solar thermal energy targets as per JNNSM

The current growth in installed capacity stands at 7% year on year. Basis this growth trend, we estimate that the phase two target of 15 million sq. m. will not be achieved with this growth rate. However, basis our calculation we estimate that to achieve the solar thermal target of 20 million sq. m. by 2022, the industry growth rate needs to increase to 11%. We estimate the 11% CAGR will continue till 2025 and the solar water heating installed targets would be as shown below:

	Cumulative Capacity (million sq. m.)	Per year capacity addition (million. Sq. m.)
2016-17	10.21	1.09
2017-18	11.44	1.23
2018-19	12.81	1.37
2019-20	14.35	1.54
2020-21	16.07	1.72
2021-22	18.00	1.93
2022-23	20.16	2.16
2023-24	22.58	2.42
2024-25	25.29	2.71
2025-26*	28.32	3.03
2026-27	31.72	3.40
2027-28	35.53	3.81
2028-29	39.79	4.26
2029-30	44.57	4.77

Table 32: Assessment of capacity addition in solar domestic water heating sector

[61] MNNRE- Annual report – 2015-16
[62] Jawaharlal Nehru Solar Mission – Phase II policy document

4.2.9.2. Concentrated Solar Thermal assessment of capacity addition

The current installed capacity of concentrated solar thermal is 45000 sq. m. [63] However, as per JNNSM policy document, by FY 2017 100,000 sq. m. installed CST was envisaged. To achieve this target a CAGR of 50% would be required in the next two years.

Hence, we have made an assumption that the target of 100000 sq. m. [64]through CST would be set for phase 2 also making CST cumulatively 200000 sq. m. With this we see a growth rate of 24% year on year till 2022 which we have extrapolated till 2025. Basis this assumption the- per year growth is observed to be:

Concentrated Solar Thermal	Cumulative Capacity (sq. m.)	Per Year capacity addition (sq. m.)
2015	45000	5266
2016	55800	10800
2017	69192	13392
2018	85798	16606
2019	106390	20592
2020	131923	25534
2021	163585	31662
2022	202845	39260
2023	251528	48683
2024	311894	60367
2025	386749	74855
2026	479569	92820
2027	594665	115097
2028	737385	142720
2029	914358	176972
2030	1133803	219446

Table 33: Assessment of capacity addition in concentrated solar thermal sector

[63] MNRE Annual report-2015-16
[64] Jawaharlal Nehru National Solar Mission – Phase II Policy document

4.2.9.3. Solar Thermal manpower estimation- Top roles

The total skill gap required in the solar thermal sector across various job roles is shown below. The norms in the sub-sector are depicted in the annexure.

Sr. No.	Designation	Current Manpower	Skill gap till FY 2022 (estimated)	Skill gap till FY 2025 (estimated)
1.	Semi-Skilled Worker installation/Solar Thermal Helper	7212	7778	14111
2.	Solar Thermal Machine Operator	2140	2180	3920
3.	Solar Thermal Domestic Water Heating Technician	1783	1816	3266
4.	Solar Thermal Plant Installation and Maintenance Technician	132	852	1720
5.	Solar Thermal Sales & Marketing Executive	352	658	900
6.	Electrician	283	432	818
7.	Solar Thermal Maintenance Technician - Manufacturing	283	432	818
8.	Fitter	78	271	542
9.	Gas Welder	112	258	505
10.	Solar Thermal Shift Supervisor	257	262	470
11.	Solar Thermal Quality Assurance Assistant	257	262	470
12.	Solar Thermal Engineer Industrial Process Heat	35	227	464
13.	Carpenter	95	144	273
14.	Solar Thermal Assembler	128	131	235
15.	Solar Thermal Fabricator	52	100	194
16.	Project Installation In-charge	9	57	116
17.	Solar Thermal Quality Assurance Engineer	43	44	78
18.	Production Manager / Operations Manager/Project Manager	43	44	78
19.	Solar Thermal Assembler	128	131	235
20.	Production Manager / Operations Manager/Project Manager(Thermal Domestic water heating manufacturing & EPC / Thermal Scheffler cooker manufacturing & installation / Thermal Dryer manufacturing & installation/ Thermal Box type cooker manufacturing/ Solar Industrial Water Heater Manufacturing) (7)	43	44	78
21.	Cutter	43	44	78

Table 34: Solar Thermal sector role wise skill gap till 2025

4.2.10. Summary of capacity addition and skill gap in solar thermal sector

The estimated capacity addition is shown in the table below. The estimated addition till 2022 have been taken in accordance with the MNRE guidelines. Post 2022, the value has been extrapolated till 2030 at the CAGR observed till 2022.

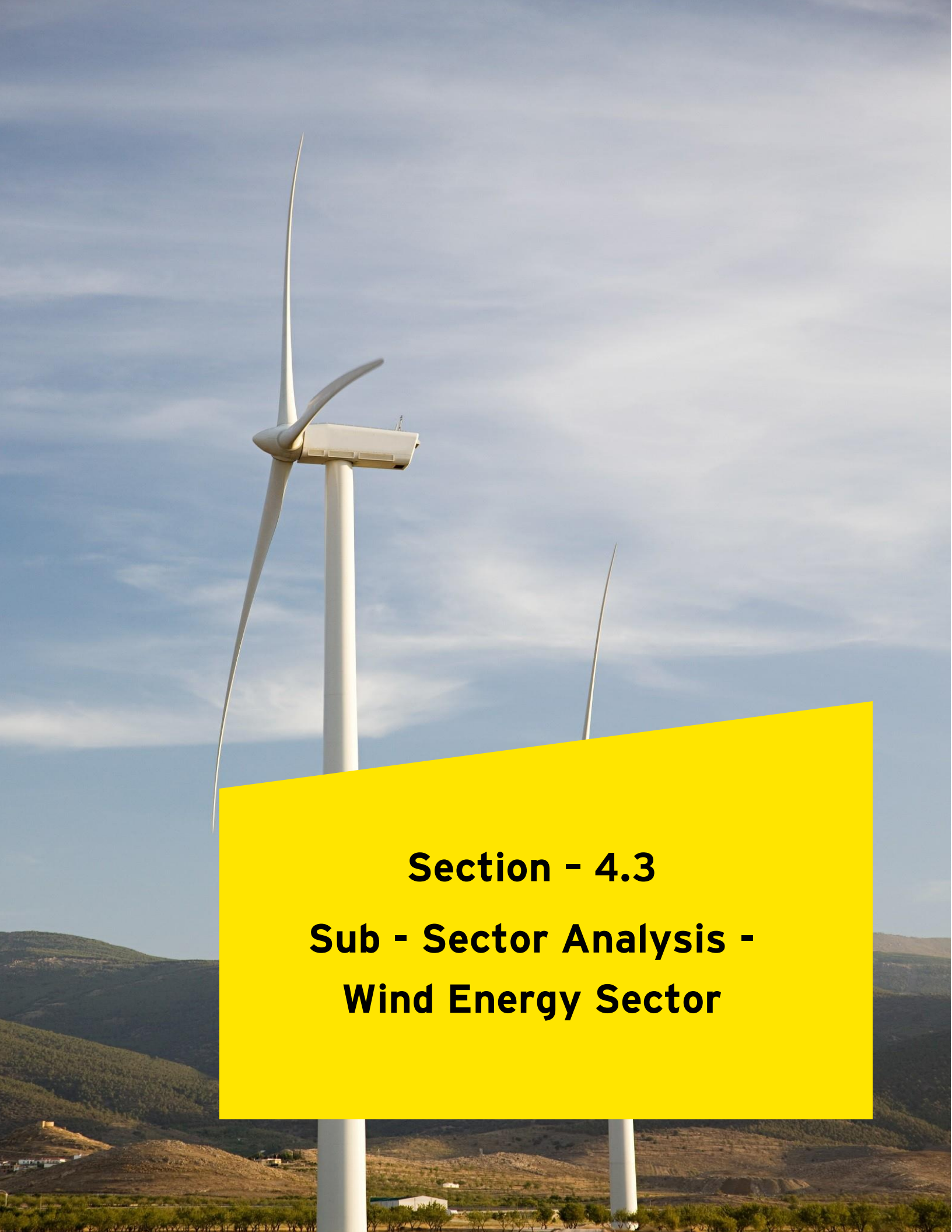
Sub - Sector	Current Capacity	Cumulative Capacity till FY 2022	Cumulative Capacity till FY 2025	Cumulative Capacity till FY 2030
Solar domestic water heating sector (million sq. m.)	9.12	18.00	25.29	44.47[65]
Concentrated solar heating sector (000 sq. m.)	55.8	202.85	386.75	1133.8[66]

Table 35: Summary of capacity addition in solar PV sector

Sub - Sector	Current Manpower	Skill gap till FY 2022	Skill gap till FY 2025	Skill gap till FY 2030
Solar thermal applications	13508	16,167	29,369	65,490[67]

Table 36: Summary of skill gap in solar PV sector

[65] CAGR of 11% assumed
[66] CAGR of 24% assumed
[67] To estimate skill gap till 2030, the CAGR of 12.8% has been taken basis the trend till 2025



Section - 4.3

Sub - Sector Analysis - Wind Energy Sector

4.3. Wind Energy Sector

4.3.1. Introduction

This form of energy is generated by the use of air flow through wind turbines to mechanically power generators for electricity. Wind power, as an alternative to burning fossil fuels, is plentiful, renewable, widely distributed, clean, produces no greenhouse gas emissions during operation, uses no water, and uses little land. The net effects on the environment are far less problematic than those of non-renewable power sources.

Among all renewable energy (RE) options, wind power, which accounts for over 70 per cent of the installed renewable energy (RE) capacity in the country, is the most commercially competitive source of renewable energy. This may be attributed to technological maturity, proven installed base and lower setup and running costs.

The installed wind power capacity in India stands at 28700 MW, as of December 2016. India saw more than 3.4 GW of wind energy capacity added in the financial year 2015-16. This was not only 48% higher than last year's capacity addition, but also 42% higher than the target set at the start of the year. The growth of wind energy in India has been largely due to the favourable policy, accelerated depreciation benefit (AD), generation based incentive (GBI) scheme and Renewable purchase obligation (RPO).[68]

The growth in capacity over the past decade is shown in Figure below.[69]

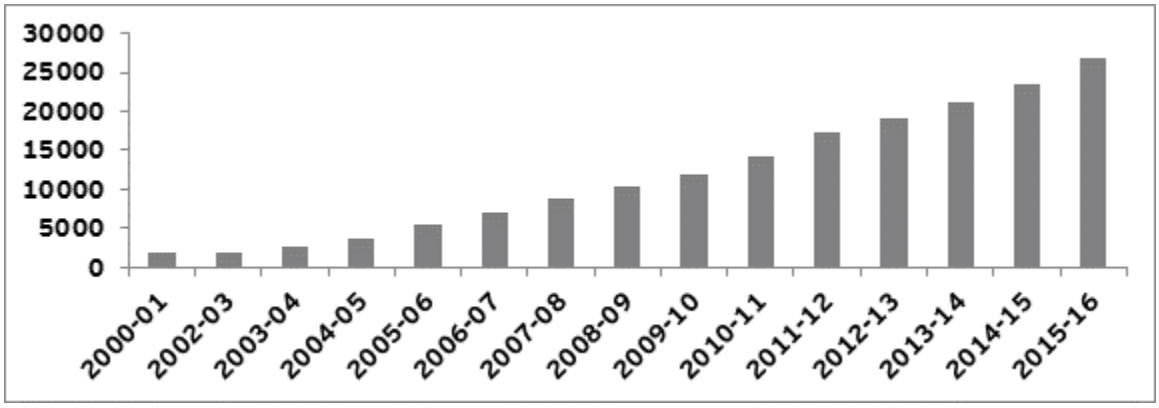


Figure 19: Growth in Installed wind capacity in India (Capacity till May-2016)

[68] Source - http://www.energyaccess.in/renewable-energy

[69] Source: MNRE; Indian Wind Turbine Manufacturers Association 2016

4.3.2. Background

India is the fourth largest wind power producer in the world, after China, USA and Germany[70]. Among all renewable energy (RE) options, wind power, which accounts for over 70 per cent of the installed renewable energy (RE) capacity in the country. The government has set a target of 60GW from wind energy in its renewable energy targets of 175 GW.

4.3.3. Wind Power Potential in India

While a total wind power potential of 1, 02,772 MW has been established in India; only one state has tapped about 75 % of the potential. The wind power capacity has been established mainly in Tamil Nadu, Gujarat, Maharashtra, Andhra Pradesh, Karnataka and Rajasthan. Other states like Gujarat, Maharashtra and Rajasthan have seen significant growth in wind capacity over the last four to five years, also due to a stable policy and regulatory regime.

Meanwhile, Karnataka (13,593 MW), Andhra Pradesh (14,497 MW) and Gujarat (13,593MW) together have 63, 161 MW of untapped wind power potential. While the installed capacity in Andhra Pradesh is only 912 MW, Gujarat and Karnataka has developed only 3581 MW and 2548 MW respectively.

4.3.4. Wind Energy Sector Value Chain

The entire value chain of wind turbine can be represented as follows: [71]

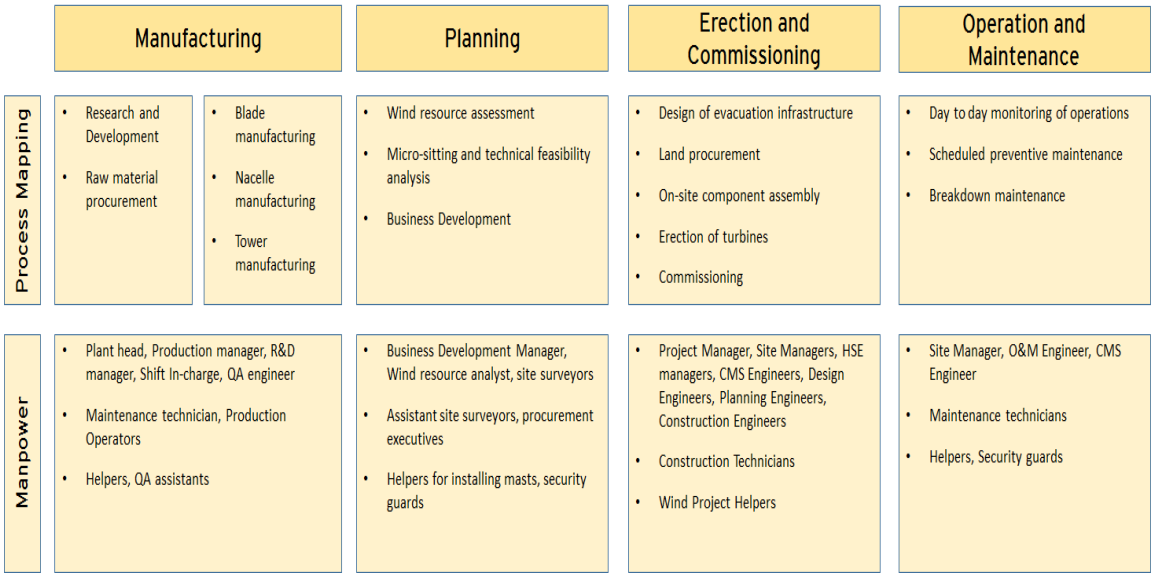


Figure 20: Wind Energy Sector Value Chain

[70] MNRE annual report 2015- 16: http://mnre.gov.in/file-manager/annual-report/2015-2016/EN/Chapter%203/chapter_3.htm
[71] Creating Green Jobs: Employment Generation by Gamesa-Renew Power's 85 Megawatt Wind Project in Jath, Maharashtra

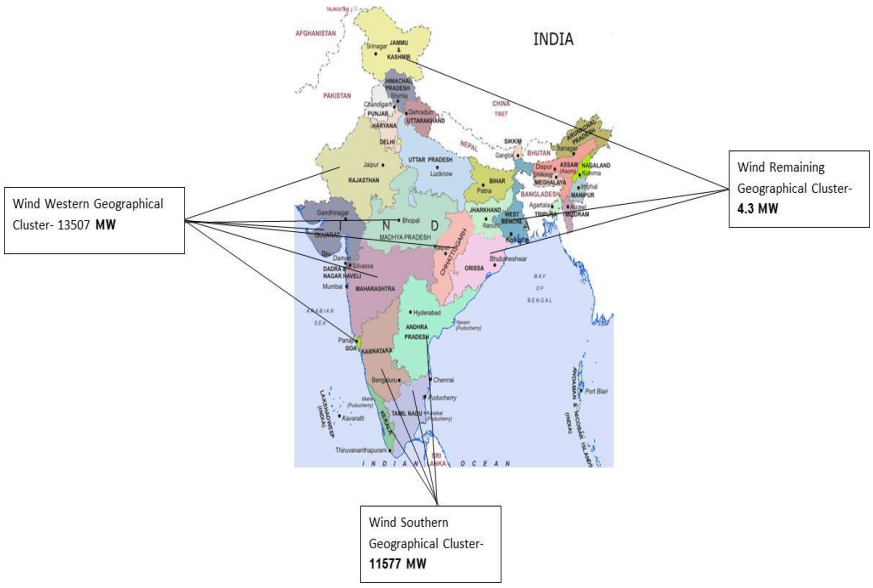
1. **Wind manufacturing:** This comprises of the following
    a. **Tools and assembly equipment:** Steel, carbon fibre, tools, etc.
    b. **Component manufacturing:** The wind turbine consists of the four key components:
        - Rotor and Blades:
        - Nacelle and controls
        - Generator and Power Electronics
        - Tower Components

        These key parts themselves have other components like brakes, bearings, ladders, etc. These components are sourced to wind turbine OEMs which assemble these parts. However, some large OEMs have vertically integrated the value chain and have in-house component manufacturing
    c. **Original equipment manufacturing:** OEMs are the actual producers of wind turbines. These companies either produce the components in-house or fabricate. These companies source the equipment to developers. Typically the developers contract with the wind OEMs for the delivery of complete wind turbines
2. **Wind developers:** Wind developers buy or lease windy land, finance the installation of wind turbines and operate and maintain the turbines for an extended period. After a project is constructed, the wind developer's role varies. The developer may own and operate the wind farm, or merely operate the project for a different owner

    In India, the wind value chain is integrated with the OEMs also acting as developers. Apart from the above depicted value chain, there are other business opportunities in terms of services such as feasibility studies, geo-technical assessments and logistics support for wind farms

4.3.5. Geographical Clustering of Wind Power

The **wind sector is primarily focused in the west and south** where it is viable to set-up wind farms due to the strong wind currents. The values shown are in MW[72].



Geographical Clustering of farms installed (MW)- Source MNRE Annual report

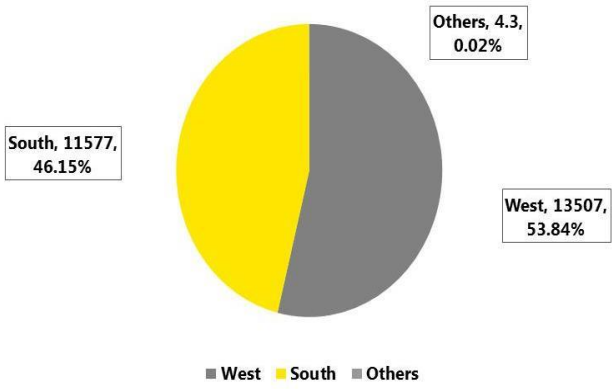


Figure 21: Geographical clustering of wind farms installed (MW)

[72] MNRE – Annual report- 2015-16

4.3.6. Current Industry Status

4.3.6.1. Wind Energy installed capacity and MNRE targets

The current installed capacity of Wind Energy in India is 27,441 MW (as on July 2016).The government as per the 12th Plan has envisaged a total installed capacity to the tune of 32,000 MW by FY-17 and 60,000 MW by 2022 as shown in the table below: [73] Basis the CAGR growth till 2022, we have estimate the growth of wind sector till 2025.

Year	Cumulative Wind Power Capacity (MW)	Capacity Addition per year (MW)
2009	10241	1485
2010	11806	1565
2011	14155	2349
2012	17352	3197
2013	19502	2150
2014	21132	1630
2015	23444	2312
2016	25306	1862
2017	29306	4000
2018	33819	4513
2019	39027	5208
2020	45037	6010
2021	51973	6936
2022	60000	8027
2023	69240	9240
2024	79903	10663
2025	92208	12305
2026-2030[74]	101659	9451

Table 37: Assessment of capacity addition in the wind energy sector (MW)

[73] (Source-http://cseindia.org/docs/photogallery/ifs/Renewable%20Energy%20in%20India%20Growth%20and%20Targets.pdf)

[74] Estimated assuming a CAGR of 10%

As per government estimates, an estimated 350 GW of power generation through renewable energy sources by 2030. This is also estimated in the context of Intended Nationally Determined Contributions (INDCs) for climate negotiations in Paris. [75][76] It is also expected that out of the targeted 350 GW, 100 GW would come out of from wind power[77].

This translates into a CAGR of 6-7% from the year 2022. However, to reach the current target of 60 GW by 2022, the sector needs to grow annually at 15%. **We estimate the current growth rate to continue till 2025, post which the growth will reduce to ~10%. The wind sector will reach its estimated wind potential of approximately 1.02 GW by 2026 – 2027** and growth will stagnate post that.

Apart from national level targets, the government has also given state level targets to be achieved by 2022 as depicted below: [78]

State/UTs	Wind(MW)
Rajasthan	8600
Northern Region	**8600**
Gujarat	8800
Madhya Pradesh	6200
Maharashtra	7600
Western Region	**22600**
Andhra Pradesh	8100
Telangana	2000
Karnataka	6200
Tamil Nadu	11900
Southern Region	**28200**
Other(New States)	600
All India	**60000**

Table 38: State level targets to achieve 2022 target in wind energy sector (MW)

The wind turbine generators (WTG) are currently being manufactured in the country by a dozen manufacturers, through (i) joint ventures under licensed production (ii) subsidiaries of foreign companies, under licensed production and (iii) Indian companies with their own

[75] http://www.business-standard.com/article/economy-policy/india-s-energy-mix-to-have-40-renewable sources-by-2030-115092200057_1.html

[76] http://www.bridgetoindia.com/is-india-aiming-for-250-gw-of-solar-by-2030-2/

[77] Source - http://thewire.in/11345/indias-energy-mix-to-have-40-renewable-sources-by-2030/

[78] Source - http://mnre.gov.in/file-manager/UserFiles/Tentative-State-wise-break-up-of-Renewable-Power-by-2022.pdf

technology. An indigenization level up to 70% has been achieved in machines of unit sizes up to 500 kW. The import content is somewhat higher in higher capacity machines. The current annual production capacity of domestic wind turbines is about 9500 MW. [79]

4.3.6.2. Wind Sector growth drivers

1. **Favourable Foreign Investment Policy-** The favourable FDI for wind sector has attracted many international players. For example, Hilliard Energy plans to invest Rs 3,600 crore (US$ 533.66 million) in Ananthapur district of Andhra Pradesh in the solar & wind power sector for the generation of 650 MW of power[80]

2. **Attractive long-term preferential tariff (feed in tariff):** The developers sign a long-term PPA at fixed tariffs, which delivers a stable revenue stream. This is an attractive incentive for developers to set up wind farms and will act as a major driver for growth

3. **Tax on conventional sources of energy**: The tax on coal for the National Clean Energy Fund (NCEF) doubled to INR 400 (EUR 5 3) per ton in the budget for FY 2015-16[81]

4. **National Wind Mission (NWM)** NWM will set a target of raising wind power generation to 60,000 MW by 2022 with an investment of Rs 10,00,000 crore. It will aim to add further capacity through a mix of fiscal incentives to encourage adoption of new technologies and flow of global investments. The need for a long-term and stable policy framework covering all key aspects such as land allocation, tariff fixation, incentives, manufacturing policy, planning for transmission infrastructure and managing intermittency (in supply) is the key driver for this exercise[82]

5. **Restoration of Accelerated Depreciation:** Accelerated Depreciation has been restored from 2014. This will help build a robust wind manufacturing base in the future. 80% Accelerated Depreciation has provided to players in the wind sector

6. **Re Invest 2015 -** To achieve the Government's target to increase India's renewable energy capacity to 175 GW by 2022, the Secretary, Ministry of New and Renewable Energy (MNRE) invited public and private sector companies and proprietorship firms to invest in the country's renewable energy sector in the five year period from 2015 - 2019. Companies were asked to voluntarily commit any quantum of generation, even 1 MW, in any renewable energy sector: solar, wind, biomass and small-hydro. It

[79] Source – MNRE - http://mnre.gov.in/schemes/grid-connected/solar-thermal-2/

[80] http://indiainbusiness.nic.in/newdesign/index.php?param=industryservices_landing/365/2

[81] http://www.gwec.net/wp-content/uploads/vip/GWEC-Global-Wind-Report_2016.pdf

[82] http://www.evwind.es/2015/07/07/india-wind-energy-mission-on-anvil-to-achieve-60000-mw-by-2022/53209

was assured to the industry players that MNRE will assist the industry in every step of the process. The conclusion of the conference resulted in [83]

- **283.30GW** in total committed by major private players & public sector companies out of which
- $200 billion to be invested in renewable energy development
- PSUs such as NTPC, Coal India, NHPC etc. have committed a total of 8,000 MW in renewable energy sector
- SBI to finance 15,000 MW, other financing bodies - 11,500 MW in renewable energy sector
- Manufacturing draws 41 GW of investment for both solar cells and wind turbines
- Noted names from all sectors, power & non-power, ready to be part of green bandwagon
- Foreign players join the fray with largest investment among all[84]

7. **Renewable Energy Certification (REC) -** RECs are aimed at addressing the mismatch of renewable energy resources in the States and their RPO requirements. Obliged entities can fulfil their RPOs by purchasing REC's. RECs are traded on the Indian Energy Exchange (IEX) and the Power Exchange of India Ltd (PXIL). In line with RPOs there are two categories of RECs – **Solar & Non-Solar.**

   Solar RECs include both PV and CSP technologies. Non-solar RECs include renewable energy technologies such as biomass, wind, biofuel, cogeneration & small hydro. Solar RECs are traded once a month – last Wednesday of every month.

