

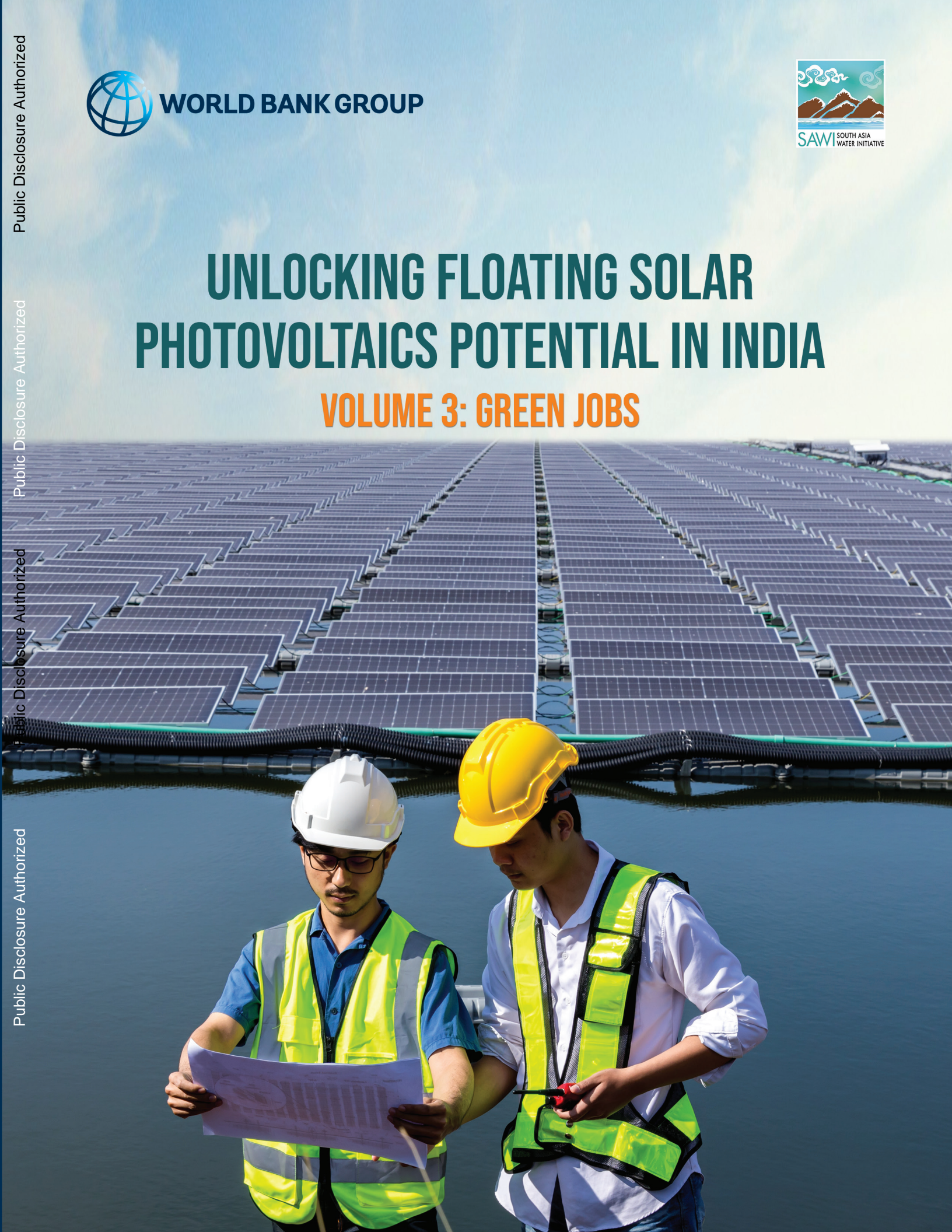


WORLD BANK GROUP



# UNLOCKING FLOATING SOLAR PHOTOVOLTAICS POTENTIAL IN INDIA

## VOLUME 3: GREEN JOBS



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**VOLUME 3: GREEN JOBS**

**OCTOBER 2023**





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# ABBREVIATIONS

AC	Alternating Current
ACDB	AC Distribution Board
AICTE	All India Council for Technical Education
BoM	Bill of Materials
BoQ	Bill of Quantities
CAD/CAM	Computer-aided design/Computer-aided manufacturing
CEEW	Council on Energy, Environment and Water
CIPET	Central Institute of Plastics Engineering & Technology
CNC	Computer Numerical Control
CPRI	Central Power Research Institute
CSIR	Council of Scientific and Industrial Research
DC	Direct Current
DGT	Directorate General of Training
DNV	Det Norske Veritas
E&S	Environment and Social
FSPV	Floating Solar Photovoltaics
GIS	Geographic Information System
GW	Giga Watt
HDPE	High Density Polyethylene
HEC RAS	Hydrologic Engineering Centre - River Analysis System
HEC HMS	Hydrologic Engineering Centre - Hydrologic Modeling System
HRES	Hybrid Renewable Energy Systems
HSE	Health, Safety and Environment
IIT	Indian Institute of Technology
ISO	International Organization for Standardization
ITI	Industrial Training Institute
MNRE	Ministry of New and Renewable Energy
NIO	National Institute of Oceanography
NIWE	National Institute of Wind Energy
NPTI	National Power Training Institute