   In order to provide a minimum of certainty on REC prices, Central Electricity Regulatory Commission (CERC) has fixed a floor and forbearance price for the period up to 2017 between which the REC can be traded.[85]

   There are three categories of solar projects that are eligible for RECs:

   - **Projects for captive consumption (Self use)** – Eligible for REC only if concessions are not availed in transmission and wheeling charges, banking charges and electricity duty
   - **PPA with distribution licensee –** PPA with local distribution company at average power purchase cost (APPC) as determined by SERC. ***Note: PPA at preferential tariff are not eligible under this scheme***

[83] http://re-invest.in/about-re-investment/green-energy-commitments/

[84] http://www.business-standard.com/article/economy-policy/re-invest-2015-companies-commit-200-billion-to-clean-energy-115021400027_1.html

[85] http://www.shansolar.com/rpo/

- **Sale to open access consumers -** Sale at mutually agreed market determined price with all the transmission & wheeling and other charges payable to the Transco / DISCOM duly paid

8. **Renewable Purchase Obligation (RPO):** This is a mechanism by which the State Electricity Regulatory Commissions are obliged to purchase a certain percentage of power from renewable energy sources. RPO is being implemented throughout the country to create demand for renewable energy. Same as REC's, RPOs are also of two categories – Solar and Non- Solar. RPOs are enforced on three categories of consumers – (a) Distribution Licensees, (b) Open Access Consumers & (c) Captive Consumers[86]

9. **Generation Based Incentives (GBI):** Generation based incentives would act as a major growth driver by attracting players in this sector. GBI given at a rate of Rs. 0.5 / unit of electricity fed into the grid for a period of minimum four years and a maximum 10 years.

10. **Inclusion of renewable energy in priority sector lending:** Loans given for renewable energy projects have been included in the priority sector from 2015

11. **Draft Renewable Energy Act, 2015-** The draft renewable energy act seeks to create an institutional structure and a support structure to encourage renewable energy in India. Some key highlights are National Renewable Energy Policy, National Renewable Energy Fund, State Green Fund, etc.

[86] http://www.shansolar.com/rpo/

4.3.7. Wind Sector Occupational Map (Industry Delivery Structure)

4.3.7.1. Blade Manufacturing

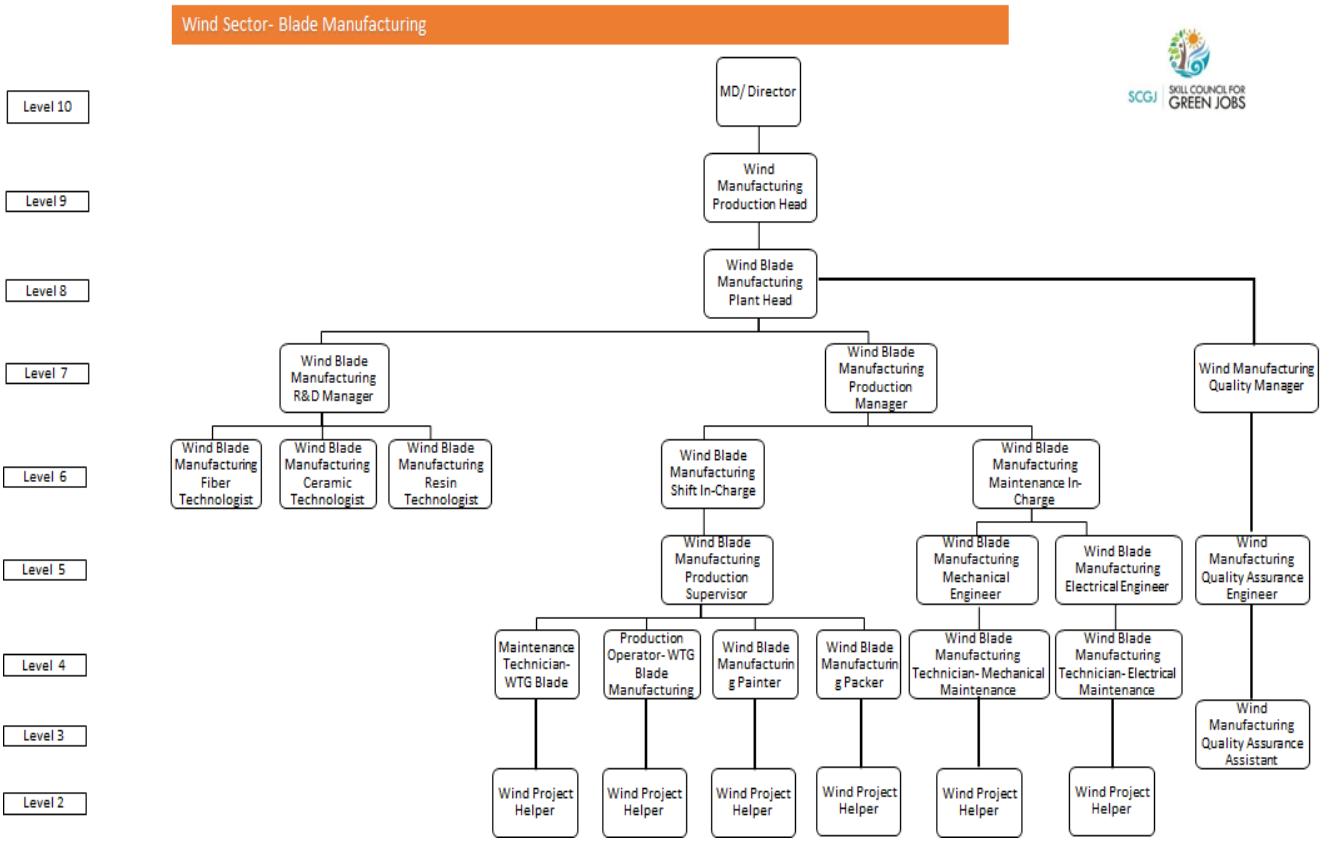


Figure 22: Wind Energy Sector - Blade Manufacturing Occupational Map

4.3.7.2. Nacelle Manufacturing

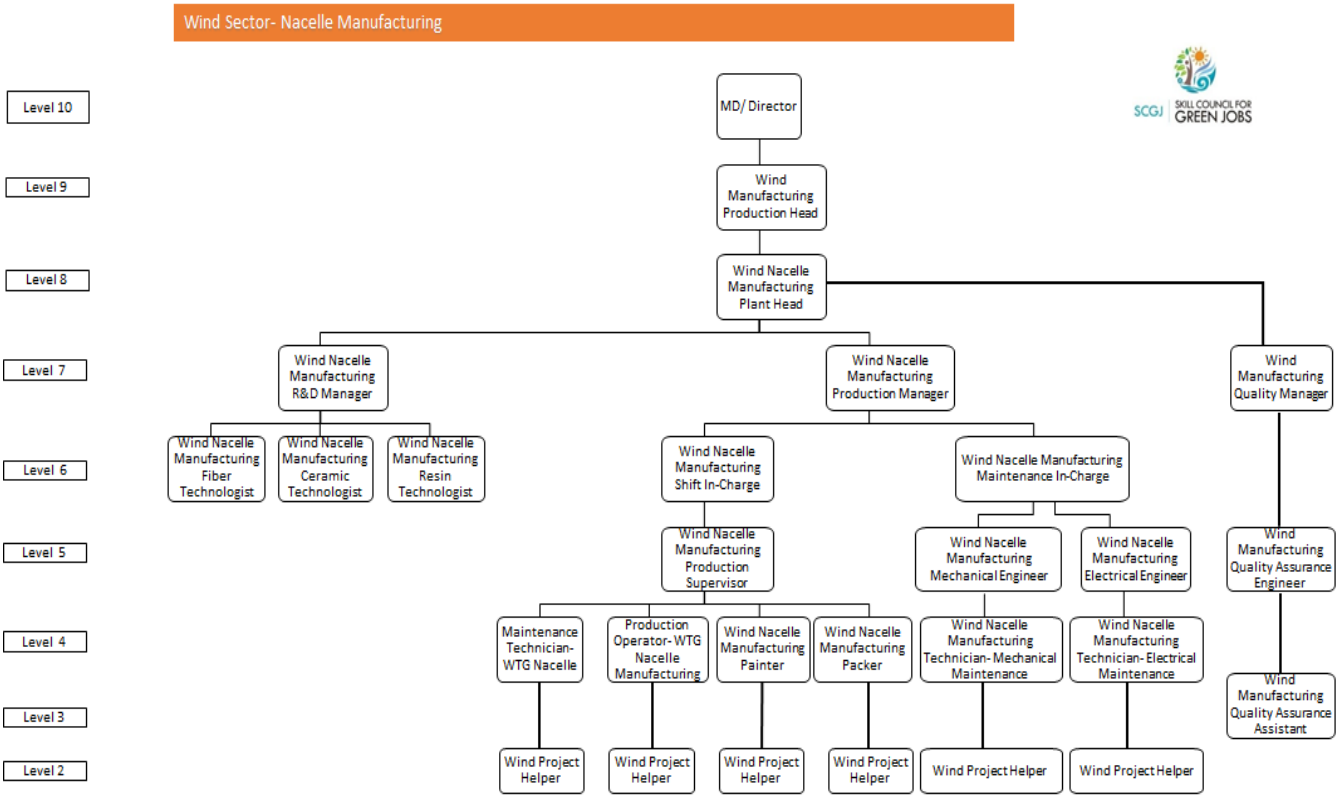


Figure 23: Wind Energy Sector - Nacelle Manufacturing Occupational Map

4.3.7.3. Tower Manufacturing/ Fabrication

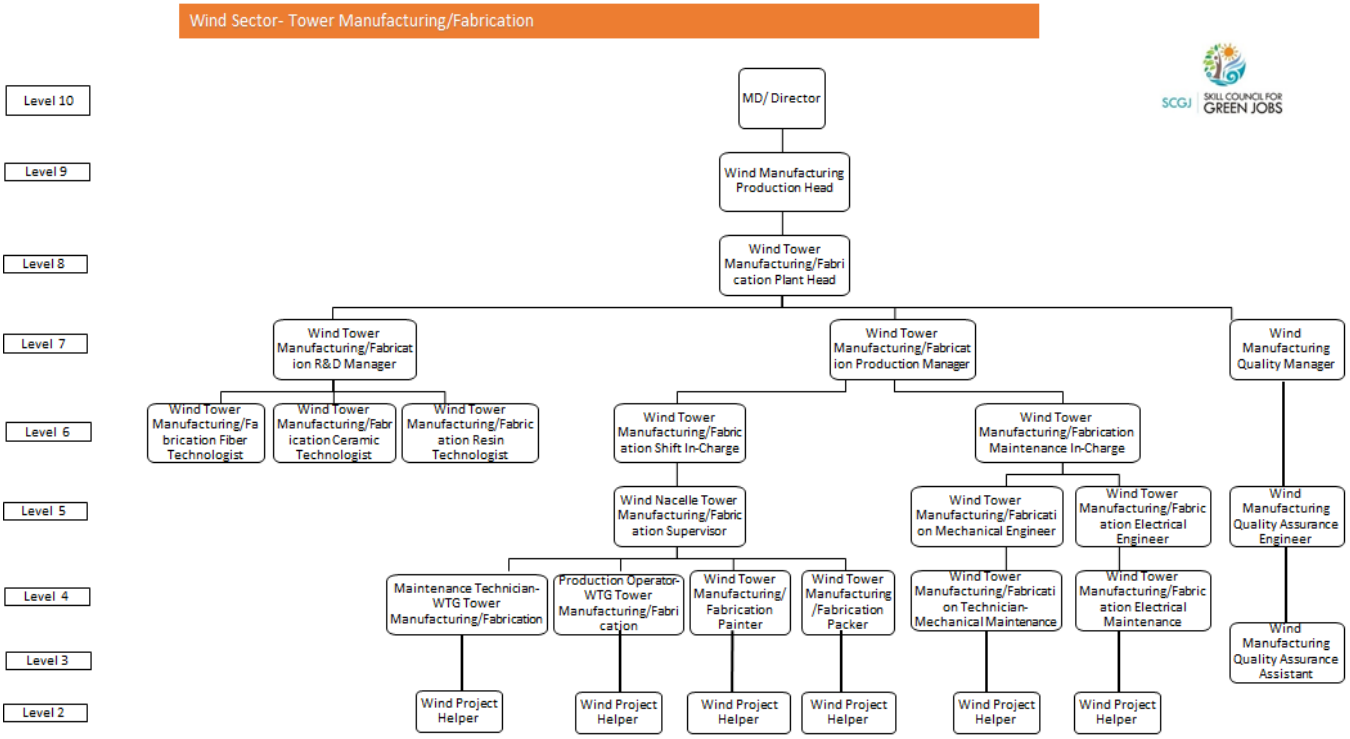


Figure 24: Wind Energy Sector - Tower Manufacturing Occupational Map

4.3.7.4. Engineering, Procurement and Commissioning

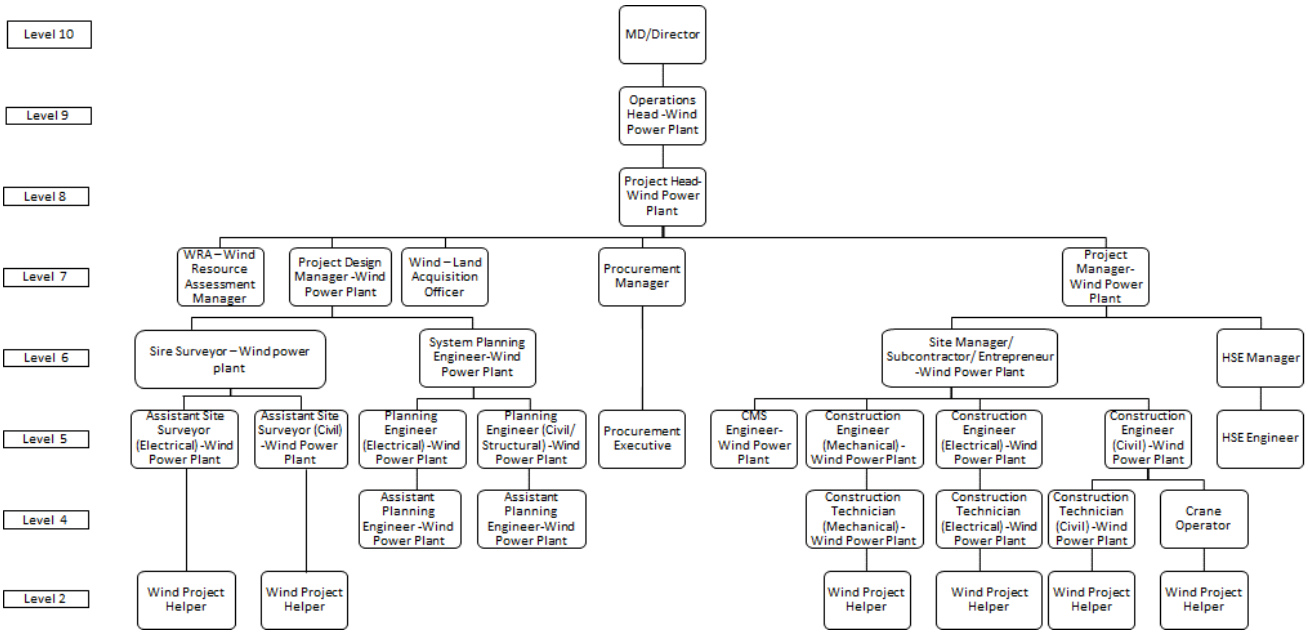


Figure 25: Wind Energy Sector – Engineering, Procurement and Commissioning Occupational Map

4.3.7.5. Operation and Maintenance

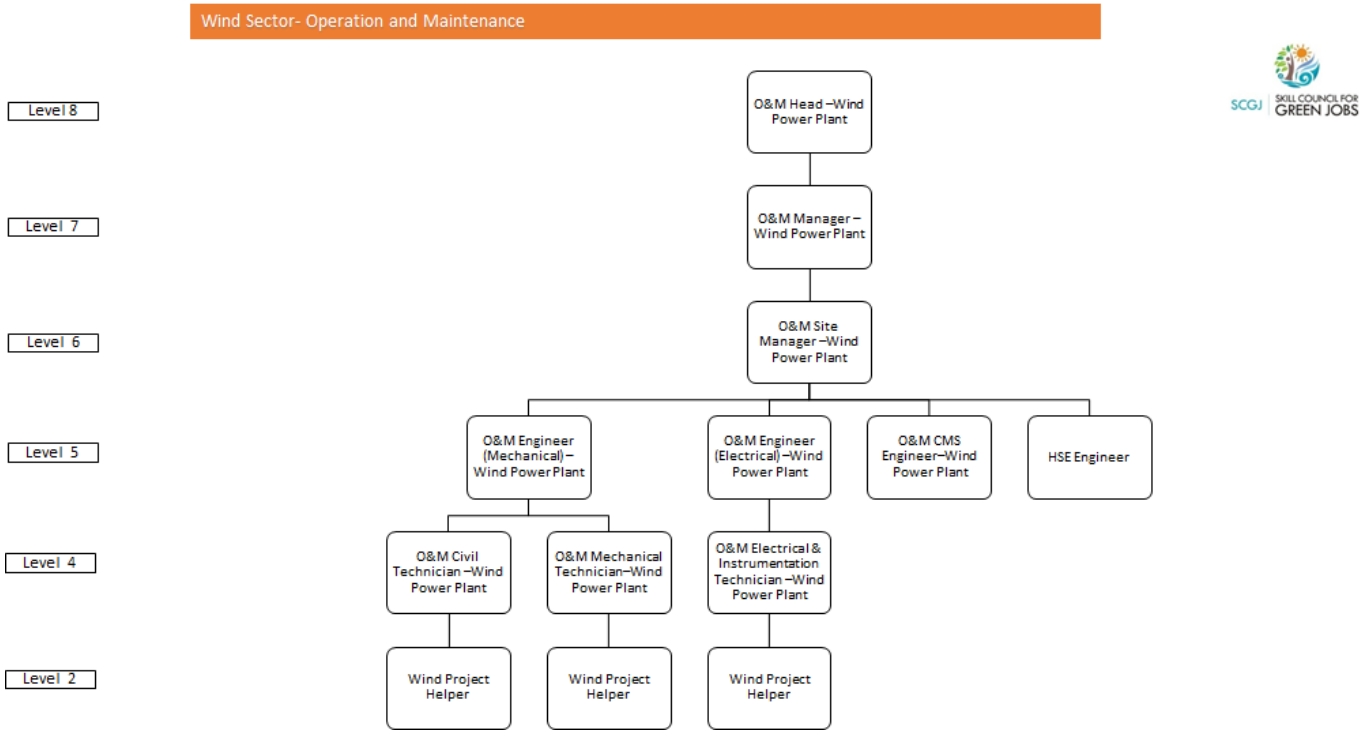


Figure 26: Wind Energy Sector – Operation and Maintenance Occupational Map

Note: The senior level roles are not depicted here, as they are depicted in the EPC segment

4.3.8. Wind Sector assumptions

- There is a plan to achieve a target of 60 GW by 2022. There is a planned addition of 4000 MW of wind energy by end of FY 2016-17. [87]. The CAGR basis the target of 60,000 GW till 2022 is calculated to be 15.54 %. The same is used to estimate the growth from 2017-2025. Current Annual wind turbine manufacturing capacity is 9500 MW.[88] Post 2025, a CAGR of 10% is assumed till 2026-27
- Wind power potential in India is taken as 102 GW and basis our calculation, the sector would reach its potential by 2026-27
- As per government estimates, an estimated 350 GW of power generation through renewable energy sources by 2030. This is also estimated in the context of Intended Nationally Determined Contributions (INDCs) for climate negotiations in Paris. [8990] It is also expected that out of the targeted 350 GW, 100 GW would come out of from wind power
- Post 2025, we estimate that the sector growth will reduce and no new manufacturing would be required to meet the domestic demand. However, export may continue as the globally the demand for wind turbine components increases

Year	Wind power installed projects capacity (MW)	Per year capacity addition in installed capacity (MW)	Wind component manufacturing/ assembly capacity (MW)
Current – 2016	26932	-	9500
2016-17	29306	4000	
2017-18	33819	4523	
2018-19	39027	5208	
2019-20	45037	6010	
2020-21	51973	6935	
2021-22	60000	8026	
2022-23	69240	9240	
2023-24	79903	10663	10663
2024-25	92208	12305	12305
2025-26	101659	9451	
2026-30*	~102000	-	

Table 39: Assessment of capacity addition in wind energy sector

[87] http://mnre.gov.in/mission-and-vision-2/achievements/
[88] Source – MNRE - http://mnre.gov.in/schemes/grid-connected/solar-thermal-2/
[89] http://www.business-standard.com/article/economy-policy/india-s-energy-mix-to-have-40-renewable sources-by-2030-115092200057_1.html
[90] http://www.bridgetoindia.com/is-india-aiming-for-250-gw-of-solar-by-2030-2/

4.3.9. Wind Sector manpower norms

Basis our interactions with multiple industry stakeholders, we have observed the following norm for wind energy power projects of 50 -100 MW size:

Designation	Manpower norm for 50-100 MW wind farm
Wind Project Helper – EPC and O&M	Diff. for EPC and O&M (EPC – 50, O&M – 5)
O&M Electrical and Instrumentation Technician - Wind Power Plant	9
Construction Technician (Electrical)- Wind Power Plant	20
Construction Technician (Civil) - Wind Power Plant	15
O&M Mechanical Technician - Wind Power Plant	6
CMS Engineer (EPC and O&M)	Diff. for EPC and O&M (EPC – 1, O&M – 4)
Construction Technician (Mechanical) - Wind Power Plant	10
Crane Operator	10
Procurement Executive- Wind	8
Site Surveyor (Civil and Electrical)	6
Assistant Planning Engineer (Civil/ Mechanical and Electrical)	6
Construction Engineer (Electrical)- Wind Power Plant	6
Construction Engineer (Civil) - Wind Power Plant	5
Construction Engineer (Mechanical)- Wind Power Plant	5
O&M Engineer (Electrical) - Wind Power Plant	2
O&M Engineer (Mechanical) - Wind Power Plant	2
O&M Manager- Wind Power Plant	1
WRA – Wind Resource Assessment Manager	3
Assistant Site Surveyor (Civil)- Wind Power Plant	2
Assistant Site Surveyor (Electrical)- Wind Power Plant	2
Wind Land Acquisition Officer	2
Procurement Manager- Wind	2
Planning Engineer (Civil/ Structural)- Wind Power Plant	2
Planning Engineer (Electrical)- Wind Power Plant	2
Site Manager/ Subcontractor/ Entrepreneur- Wind Power Plant	2
HSE Engineer	2
Project Design Manager - Wind Power Plant	1
Project Manager- Wind Power Plant	1
System Planning Engineer - Wind Power Plant	1
HSE Manager	1

Table 40: Norms observed in the wind energy sector

4.3.10. Wind Sector Skill Gap

The wind sector is one the areas of focus under the renewable energy target. Current installed wind capacity of India is 27 GW. There is a plan to achieve a target of 60 GW by 2022. There is a planned addition of 4000 MW of wind energy by end of FY 2016-17. [91]

This section focuses on wind sector for the four phases namely Project Planning, EPC, Operation and Maintenance and Manufacturing.

1. **Wind resource assessment and planning:** The process requires two phases, installation of wind mast and data analysis. Basis the Gamesa - Renew report, for an 85 MW project, the wind resource assessment phase goes on for close to 2 years.
2. **Wind manufacturing:** Wind turbine manufacturing is the most critical part in the wind sector. The three key activities in manufacturing of a wind turbine are Nacelle manufacturing, Blade manufacturing and Tower fabrication. The blade is the component with the most wear and tear and hence forms a critical part in the wind turbine.

4.3.10.1. Assessment of capacity addition

The wind sector is one the areas of focus under the renewable energy target. Current installed wind capacity of India is close to 27 GW[92]. There is a plan to achieve a target of 60 GW by 2022. There is a planned addition of 4000 MW of wind energy by end of FY 2016-17. [93]. The CAGR basis the target of 60,000 GW till 2022 is calculated to be 15.54 %. The same is used to estimate the growth from 2017-2025. Current Annual wind turbine manufacturing capacity is 9500 MW.[94]

Year	Wind power installed projects capacity (MW)	Per year capacity addition in installed capacity (MW)	Wind component manufacturing/ assembly capacity (MW)
Current – 2016	26932	-	9500
2016-17	29306	4000	
2017-18	33819	4523	
2018-19	39027	5208	
2019-20	45037	6010	
2020-21	51973	6935	
2021-22	60000	8026	
2022-23	69240	9240	
2023-24	79903	10663	10663
2024-25	92208	12305	12305
2025-26	101659	9451	
2026-30*	~102000	-	

Table 41: Assessment of capacity addition in the wind energy sector

[91] http://mnre.gov.in/mission-and-vision-2/achievements/
[92] http://mnre.gov.in/mission-and-vision-2/achievements/
[93] http://mnre.gov.in/mission-and-vision-2/achievements/
[94] Source – MNRE - http://mnre.gov.in/schemes/grid-connected/solar-thermal-2/

*- As per government estimates, an estimated 350 GW of power generation through renewable energy sources by 2030. This is also estimated in the context of Intended Nationally Determined Contributions (INDCs) for climate negotiations in Paris. [9596] It is also expected that out of the targeted 350 GW, 100 GW would come out of from wind power[97].

This translates into a CAGR of 6-7% from the year 2022. However, to reach the current target of 60 GW by 2022, the sector needs to grow annually at 15%. **It is estimated that the current growth rate to continue till 2025, post which the growth will reduce to ~10%. The wind sector will reach its estimated wind potential of approximately 1.02 GW by 2026 – 2027** and growth will stagnate post that.

The current wind manufacturing capacity is 9500 MW[98] per annum. The expected growth in the wind energy sector installation is shown above. The current installed manufacturing capacity can cater to the capacity increase till 2022. The projected increase in capacity beyond 2022 will need to be catered by an increase in the domestic manufacturing capacity increase of 2805 (12305-9500 MW) MW. Post 2025, we estimate that the sector growth will stagnate and no new manufacturing would be required to meet the domestic demand. However, export may continue as the globally the demand for wind turbine components increases.

4.3.10.2. Skill Gap assessment - Wind power Engineering, Procurement and commissioning and Operation and Maintenance

To carry out the skill gap assessment of the wind sector, primary research was carried out with major stakeholders in the Wind energy sector. A report on the case study of Gamesa-Renew power was also taken as a reference.

This phase of wind sector consists of project planning, design, erection and commissioning and operation and maintenance. Based on our interaction with the stakeholders we have observed the following norm:

- The project planning phase consists of wind resource assessment, micro-sitting and surveying and takes place for 2 years
- The erection and commissioning phase takes 15 months. Includes civil foundation, erection and commissioning of the wind farm
- The operation and maintenance is a year-long activity. Apart from on-site manpower, there are also manpower deployed for SCADA monitoring at headquarters

It is observed through interactions that the average size of wind farms in the future would be 50-100 MW. Further due to economies of scale the manpower required for the project

[95] http://www.business-standard.com/article/economy-policy/india-s-energy-mix-to-have-40-renewable sources-by-2030-115092200057_1.html
[96] http://www.bridgetoindia.com/is-india-aiming-for-250-gw-of-solar-by-2030-2/
[97] Source - http://thewire.in/11345/indias-energy-mix-to-have-40-renewable-sources-by-2030/
[98] Source – MNRE - http://mnre.gov.in/schemes/grid-connected/solar-thermal-2/

size is similar across the project size. Basis these observations the following skill gap for the future has been estimated.