NUS	National University of Singapore
O&M	Operation & Maintenance
PGDC	Post Graduate Diploma Course
PV	Photovoltaic
QA/QC	Quality Assurance/Quality Control
R&D	Research & Development
RE	Renewable Energy
RFQ	Request for Quotation
RMS	Root Mean Square
SCADA	Supervisory Control and Data Acquisition
SECI	Solar Energy Corporation of India Limited
SERIS	Solar Energy Research Institute of Singapore
STCW	Standards of Training, Certification and Watchkeeping
STEM	Science, Technology, Engineering, and Mathematics
VTI	Vocational Training Institute



# EXECUTIVE SUMMARY



## EXECUTIVE SUMMARY

Given the rate at which floating solar is expanding in India, it will soon function as a vital source of energy that fulfils India's energy demands. With the focus on providing last mile connectivity, affordable electricity, and control impact on climate, clean energy is here to grow. Further, given the challenges posed by ground mounted solar plants, a spur in floating solar plants is inevitable.

While floating solar offers multiple advantages such as high energy efficiency and water conservation, the availability of skilled manpower for generic as well as niche skills remains a challenge. The shortage of a skilled workforce may adversely impact the growth of this industry. There is a need to identify the gaps, assess the demand, re-train and upskill existing manpower, and build capabilities for the emerging skills—for which all the stakeholders must work collectively. Currently the skill gaps are mitigated by hiring skilled workforce from similar industries but, in the

long term, the sector needs to align skill availability to the demand and possibly attain self-sufficiency of skilled manpower from within the sector.

To narrow the skill gaps in floating technology, there is a need for enhanced focus and drive from the government. The Government must clearly lay down the floating solar targets on both short- and long-term basis. This will help to estimate the manpower requirements and devise training plans accordingly. To upskill the workforce and/or reskill existing solar workforce, it is necessary that an overall skilling agenda/strategy for floating solar be developed by the government. A robust governance mechanism and monitoring framework to track progress of enhancement of skill should be established to enable the development of the right skills for FSPV technology, products and processes in India.

This report looks at some of these aspects.



# 1. INTRODUCTION





# 1 INTRODUCTION

With the emergence of solar power plants there was emergence of new skills required for its successful inception, installation and commissioning. According to the report '*Filling the Skill Gap in India's Clean Energy Market*' by the Council on Energy, Environment and Water (CEEW) and the Natural Resources Defense Council, solar energy projects would create one million jobs by 2022 to achieve a target of 100 Giga Watt (GW). Out of these one million jobs, India would need nearly 20 percent skilled plant design and site engineers and approximately 56 percent semi-skilled technicians for construction. Further 16 percent workers would be needed to conduct low-skill O&M functions and seven percent highly skilled manpower would be needed for ongoing performance data monitoring.

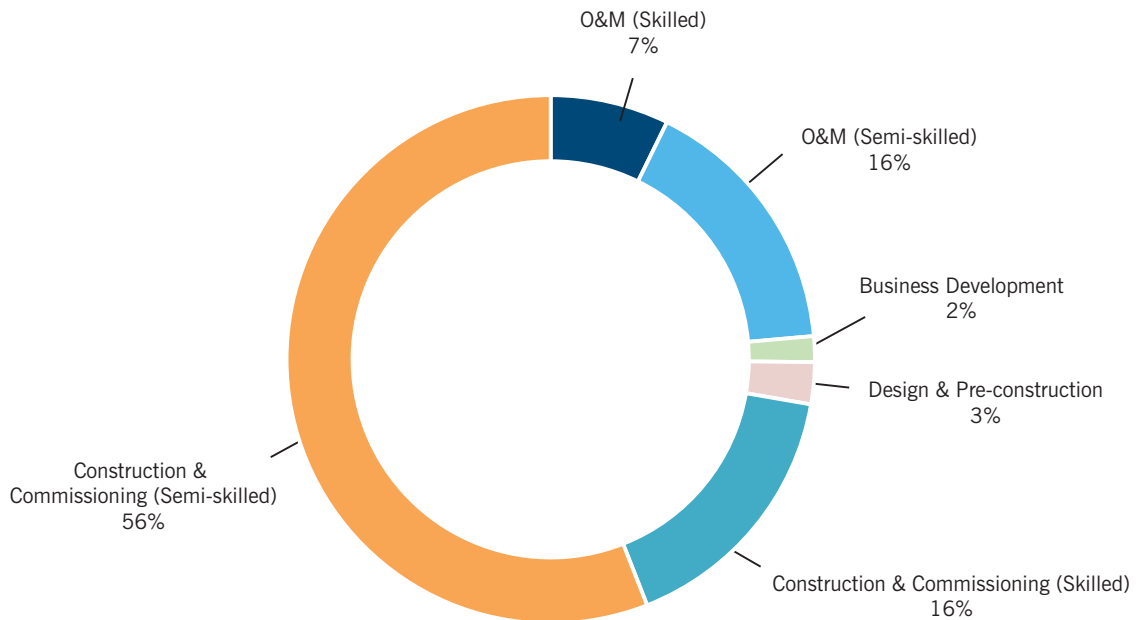
## 1.1. Floating Solar and Employment Opportunities

New FSPV project development would create additional employment opportunities for semi-skilled, highly skilled and casual workers. However, FSPV still faces challenges in terms of skilled manpower availability for both generic and niche skills. Requisite experience and skill sets need to be built within the sector. It, however, benefits from availability of parallel industries such as oil and gas (where offshore/marine installations have a long history and robust standards), automotive sector (with long experience in plastic processing), offshore wind, inter alia. It is expected that with growing interest in FSPV, requisite skill

sets, and experience would be assimilated by solar developers from parallel industries. The government, in collaboration with national and international institutes, could undertake a detailed skill and manpower analysis to identify the skill gaps and initiatives needed to close the skill gaps. The subsequent section provides insights into the various direct employment opportunities created across different stages and types of FSPV plants.

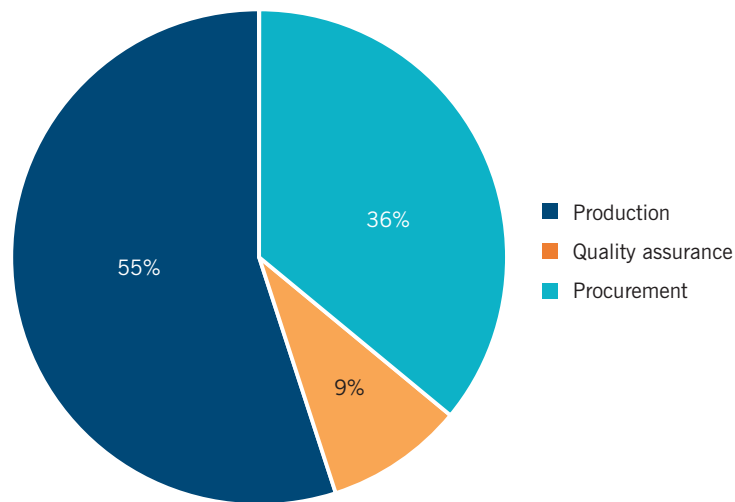
As per the CEEW report, domestic production of solar modules employs 2,900 people per 1.5 GW of manufacturing capacity. To achieve 100 GW of solar capacity, 45,000 additional employees would be needed. The growth of FSPV industry in India would increase the demand for floaters, anchors and mooring lines and the workforce with right skills to design, commission, operate and maintain them. Design and manufacturing of floats involves material experts, chemical researchers, and skilled Original Equipment Manufacturer (with established Quality Assurance Plan procedures). Highly skilled naval architects would be required for the design and installation of anchoring and mooring systems. Therefore, manufacturing of anchors and mooring lines would create additional downstream job opportunities. From the example of a typical executed mid-scale (<10 MW) FSPV plant from manufacturing and design perspective, largely contractual workers are employed, where 55 percent, 36 percent, 9 percent of the workers are involved in Production, Quality Assurance (QA) and Procurement (**Figure 1.1**) respectively, having an equal split of highly

**FIGURE 1.1: Type of jobs created in India's Solar Sector by 2022**



**Source:** World Bank analysis based on market research.

**FIGURE 1.2: Percentage of workers engaged in production, QA and procurement**



**Source:** World Bank analysis based on market research.

skilled and semi-skilled manpower on an average. However, actual manpower needed and deployment would depend on the type of waterbody, size and location of the plant.

Business Development involves detailed project report preparation, feasibility studies, bidding and liaising; highly skilled staff with formal

education qualifications, knowledge of finance, sales, contracting, and legal norms would be required.

The design and pre-construction stage requires highly skilled civil, mechanical, hydrographic and electrical engineers. Once the design is completed, a team of technicians and

engineers (civil, electrical and hydrographic), along with the support of labourers and marine transportation experts would be required to undertake installations. For operations and maintenance generally, contractual workforce is used for basic level on ground technical support activities.

It can be clearly seen in **Figure 1.3** that Business Development and the design & pre-construction stages need a relatively higher proportion of highly skilled manpower in contrast to construction & commissioning and O&M stages.

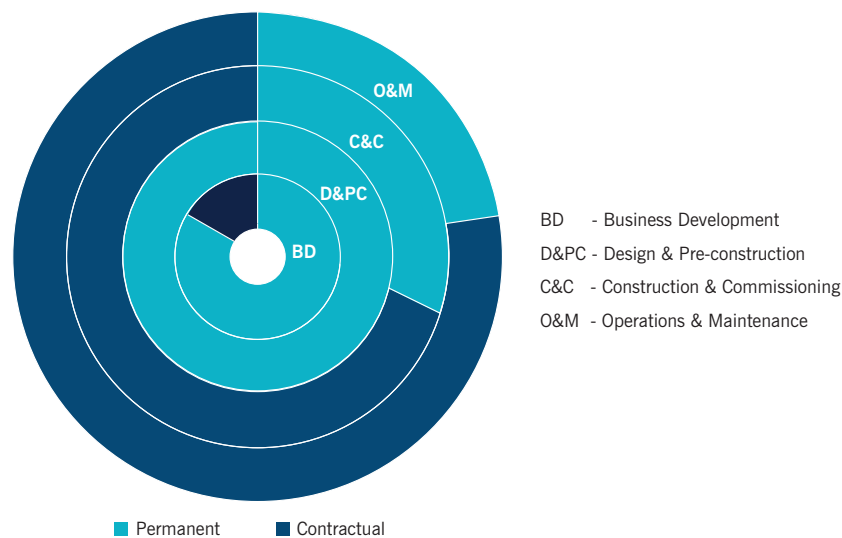
While ground mounted and floating solar plants have plenty of skills required in common, FSPV will create new job opportunities due to its peculiar needs in the areas of research and product design of the floating and mooring

structures, materials research for floats, corrosion-resistant PV modules, commissioning of floating structures and maintenance of floats along with key electrical and structural elements. FSPV will require specialized and new skills in the areas of hydrography, marine architecture, submarine electrical installation and O&M, over and above the existing solar PV skills.