The present projected strength is arrived at the looking at the projects installed in the last two years i.e. 2014-15 and 2015-16. For EPC segment, basis the capacity installed in these two years, we have projected the current manpower using the norm arrived. For arriving at skill gap, the capacity addition per year is assessed in periods of two years till FY 2025.

Post FY 2025, we estimate a growth a growth rate of 10% for 1-2 years and the wind sector will reach its estimated potential by 2026-27. Hence, no extra manpower would be required for Planning and EPC activities. However, since Operation and Maintenance being a yearlong activity, manpower required for O&M activities will increase.

However, for the O&M segment, since the activities are carried out throughout the year, calculation is done per MW basis.

S. No.	Designation	Current manpower	Skill gap till FY 2022	Skill gap till FY 2025
1.	Wind Project Helper – EPC and O&M	6867	22514	34562
2.	O&M Electrical and Instrumentation Technician - Wind Power Plant	4848	5952	11750
3.	Construction Technician (Electrical)- Wind Power Plant	1670	7683	11214
4.	Construction Technician (Civil) - Wind Power Plant	1252	5762	8410
5.	O&M Mechanical Technician - Wind Power Plant	3232	3968	7833
6.	CMS Engineer (EPC and O&M)	2238	3030	5783
7.	Construction Technician (Mechanical) - Wind Power Plant	835	3841	5607
8.	Crane Operator	835	3841	5607
9.	Procurement Executive- Wind	668	3073	4485
10.	Site Surveyor (Civil and Electrical)	501	2305	3364
11.	Assistant Planning Engineer (Civil/ Mechanical and Electrical)	501	2305	3364
12.	Construction Engineer (Electrical)- Wind Power Plant	501	2305	3364
13.	Construction Engineer (Civil) - Wind Power Plant	417	1921	2803
14.	Construction Engineer (Mechanical)- Wind Power Plant	417	1921	2803
15.	O&M Engineer (Electrical) - Wind Power Plant	1077	1323	2611
16.	O&M Engineer (Mechanical) - Wind Power Plant	1077	1323	2611
17.	O&M Manager- Wind Power Plant	539	661	1306
18.	WRA – Wind Resource Assessment Manager	250	1152	1682
19.	Assistant Site Surveyor (Civil)- Wind Power Plant	167	768	1121
20.	Assistant Site Surveyor (Electrical)- Wind Power Plant	167	768	1121
21.	Wind Land Acquisition Officer	167	768	1121
22.	Procurement Manager- Wind	167	768	1121
23.	Planning Engineer (Civil/ Structural)- Wind Power Plant	167	768	1121
24.	Planning Engineer (Electrical)- Wind Power Plant	167	768	1121
25.	Site Manager/ Subcontractor/ Entrepreneur- Wind Power Plant	167	768	1121
26.	HSE Engineer	167	768	1121
27.	Project Design Manager - Wind Power Plant	83	384	561
28.	Project Manager- Wind Power Plant	83	384	561
29.	System Planning Engineer - Wind Power Plant	83	384	561
30.	HSE Manager	83	384	561

Table 42: Wind Energy Sector role wise skill gap in EPC segment

4.3.10.3. Wind component manufacturing

The current wind manufacturing capacity is 9500 MW[99] per annum. The current installed manufacturing capacity can cater to the capacity increase till 2022. The projected increase in capacity beyond 2022 will need to be catered by an increase in the domestic manufacturing capacity increase of 2805 (12305-9500 MW) MW.

The current manpower data was collected and a per-MW was arrived at and extrapolated for the current manufacturing capacity.

S. No.	Designation	Current Manpower	Skill gap till FY 2025	Total skilled manpower required till FY 2025
1.	Wind Project Helper	2464	727	3191
2.	Maintenance Technician- WTG Blade	1516	448	1964
3.	Production Operator- WTG Blade Manufacturing	585	173	758
4.	Wind Manufacturing Quality Assurance Assistant	525	155	680
5.	Wind Nacelle/Blade/Tower Manufacturing-Fabrication Painter	387	114	502
6.	Wind Nacelle/Blade/Tower Manufacturing-Fabrication Packer	387	114	502
7.	Maintenance Technician- WTG Nacelle	262	77	340
8.	Wind Nacelle/Blade/Tower Manufacturing-Fabrication Technician- Electrical Maintenance	254	75	329
9.	Maintenance Technician- WTG Tower Manufacturing/Fabrication	203	60	263
10.	Wind Nacelle/Blade/Tower Manufacturing-Fabrication Technician- Mechanical Maintenance	195	58	252
11.	Wind Nacelle/Blade/Tower Manufacturing-Fabrication Production Supervisor	192	57	248
12.	Wind Nacelle/Blade/Tower Manufacturing-Fabrication Mechanical Engineer	190	56	246
13.	Wind Nacelle/Blade/Tower Manufacturing-Fabrication Electrical Engineer	190	56	246
14.	Wind Manufacturing Quality Assurance Engineer	171	51	222
15.	Wind Nacelle/Blade/Tower Manufacturing-Fabrication Shift In-Charge	111	33	143
16.	Production Operator- WTG Nacelle Manufacturing	83	24	107
17.	Production Operator- WTG Tower Manufacturing/Fabrication	83	24	107
18.	Wind Nacelle/Blade/Tower Manufacturing-Fabrication Maintenance In-Charge	66	20	86
19.	Wind Manufacturing Quality Manager	55	16	71
20.	Wind Nacelle/Blade/Tower Manufacturing-Fabrication Production Manager	41	12	53
21.	Wind Nacelle/Blade/Tower Manufacturing-Fabrication Fiber Technologist	56	17	73
22.	Wind Nacelle/Blade/Tower Manufacturing-Fabrication Resin Technologist	63	19	82
23.	Wind Nacelle/Blade/Tower Manufacturing-Fabrication Ceramic Technologist	48	14	62
24.	Wind Nacelle/Blade/Tower Manufacturing-Fabrication R&D Manager	27	8	35

Table 43: Wind Energy Sector role wise skill gap in manufacturing segment

[99] Source – MNRE - http://mnre.gov.in/schemes/grid-connected/solar-thermal-2/

The skill gap for the manufacturing sector till 2022 is not there as the current manufacturing capacity can cater to the capacity increase in the wind sector till 2022 as the per year capacity addition in the wind sector is maximum 8027 MW. Post 2022, to achieve 12305 MW capacity the per year capacity addition is 10663 and 12305 MW. This would require capacity addition in the manufacturing sector. Hence there is a requirement of additional skill till FY 2025.

However, the wind manufacturing sector is a rapidly growing segment with changes in technology happening frequently. Hence, to assess skill gap till 2025 we have included the current manpower also.

4.3.11. Wind Energy Sector – Top Job Roles

Job Roles	Skill Gap till 2025
Wind Project Helper - EPC, O&M and Manufacturing	35773
O&M Electrical and Instrumentation Technician - Wind Power Plant	11750
Construction Technician (Electrical)- Wind Power Plant	11214
Construction Technician (Civil) - Wind Power Plant	8410
O&M Mechanical Technician - Wind Power Plant	7833
CMS Engineer - EPC and O&M - Wind Power Plant	5783
Construction Technician (Mechanical) - Wind Power Plant	5607
Crane Operator	5607
Procurement Executive- Wind	4485
Site Surveyor- Wind Power Plant	3364
Assistant Planning Engineer - Wind Power Plant	3364
Construction Engineer (Electrical)- Wind Power Plant	3364
Construction Engineer (Civil) - Wind Power Plant	2803
Construction Engineer (Mechanical)- Wind Power Plant	2803
O&M Engineer (Mechanical) - Wind Power Plant	2611
O&M Engineer (Electrical) - Wind Power Plant	2611
Assistant Site Surveyor- Wind Power Plant	2243
Maintenance Technician- WTG Blade	1964
O&M Manager- Wind Power Plant	1682
WRA – Wind Resource Assessment Manager	1682
Wind Land Acquisition Officer	1121
Procurement Manager- Wind	1121
Planning Engineer (Civil/ Structural)- Wind Power Plant	1121
Planning Engineer (Electrical)- Wind Power Plant	1121
Site Manager/ Subcontractor/ Entrepreneur- Wind Power Plant	1121
HSE Engineer	1121
Production Operator- WTG Blade Manufacturing	758
Project Head - Wind Power Plant	561
Project Design Manager - Wind Power Plant	561
Project Manager- Wind Power Plant	561
System Planning Engineer - Wind Power Plant	561
HSE Manager	561
Wind Nacelle/Blade/Tower Manufacturing-Fabrication Painter	502
Wind Nacelle/Blade/Tower Manufacturing-Fabrication Packer	502
Maintenance Technician- WTG Nacelle	340

Wind Nacelle/Blade/Tower Manufacturing-Fabrication Technician- Electrical Maintenance	329
Maintenance Technician- WTG Tower Manufacturing/Fabrication	263
Wind Nacelle/Blade/Tower Manufacturing-Fabrication Technician- Mechanical Maintenance	252
Wind Nacelle/Blade/Tower Manufacturing-Fabrication Production Supervisor	248
Wind Nacelle/Blade/Tower Manufacturing-Fabrication Mechanical Engineer	246
Wind Nacelle/Blade/Tower Manufacturing-Fabrication Electrical Engineer	246
Wind Manufacturing Quality Assurance Engineer	222
Production Operator- WTG Nacelle Manufacturing	107
Production Operator- WTG Tower Manufacturing/Fabrication	107
Wind Nacelle/Blade/Tower Manufacturing-Fabrication Maintenance In-Charge	86
Wind Manufacturing Quality Manager	71
Wind Nacelle/Blade/Tower Manufacturing-Fabrication Production Manager	53
Wind Nacelle/Blade/Tower Manufacturing-Fabrication Fiber Technologist	73
Wind Nacelle/Blade/Tower Manufacturing-Fabrication Resin Technologist	82
Wind Nacelle/Blade/Tower Manufacturing-Fabrication Ceramic Technologist	62
Wind Nacelle/Blade/Tower Manufacturing-Fabrication R&D Manager	35

Table 44: Wind Energy Sector top job roles as per skill gap till FY 2025

4.3.12. Summary of capacity addition and skill gap in wind energy sector

The estimated capacity addition is shown in the table below. The estimated addition till 2022 have been taken in accordance with the MNRE guidelines. Post 2022, the value has been extrapolated till 2030 at the CAGR observed till 2022.

Sub - Sector	Current Capacity*	Cumulative Capacity till FY 2022	Cumulative Capacity till FY 2025	Cumulative Capacity till FY 2030
Wind Energy Installed Projects (MW)	26,932	60,000	92,208	~102022
Wind Energy Installed Manufacturing Capacity (MW)	9500	9500	12305	~12305

Table 45: Summary of capacity addition in Wind Energy sector

*- As on august 2016

S.No.	Sector	Current Manpower	Skill gap till FY 2022	Skill Gap till FY 2025	Skill Gap till FY 2030
1.	Engineering, Procurement and Commissioning	13,691	62,999	91,952	91,952
2.	Operation and Maintenance	16,159	19,841	39,166	60,448
3.	Manufacturing	8,215	-	2,426	2,4266
	Total	**39,317**	**82,840**	**1,33,544**	**1,76,666**

Table 46: Summary of skill gap in wind energy sector

Section - 4.4

Sub - Sector Analysis - Small Hydro Sector Analysis

4.4. Small Hydro Energy

4.4.1. Introduction

Small hydro energy is produced through the same concept as that of conventional hydro power. The running flow of water rotates a turbine which is connected to the rotor shaft of a generator. The kinetic energy stored in the river water is converted in electric energy through this process.

Small hydro power is categorized in India as those with less than 25MW size. Small hydropower projects (i.e. up to 25MW in India) are much more advantageous than conventional medium or large hydropower projects. Small hydropower plant requires very less flow or head compared to conventional hydropower plants. Reservoir is also not required for small hydropower projects as they are mostly run-of-river type

Environmental and social impacts of small hydropower projects are also negligible compared to conventional medium or large hydropower projects[100].

Small hydro projects are further categorized into:

1. **Run – of – river scheme:** There is no storage of water and the output is subject to instantaneous flow. Reliability of discharge and geological conditions should be ensured
2. **Canal fall based scheme:** Utilizes the fall and flow in the canals. May be planned in main canal or in bye-pass canal. Nearby drops should be clubbed in existing canals. In canals under planning concentrated drops should be considered.
3. **Dam toe scheme**: In dam based schemes, water is stored during monsoons in a dam and is utilized for power generation

[100] Source - small hydropower project: standard practices, International Journal of Engineering Science & Advanced Technology

4.4.2. Background

India has an estimated potential of 20GW from small hydro power[101]. In the year 2015, the government of India has up scaled its renewable energy targets to 175 GW from renewable energy. Of this, 5 GW is targeted through small hydro power. The draft national mission on small hydro envisaged an enabling policy framework along with the state governments for the deployment of 5000MW of small hydro projects by 2019[102].

4.4.3. Small Hydro Value Chain

The typical value chain of the Small hydro sector is depicted below:

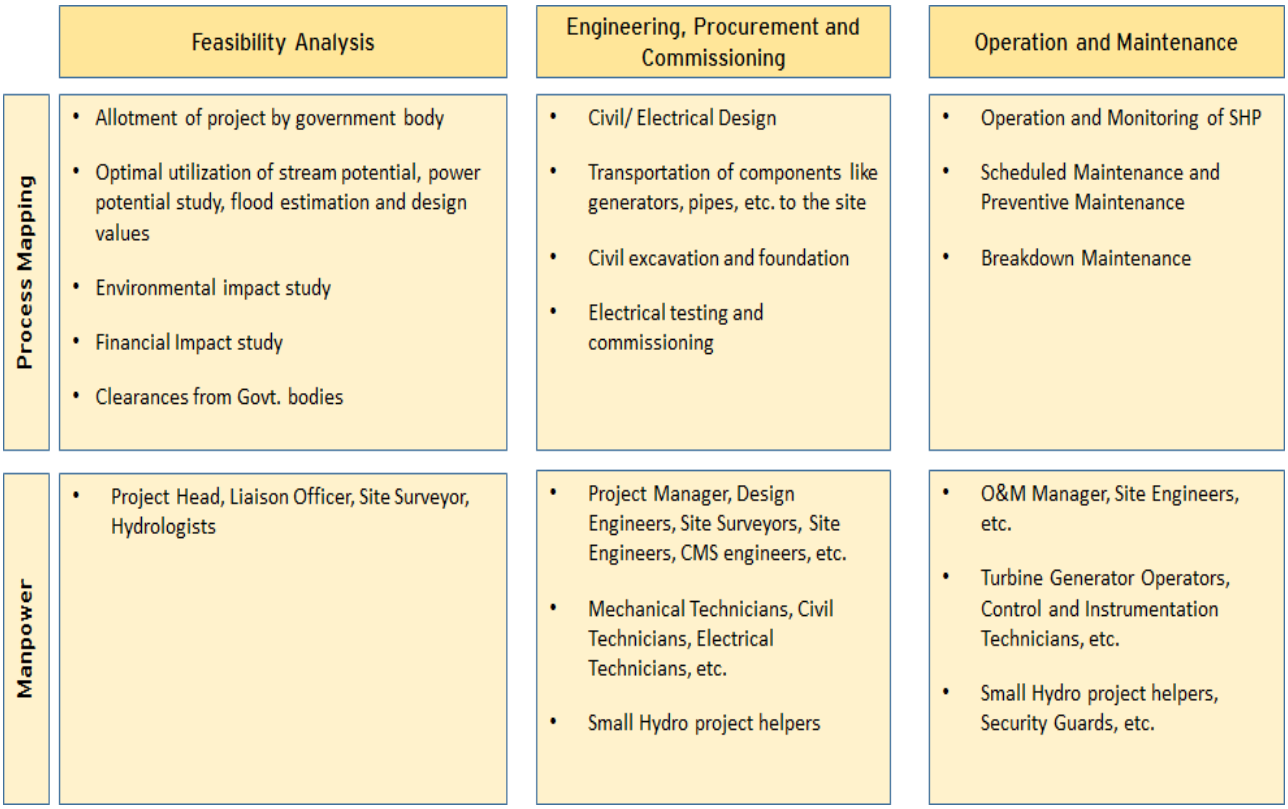


Figure 27: Small Hydro sector industry value chain

A small hydro plant has the following parts for which manpower is deployed:

1. **Water Intake/ Weir:** The source of water (canal/ reservoir) is connected here. Water is collected from here and transported to the turbine
2. **Forebay tank/ Reservoir:** The water from the intake is transported to forebay tanks through channels or headrace

[101] MNRE – Annual report 2015-16. http://mnre.gov.in/file-manager/annual-report/2015-2016/EN/Chapter%201/chapter_1.htm

[102] http://www.indiaenvironmentportal.org.in/files/file/Draft-national-mission-on-SHP.pdf

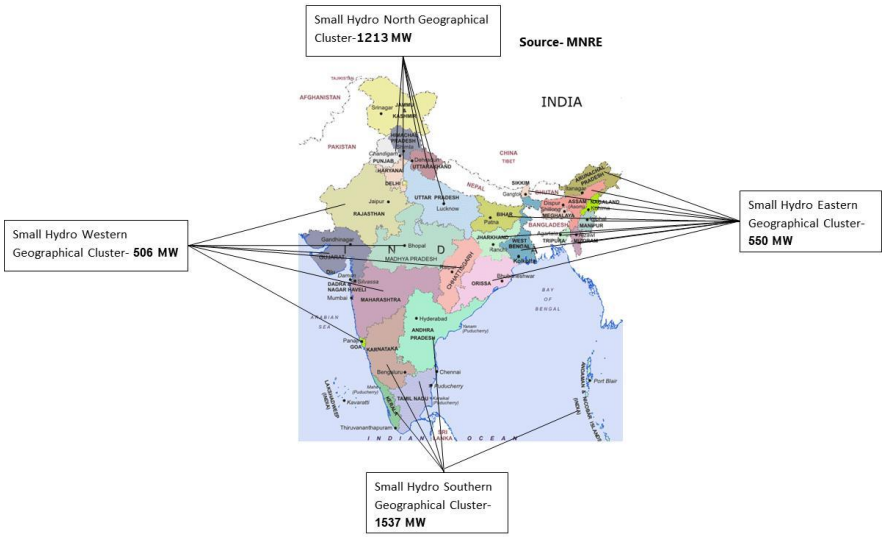
3. **Penstock:** Water from the forebay is transported to the powerhouse through penstock which is basically a pipe
4. **Powerhouse:** The powerhouse consists of a turbine and a generator for producing electricity
5. **Transmission :** The power generated from the power house is transported through transmission cables to the sub-station making it grid connected

4.4.4. Current industry status

4.4.4.1. Current installed capacity and geographical clustering

Although capacity has steadily increased, the contribution of hydropower to Indian power generation has been on a declining trend in recent decades, from close to 40% in 1980 to 12% in 2013. Currently the total installed capacity is close to 4 GW. So far, 1001 small hydropower projects aggregating to 3,832 MW have been set up in the country, of which 320 projects of 1662 MW are from private developers[103].

Geographical Clustering in installed small hydro projects (MW)



[103] Source – Draft national mission on small hydro, http://www.indiaenvironmentportal.org.in/files/file/Draft-national-mission-on-SHP.pdf

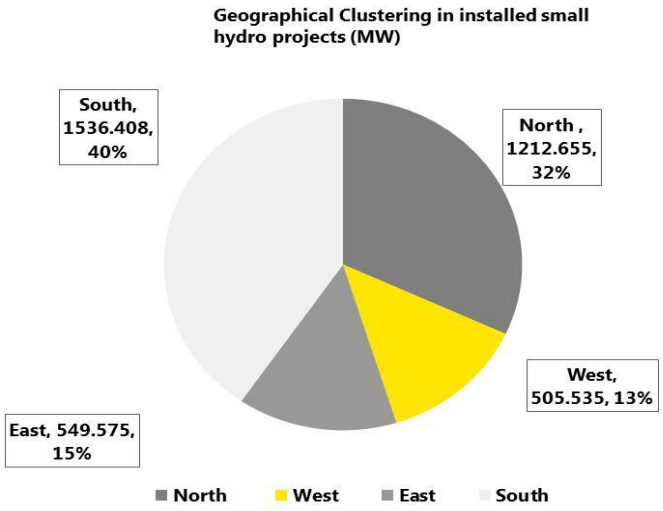


Figure 28: Geographical clustering of small hydro installed projects

4.4.4.2. Small hydro potential in India and MNRE targets

It is estimated that India has close to 20 GW potential of Small Hydro projects in various states. Of an estimated potential of 19749 MW, only 4000 MW has been installed making a percentage utilization of 18 %. The capacity of 19749 MW is made up by 6474 sites with the potential to have small hydro to be installed.

1048 small hydropower projects aggregating to 4161.905MW have been set up in various parts of the country. In addition, 204 projects of about 561.71MW are in various stages of implementation[104]

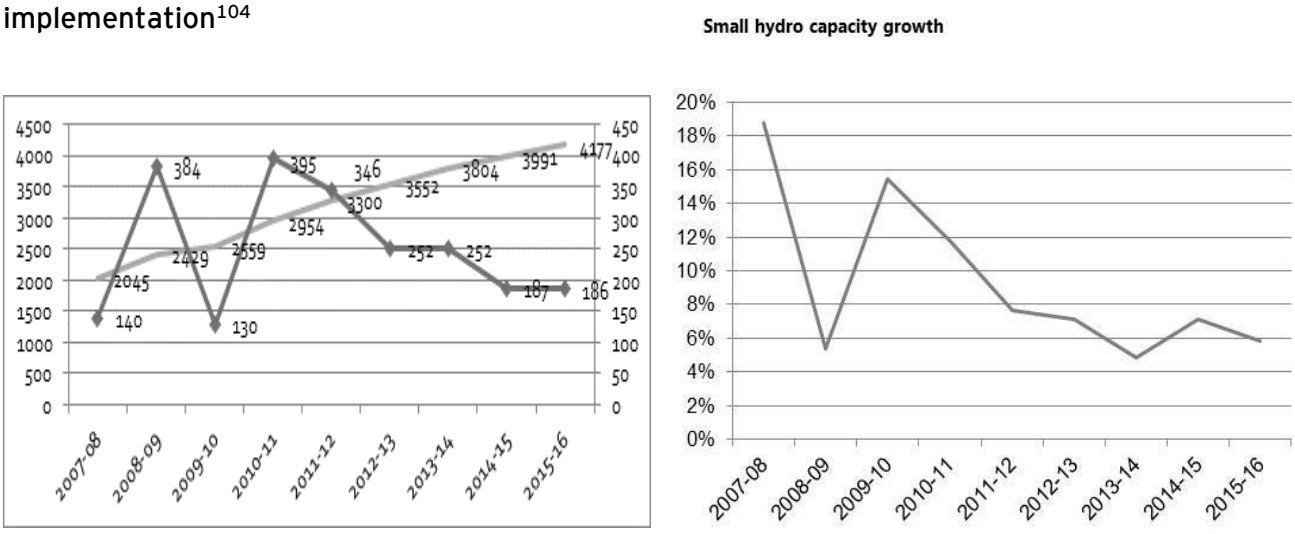


Figure 29: Historical growth trend of small hydro projects (MW and %)

[104] MNRE-Annual report 2015-16

Under the national level target of 175 GW from renewable energy sector, 5 GW has to be from small hydro power. In April 2014, the government of India formulated the Draft National mission on Small Hydro which set a target of 5000 MW of small hydro by 2019. However, this mission is yet to be formulated. We observe that the growth has a declining trend. In the year 2010-11, close to 395 MW of small hydro was added which has come down to around 250 MW per year. Further, the target for 2016-17 is also set at 250 MW. Basis this to estimate future growth till 2022 and 2025 we have assumed the per year capacity addition to be 250 MW.

The same growth i.e. 250 MW projects per year till 2030. No significant growth in this sector is envisioned in the coming years

Year	Per Year Capacity Addition	Cumulative Small Hydro Capacity	% Growth in Small Hydro Capacity
2007-08	140	2045	19%
2008-09	384	2429	5%
2009-10	130	2559	15%
2010-11	395	2954	12%
2011-12	346	3300	8%
2012-13	252	3552	7%
2013-14	252	3804	5%
2014-15	187	3991	5%
2015-16	186	4177	6%
2016-17	250	4426	6%
2017-18	250	4676	5%
2018-19	250	4926	5%
2019-20	250	5176	5%
2020-21	250	5426	5%
2021-22	250	5676	4%
2022-23	250	5926	4%
2023-24	250	6176	4%
2024-25	250	6426	4%
2025-2030	250	7676	-

Table 47: Assessment of capacity addition in the small hydro sector

As per the draft national mission on small hydro the current manufacturing capacity of small hydro equipment is 1500 MW per year. The advancements in the future will be of the way of technical up-gradation[105]. Hence, this report doesn't focus on small hydro manufacturing sector as the sector is mature.

[105] Draft National Mission of small hydro

4.4.4.3. Small hydro sector growth drivers

1. **Draft National Mission on Small Hydro**: The draft national mission on Small Hydro which was released in 2014 envisaged a small hydro capacity of 5 GW by 2019. The initial objective of the national mission is to identify the reasons for the slowdown in the small hydro sector and address these through appropriate policy interventions.
2. **Small Hydro Power Programme**: The ministry has launched the programme with the aim of installing about 7000 MW by the end of 2017. About 1,000 MW of this is proposed to be developed through projects on canal drops, dam outlets and water outfall structures. The focus of the SHP programme is to:-
   - help the state governments in renovating the existing projects in a bid to improve their efficiency and capacity as its estimated that renovation of old projects itself would result in about 30-35 per cent increase in electricity generation
   - lower the cost of equipment
   - increase its SHP reliability
   - set up projects in areas which give the maximum advantage in terms of capacity utilization

   Though hilly areas offer much better prospects for small hydro projects – about 50 per cent of the small hydro potential lies in the Himalayan states of Arunachal Pradesh, Uttarakhand, Jammu and Kashmir and Himachal Pradesh – significant potential has been identified in Maharashtra, Chhattisgarh and Karnataka as well.106
3. **Demand size driver**: Population growth coupled with need to reduce dependency on conventional energy sources will enhance global small hydropower market growth
4. **Rising environmental concerns** pertaining to GHG emission and favourable regulatory policies to promote small hydropower in remote areas as a sustainable energy generation are promising trend to positively influence industry demand[107]
5. **Renewable Energy Certification (REC) -** RECs are aimed at addressing the mismatch of renewable energy resources in the States and their RPO requirements. Obliged entities can fulfil their RPOs by purchasing REC's. RECs are traded on the Indian Energy Exchange (IEX) and the Power Exchange of India Ltd (PXIL). In line with RPOs there are two categories of RECs – **Solar & Non-Solar.**

[106] http://indianexpress.com/article/india/india-others/govt-turns-to-small-hydro-projects-to-meet-power-needs/

[107] https://www.gminsights.com/pressrelease/small-hydropower-market

Solar RECs include both PV and CSP technologies. Non-solar RECs include renewable energy technologies such as biomass, wind, biofuel, cogeneration & small hydro. Solar RECs are traded once a month – last Wednesday of every month.