## 1.2. Approach and Methodology

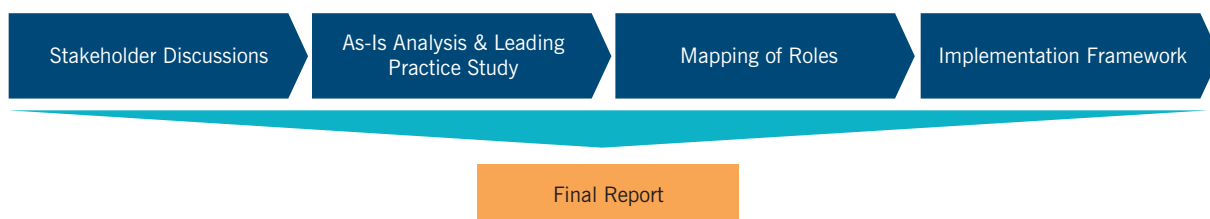
To understand the skills required for FSPV in India, a systematic approach was followed as presented in **Figure 1.4**. The data has been collected based on the broad value chain of the sector and the occupational map which was developed based on the discussion with stakeholders. The overall approach adopted to arrive at the skill requirements for various job roles across the value chain is as follows:

**FIGURE 1.3: Manpower mix across various stages of FSPV value chain**

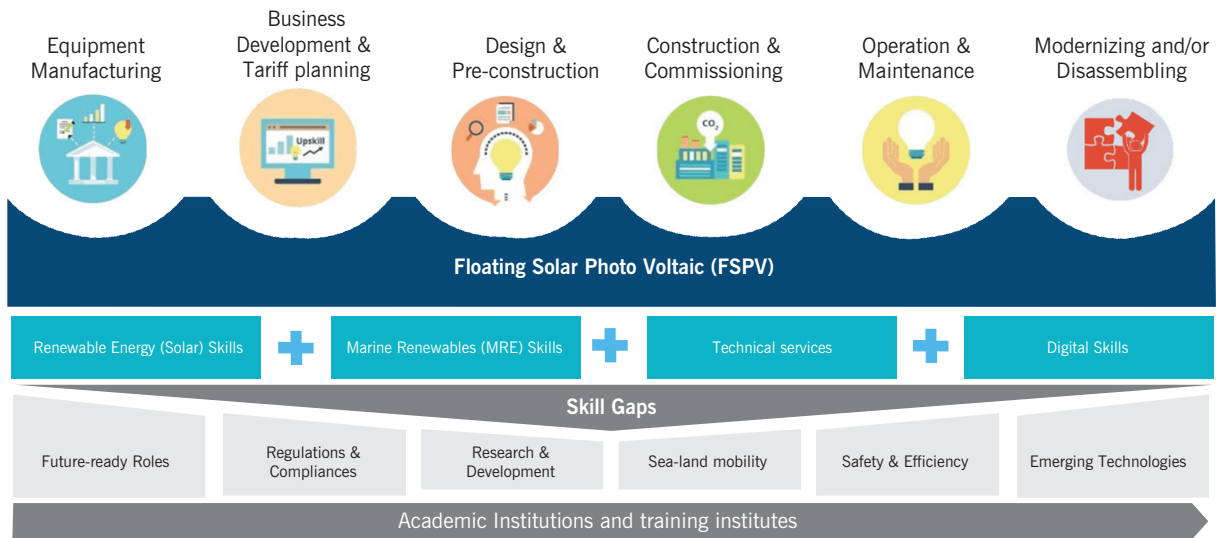


**Source:** World Bank analysis based on market research

**FIGURE 1.4: Overall Approach**



**FIGURE 1.5: Skill Gap Analysis Framework**



**Stakeholder Interactions:** Discussions were conducted with industry experts and representatives from multiple organizations, as well as with representatives from key policy-making bodies such as Solar Energy Corporation of India Limited (SECI), the Ministry of New and Renewable Energy (MNRE), and the World Bank to understand the vision, future potential, and direction for FSPV plants in India.

As per consultations with industry representatives from NTPC Limited, National Hydro Power Corporation and Green Jobs Skill Council, to understand the emerging skills requirement, challenges and opportunities in the sector, a framework (refer **Figure 1.5**) for identifying the skills has been developed.

**As-Is Analysis and Leading Practice Study:** In this phase, a study of the skill set requirements from Green Jobs Skilling initiative, internal database and leading practices (FSPV-related roles and skills) across select countries (China, Japan and Singapore) was undertaken to understand skill requirements and capacity-building initiatives. The occupational standards were studied to understand the role requirements and existing skills in India from

a solar PV requirement perspective. Further, particular leading global organizations were studied across multiple countries to identify focus areas in the FSPV sector. Lessons were taken from organizations such as Ciel et Terre, ABB, Bayer, Swimsol and Sungrow which have developed technology, components and the end-to-end FSPV plants. **Table 1.1** on next page highlights some of the leading practices.

**Mapping of Roles:** Based on an understanding of the existing ecosystem and inputs from leading practices, unique roles were identified. These unique roles were aligned to the FSPV value chain (**Table 1.2** provides a breakup of these roles). Role analysis was undertaken to identify the knowledge, skills, experience and behavioral attributes required for these roles. Leveraging understanding of the market and industry from previous steps, skill gaps were identified in terms of emerging and existing skills for each role.

**Challenges, Mitigation Plan and Implementation Framework:** Post identification of the skill gaps and emerging skills, various trainings available across multiple disciplines for bridging the skill gap is suggested.



**TABLE 1.1: Leading Practices**

Development of the “floatovoltaic” technology in China, which also preserves waterbodies from algae proliferation and oxidation and conserves water sources by reducing evaporation.
Focus on space efficiency and climate change with FSPV plants in Japan when building their solar plants on lakes and reservoirs.
Growth in Offshore (marine) PVs, island micro-grids and heavy-duty tropical solar PV systems in Malaysia and the Maldives.
The key focus, overall, is on reliable and efficient floating mounting system (floaters) with safe anchoring methods.
Key emerging skills include hydrology, bathymetry, anchoring/mooring and diving, in addition to solar PV skills in manufacturing, feasibility studies, installation, O&M.
Demand is surging for highly skilled workers in the fields of marine architecture, plastic blow moulding, hydrography and the so on.

**TABLE 1.2: Breakup of roles across FSPV value chain (the most common roles in the FSPV sector)**

	# of roles
Manufacturing & Procurement	9
Feasibility	4
Design & Development	18
Construction	10
O&M	7
Decommissioning	2

An implementation framework detailing the challenges and mitigation strategies has been developed to institutionalize the capacity-building process.

The subsequent chapters detail each of these steps and outline the key outcomes.



## 2. FSPV VALUE CHAIN AND SKILL GAP ASSESSMENT



# 2 FSPV VALUE CHAIN AND SKILL GAP ASSESSMENT

Based on mapping of the unique roles across the floating solar value chain, a detailed study was conducted to identify the skills required for each of these roles. The subsequent sections details the key roles and skills required at different stages of the value chain.

## 2.1. Manufacturing

India has a robust domestic demand opportunity. At the same time, the global trade dynamics can create opportunities for Indian manufacturers in the solar power sector, including the floating solar domain. With a growing focus on green sources of energy in the country, solar PV manufacturing in India is getting an impetus with easier acceptance across potential users. This may further leverage certain inherent advantages such as low cost of human resource capital, both white and blue collar (in India vis-à-vis international labour markets), ease of capital investment, maximizing

indigenization in a phased, systematic manner with minimal technology obsolescence exposure.

### 2.1.1. Occupation Skills and Key Roles

Dedicated focus on manufacturing for floating solar PV shall include solar PV modules, module support systems, pontoon/floating structure, mooring systems, grid connection equipment, central/string inverters, cables and connectors (water resistant clamp kits, bolt kits, fasteners etc.), transformers, Supervisory Control and Data Acquisition (SCADA), software and applications. To achieve manufacturing expertise and production excellence in all the components, research and development combined with adequate production and safety measures emerge as key skills required for FSPV manufacturing. A list of the key roles for equipment manufacturers is presented in **Table 2.1** below. The abbreviations, S-Senior, M-Middle, J-Junior,

**TABLE 2.1: Key roles identified at Manufacturing Stage**

Sub-stage	Roles
<b>Research and Development</b>	<ul style="list-style-type: none"> <li>Physicist (S/M)</li> <li>Chemists (S/M)</li> <li>Material Scientists (S/M/J)</li> </ul>
<b>Development &amp; Engineering</b>	<ul style="list-style-type: none"> <li>Industrial Production Managers (M)</li> <li>Electrical Component Engineer (M)</li> <li>Semiconductor Designer (J/M)</li> </ul>
<b>Production</b>	<ul style="list-style-type: none"> <li>Computer-Controlled Machine Tool Operators (J)</li> <li>Electrical and Electronic Equipment Assemblers (J)</li> <li>Coating and Painting Machine Operator (J)</li> <li>Welder (J)</li> </ul>



stand for the levels of roles in a typical organization hierarchy. These are management levels and not designations.

### 2.1.2. Skill Requirements

Businesses operating at this spectrum of the value chain develop, manufacture and sell FSPV components. This stage of the work is capital intensive. The skills involved are similar to those required in developing and manufacturing electronic components for solar PV modules. They include research skills in chemistry, physics, materials science, systems design and process engineering among other manufacturing skills. It requires a range of skills in fabricating, assembling and testing products, at levels including professional engineer, technician and manufacturing operator.

Qualifications such as Doctorate (Ph.D.), undergraduate/post-graduation degrees (B. Tech/M. Tech degree in electronics, electrical, mechanical engineering) or Diploma/Industrial Training Institute (ITI) or any other vocational certificate in specific area of work (electronics/instrumentation/electrical/fitter/welder) are sufficiently available in the market. While some traditional skills for the key roles identified cutting across the equipment manufacturing stage may exist, there is a need for specialists in areas such as FSPV material sciences (High Density Polyethylene [HDPE], Ultraviolet

[UV] resistance), marine physics, marine/ocean chemistry, naval architecture, ocean engineering, and those requiring knowledge/experience of offshore platforms.

While existing skills relevant to rooftop and ground mounted solar PV shall be required for manufacturing of FSPV solar modules, there is a need to build capabilities around certain emerging skills.

**Table A.1 in Appendix A** lists the requisite technical skills required for the key roles at this stage of value chain.

## 2.2. Feasibility

Floating solar presents several technical, socio-economic and environmental challenges in line with commercial and other feasibility considerations. Active project/business development is necessary to overcome the potential risks which arise during and after implementation of floating solar projects. Project/business development for floating solar is spread across multiple phases or activities including site identification/conceptualization stage, pre-feasibility analysis, environmental impact assessments and financing/contract management.