In order to provide a minimum of certainty on REC prices, Central Electricity Regulatory Commission (CERC) has fixed a floor and forbearance price for the period up to 2017 between which the REC can be traded.[108] There are three categories of solar projects that are eligible for RECs:

- **Projects for captive consumption (Self use)** – Eligible for REC only if concessions are not availed in transmission and wheeling charges, banking charges and electricity duty
- **PPA with distribution licensee** – PPA with local distribution company at average power purchase cost (APPC) as determined by SERC. ***Note: PPA at preferential tariff are not eligible under this scheme***
- **Sale to open access consumers** – Sale at mutually agreed market determined price with all the transmission & wheeling and other charges payable to the Transco / DISCOM duly paid

6. **Government Incentives**: A budget of Rs 386.5 crore for offering incentives for development of the sector has already been approved for the remaining two years of the 12th Plan, which is going to be the first phase of the mission. For phase II, financial allocations are proposed to be made in the 13th Plan[109]

7. **Preferential Tariffs**: Preferential tariffs by State Electricity Regulation Commission will add to the growth as water is a state subject as per Indian constitution

8. **Draft Renewable Energy Act, 2015-** The draft renewable energy act seeks to create an institutional structure and a support structure to encourage renewable energy in India. Some key highlights are National Renewable Energy Policy, National Renewable Energy Fund, State Green Fund, etc.

[108] http://www.shansolar.com/rpo/

[109] http://indianexpress.com/article/india/india-others/govt-turns-to-small-hydro-projects-to-meet-power-needs/

4.4.5. Small Hydro Occupational Map (Industry Delivery Structure)

The small hydro manufacturing is not focused in this report as the current capacity and manufacturers are sufficient to drive growth in the future.

4.4.5.1. Engineering, Procurement and Commissioning

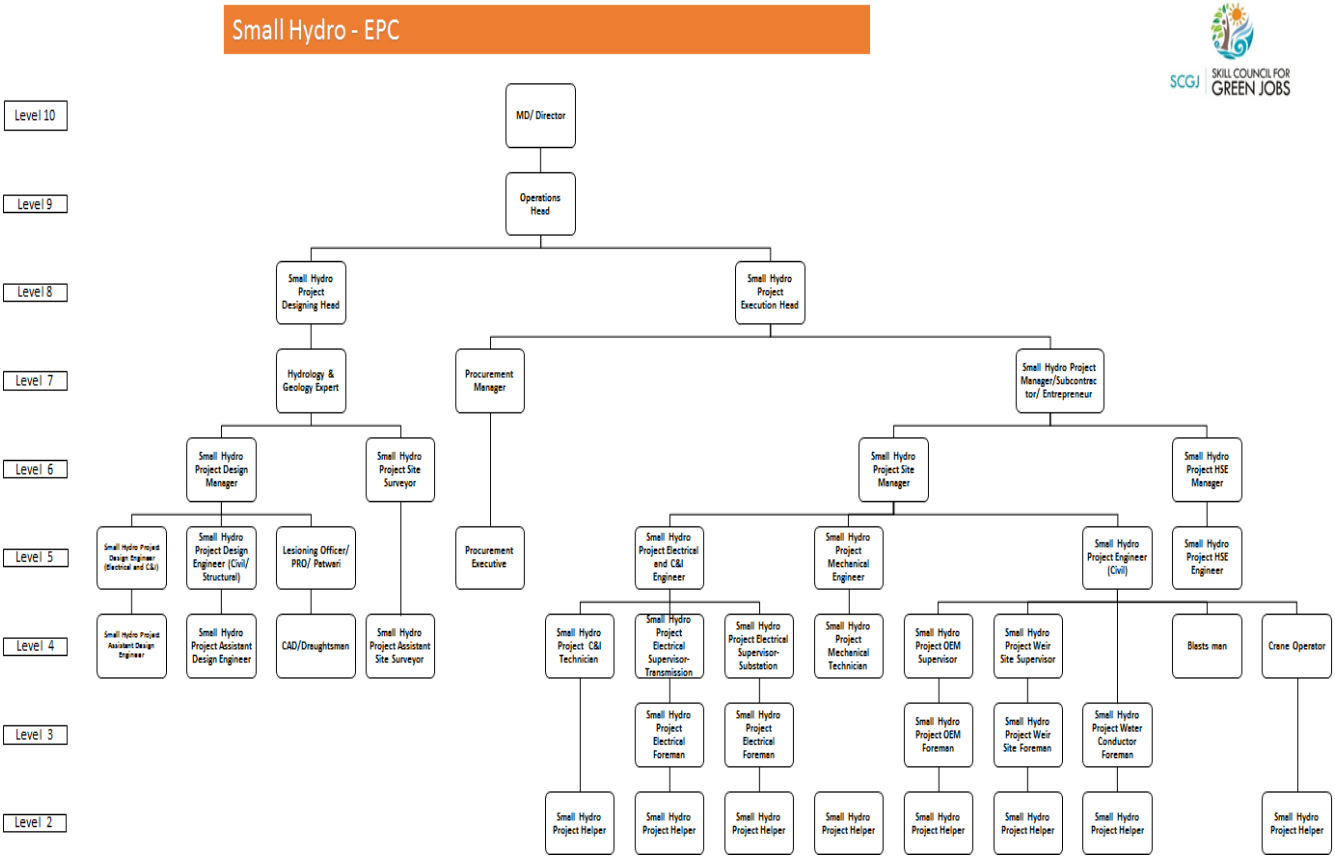


Figure 30: Small Hydro Sector – Engineering, Procurement and Commissioning Occupational Map

4.4.5.2. Operation and Maintenance

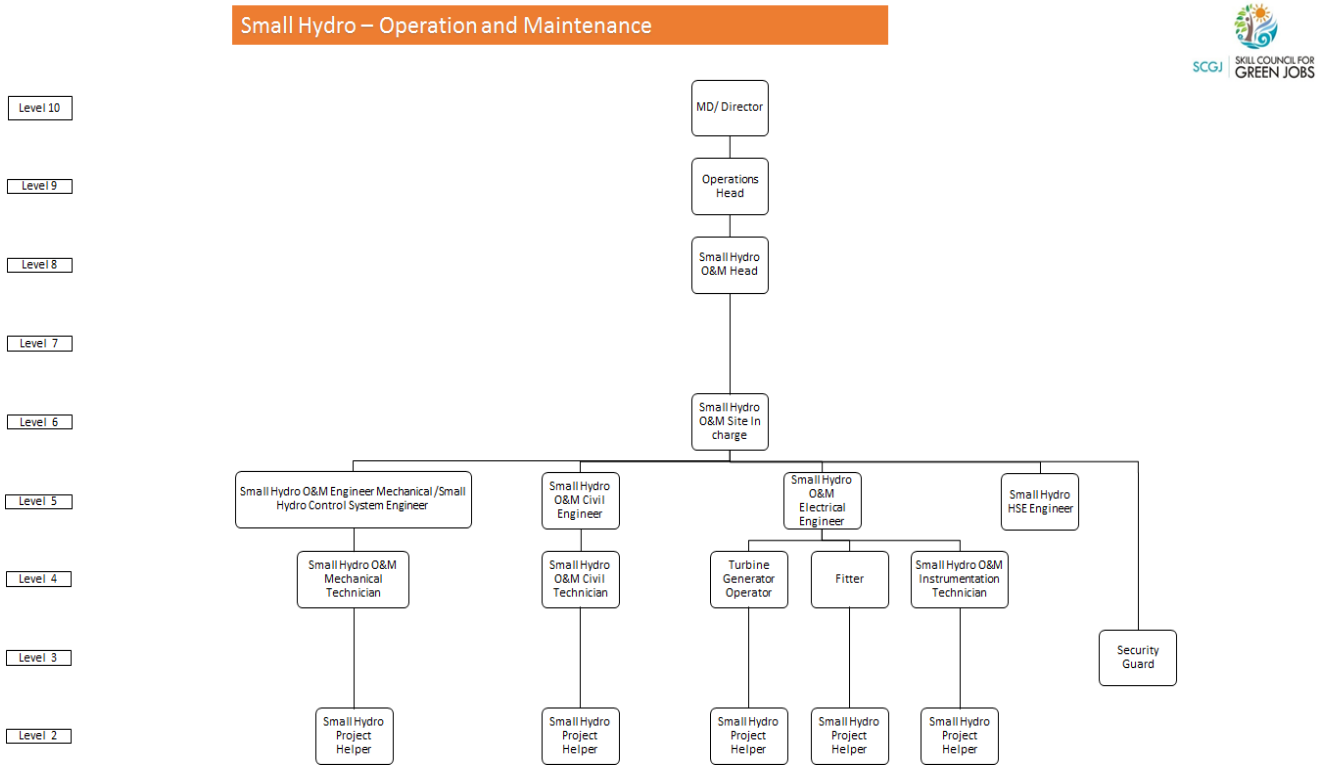


Figure 31: Small Hydro Sector – Operation and Maintenance Occupational Map

4.4.6. Small Hydro sector assumptions

- The capacity increase envisaged in the Small Hydro mission is close to 2500 MW till 2025 as per estimates. 5000MW of capacity is to be achieved by FY 2019 which translates into a capacity addition of 250 MW per year. The same is extrapolated till 2025. To install this capacity we have estimated that the current manpower can cater to the capacity increase. As operation and maintenance is a year-long activity, the manpower required for this phase will increase with increase in the capacity
- The current average project size is 0-10 MW. The capacity added in the last two years is close to 440 MW. As per the growth trends, the year on year capacity addition is 250 MW

4.4.7. Small Hydro sector manpower norms

4.4.7.1. Small Hydro – Engineering, Procurement and Commissioning

Basis our interactions with multiple industry stakeholders, we have observed the following norm for small hydro power projects of 0-10 MW size:

Designation	Typical manpower requirement for 0-10 MW
Small Hydro Project Helper	80
Small Hydro Project Site Surveyor	6
Small Hydro Project Assistant Site Surveyor	3
Small Hydro Procurement Executive	3
Small Hydro Project Electrical Foreman- Transmission	3
Small Hydro Project Weir Site Foreman	3
Small Hydro Project Water Conductor Foreman	3
Small Hydro Project Electrical Supervisor- Transmission	2
Small Hydro Project Electrical Supervisor- Substation	2
Small Hydro Project Electrical Foreman	2
Small Hydro Project Mechanical Technician	2
Small Hydro Project OEM Foreman	2
Small Hydro Crane Operator	2
Small Hydro Project Designing Head	1
Hydrology & Geology Expert	1
Small Hydro Project Design Engineer (Electrical and C&I)	1
Small Hydro Project Design Engineer (Civil/ Structural)	1
Small Hydro Liaison Officer/ PRO/ Patwari	1
CAD/Draughtsman	1
Small Hydro Procurement Manager	1
Small Hydro Project Manager/Subcontractor	1
Small Hydro Project Electrical and C&I Engineer	1
Small Hydro Project C&I Technician	1
Small Hydro Project Mechanical Engineer	1
Small Hydro Project Engineer (Civil)	1
Small Hydro Project OEM Supervisor	1
Small Hydro Project Weir Site Supervisor	1
Small Hydro Blasts man	1
Small Hydro Project HSE Manager	1
Small Hydro Project HSE Engineer	1

Table 48: Norms observed in the small hydro sector

4.4.7.2. Small Hydro – Operation and Maintenance

Basis our interactions with multiple industry stakeholders, we have observed the following norm for small hydro power projects of 0-10 MW size:

Designation	Manpower norm 0-10 MW
Small Hydro Project Helper	10
Small Hydro O&M Mechanical Technician	9
Turbine Generator Operator	7
Fitter	7
Small Hydro O&M Instrumentation Technician	4
Security Guard	4
Small Hydro O&M Engineer Mechanical /Small Hydro Control System Engineer	4
Small Hydro O&M Civil Technician	3
Small Hydro O&M Electrical Engineer	2
Small Hydro O&M Site In charge	1
Small Hydro O&M Civil Engineer	1

Table 49: Norms observed in the small hydro sector

4.4.8. Small Hydro Skill Gap Analysis

The small hydro sector is still a small sector. However, it has a potential of 80% which can be utilized. [110]

One of the main challenges of the small hydro sector is the deployment of manpower. A small hydro project requires full time deployment of the team for a span of close to 1-2 years. Also, unlike solar or wind sector, the small hydro sector does not have a separate design and construction team. The same team is usually deployed for both phases.

Employment in the manufacturing of small hydro turbines, alternators, etc., is not considered because the conventional industry can cover the capacity increase.

Basis our interaction with the stakeholders we observed the following:

- The Engineering, Procurement and Commissioning phase of a small hydro project takes place for a period of two years which includes planning, clearances, designing, erection and commissioning
- The operation phase takes place throughout the year and is manpower intensive

The capacity increase envisaged in the Small Hydro mission is close to 2500 MW till 2025 as per estimates. 5000MW of capacity is to be achieved by FY 2019 which translates into a capacity addition of 250 MW per year. The same is extrapolated till 2025. To install this capacity we have estimated that the current manpower can cater to the capacity increase.

Similar growth has been assumed till 2030 to estimate the skill gap.

[110] (Source- MNRE)

The current average project size is 0-10 MW. The capacity added in the last two years is close to 440 MW. As per the growth trends, the year on year capacity addition is 250 MW. Hence the current manpower present in the industry can cater to an increase in the future. However, there is a need for skilling and training the current manpower also.

As operation and maintenance is a year-long activity, the manpower required for this phase will increase with increase in the capacity.

S. No.	Designation	Current Manpower	Total skilled manpower required till FY 2025
1.	Small Hydro Project Helper	8064	8064
2.	Small Hydro Project Site Surveyor	605	605
3.	Small Hydro Project Assistant Site Surveyor	302	302
4.	Small Hydro Procurement Executive	302	302
5.	Small Hydro Project Electrical Foreman- Transmission	302	302
6.	Small Hydro Project Weir Site Foreman	302	302
7.	Small Hydro Project Water Conductor Foreman	202	202
8.	Small Hydro Project Electrical Supervisor- Transmission	202	202
9.	Small Hydro Project Electrical Supervisor- Substation	202	202
10.	Small Hydro Project Electrical Foreman	202	202
11.	Small Hydro Project Mechanical Technician	202	202
12.	Small Hydro Project OEM Foreman	202	202
13.	Small Hydro Crane Operator	202	202
14.	Small Hydro Project Designing Head	101	101
15.	Hydrology & Geology Expert	101	101
16.	Small Hydro Project Design Engineer (Electrical and C&I)	101	101
17.	Small Hydro Project Design Engineer (Civil/ Structural)	101	101
18.	Small Hydro Liaison Officer/ PRO/ Patwari	101	101
19.	CAD/Draughtsman	101	101
20.	Small Hydro Procurement Manager	101	101
21.	Small Hydro Project Manager/Subcontractor	101	101
22.	Small Hydro Project Electrical and C&I Engineer	101	101
23.	Small Hydro Project C&I Technician	101	101
24.	Small Hydro Project Mechanical Engineer	101	101
25.	Small Hydro Project Engineer (Civil)	101	101
26.	Small Hydro Project OEM Supervisor	101	101
27.	Small Hydro Project Weir Site Supervisor	101	101
28.	Small Hydro Blasts man	101	101
29.	Small Hydro Project HSE Manager	101	101
30.	Small Hydro Project HSE Engineer	101	101

Table 50: Small hydro sector role wise skill gap - EPC

Note: No gap in skill requirement is estimated till 2025. However, as indicated above the skill till FY 2025 is taken with the assumption that the current manpower also needs to be trained in order to sustain growth.

No additional manpower requirement is envisaged till 2030, hence there is no addition skill gap till 2030

There is a demand for skilled manpower in the operation and maintenance phase as the manpower is deployed throughout the year. The manpower required in the Operation and Maintenance phase is:

S. No.	Designation	Current manpower	Skill gap till FY 2022	Skill gap till FY 2025
1.	Small Hydro Project Helper	8354	2500	5000
2.	Small Hydro O&M Mechanical Technician	7519	3150	4500
3.	Turbine Generator Operator	5848	2450	3500
4.	Fitter	5848	2450	3500
5.	Small Hydro O&M Instrumentation Technician	3342	1400	2000
6.	Security Guard	3342	1400	2000
7.	Small Hydro O&M Engineer Mechanical /Small Hydro Control System Engineer	3342	1400	2000
8.	Small Hydro O&M Civil Technician	2506	1050	1500
9.	Small Hydro O&M Electrical Engineer	1671	700	1000
10.	Small Hydro O&M Site In charge	835	350	500
11.	Small Hydro O&M Civil Engineer	835	350	500

Table 51: Small hydro sector role wise skill gap – Operation and Maintenance

4.4.9. Top Roles Small Hydro

As indicated above, there is a need for training and skilling the current manpower in the industry especially in the EPC segment for this sector to achieve the targeted growth

Job Role	Current Manpower	Skill Gap till FY 2025
Small Hydro Project Helper- EPC and O&M	16418	5000
Small Hydro O&M Mechanical Technician	7519	4500
Turbine Generator Operator	5848	3500
Fitter	5848	3500
Small Hydro O&M Instrumentation Technician	3342	2000
Security Guard	3342	2000
Small Hydro O&M Engineer Mechanical /Small Hydro Control System Engineer	3342	2000
Small Hydro O&M Civil Technician	2506	1500
Small Hydro O&M Electrical Engineer	1671	1000
Small Hydro O&M Civil Engineer	835	500
Small Hydro Project Site Surveyor	605	-
Small Hydro Project Assistant Site Surveyor	302	-
Small Hydro Procurement Executive	302	-
Small Hydro Project Electrical Foreman- Transmission	302	-
Small Hydro Project Weir Site Foreman	302	-
Small Hydro Project Water Conductor Foreman	302	-
Small Hydro O&M Site In charge	264	-
Small Hydro Project Electrical Supervisor- Transmission	202	-
Small Hydro Project Electrical Supervisor- Substation	202	-
Small Hydro Project Electrical Foreman	202	-
Small Hydro Project Mechanical Technician	202	-
Small Hydro Project OEM Foreman	202	-
Small Hydro Crane Operator	202	-
Hydrology & Geology Expert	101	-
Small Hydro Liaison Officer/ PRO/ Patwari	101	-
Small Hydro Project Designing Head	101	-
Small Hydro Project Design Engineer (Electrical and C&I)	101	-
Small Hydro Project Design Engineer (Civil/ Structural)	101	-
CAD/Draughtsman	101	-
Small Hydro Procurement Manager	101	-
Small Hydro Project Manager/Subcontractor	101	-
Small Hydro Project Electrical and C&I Engineer	101	-
Small Hydro Project C&I Technician	101	-
Small Hydro Project Mechanical Engineer	101	-
Small Hydro Project Engineer (Civil)	101	-
Small Hydro Project OEM Supervisor	101	-
Small Hydro Project Weir Site Supervisor	101	-
Small Hydro Blasts man	101	-
Small Hydro Project HSE Manager	101	-
Small Hydro Project HSE Engineer	101	-

Table 52: Top job roles in small hydro sector

4.4.10. Summary of capacity addition and skill gap in small hydro sector

The estimated capacity addition is shown in the table below. The estimated addition till 2022 have been taken in accordance with the MNRE guidelines. Post 2022, the value has been extrapolated till 2030 at the CAGR observed till 2022.

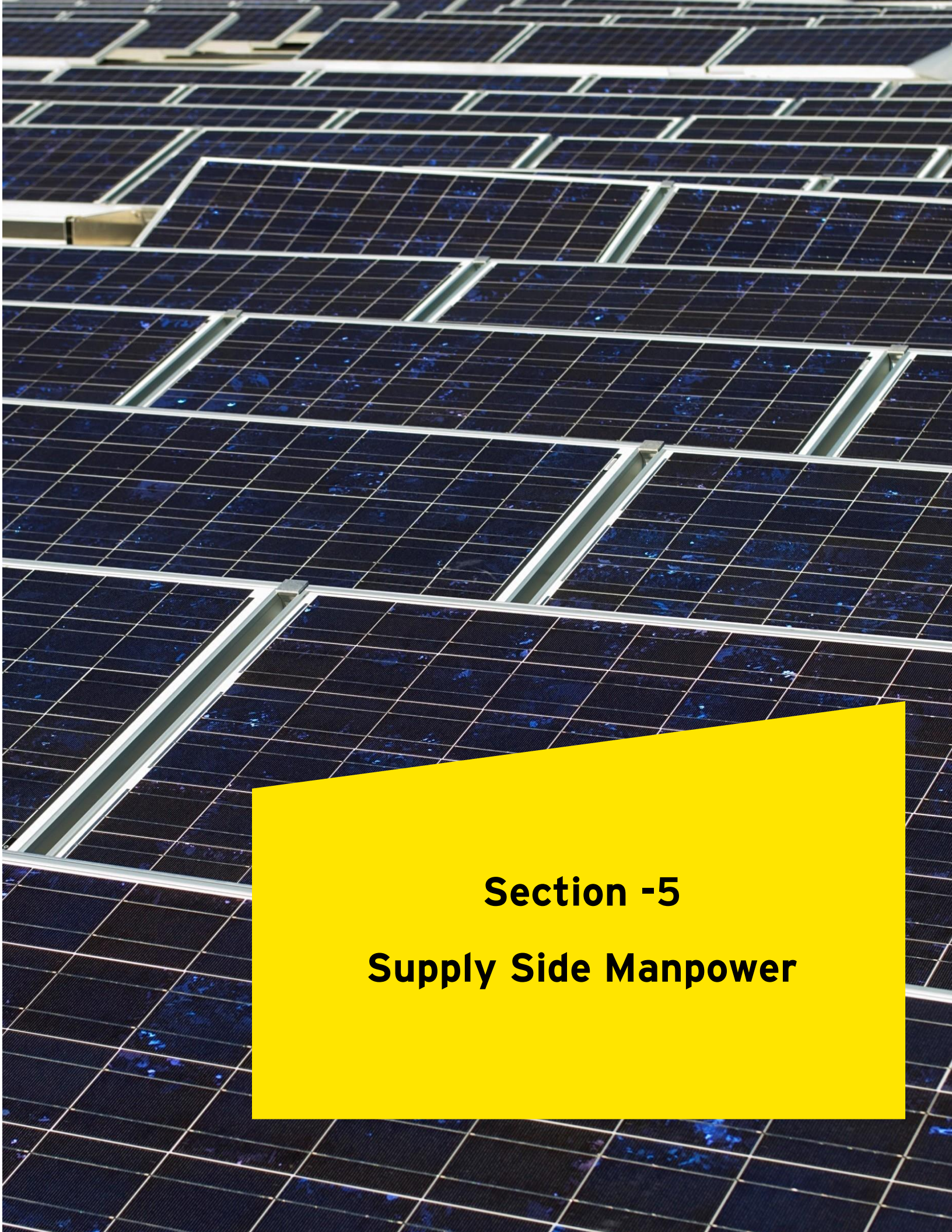
Sub - Sector	Current Capacity*	Cumulative Capacity till FY 2022	Cumulative Capacity till FY 2025	Cumulative Capacity till FY 2030
Small hydro installed project (MW)	4,274	5,774	6,524	~7,774

Table 53: Summary of capacity addition in Small Hydro sector

*- As on August 2016

S.No.	Sector	Current Manpower	Skill gap till FY 2022	Skill Gap till FY 2025	Skilled manpower required till FY 2025	Skill Gap till FY 2030
1.	Engineering, Procurement and Commissioning	13,104	-	-	13,104	-
2.	Operation and Maintenance	45,947	18,200	26,000	71, 947	36,400
	Total	**59,051**	**18,200**	**26,000**	**85,051**	**36,400**

Table 54: Summary of skill gap in Small Hydro sector



Section -5

Supply Side Manpower

5. Supply side Manpower

The existing sources of skilled manpower in the sector are majorly ITI, Polytechnics and engineering colleges. Through the below sections, spread of ITI's, Polytechnics and Engineering colleges are described.

5.1. ITI

As per the present scenario, there are 12,341 ITI spread across the country. The total number of seats in all 126 trades in ITI's is ~25.19 lacs. However, the number of seats in ITI's in relevant trades related to power sector are ~20.5 Lacs.[111]

The trades studied at various ITI's are relevant to multiple sectors across the industry. Out of the relevant trades studied at ITI's, trades with related to renewable energy sector

- Welder
- Electrician
- Fitter
- Draughtsman (Civil)
- Electrician

are major contributors to the renewable energy sector . Taking into consideration that there is~ 70% seats utilization and contribution to power sector about 20%, the employable workforce for power sector would be ~1.6 Lacs per year. Out of these close to 13% would be available for renewable energy sector as per the installed capacity.[112] Basis this the employable workforce in the renewable energy sector would be 21,000 per year.

The other relevant trades serve more in other sectors of the industry and the contribution to power sector is ~5% to 7%. The employable workforce for power sector would be ~43,000 per year. Using the contribution of 13% to the renewable energy sector the employable workforce available for the renewable energy sector would be ~6000 per year.

[111] (Source- As per*https://ncvtmis.gov.in (as on may'16))*

[112] http://www.cea.nic.in/reports/monthly/installedcapacity/2016/installed_capacity-08.pdf

The spread over various regions is described below:

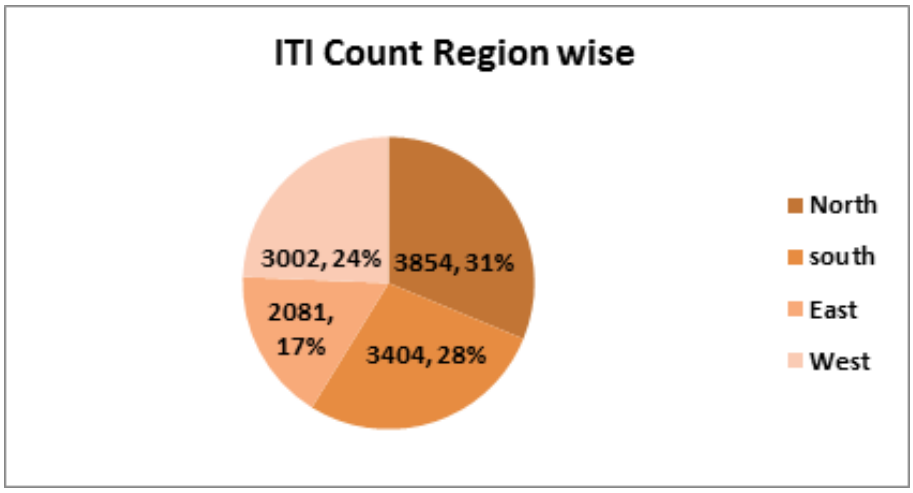


Figure 32: ITI count region wise

In the following graphs, we have covered region wise current Seats in varied Trades in ITIs.