The key activities and the unique roles associated at this stage of the floating solar plants are highlighted in **Figure 2.1**.

**FIGURE 2.1: Feasibility sub-stages**



### 2.2.1. Occupation Skills and Key Roles

The initial stage includes activities related to identification of specific waterbodies (natural or man-made reservoirs) and land. Similar to the development of a conventional ground-based plant, the executives are required to assess desirable sites with favourable climatic conditions, availability for leasing/agreements, grid connections, and environmental/social concerns associated with development of FSPV plant.

The executives are expected to undertake legal and technical assessment of the overall site, conceptual design (including financial impact, estimation of installed capacity), approximate costs (for land, construction and operation), energy yields and estimates the overall timelines and anticipate any changes expected in the regulatory environment. Further, workers are required to be adept at technical design of the system (layouts, site topographical plan, water information, drag forces calculations, solar resource calculations, cabling and connection layouts and grid connections), permissions and Health, Safety and Environment (HSE) requirements (permissions and licencing for construction & operation of plant, social impact assessments, environmental clearances), financial feasibility (Power Purchase Agreement, using market based instruments, negotiation of tariffs) and commercial aspects (overall implementation plan of the construction and operation).

Key roles identified during this stage are listed in **Table 2.2** below:

### 2.2.2. Skill Requirements

Large solar project/business development involves obtaining licences, permits after conducting suitable site surveys and technical, commercial, environmental, social and financial feasibility of the project. There is a similarity between the skills required for a ground/roof top based solar setups and floating solar setups.

The main skills associated with solar PV installations require identifying suitable sites, obtaining permissions, negotiating with public and private parties with respect to agreements and contract management with relevant parties. It also involves skills relevant to technical designs of the solar plant, legal framework, and coordination with other public (national/state) utilities and private parties or services concerned with obtaining consent from communities, politicians or other interested groups.

As with implementation of solar projects, it requires adequate expertise in feasibility study and analysis of large-scale power projects. Occupations involved in this stage are mostly restricted to middle-senior level management which may involve engineers (with multi-disciplinary skills), professions related to meteorology, lobbyists, negotiators, public relations, legal, and financial occupations. Skills related to assessment of project impact including social science, environmental planning, specializations in economics and risk assessment also add value to the roles.

In addition to all the skills required in a conventional ground mounted installation,

**TABLE 2.2: Key roles identified for Feasibility stage**

Sub-stage	Roles
Concept Development & Site Identification	Solar PV Business Development Executive (J)
Pre-Feasibility Study	Solar Proposal Evaluation Specialist (M)
Feasibility Study	Solar Proposal Evaluation Specialist (M) Proposal Development Specialist
Permitting, Contracts & Financing	Business Development Manager (M/S)

floating solar installations require skills specific to waterbodies and related assessments.

Key occupations in any solar installation project/business development including floating solar are centred around assessment of environmental, social and technical impact of installation of PV modules (on floats) on waterbodies. Initial site assessments require adequate expertise in Geographic Information System (GIS)-based study focused on waterbodies to identify optimum surface area for the installations.

Key skills which are required during project development of a FSPV plant are bathymetry/hydrography, topography, hydrology experts, soil testing and assessment of environmental and social aspects (social usages of waterbodies such as fishing, farming, navigation, drinking etc) and project layout design. Project design requires skills in meteorology, assessment of water information (crucial for calculations

related to drag forces, anchoring & mooring of floats and end/safe loads).

**Table A.2 in Appendix A** lists the requisite skills and knowledge required for the key roles at this stage.

## 2.3. Design and Development

In India, FSPV as a technology is still in the developing phase and there are several critical elements including methods/steps for design and development of the FSPV plants. Concisely, major steps involved during the project design and development phase and associated roles are depicted in **Figure 2.2**.

### 2.3.1. Occupation Skills and Key Roles

The entity developing the project could be involved in obtaining finance/funds, identifying a suitable area, obtaining clearances from various regulatory bodies, negotiating

**FIGURE 2.2: Flow chart of floating solar PV project design**

Site Assessments	Bathymetry and Soil Testing	Environment and Social Impact Assessment	Project Design
<ul style="list-style-type: none"> <li>Field visit</li> <li>GIS based studies</li> <li>Site access</li> <li>Type of waterbody</li> </ul>	<ul style="list-style-type: none"> <li>Soil properties</li> <li>Elevation of waterbody</li> <li>Anchoring &amp; mooring feasibility</li> <li>Bathymetric Surveys</li> <li>Geotechnical</li> <li>Wind speed, direction etc.</li> </ul>	<ul style="list-style-type: none"> <li>Impact on biodiversity</li> <li>Impact on fishing, farming</li> <li>Socio economic survey</li> <li>Environment and Social Management Framework</li> </ul>	<ul style="list-style-type: none"> <li>Substation Design</li> <li>Structural Design (foundation, mounting)</li> <li>Anchoring Design</li> <li>Switchyard design</li> <li>Civil, electrical and mechanical design</li> </ul>

#### Key Roles

Site surveyor	Geotechnical Engineer	Environmental Scientists	Electrical Engineer	Solar PV Installer (Civil) -Anchoring Designer
Atmospheric scientists/ meteorologists	Bathymetrist/Hydrologist	Environment & Social Impact Assessment Specialist	Structural Design Engineer	Bathymetrist/ Hydrologist
Wind Energy Analyst	Hydrologic Engineer		Solar PV Designer	Substation Design Engineer
	Hydrologic Technician		Solar PV Installer	Computer software developers
	Soil Testing Technician			

contractual arrangements on power supply, contracting for the commissioning of engineering works, purchasing solar panels and ancillary components etc. It will also subcontract services, such as technical design services, legal services, impact assessment on communities, organizations and other interest groups amongst others.