Over the North region, seat counts across various trades are depicted below:

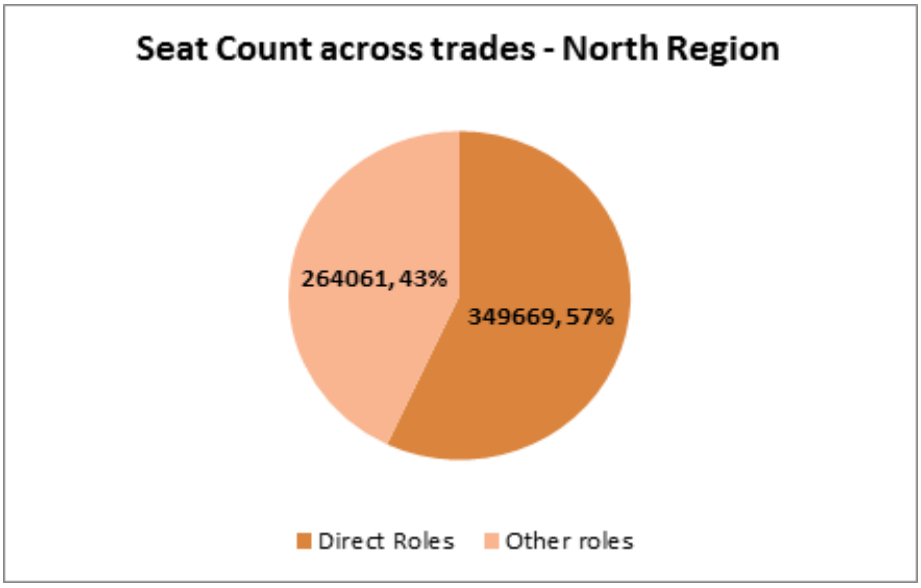


Figure 33: ITI seat count across trades – North region

Similarly, seat count over South region is given below:

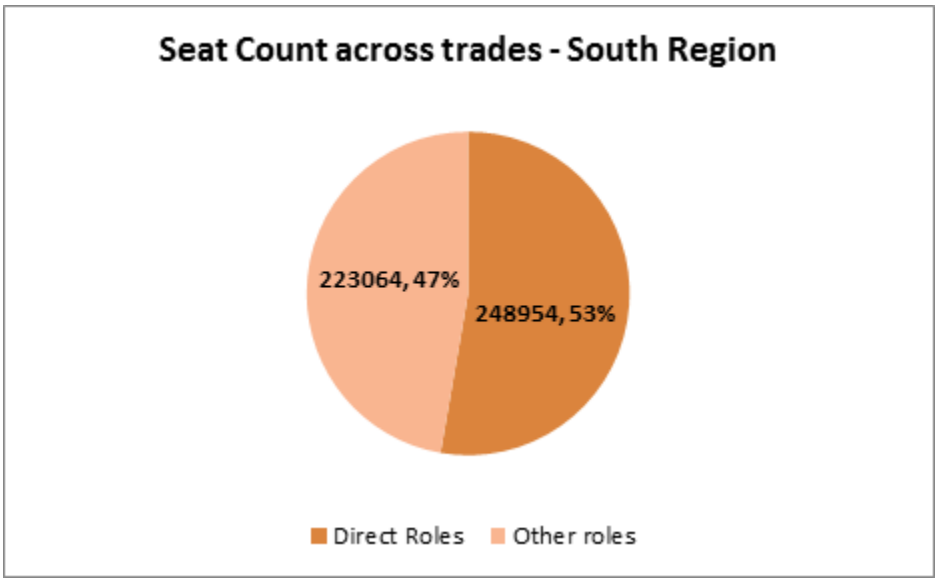


Figure 34: ITI seat count across trades – South region

Further, spread across the East, West region is given below:

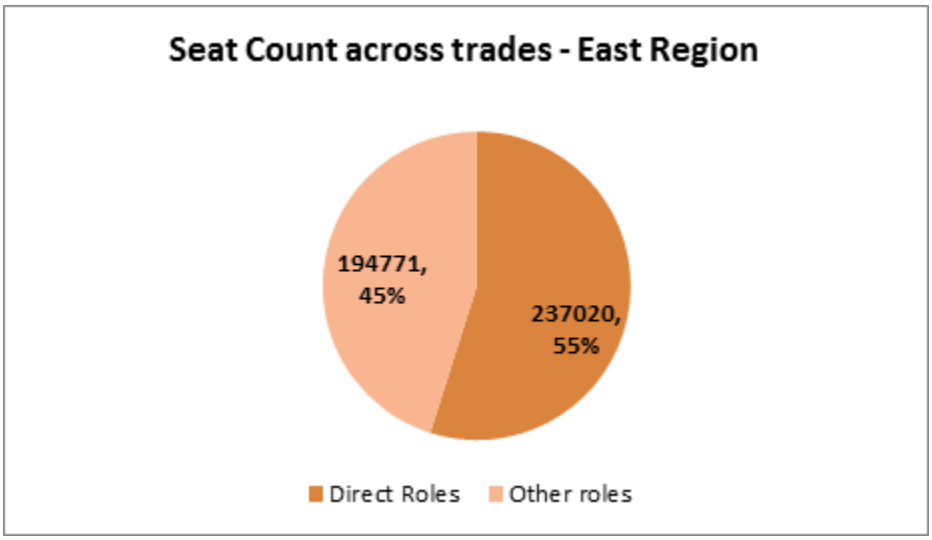


Figure 35: ITI seat count across trades – East region

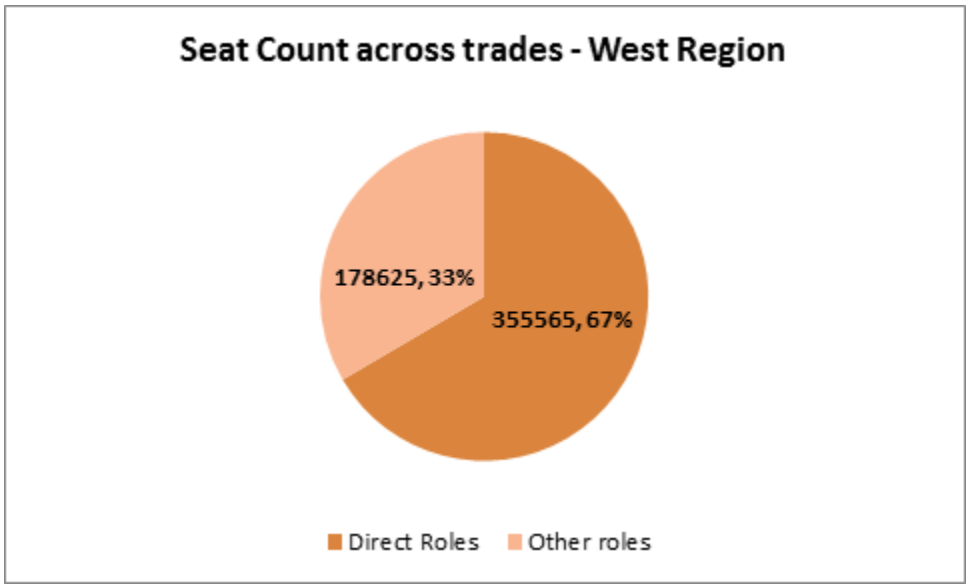


Figure 36: ITI seat count across trades – West region

5.2. Polytechnics.

As per the present scenario, there are 843 Polytechnics spread across the country. The number of seats in Polytechnics is ~2.65 Lacs.[113] Assuming a 13% contribution to the renewable energy sector, the employable workforce in the renewable energy sector would be ~35,000.

Taking into consideration the availability of seats in Polytechnics colleges and industry interactions, it is considered that the demand for additional workforce in the renewable energy sector for workmen with diploma degree job roles should be met with the current polytechnics spread across the country.

5.3. Engineering Colleges

As per the present scenario, 1346[114] engineering colleges are spread across the country approved by All India Council of Technical Education. The number of seats in colleges is ~ 4, 40,000. Assuming a 13% contribution to the renewable energy sector, the employable workforce in the renewable energy sector would be ~58000.

This includes the students who pass out from NPTI with specialization in B.Tech /BE degree in power engineering.

[113] (Source - Assessment of Manpower available for induction in power sector (www.cea.nic.in)- reference report :interim report on human capital challenges in the power sector by IEMR research)

[114] (Source - Assessment of Manpower available for induction in power sector (www.cea.nic.in)- reference report :interim report on human capital challenges in the power sector by IEMR research)

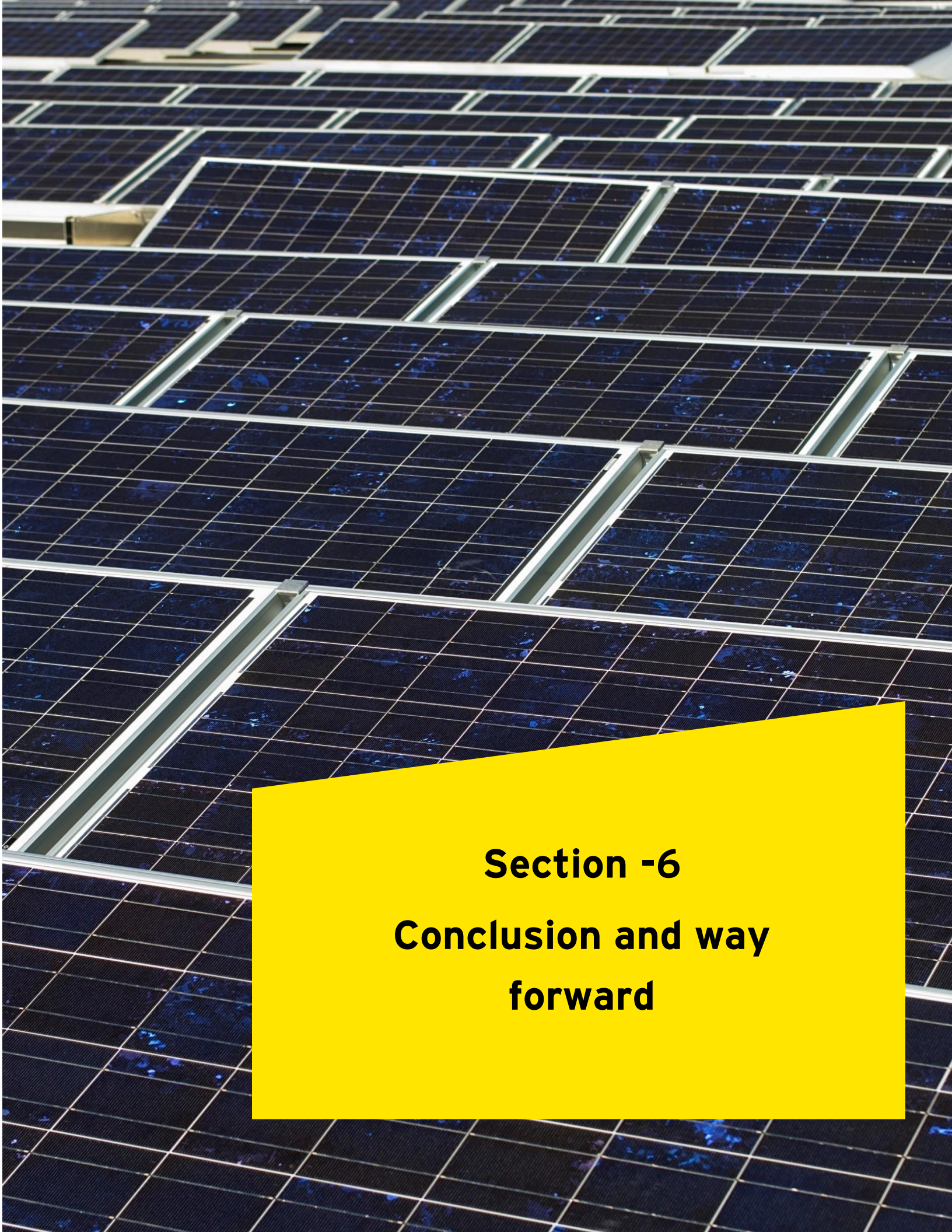
Taking into consideration the availability of seats in engineering colleges, it is considered that demand for additional workforce in the power sector with engineering qualification job roles shall be met with the current engineering colleges present in the country

5.4. Conclusion Supply side manpower

Taking into consideration the supply of workforce for renewable energy sector, it is hereby evident from industry interactions and the availability of seats, that there is sufficient capacity present in polytechnics and engineering colleges to meet the additional demand of workforce in those roles.

With renewable energy sector being a technically intensive workforce based, it is needed that there are trainings undertaken to align with the industry requirements of workforce for other job roles.

Along with the skill gap assessment and development of QP/NOS , the major consideration to be addressed are proper trainings conducted by training partners which are industry specific along with relevant industry certifications.



Section -6

Conclusion and way forward

6. Conclusion and way forward

Based on the skill gap survey following job roles are observed to have significant requirement in the industry. The sector wise skill gap summary and way forward is reproduced in subsequent section.

Additionally, this report focuses on the requirement of additional manpower in the Indian renewable energy sector (in the four sub-sectors covered) in the next 10 years and till 2025. The skill proficiency gap of the existing manpower, within the various entities in the renewable energy sector, is addressed by specific organizations through their respective Training, learning & development functions.

The renewable energy sector is growing and with the recent initiatives in the 12th and 13th plan, the skill requirement will increase exponentially.

6.1. Summary

The skill requirement in the renewable energy sector till 2025 is summarized below:

1. **Solar PV sector- Ground Mount and rooftop**

S.No.	Sector	Current Manpower	Skill Gap till FY 2022	Skill Gap till FY 2025	Skill Gap till FY 2030
1.	Engineering, Procurement and Commissioning	37,097	4,00,257	4,00,257	6,40,320
2.	Operation and Maintenance	24,572	2,34,951	2,81,693	4,24,055
3.	Off-Grid	10,409	36,628	1,00,087	3,99,854
	Total	**72,258**	**6,71, 594**	**7,81, 795**	**14,67, 682**

Table 55: Skill gap summary of solar PV sector

2. **Solar thermal sector**

Sub - Sector	Current Manpower	Skill gap till FY 2022	Skill gap till FY 2025	Skill gap till FY 2030
Solar thermal applications	13508	16,167	29,369	65,490

Table 56: Skill gap summary of solar thermal sector

3. Wind Sector

S.No.	Sector	Current Manpower	Skill gap till FY 2022	Skill Gap till FY 2025	Skill Gap till FY 2030
1.	Engineering, Procurement and Commissioning	13,691	62,999	91,952	91,952
2.	Operation and Maintenance	16,159	19,841	39,166	60,448
3.	Manufacturing	8,215	-	2,426	2,4266
	Total	**39,317**	**82,840**	**1,33,544**	**1,76,666**

Table 57: Skill gap summary of wind energy sector

*- No significant manpower addition required in the wind manufacturing sector, however WTG manufacturing remains a critical component of the Wind Value Chain. Further, there are constant innovations happening in the wind manufacturing. Further, blades are exposed to wear and tear. Hence blade manufacturing is a critical focus. Hence, even the current manpower is included in the calculation of the skilled manpower requirement

4. Small hydro Sector

S.No.	Sector	Current Manpower	Skill gap till FY 2022	Skill Gap till FY 2025	Skilled manpower required till FY 2025*	Skill Gap till FY 2030
1.	Engineering, Procurement and Commissioning	13,104	-	-	13,104	-
2.	Operation and Maintenance	45,947	18,200	26,000	71, 947	36,400
	Total	**59,051**	**18,200**	**26,000**	**85,051**	**36,400**

Table 58: Skill gap summary of small hydro sector

*- The current manpower also needs to be trained and skilled in order to sustain the growth.

6.2. QPs to be developed in the Solar PV sector

Job role	Total Skill Gap till FY 2025	Rationale
Solar Project Helper - EPC, Off-Grid	227770	Significant manpower requirement
Solar PV Maintenance Technician (Electrical)	98663	
Solar PV Installer (Civil)	78013	
Solar PV Engineer (Site/ QA/ HSE/ Pump)	60097	
Solar PV Installer (Electrical)	57469	
Solar PV Installer (Suryamitra)	50000	
Solar PV O&M Engineer	27440	
Solar PV Maintenance Technician (Civil/Mechanical)	27207	
Solar Site In-charge	8624	
Rooftop Solar Photovoltaic Entrepreneur	7516	
Solar PV Project Manager - E&C/ Project Execution Subcontractor	7204	
Rooftop Solar Grid Engineer	6429	
Solar PV Designer	5875	
Solar PV Structural Design Engineer	5875	
Solar PV Business Development Executive	5859	
Solar Off-Grid Entrepreneur	5763	
Solar Proposal Evaluation Specialist	4652	
Solar PV Site Surveyor	1720	Role is critical in solar PV value chain and requires unique skill

Table 59: QPs to be developed in the Solar PV sector

6.3. QPs to be developed for Solar Thermal

Designation	Total Skill Gap till FY 2025	Rationale
Solar Thermal Domestic Water Heating Technician	3266	Role is critical in solar thermal value chain and requires unique skill
Solar Thermal Plant Installation/ Maintenance Technician	1720	Role is critical in solar thermal value chain and requires unique skill
Solar Thermal Engineer - Industrial Process Heat	464	Role is critical in solar thermal value chain and requires unique skill

Table 60: QPs to be developed in the Solar Thermal sector

6.4. QPs to developed for Wind Sector

Job Roles	Total Skill Gap till 2025	Rationale
O&M Electrical and Instrumentation Technician - Wind Power Plant	11750	Significant manpower requirement
Construction Technician (Electrical)- Wind Power Plant	11214	
Construction Technician (Civil) - Wind Power Plant	8410	
O&M Mechanical Technician - Wind Power Plant	7833	
CMS Engineer - EPC and O&M - Wind Power Plant	5783	
Construction Technician (Mechanical) - Wind Power Plant	5607	
Site Surveyor- Wind Power Plant*	3364	Role is critical in solar thermal value chain and requires unique skill
Assistant Planning Engineer - Wind Power Plant*	3364	
Maintenance Technician- WTG Blade**	1964	
Production Operator- WTG Blade Manufacturing**	758	

Table 61: QPs to be developed in the Wind Energy sector

*- These roles are very unique to the wind sector and hence have been proposed for development of QP

**- WTG manufacturing remains a critical component of the Wind Value Chain. Further, there are constant innovations happening in the wind manufacturing. Further, blades are exposed to wear and tear. Hence blade manufacturing is a critical focus and would require trained

manpower to support the increase in the Wind Capacity. Hence, the two roles have been chosen for development of QP.

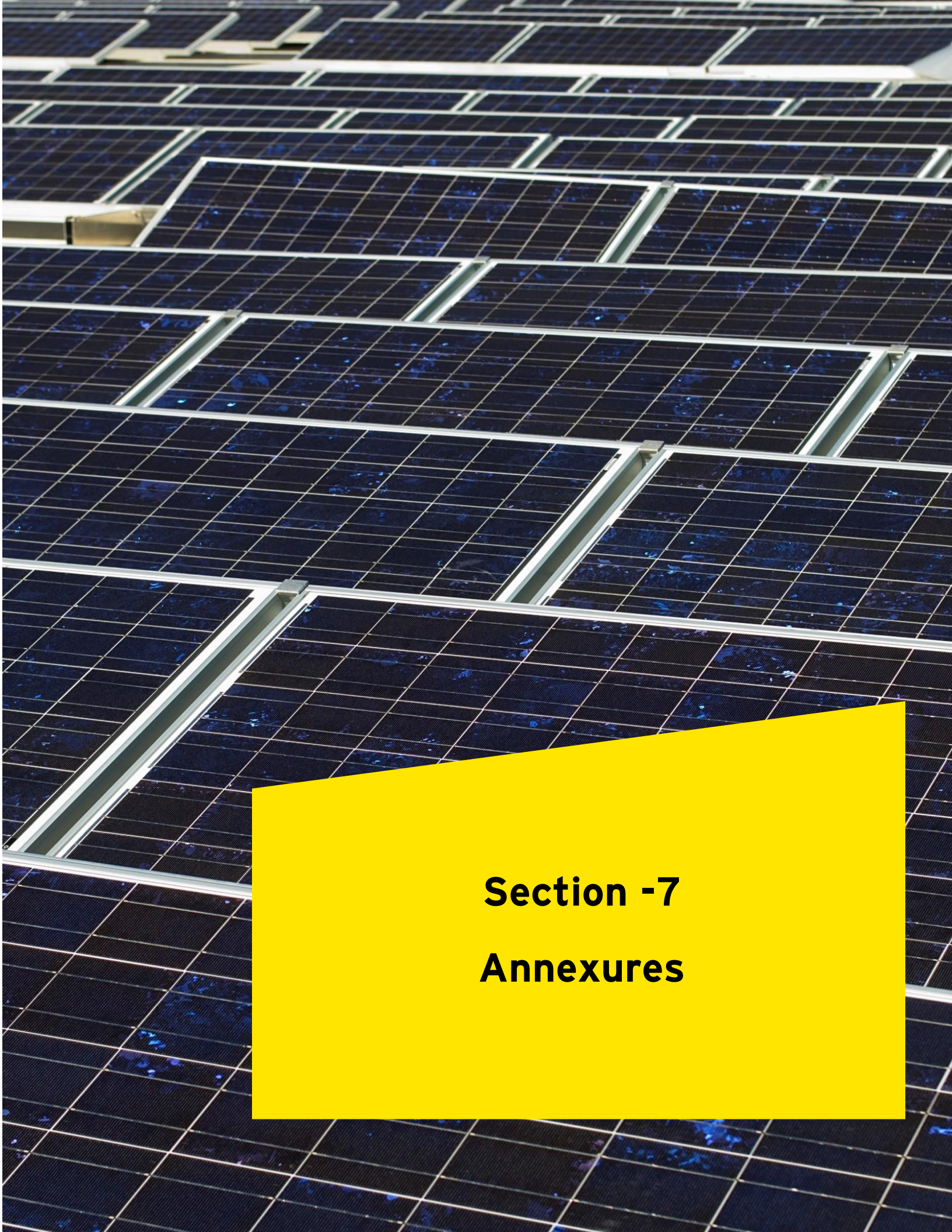
6.5. QPs to be developed for Small Hydro Sector

Job Role	Total Skill Gap till FY 2025	Remarks
Small Hydro O&M Mechanical Technician	12019	Significant manpower requirement
Turbine Generator Operator*	9348	
Small Hydro O&M Engineer Mechanical /Small Hydro Control System Engineer *	5342	
Small Hydro Project Site Surveyor **	605	Role is critical in solar thermal value chain and requires unique skill

Table 62: QPs to be developed in the Small Hydro sector

*- The small hydro sector is not expected to grow in the coming years. However, Operation and Maintenance is a continuous activity which requires dedicated manpower deployed at site. Further, the skill set required is very specific hence these roles have been chosen for development of QP.

**- The skill set required is very specific hence these roles have been chosen for development of QP.



Section -7

Annexures

7. Annexures

7.1. List of assumptions used in the report

7.1.1. Solar PV – Ground Mount

- To carry out the skill gap assessment, the respondents in the solar ground mount were categorised according to the sizes into three categories:
  4. 1-5 MW category
  5. 5 MW- 50 MW category
  6. Greater than 50 MW category
- The manpower requirement for different project sizes varies largely. For lower size projects, there is a minimum number of manpower required per project. However, as the size of the project increases, due to economies of scale, the manpower requirement per MW reduces
- The distribution of the project sizes is assumed as follows basis the secondary and primary data collected. The same distribution has been assumed for each year till 2022

Project Size	Assumed distribution
>50 MW	**5%**
5 MW- 50 MW	**60%**
1-5 MW	**35%**

Table 63: Assumed distribution of solar PV ground mount projects

- **The total number of days has been taken as 240 in a year**
- For estimating the number of people required in the sector, a deployment of 80% in projects in a year has been assumed for the manpower in all phases except Operation and Maintenance
- The manpower already present in the sector is taken into consideration while estimating the skill gap for EPC phase. Hence, only the skill gap arising due to increase in per – year capacity addition has been taken
- For Operation and maintenance, the skill gap has been calculated as per MW requirement
- Ground Mount and Rooftop Entrepreneur- 20 GW scheme of new entrepreneurs. Considered an 80:20 ratio, where 80% of the 20 GW will be through rooftop schemes and 20% through ground mount schemes

- To estimate capacity addition till 2030, the target of 250 GW for the solar PV sector has been assumed. Further, a distribution of 50: 50 from ground mount and rooftop has been assumed

- **Solar PV Ground Mount Entrepreneur:** 80% of the 20 GW will be to cater to rooftop schemes and 20% of the 20GW scheme will be through Ground Mount solar PV power plant of size 1 MW. It is observed that solar PV ground mount entrepreneurs who is at NSQF level will owners of companies undertaking end to end EPC of a ground mount solar PV power plant

- Current maximum installation of solar PV ground mount projects done in an year: 3700 MW

- Distribution of projects within the range of 1-5 MW

- Number of projects undertaken by a Solar PV Ground Mount Entrepreneur ~ 10

Project Size	Assumed distribution	Project Sizes
1 MW	**20%**	**259 MW**
>1 MW	**80%**	**1036 MW**

- Maximum per year capacity addition in Ground Mount Sector = 10,000 MW
- Number of project sizes of 1-5 MW = 0.35*10,000= 3500 MW per year
- Number of projects of 1 MW added per year till 2022 and 2025 = 700
- Solar Proposal evaluation specialist has been estimated basis discussions with bankers, developers and developer associations:

Project Size	Number of people required	Number of days deployed	Average number of projects in an year
1-5 MW	1	5	40
5- 50 MW	1	15	10
>50 MW	1	15	10

Table 64: Norm for Solar Proposal Evaluation Specialist

- Solar PV Engineer (Grid Interconnection) data was taken from companies separately

Project Size	Team composition	Deployment	Number of projects
1- 5MW	2 Solar PV Engineers (Grid Interconnection) 2 Helpers	10 days	20
5- 50 MW	3 Solar PV Engineers (Grid Interconnection) 2 Helpers	15 days	12
More than 50 MW	3 Solar PV Engineers (Grid Interconnection) 2 Helpers	15 days	12

Table 65: Norm for Solar PV Engineer (Grid Interconnection)

Note: The helpers shown in the above table have not been taken separately to calculated the skill gap numbers of solar project helpers

- Current maximum installation of solar PV ground mount projects done in an year: 3700 MW
- Current Manpower numbers assuming a maximum of 3700 MW added in a single year is

Project Size	Project distribution (MW)	Average Project Size assumed	Number of projects (Approx.	Current Manpower
1- 5MW	1295	2 MW	~ 647	64
5- 50 MW	2220	20 MW	~ 111	30
More than 50 MW	185	50 MW	~ 4	3
Total				**~ 97**

Table 66: Project distributions for calculation of solar PV Engineer (Grid Interconnection)

7.1.2. Solar Photovoltaic Rooftop

- To carry out the skill gap assessment, the respondents in the solar rooftop were categorised according to the sizes into two categories:
  3. Less than 50 KW – Residential and Small Commercial Category
  4. 50-500 KW – Large Commercial and Industrial Category
- The following distribution has been assumed basis secondary and primary data collected

Project Size	Distribution of rooftop projects for current year[115]	Assumed distribution of rooftop projects for future

[115] Bridge to India - Solar Rooftop Map 2016

< 50 KW	**30 %**	**50%** (Increase in small installations due to government focus)
50 – 500 KW	**70 %**	**50%**

Table 67: Assumed distribution of solar PV rooftop projects

- **The total number of days has been taken as 240 in a year**
- For estimating the number of people required in the sector, a deployment of 80% in projects in a year has been assumed for the manpower in all phases
- The manpower already present in the sector is taken into consideration while estimating the skill gap for EPC and O&M phase. Hence, only the skill gap arising due to increase in per – year capacity addition has been taken
- To estimate capacity addition till 2030, the target of 250 GW for the solar PV sector has been assumed. Further, a distribution of 50: 50 from ground mount and rooftop has been assumed
- Rooftop Solar Grid Engineer data was taken from companies and discoms:

Team composition	Deployment	Number of projects (assuming 80% deployment)
1 Rooftop Solar Grid Engineer 1 helper	5 days	40

Table 68: Norms observed in the solar Rooftop Solar Grid Engineer

Note: solar project helpers in the above table have not been taken separately to calculated the skill gap numbers

7.1.3. Solar Off- grid

7.1.3.1. Solar PV Pumps

According to the government sanctioned targets[116] we have estimated the capacity addition in the solar pumps segment till 2025 as follows.

Basis MNRE target, a CAGR of 46% till 2021 has been derived. The CAGR has been extrapolated to estimate capacity addition till 2030

(Numbers in lakhs)

	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025

[116] MNRE Notification - No. 42/25/2014-15/PVSE- Supplementary programme for implementation of "Solar Pumping Programme for irrigation and drinking water under off-grid and decentralised solar applications scheme"

Current Sanctioned Numbers	1.47	2.16	3.17	4.66	6.86	10	14.70	21.60	31.76	46.69
Capacity addition required @ 46% CAGR	0.47	0.69	1.01	1.49	2.19	3.13	4.60	6.77	9.96	14.64

Table 69: Assessment of capacity addition in solar pump sectors

7.1.4. Solar off grid home-lighting/ street lighting/ lanterns

- For the manpower estimation in the solar off grid sector, the following numbers have used:
  3. The total number of channel partners for the off-grid segment = 549 [117]
  4. Targeted total number of units to be sold by 2022 is 20 million.[118] [119]
- Basis the MNRE target to sell 20 million units by 2022, we calculated the following:

	Target	Current
Cumulative installed capacity (units)	20 million	2.3 million
CAGR required (%)	**43%**	
Increase in capacity (growth) of current channel partners (%)	**30%**	

Table 70: assessment of capacity addition in the solar off- grid sector

- It is assumed that 70% of this growth will be through increase in the numbers of channel partners, while 30% of this growth will be through increase in individual level sales.

7.1.5. Solar thermal

- Solar thermal capacity is measured as total solar collector area. The solar collector targets as set under JNNSM are shown below. As envisaged under phase 1, the total achievement was 7.001 Sq. million

Application segment	Target Phase 1 (2010-13)	Cumulative target phase 2 (2013- 17)	Cumulative Target phase 3 (2017 – 22)
Solar collectors	~7 Sq. Million	15 Sq. Million	20 Sq. Million

Table 71: Assessment of capacity addition in the solar thermal sector

[117] MNRE- Final List of channel partners for Off Grid and Decentralised Solar Applications Programme accessed on 29/08/2016

[118] MNRE- Policy document JNNSM phase 2

[119] Business Case for off-grid energy in India- The Climate Group, GoldmanSachs

- The current growth in installed capacity stands at 7% year on year. Basis this growth trend, we estimate that the phase two target of 15 million sq. m. will not be achieved with this growth rate. Basis our calculation we estimate that to achieve the solar thermal target of 20 million sq. m. by 2022, the industry growth rate needs to increase to 11%.
- It is assumed that 11% CAGR will continue till 2025 and has been extrapolated till 2030
- For concentrated solar thermal, we have taken a growth rate of 24% annually basis historical trends and sector targets
- For the end to end installation of a solar water heating system of 100 -150 sq. m. would require the deployment of the following roles for duration of 7 days:
    a. 1 Overall MD/CEO of the organisation
    b. 1 Project head (Solar Thermal) looking after multiple projects
    c. 5 Solar thermal domestic water heating technician
    d. 5 Solar thermal helpers/ semi –skilled technicians
- Total number of projects which can be undertaken = 80% of (251/ 7) ~ 30 projects in a year
- For manufacturing and installation of solar thermal water heating the current installed capacity is catering to close to 1.07 million sq. m. per year. By 2022, to achieve the target of 20 million sq. m. of solar water heaters, the -per year capacity addition needs to increase to 2.16 million sq. m. per year. By 2025, this needs to increase to 3.02 million sq. m. per year
- According to JNNSM phase -2, a target of 50,000 solar cookers has been set till 2022. Basis the MNRE annual report 2015-16, we observe that currently 6, 80, 669 of box type solar cookers and 15,000 of dish type of solar cookers were sold by 2015-16120. A total of 29 channel partners have been associated with MNRE. It is assumed that the current manpower can cater to the future capacity increase by targets.
- For Industrial water heating applications the manpower deployment for a 100-200 sq. m. project is:
    a. 15 solar thermal plant installation/ maintenance technicians
    b. 10 Solar thermal helpers
    c. 4 Fitters
    d. 4 Cutters
    e. 4 Solar thermal process heat engineers
    f. 3 Solar thermal maintenance technician- Manufacturing
    g. 3 Solar thermal electricians

[120] MNRE- Annual Report – 2015-16

h. 3 Solar thermal gas welders
i. 1 Project head (Solar Thermal)
j. 1 Project installation in-charge
k. 1 Solar thermal Fabricator
l. 1 Carpenter

- The time taken for a concentrated solar thermal- for industrial water heating is as follows:
  - 1 Week – Engineering and Assessment
  - 3 Weeks – Manufacturing and Transportation
  - 2 Weeks - Erection and Commissioning + 1 week for testing
- Total projects which can be undertaken in a year = 4 at 80% deployment
- In CST projects, the same manpower deployed for the erection and commissioning of the system will take care of the operation and maintenance also. Hence, with increase in capacity, more manpower needs to be trained. For calculation we have assumed the current capacity as the capacity added in the previous year i.e. 5266 sq. m. of CST[121]

7.1.6. Wind Energy Sector

- There is a plan to achieve a target of 60 GW by 2022. There is a planned addition of 4000 MW of wind energy by end of FY 2016-17. [122]. The CAGR basis the target of 60,000 GW till 2022 is calculated to be 15.54 %. The same is used to estimate the growth from 2017-2025. Current Annual wind turbine manufacturing capacity is 9500 MW.[123] Post 2025, a CAGR of 10% is assumed till 2026-27
- Wind power potential in India is taken as 102 GW and basis our calculation, the sector would reach its potential by 2026-27
- As per government estimates, an estimated 350 GW of power generation through renewable energy sources by 2030. This is also estimated in the context of Intended Nationally Determined Contributions (INDCs) for climate negotiations in Paris. [124][125] It is also expected that out of the targeted 350 GW, 100 GW would come out of from wind power
- Post 2025, we estimate that the sector growth will reduce and no new manufacturing would be required to meet the domestic demand. However, export may continue as the globally the demand for wind turbine components increases

[121] MNNRE- Annual report – 2015-16
[122] http://mnre.gov.in/mission-and-vision-2/achievements/
[123] Source – MNRE - http://mnre.gov.in/schemes/grid-connected/solar-thermal-2/
[124] http://www.business-standard.com/article/economy-policy/india-s-energy-mix-to-have-40-renewable sources-by-2030-115092200057_1.html
[125] http://www.bridgetoindia.com/is-india-aiming-for-250-gw-of-solar-by-2030-2/

Year	Wind power installed projects capacity (MW)	Per year capacity addition in installed capacity (MW)	Wind component manufacturing/ assembly capacity (MW)
Current – 2016	26932	-	9500
2016-17	29306	4000	
2017-18	33819	4523	
2018-19	39027	5208	
2019-20	45037	6010	
2020-21	51973	6935	
2021-22	60000	8026	
2022-23	69240	9240	
2023-24	79903	10663	10663
2024-25	92208	12305	12305
2025-26	101659	9451	
2026-30*	~102000	-	

Table 72: Assessment of capacity addition in wind energy sector

7.1.7. Small hydro sector

- The capacity increase envisaged in the Small Hydro mission is close to 2500 MW till 2025 as per estimates. 5000MW of capacity is to be achieved by FY 2019 which translates into a capacity addition of 250 MW per year. The same is extrapolated till 2025. To install this capacity we have estimated that the current manpower can cater to the capacity increase. As operation and maintenance is a year-long activity, the manpower required for this phase will increase with increase in the capacity
- The current average project size is 0-10 MW. The capacity added in the last two years is close to 440 MW. As per the growth trends, the year on year capacity addition is 250 MW

7.2. Manpower norms observed across sub- sectors

7.2.1. Solar PV

7.2.1.1. Solar PV - Ground Mount

Basis our interactions with multiple industry stakeholders, we have observed the following norm for Solar PV ground mount projects:

Project Size	>50 MW	5- 50 MW	1-5 MW
Engineering and Design			
Average time required	90 days	70 days	20 days
MD/ Director	1	1	1
Operations Head	1	1	-
Project Head	1	1	1
Solar Proposal Evaluation Specialist*	1	1	1
Liaison Officer	1	1	-
Solar PV Business Development Manager	2	2	1
Market Research Analyst	1	1	1
Solar PV Business Development Executive	4	4	3
Solar PV Designer/ Solar PV Design Consultant	2	1	1
Solar PV Site Surveyor	2	2	1
Assistant Site Surveyor	1	1	-
Energy Modeller	1	1	-
Solar PV Plant Structural Design Engineer	2	1	1
Solar PV Plant Assistant Structural Design Engineer	3	1	0
CAD/ Draughtsman (Mechanical)	1	1	1
Solar PV Electrical Design Engineer	2	1	1
Solar PV Assistant Electrical Design Engineer	3	1	0
Procurement Manager	1	1	1
Procurement Executive	3	3	2
Erection and Commissioning			
Average time required	300	120	90
Solar PV Project Manager- E&C	1	1	1
Solar PV Ground Mount Entrepreneur	-	-	1
Project execution sub-contractor	2	2	1
Site In-charge (Solar PV)/ Solar Site Supervisor	4	3	2
Solar PV Engineer (Grid Interconnection)**	3	3	2
Solar PV Engineer (Site)	6	6	4
Solar PV Engineer (HSE)	1	1	0
Solar PV Engineer (Quality assurance)	2	2	-
Solar PV Installer (Civil)	10	10	4
Solar PV Installer (Electrical)	10	10	5
Solar Project Helper	70	40	20
Operation and Maintenance			
Solar PV O&M Manager	2	1	0
Solar PV O&M Engineer	6	3	1
Solar PV Maintenance Technician (Electrical)	15	6	4
Solar PV Maintenance Technician (Civil/Mechanical)	3	3	1
Solar Project Helper	10	6	4
HSE Engineer	-	-	-

Table 73: Norms in Solar PV Ground Mount sub-sector

*- Solar Proposal evaluation specialist was estimated basis discussions with bankers, developers and developer associations:

A Solar proposal evaluation specialist is a person from the BD team, with a financial background who gets inputs from the design team.

Basis our discussions we developed the following norm:

Project Size	Number of people required	Number of days deployed	Average number of projects in an year
1-5 MW	1	5	40
5- 50 MW	1	15	10
>50 MW	1	15	10

Table 74: Norms for Solar Proposal Evaluation Specialist

**- Solar PV Engineer (Grid Interconnection) data was taken from companies and discoms:

Project Size	Team composition	Deployment	Number of projects
1- 5MW	2 Solar PV Engineers (Grid Interconnection) 2 Helpers	10 days	20
5- 50 MW	3 Solar PV Engineers (Grid Interconnection) 2 Helpers	15 days	12
More than 50 MW	3 Solar PV Engineers (Grid Interconnection) 2 Helpers	15 days	12

Table 75: Norm for Solar Proposal Evaluation Specialist

Note: The helpers shown in the above table have not been taken separately to calculated the skill gap numbers of solar project helpers

7.2.1.2. Solar PV Rooftop

Basis our interactions with multiple industry stakeholders, we have observed the following norm for Solar PV rooftop projects:

Project Size	< 50 KW	50-500 KW
Engineering and Design		
Average time required	**2 days**	**7 days**
MD/Director	1	1
Operations Head	-	-
Project Head	1	1
Solar Proposal Evaluation Specialist	1	1
Liaison Officer	-	-
Solar PV Business Development Manager	1	1
Market Research analyst	-	-
Solar PV Business Development Executive	1	2
Solar PV Designer/ Solar PV Design Consultant	1	1
Solar PV Site Surveyor	-	-
Assistant Site Surveyor	-	-
Solar Project Helper	-	-
Energy Modeller	-	-
Solar PV Structural Design Engineer	1	1
Solar PV Rooftop Assistant Structural Design Engineer	-	-
CAD / Draughtsman (Mech.)	-	1
Solar PV Electrical Design Engineer	1	1
Solar PV Assistant Electrical Design Engineer	-	1
CAD / Draughtsman (Electrical)	-	-
Procurement Manager	0	2
Procurement Executive	1	2
Erection and commissioning		
Average time required	**10 days**	**30 days**
Solar PV Project Manager - E&C/ Project Execution Subcontractor	1	1
Rooftop Solar Photovoltaic Entrepreneur	1	1
Solar Site Supervisor		1
Rooftop Solar Grid Engineer*	1	1
Solar PV Engineer (Site)	2	2
Solar PV Engineer (HSE)	-	-
Solar PV Engineer (Quality Assurance)	-	-
Solar PV Installer (Civil)	3	3
Solar PV Installer (Electrical)	2	3
Solar PV Installer (Suryamitra)	-	-
Solar Project Helper	3	3
Operation and Maintenance		
Solar PV O&M Manager (Rooftop) / Solar PV O&M Entrepreneur	-	0
Solar PV O&M Engineer	-	1
Solar PV HSE Engineer	-	-
Solar PV Maintenance Technician (Electrical)	1	2
Solar PV Maintenance Technician (Civil/ Mechanical)	0	1
Solar PV Maintenance Technician (Suryamitra)	-	-
Solar Project Helper – O& M	2	2

Table 76: Norms observed in the solar PV rooftop projects

*- Rooftop Solar Grid Engineer data was taken from companies and discoms:

Team composition	Deployment	Number of projects (assuming 80% deployment)
1 Rooftop Solar Grid Engineer 1 helpers	5 days	40

Table 77: Norms observed in the solar PV rooftop projects

Note: The helpers shown in the above table have not been taken separately to calculated the skill gap numbers of solar project helpers

7.2.1.3. Solar PV Pump Sector

	Manpower norms for a 0-10 HP pump
Solar Project Helper	2
Solar Pump Technician	1
Solar PV pump Installation and Maintenance Engineer	1
Solar PV Pump Installation and Maintenance Manager /Solar Pump Entrepreneur	1
Category Head (Solar PV Pumps)	1

Table 78: Norms observed in the solar PV pumps sector

7.2.2. Solar Thermal Sector

7.2.2.1. Solar water heating and solar cooking – installation and manufacturing – Norms

1. For the end to end installation of a solar water heating system of 100 -150 sq. m. would require the deployment of the following roles for duration of 7 days:

- 1 Overall MD/CEO of the organisation
- 1 Project head (Solar Thermal) looking after multiple projects
- 5 Solar thermal domestic water heating technician
- 5 Solar thermal helpers/ semi –skilled technicians

2. Total number of projects which can be undertaken = 80% of (251/ 7) ~ 30 projects in a year
3. For manufacturing and installation of solar thermal water heating we observed that the current installed capacity is catering to close to 1.07 million sq. m. per year. By 2022, to

achieve the target of 20 million sq. m. of solar water heaters, the -per year capacity addition needs to increase to 2.16 million sq. m. per year. By 2025, this needs to increase to 3.02 million sq. m. per year. Hence we have calculated the manpower numbers basis this assumption

4. According to JNNSM phase -2, a target of 50,000 solar cookers has been set till 2022. Basis the MNRE annual report 2015-16, we observe that currently 6, 80, 669 of box type solar cookers and 15,000 of dish type of solar cookers were sold by 2015-16126. A total of 29 channel partners have been associated with MNRE. The current manpower can cater to the future capacity increase by targets

7.2.2.2. Solar Thermal CST (Industrial Process Heating)- Norms

1. For Industrial water heating applications the manpower deployment for a 100-200 sq. m. project is:
    - 15 solar thermal plant installation/ maintenance technicians
    - 10 Solar thermal helpers
    - 4 Fitters
    - 4 Cutters
    - 4 Solar thermal process heat engineers
    - 3 Solar thermal maintenance technician- Manufacturing
    - 3 Solar thermal electricians
    - 3 Solar thermal gas welders
    - 1 Project head (Solar Thermal)
    - 1 Project installation in-charge
    - 1 Solar thermal Fabricator
    - 1 Carpenter
2. The time taken for a concentrated solar thermal- for industrial water heating is:
    - 1 Week – Engineering and Assessment
    - 3 Weeks – Manufacturing and Transportation
    - 2 Weeks - Erection and Commissioning + 1 week for testing
3. Total projects which can be undertaken in a year = 4 at 80% deployment
4. In CST projects, the same manpower deployed for the erection and commissioning of the system will take care of the operation and maintenance also. Hence, with increase in capacity, more manpower needs to be trained. For calculation the current capacity is taken as the capacity added in the previous year i.e. 5266 sq. m. of CST[127]

[126] MNRE- Annual Report – 2015-16

[127] MNNRE- Annual report – 2015-16

7.2.3. Wind Energy Sector

Basis our interactions with multiple industry stakeholders, we have observed the following norm for wind energy power projects of 50 -100 MW size:

Designation	Manpower norm for 50-100 MW wind farm
Wind Project Helper – EPC and O&M	Diff. for EPC and O&M (EPC – 50, O&M – 5)
O&M Electrical and Instrumentation Technician - Wind Power Plant	9
Construction Technician (Electrical)- Wind Power Plant	20
Construction Technician (Civil) - Wind Power Plant	15
O&M Mechanical Technician - Wind Power Plant	6
CMS Engineer (EPC and O&M)	Diff. for EPC and O&M (EPC – 1, O&M – 4)
Construction Technician (Mechanical) - Wind Power Plant	10
Crane Operator	10
Procurement Executive- Wind	8
Site Surveyor (Civil and Electrical)	6
Assistant Planning Engineer (Civil/ Mechanical and Electrical)	6
Construction Engineer (Electrical)- Wind Power Plant	6
Construction Engineer (Civil) - Wind Power Plant	5
Construction Engineer (Mechanical)- Wind Power Plant	5
O&M Engineer (Electrical) - Wind Power Plant	2
O&M Engineer (Mechanical) - Wind Power Plant	2
O&M Manager- Wind Power Plant	1
WRA – Wind Resource Assessment Manager	3
Assistant Site Surveyor (Civil)- Wind Power Plant	2
Assistant Site Surveyor (Electrical)- Wind Power Plant	2
Wind Land Acquisition Officer	2
Procurement Manager- Wind	2
Planning Engineer (Civil/ Structural)- Wind Power Plant	2
Planning Engineer (Electrical)- Wind Power Plant	2
Site Manager/ Subcontractor/ Entrepreneur- Wind Power Plant	2
HSE Engineer	2
Project Design Manager - Wind Power Plant	1
Project Manager- Wind Power Plant	1
System Planning Engineer - Wind Power Plant	1
HSE Manager	1

Table 79: Norms observed in the wind energy sector

7.2.4. Small Hydro

7.2.4.1. Small Hydro – Engineering, Procurement and Commissioning

Basis our interactions with multiple industry stakeholders, we have observed the following norm for small hydro power projects of 0-10 MW size:

Designation	Typical manpower requirement for 0-10 MW
Small Hydro Project Helper	80
Small Hydro Project Site Surveyor	6
Small Hydro Project Assistant Site Surveyor	3
Small Hydro Procurement Executive	3
Small Hydro Project Electrical Foreman- Transmission	3
Small Hydro Project Weir Site Foreman	3
Small Hydro Project Water Conductor Foreman	3
Small Hydro Project Electrical Supervisor- Transmission	2
Small Hydro Project Electrical Supervisor- Substation	2
Small Hydro Project Electrical Foreman	2
Small Hydro Project Mechanical Technician	2
Small Hydro Project OEM Foreman	2
Small Hydro Crane Operator	2
Small Hydro Project Designing Head	1
Hydrology & Geology Expert	1
Small Hydro Project Design Engineer (Electrical and C&I)	1
Small Hydro Project Design Engineer (Civil/ Structural)	1
Small Hydro Liaison Officer/ PRO/ Patwari	1
CAD/Draughtsman	1
Small Hydro Procurement Manager	1
Small Hydro Project Manager/Subcontractor	1
Small Hydro Project Electrical and C&I Engineer	1
Small Hydro Project C&I Technician	1
Small Hydro Project Mechanical Engineer	1
Small Hydro Project Engineer (Civil)	1
Small Hydro Project OEM Supervisor	1
Small Hydro Project Weir Site Supervisor	1
Small Hydro Blasts man	1
Small Hydro Project HSE Manager	1
Small Hydro Project HSE Engineer	1

Table 80: Norms observed in the small hydro sector

7.2.4.2. Small Hydro – Operation and Maintenance

Basis our interactions with multiple industry stakeholders, we have observed the following norm for small hydro power projects of 0-10 MW size:

Designation	Manpower norm 0-10 MW
Small Hydro Project Helper	10
Small Hydro O&M Mechanical Technician	9
Turbine Generator Operator	7
Fitter	7
Small Hydro O&M Instrumentation Technician	4
Security Guard	4
Small Hydro O&M Engineer Mechanical /Small Hydro Control System Engineer	4
Small Hydro O&M Civil Technician	3
Small Hydro O&M Electrical Engineer	2
Small Hydro O&M Site In charge	1
Small Hydro O&M Civil Engineer	1

Table 81: Norms observed in the small hydro sector

7.3. Profile of respondents

To conduct the skill gap study, primary survey in the form of telephonic conversation and face- face meetings were conducted. The profile of the respondents is shown below

7.3.1. Project Type

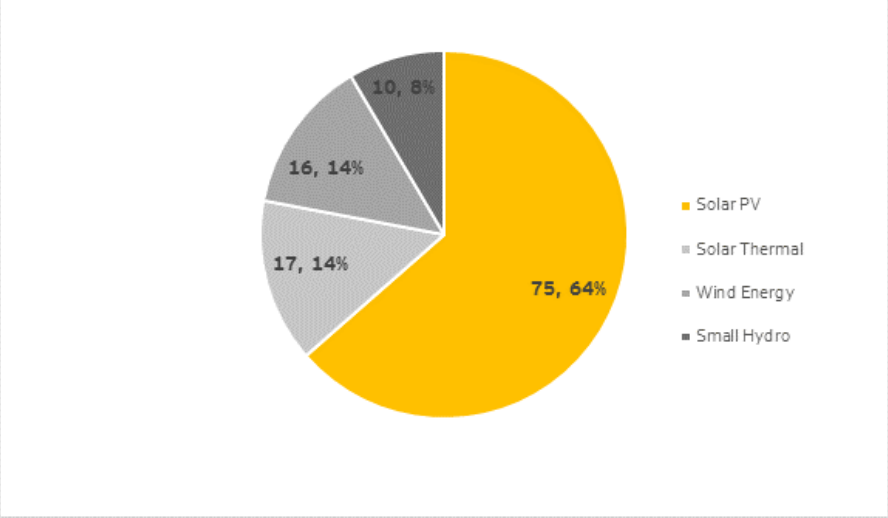


Figure 37: Distribution of respondents according to project type

7.3.2. Areas of operation

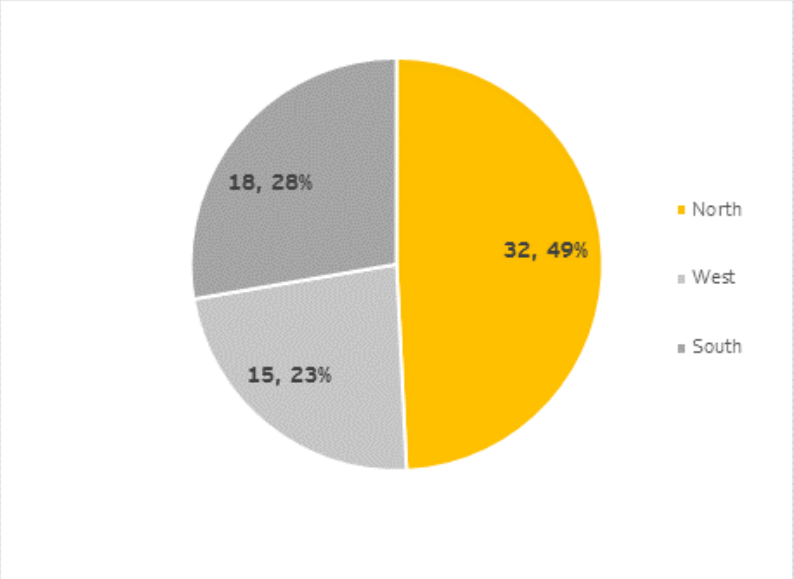


Figure 38: Distribution of respondents according to area of operation

7.4. List of abbreviations

S.No.	Abbreviation	Full form
1.	AMRUT	Atal Mission for Rejuvenation and Urban Transformation
2.	BE/ B.Tech	Bachelor's in Technology/ Bachelor's in Engineering
3.	CAGR	Compound Annual Growth Rate
4.	CNC	Computerized Numeric Control
5.	CSP	Concentrated Solar Power
6.	CST	Concentrated Solar Thermal
7.	DISCOM	Distribution Companies
8.	EPC	Engineering, Procurement and Commissioning
9.	FDI	Foreign Direct Investment
10.	GBI	Generation Based Incentive
11.	GHG	Green House Gas
12.	GW	Giga-Watt
13.	HSE	Health and Safety Engineer
14.	IPP	Individual Power Producer
15.	ITI	Industrial Training Institute
16.	JNNSM	Jawaharlal Nehru Solar Mission
17.	MD	Managing Director
18.	MNRE	Ministry of New and Renewable Energy
19.	MW	Mega Watt
20.	NCEF	National Clean Energy Fund
21.	NOS	National Occupational Standards
22.	NPACC	National Action Plan for Climate Change
23.	NSQF	National Skills Qualification Framework
24.	NWM	National Wind Mission
25.	O&M	Operation and Maintenance
26.	OEM	Original Equipment Manufacturer
27.	PSU	Public Sector Unit
28.	PV	Photovoltaic
29.	QA	Quality Assurance
30.	QP	Qualification Pack
31.	R&D	Research and Development
32.	RE	Renewable Energy
33.	REC	Renewable Energy Certificate
34.	RPO	Renewable Purchase Obligation
35.	SCADA	Supervisory Control and Data Acquisition
36.	SECI	Solar Energy Corporation of India
37.	WRA	Wind Resource Assessment
38.	WTG	Wind Turbine Generator