The occupations involved in this stage of the value chain reflect the diverse range of activities carried out. Most of the roles are at senior and middle level reflecting high skill requirements, with some support staff. Key areas where skills are required during pre-construction and design of the project include civil, electrical, mechanical and environmental engineering. These skills support the value chain through the design of mounting, anchoring, mooring and other physical infrastructure; installation,

testing and commissioning different electrical components of PV systems. Skills involved in assessing the project's impact and feasibility include social science, hydrology, geology, ecology, sociology, and specialists in economics, finance and risk assessment.

Key roles identified during this stage are listed in **Table 2.3** below:

### 2.3.2. Skill Requirements

Qualifications such as an engineering degree in civil, electrical, mechanical field or Diploma/ ITI or any other vocational certificate in specific area of work (instrumentation/electrical/fitter/welder) cut across the value chain and may be available sufficiently in the market. While some traditional skills for the key roles identified in **Table 2.5** cutting across the design and

**TABLE 2.3: Key roles identified at Design and Development stage**

Sub-stage	Roles
<b>Site Assessments</b>	<ul style="list-style-type: none"> <li>▪ Site Surveyor (M)</li> <li>▪ Atmospheric Scientists/Meteorologists (S/M/J)</li> <li>▪ Wind Energy Analyst (J/M)</li> </ul>
<b>Bathymetry and Soil Testing</b>	<ul style="list-style-type: none"> <li>▪ Geotechnical Engineer (J/M)</li> <li>▪ Bathymetrist/Hydrologist (J)</li> <li>▪ Hydrologic Engineer(J/M)</li> <li>▪ Hydrologic Technician (J)</li> <li>▪ Soil Testing Technician (J)</li> </ul>
<b>Environment and Social (E&amp;S) Impact Assessment</b>	<ul style="list-style-type: none"> <li>▪ Environmental Scientists (S/M/J)</li> <li>▪ Environment &amp; Social Impact Assessment Specialist (M)</li> <li>▪ Sociologist (S/M)</li> </ul>
<b>Project Design</b>	<ul style="list-style-type: none"> <li>▪ Electrical Engineer (Design) (M)</li> <li>▪ Energy Modeller</li> <li>▪ Structural Design Engineer (J/M)</li> <li>▪ Switchyard Engineer – Civil (M)</li> <li>▪ Solar PV Designer (M/S)</li> <li>▪ Solar PV Installer (Electrical) (J)</li> <li>▪ Solar PV Installer (Civil) – Anchoring Designer (J)</li> <li>▪ Substation Design Engineer (M/S)</li> <li>▪ Computer Software Developers (J/M)</li> </ul>

development stage may exist, there is a need for specialists in the areas such as geology, geophysics, oceanography, hydrography engineering, marine biology, environmental monitoring, and meteorology.

Further, for the existing skills there is a need for advanced level of specialization in areas such as design of under and over water civil structures, electrical and mechanical works. High levels of knowledge and proficiency in offshore first aid, fire-fighting and prevention and personal survival techniques are critical skills across levels and FSPV value chain.

**Table A.3 in Appendix A** lists the requisite skills required for the key roles during the Design & Development stage.

## 2.4. Construction

Construction activities in floating solar PV plants are expected to be comparatively more challenging than that of conventional ground

based/roof top solar plants. However, there can be fewer heavy civil installations for the floating solar plants.

All activities and task sequences can be classified and clustered into three main categories:

- Site Preparation
- Installation
- Commissioning

### 2.4.1. Occupation Skills and Key Roles

Activities in construction and commissioning of a FSPV plant involve civil, mechanical and electrical expertise including requirement of quality assurance of all related tasks.

The occupations in this segment of the value chain involve roles across the complete ladder—senior/mid/junior levels involving structural works, fitting, cabling, fixing of mooring and anchoring systems, floats

**FIGURE 2.3: A flow chart of floating solar construction**

Site Preparation	Installation	Commissioning
<ul style="list-style-type: none"> <li>• Site Access</li> <li>• Security Management</li> <li>• Foundation &amp; Supporting structure construction</li> <li>• Interface Management</li> </ul>	<ul style="list-style-type: none"> <li>• Finalization of Design of equipment</li> <li>• Mounting frame construction</li> <li>• Module installation</li> <li>• Substation Construction</li> <li>• Electrical Site Works</li> </ul>	<ul style="list-style-type: none"> <li>• Grid Connection works</li> <li>• Commissioning &amp; Testing</li> </ul>

#### Key Roles

Solar PV Technical Manager	Solar PV Project Manager (E&C)	Cable Installation Technician/Engineer	Solar PV Project Manager (E&C)
Project Engineer (Civil)	Solar PV Project Helper	Project Engineer (Civil)	Solar Site-in charge
Quality Assurance Executive	Solar PV Engineer	Quality Assurance Executive	Quality Assurance Executive
Roustabouts	Solar Site-in charge	Marine Fitter	Quality Assurance Manager
	Roustabouts		Roustabouts



installation, electrical system installation and, most importantly, installation of PV arrays on the floats and connecting them with the electrical systems.