7.5. Occupational Maps

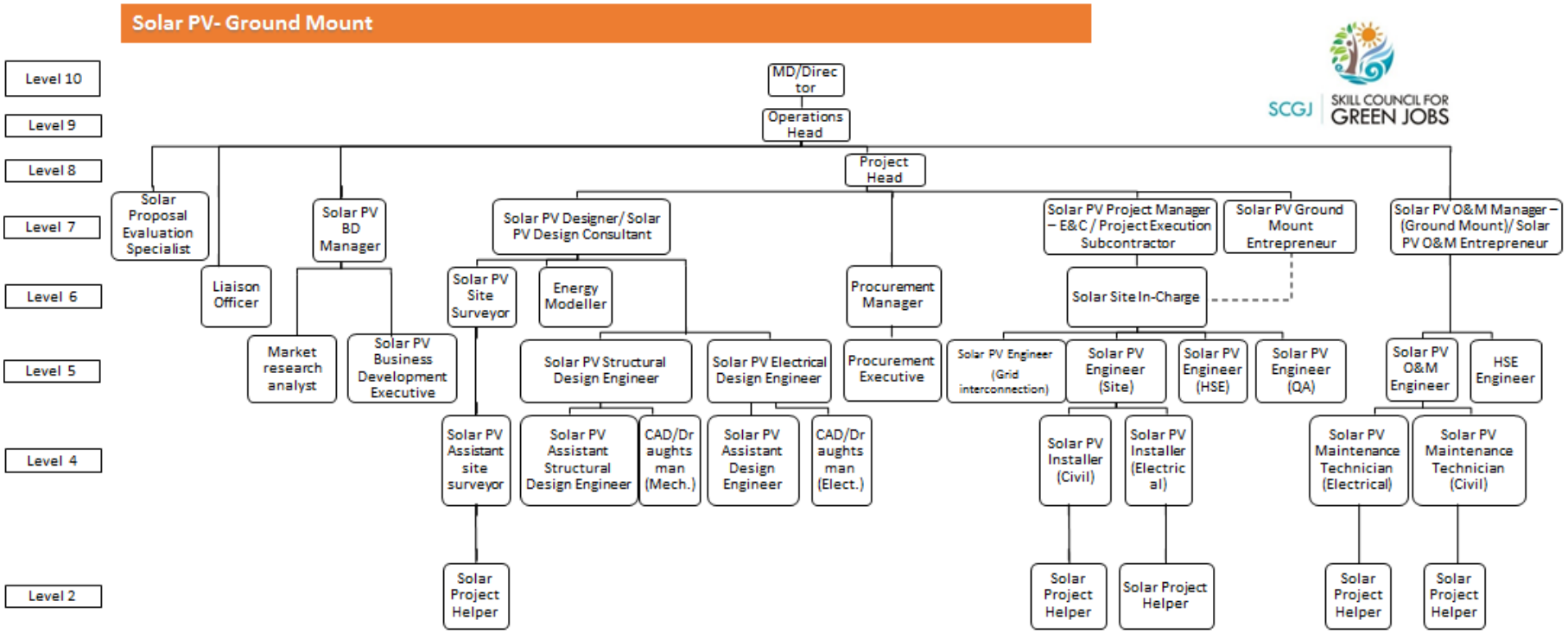


Figure 39: Solar PV Occupational Map – Ground Mount

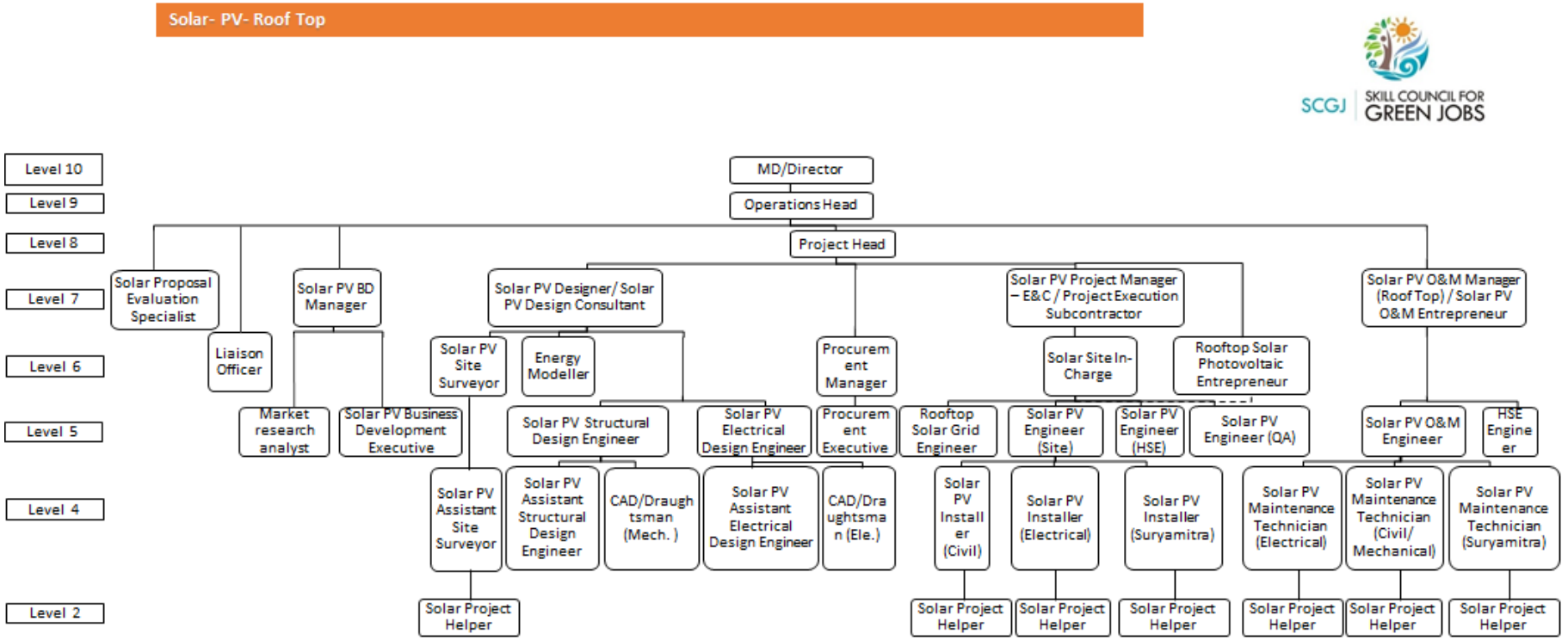


Figure 40: Solar PV Occupational Map – Rooftop

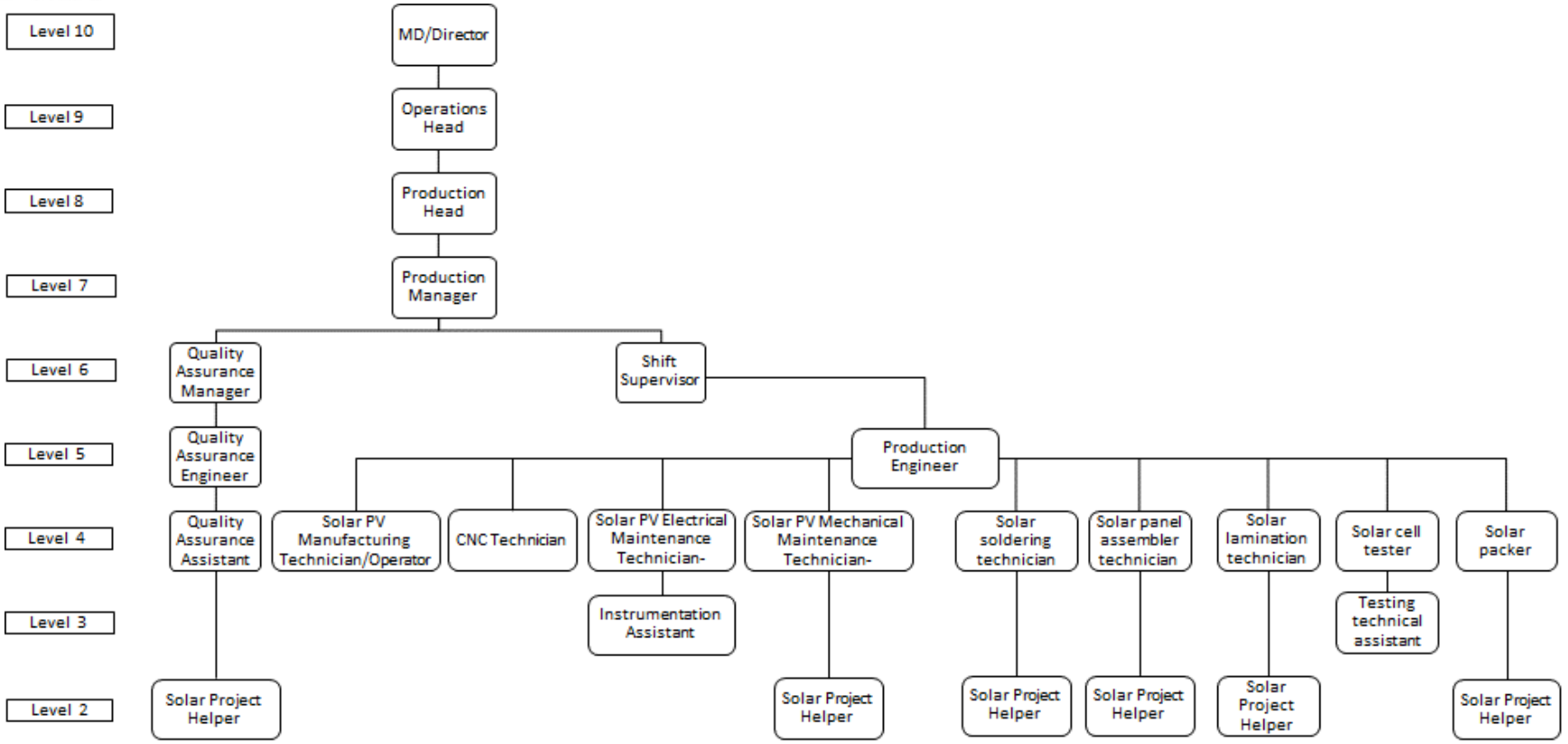


Figure 41: Solar PV Occupational Map – Manufacturing

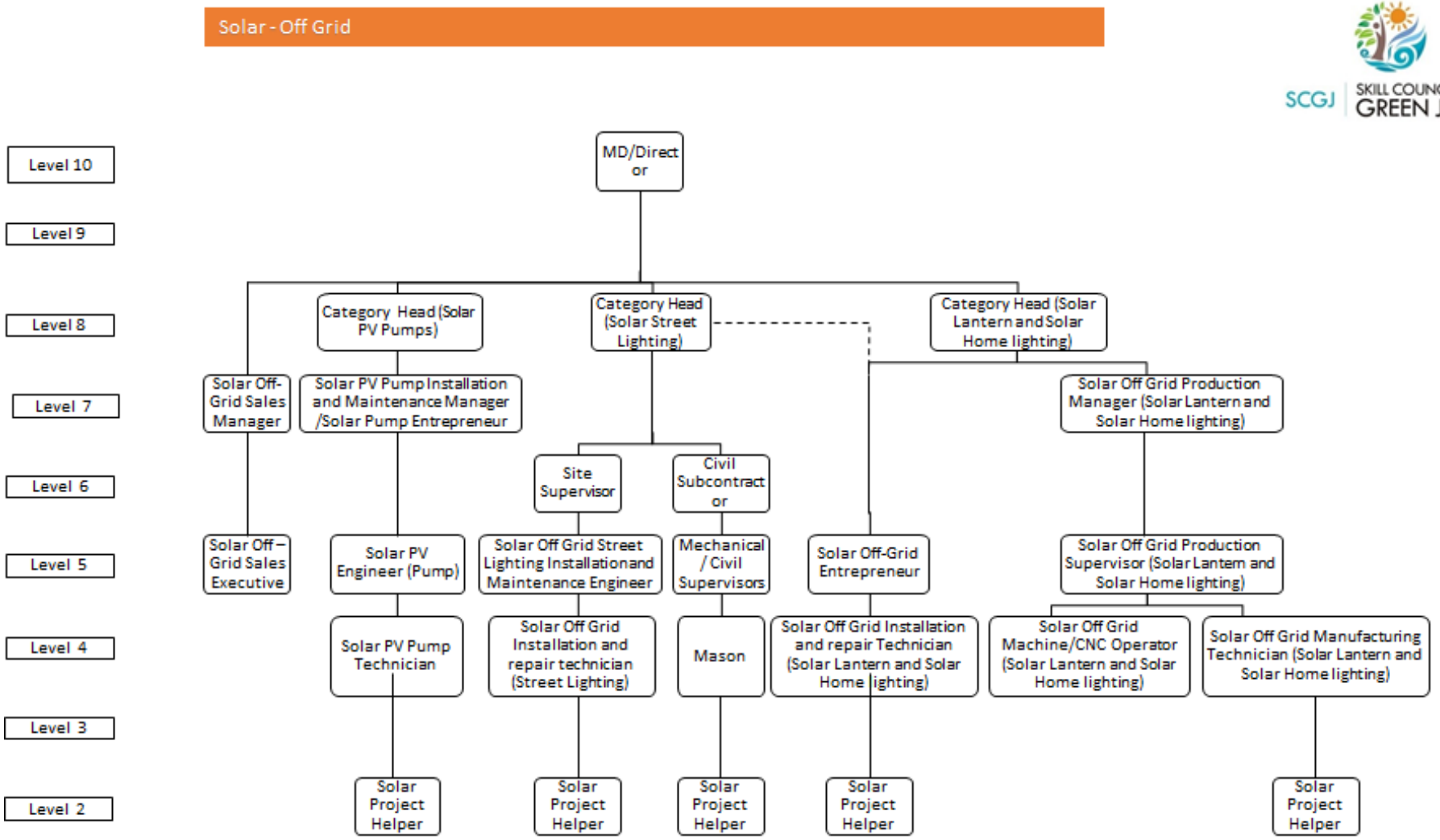


Figure 42: Solar PV Occupational Map –Off- Grid

Solar Thermal

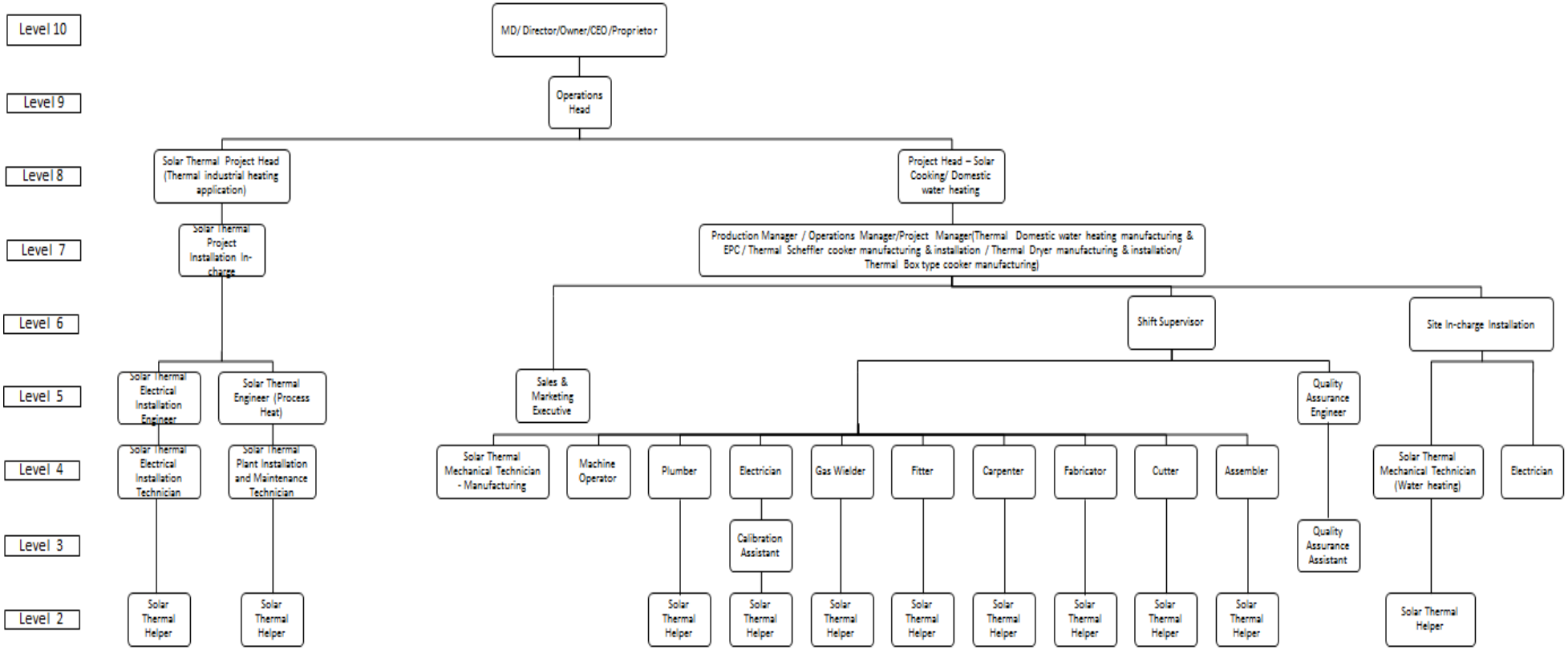


Figure 43: Solar thermal Occupational Map

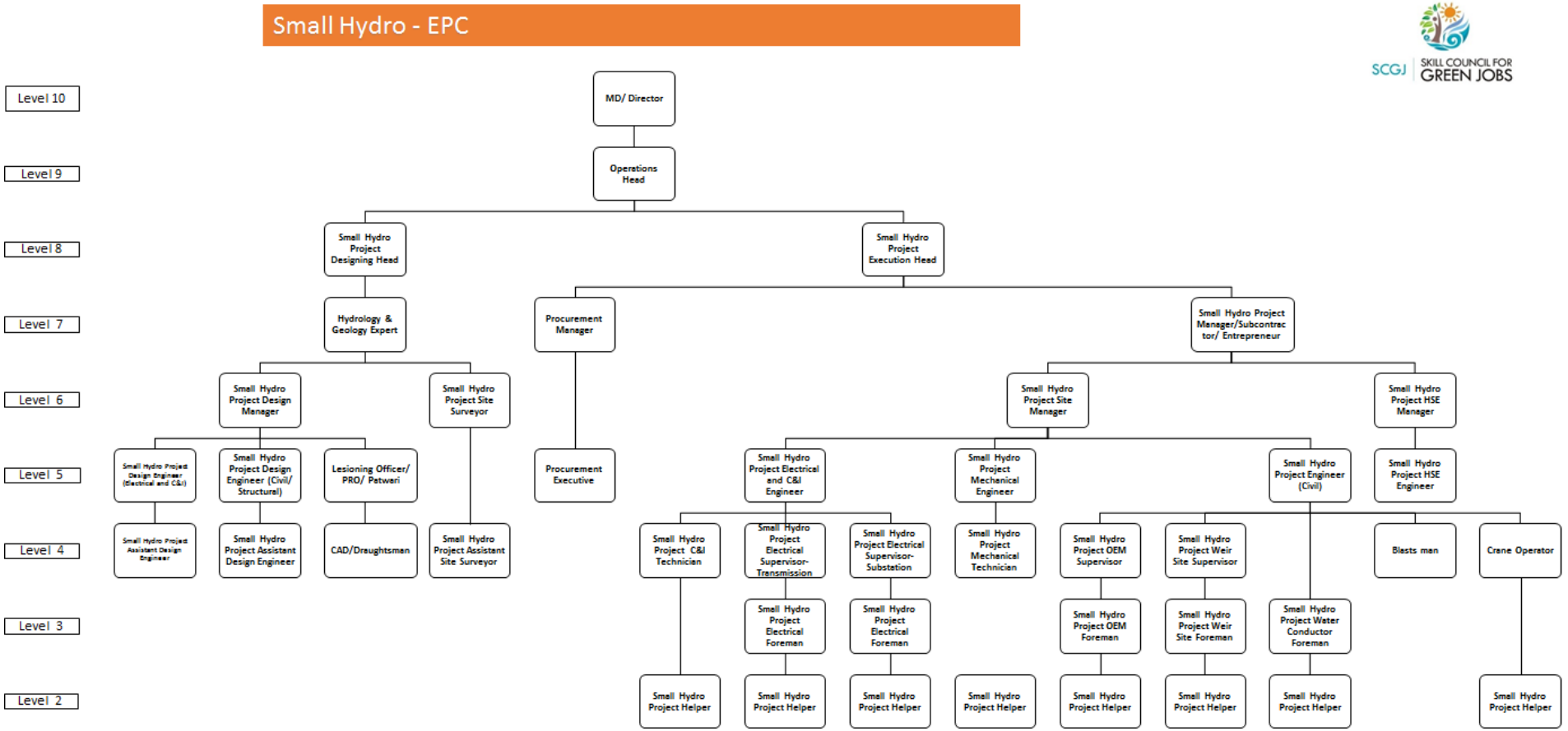


Figure 44: Small Hydro Sector Occupational Map - EPC

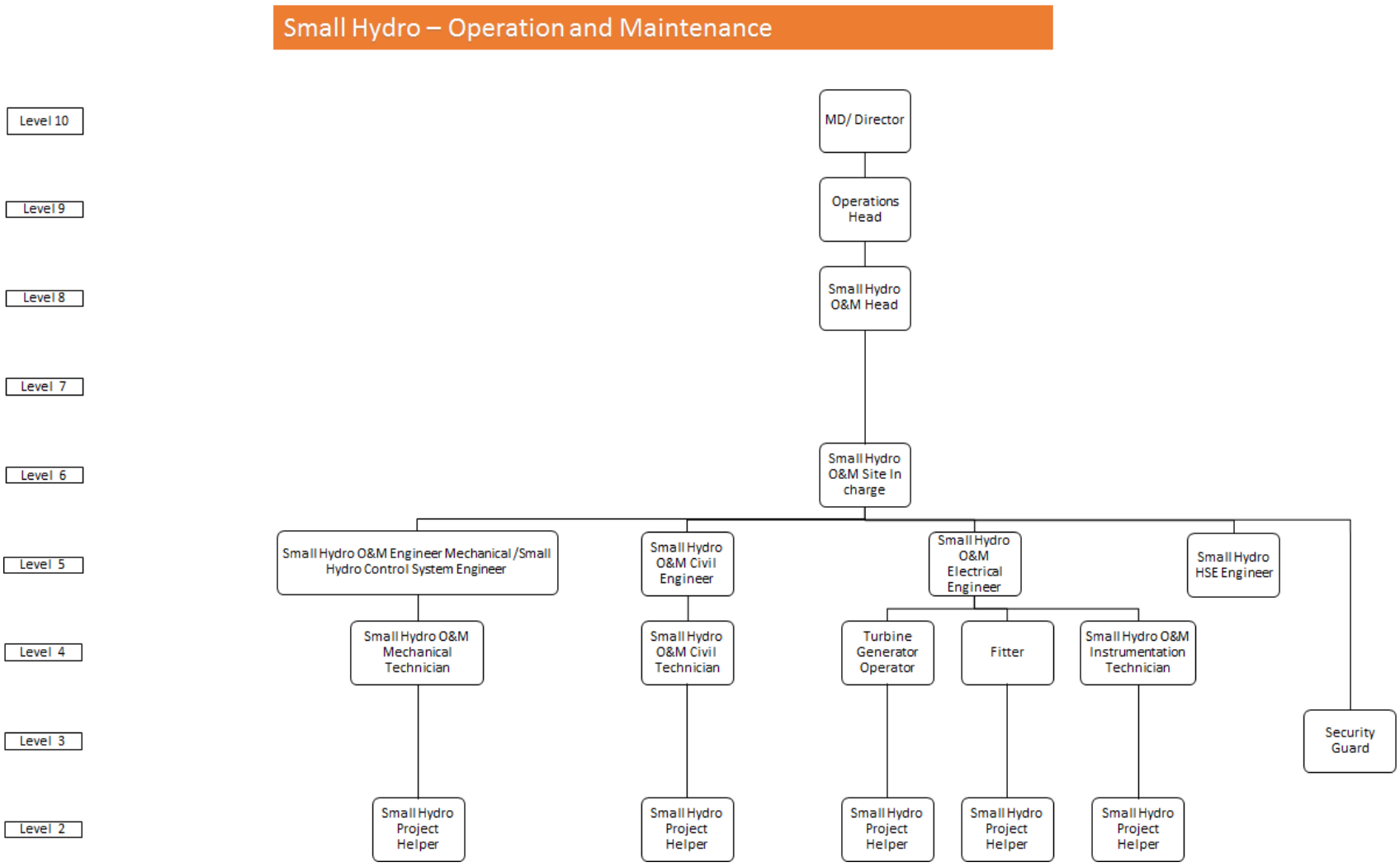


Figure 45: Small Hydro Sector Occupational Map – Operation and Maintenance

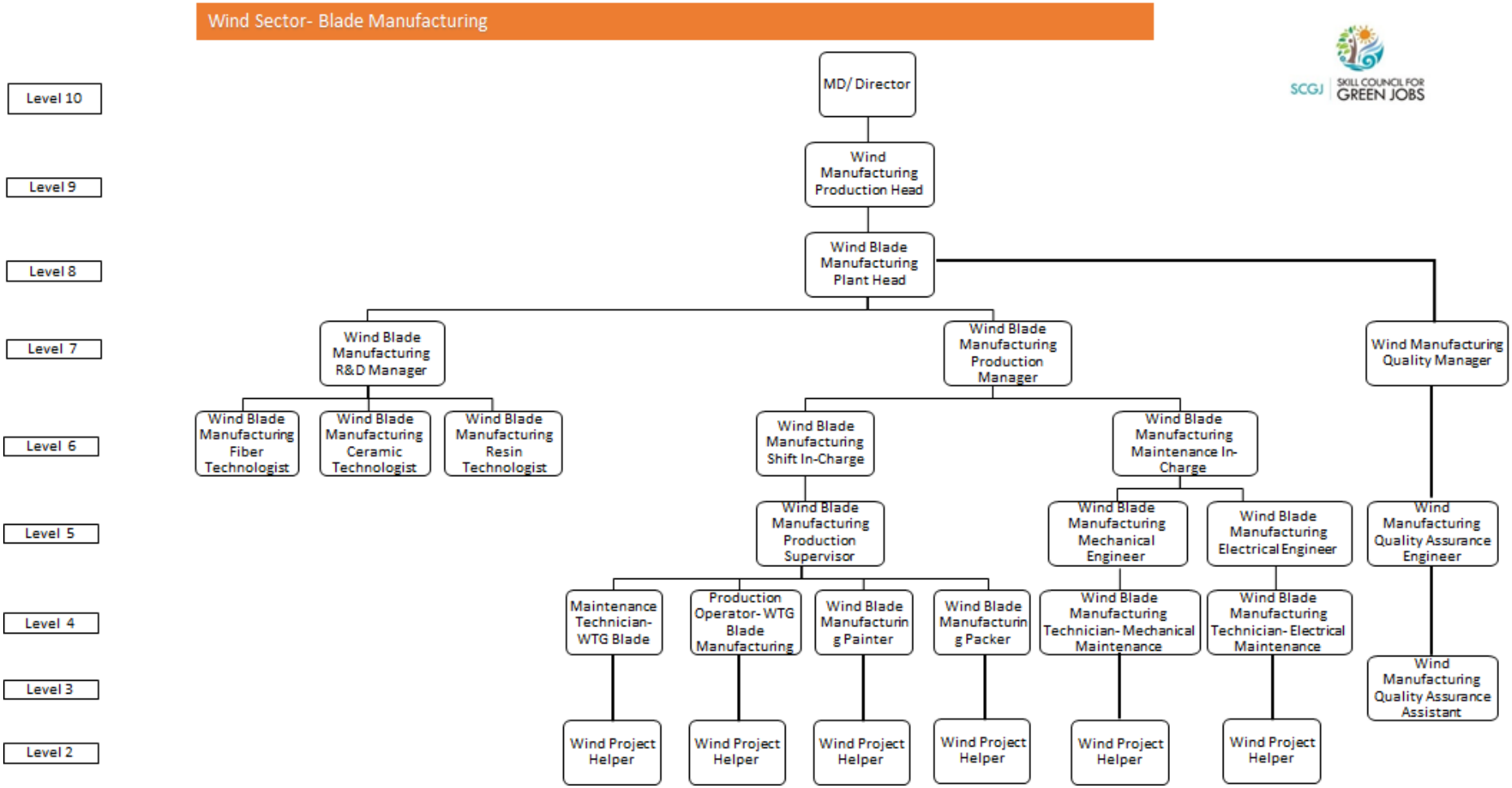


Figure 46: Wind Energy Sector Occupational Map – Blade Manufacturing

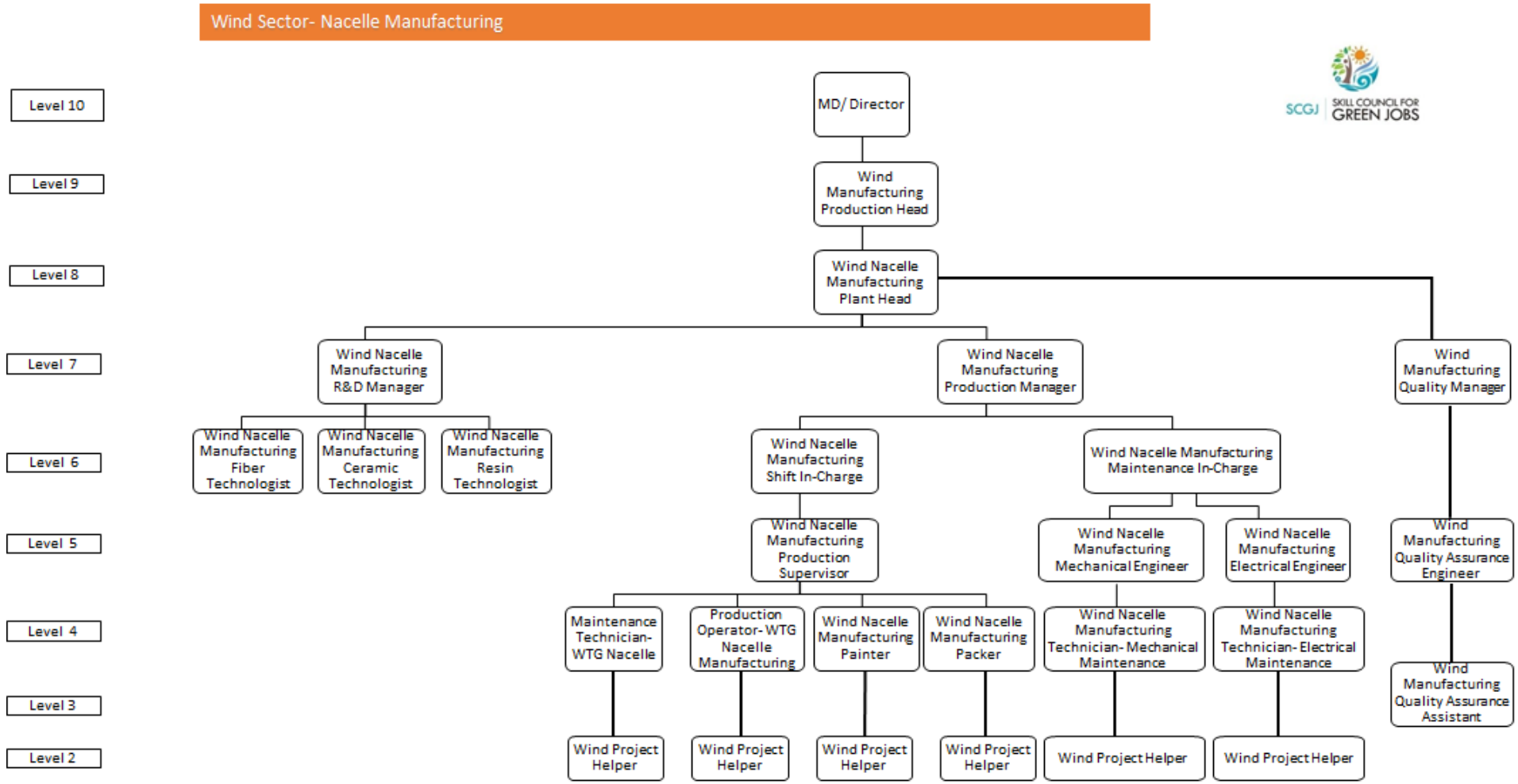


Figure 47: Wind Energy Sector Occupational Map – Nacelle Manufacturing

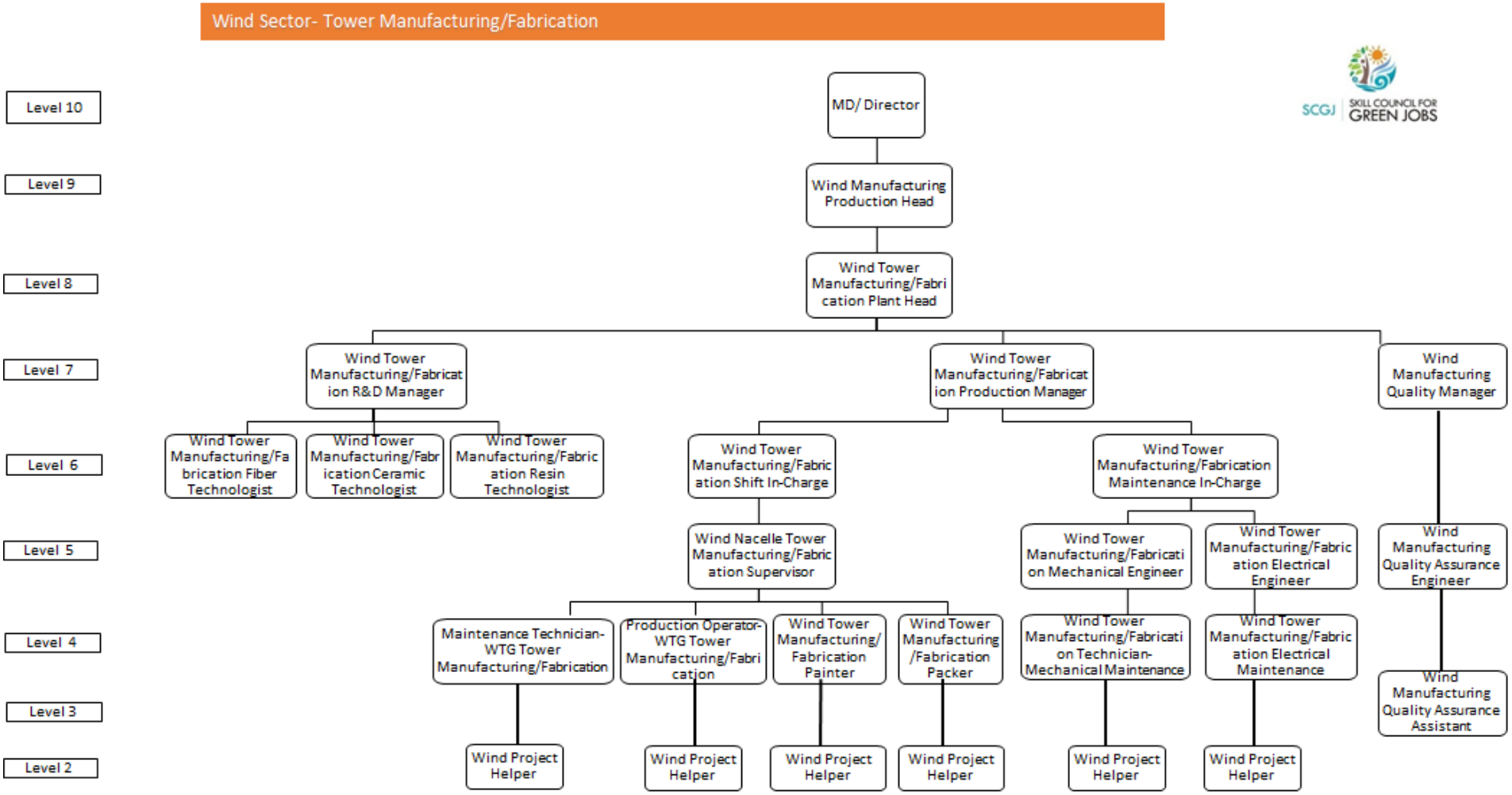


Figure 48: Wind Energy Sector Occupational Map – Tower Manufacturing

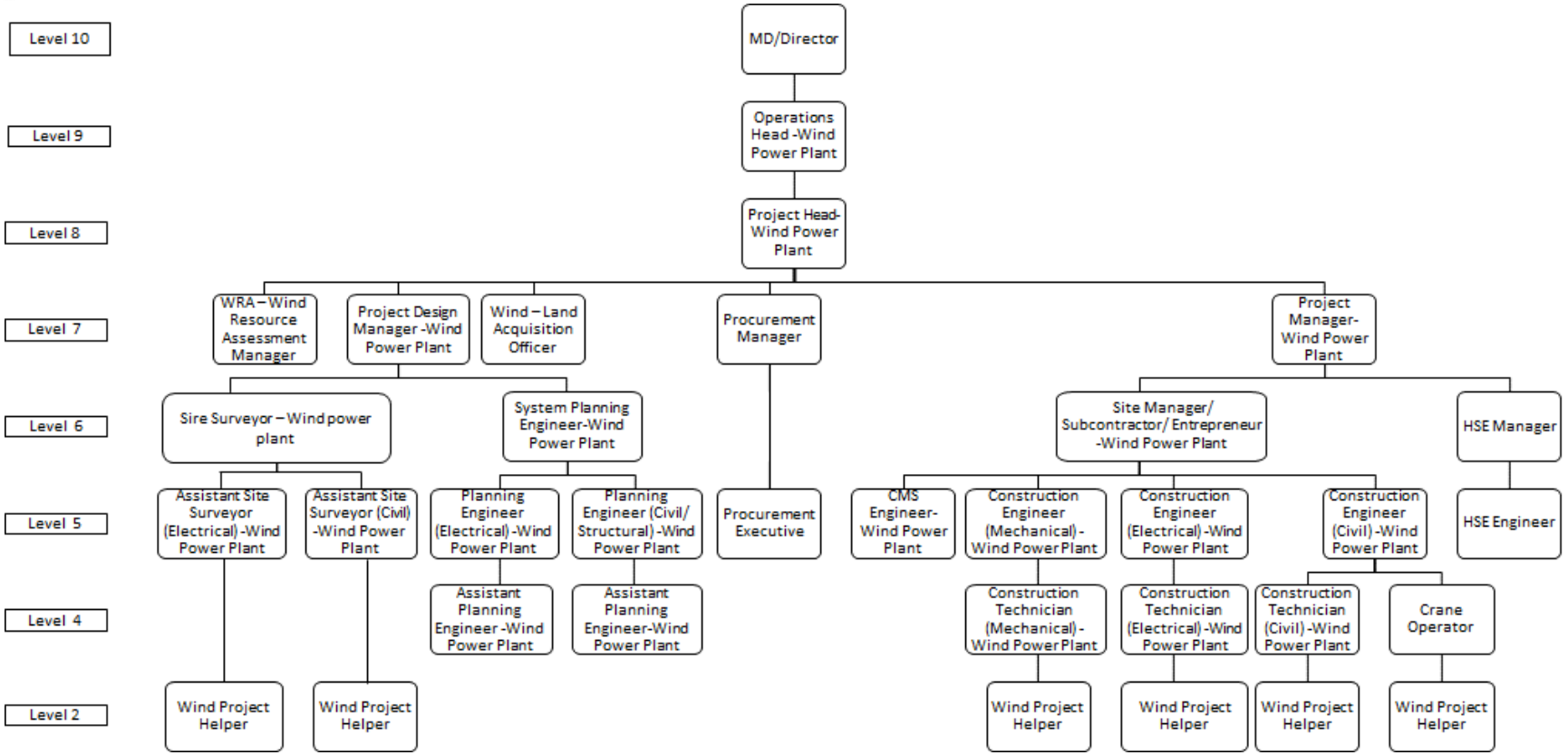


Figure 49: Wind Energy Sector Occupational Map – Engineering, Procurement and Commissioning

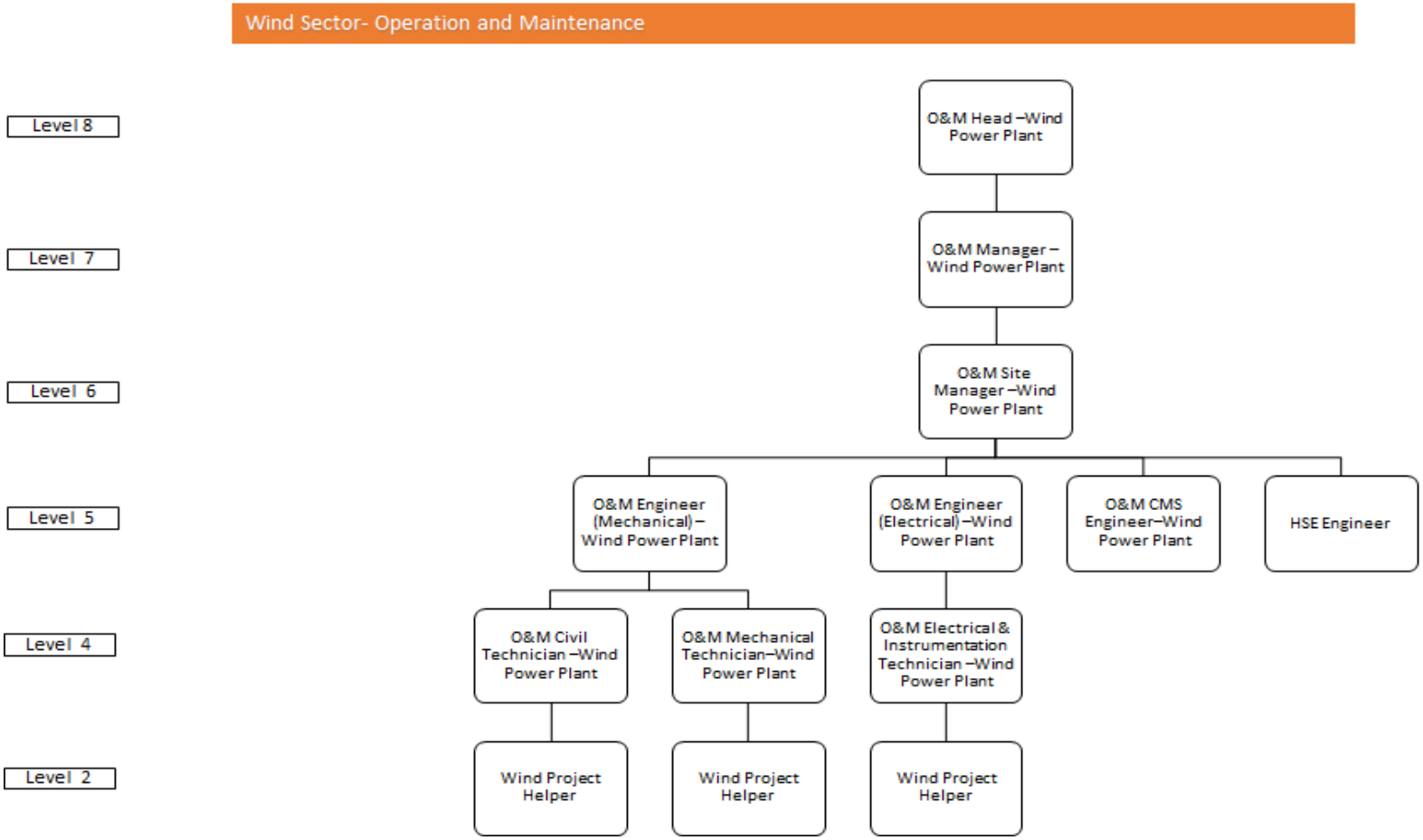


Figure 50: Wind Energy Sector Occupational Map – Operation and Maintenance

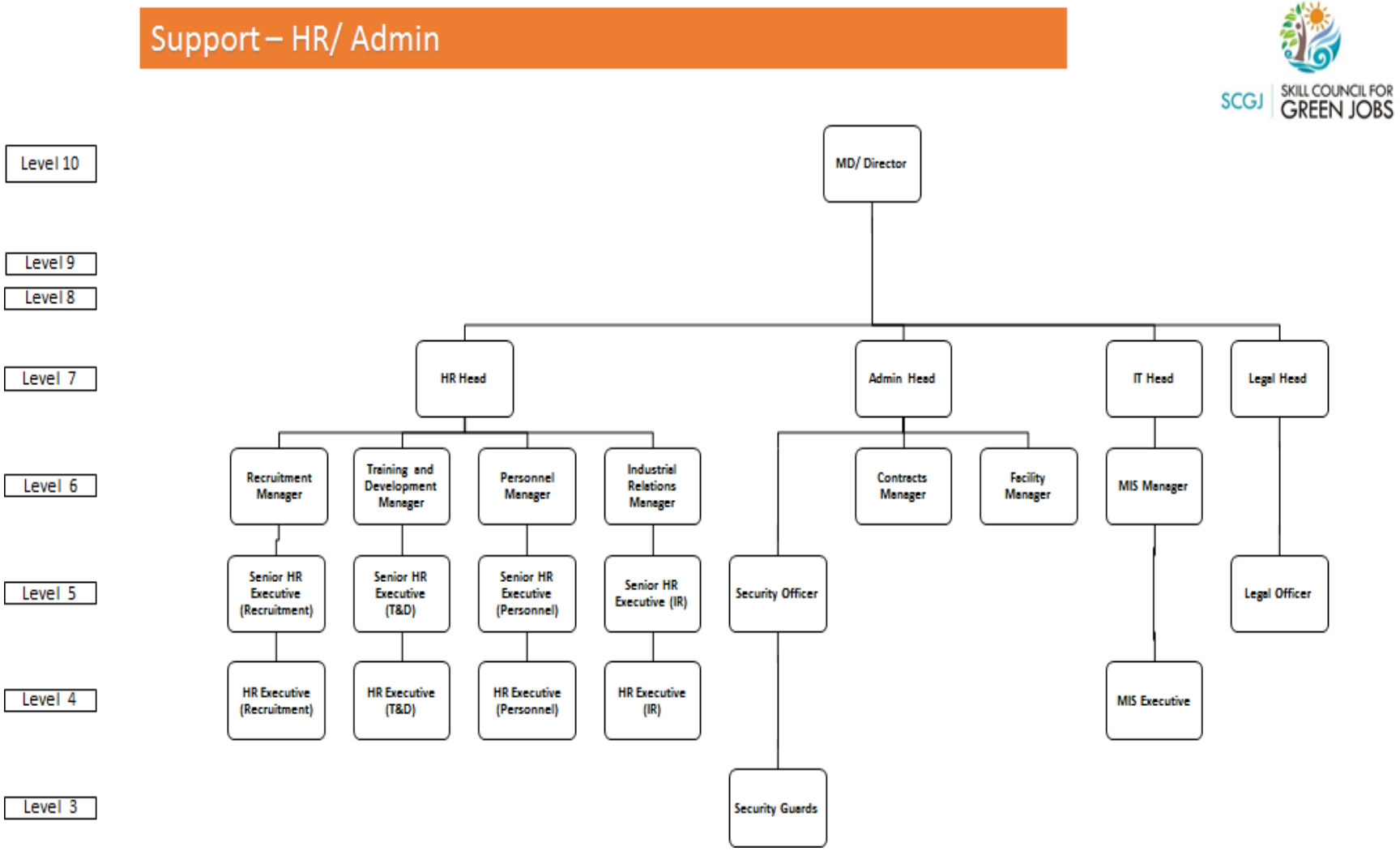


Figure 51: Support roles – HR/ Admin Occupation Map

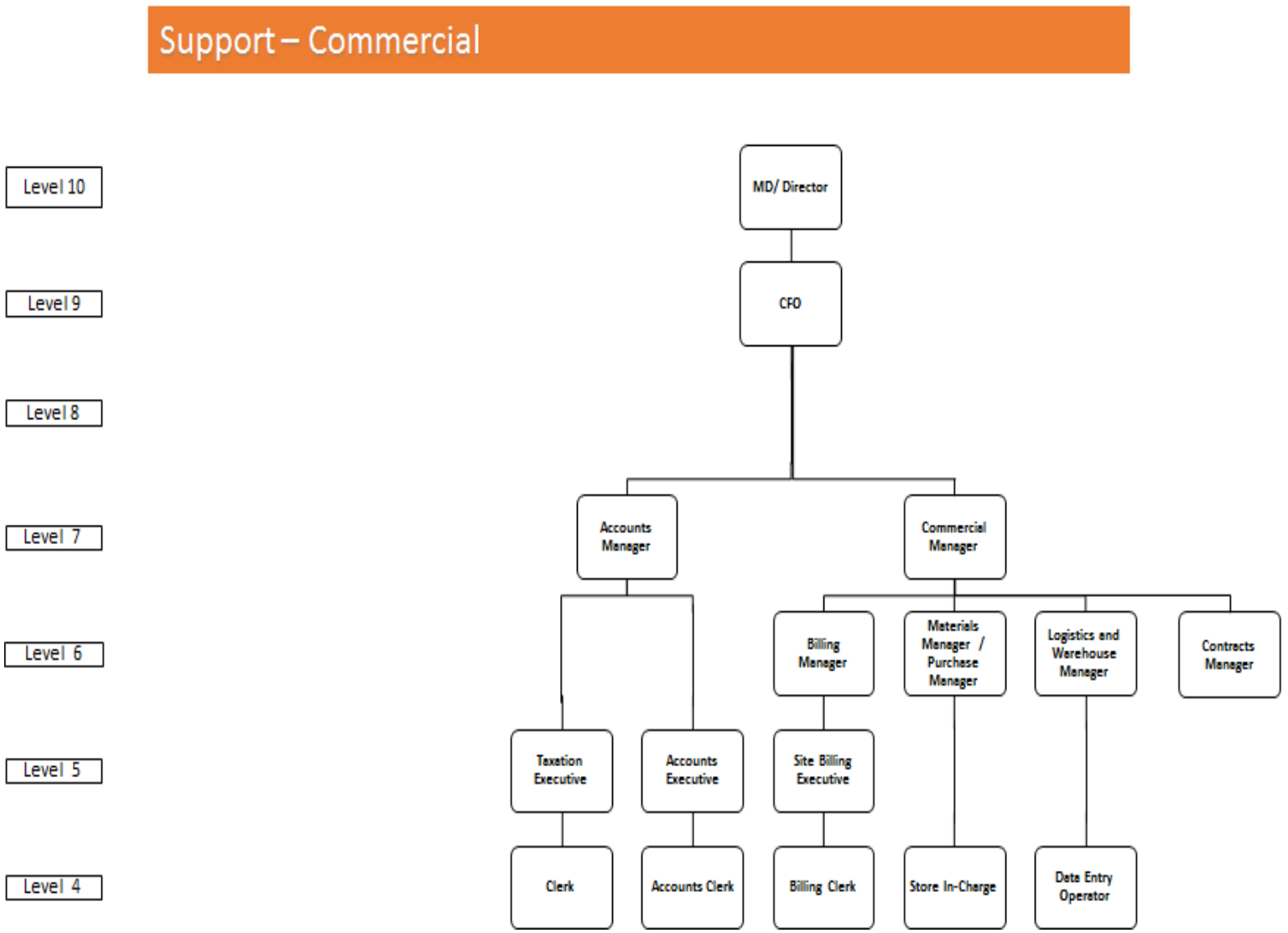


Figure 52: Support roles – Commercial Occupation Map

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