Because of a significant divergence from the conventional installations, FSPV plants require additional due diligence in safety and quality assurance. Sub-standard installations can potentially lead to electrical, environmental and social hazards during O&M. It is also because of this that a typical FSPV requires skills pertaining to offshore/marine/submarine installations including connection of cabling, fixing floats and mooring systems, installation of platforms which necessitates requirement of low-skilled/semi-skilled/skilled roustabouts and fitters (having expertise in working on offshore installations).

Key roles identified during this stage are listed in **Table 2.4** below:

## 2.4.2. Skill Requirements

Key skills which are required during construction & commissioning also require qualifications like Bachelors/Diploma/ ITI or any other vocational certificate spanning across multiple domains including electrical, mechanical and civil fields.

FSPV plant requires skills with specific construction experience including working with heavy equipment for installations, knowledge of standards & drawings, project management along with differentiated skills required such as installation of structures and foundations/anchors after preparation of the project site, installation of PV arrays on floats and connecting them to cables and the electrical grid.

The marine fitters, divers and roustabouts should have the knowledge of local waters

**TABLE 2.4: Roles identified at Construction stage**

Sub-stage	Roles
<b>Site Preparation</b>	<ul style="list-style-type: none"> <li>▪ Technical Manager (M/S)</li> <li>▪ Project Engineer (Civil) (M)</li> <li>▪ Quality Assurance (QA) Executive (J/M)</li> <li>▪ Roustabouts (J)</li> </ul>
<b>Installation</b>	<ul style="list-style-type: none"> <li>▪ Project Manager (E&amp;C) (M/S)</li> <li>▪ Project Helper (J)</li> <li>▪ Engineer (M)</li> <li>▪ Solar Site-in charge (M/S)</li> <li>▪ Cable Installation Technician/Engineer (J/M)</li> <li>▪ Project Engineer (Civil) (M)</li> <li>▪ QA Executive (J/M)</li> <li>▪ Marine Fitter (J)</li> <li>▪ Roustabouts (J)</li> </ul>
<b>Commissioning</b>	<ul style="list-style-type: none"> <li>▪ Project Manager (E&amp;C) (M/S)</li> <li>▪ Site-in charge (M/S)</li> <li>▪ QA Executive (J/M)</li> <li>▪ QA Manager (M)</li> <li>▪ Roustabouts (J)</li> </ul>

and should also be able to work in marine and submarine conditions (depending on the type of installation). As a typical FSPV plant is prone to several potential hazards, special attention is required toward quality assurance and knowledge of technical standards and specifications for the installations (including water and soil considerations).

While existing skills will still be required for FSPV, as with other components of the value chain, there are specific activities pertaining to FSPV installations and the challenges therein (HSE and technical) which require additional expertise.

**Table A.4 in Appendix A** lists the requisite skills required for the key roles during this stage.

## 2.5. O&M

Once the floating solar plant is commercially operational, this stage of the value chain will become crucial as it will have a direct bearing on optimizing the energy yield of the plant and achieve and maintain a certain level of performance to meet the yield targets.

There are typically three types of maintenance performed to monitor a FSPV system.

### 2.5.1. Occupation Skills and Key Roles

A FSPV system is similar to a conventional solar PV system, the only difference being that it floats on the water surface rather than being situated on land. However, since FSPV plants are installed on a water surface, it is relatively difficult to perform O&M activities. Maintenance work in floating solar technology requires new skill sets, techniques and procedures. The occupations involved in this stage of the value chain range from junior to middle level, but due to the complex activities to be performed, a diverse set of skills is required which includes civil, electrical, electronics and hydro engineering, equipment installation and maintenance including marine equipment, SCADA systems, knowledge of local waters, experience of electrical wiring, cabling, in-depth understanding of the pontoon structure and, most importantly, diving skills.

Key roles identified during this stage are listed in **Table 2.5** on next page:

**FIGURE 2.4: A flow chart of floating solar Operations & Maintenance**

Preventive Maintenance	Corrective Maintenance	Predictive Maintenance
<p>Planned routine inspection on a regular basis Maintenance at predetermined intervals to ensure plant's stability</p> <p>Prevent the plant breakdown or damage</p>	<p>Corrective Maintenance or unscheduled maintenance in case of breakdown or malfunction in one of the components of a plant</p>	<p>Maintenance is performed using real time data analytics to predict possible failure</p> <p>Aim is to sustain long term efficiency of a solar power plant</p>

#### Key Roles

Solar PV O&M Engineer	Switchyard Engineer	Solar PV Manufacturing Technician / Operator
Solar PV O&M Technician - Electrical	Solar PV O&M Technician - Civil	Marine Operation Technician
	Surface Supplied Air Diver	

**TABLE 2.5: Roles identified at Operations & Maintenance Stage**

Roles	
<ul style="list-style-type: none"> <li>▪ Solar PV O&amp;M Engineer (M)</li> <li>▪ Switchyard Engineer – Electrical (S/M)</li> <li>▪ Solar PV Manufacturing Technician/Operator (M/J)</li> <li>▪ Solar PV O&amp;M Technician – Electrical (M/J)</li> </ul>	<ul style="list-style-type: none"> <li>▪ Solar PV O&amp;M Technician – Civil (M/J)</li> <li>▪ Marine Operation Technician (J)</li> <li>▪ Surface Supplied Air Diver (S/M)</li> </ul>

### 2.5.2. Skill Requirements

The skill requirements for this value chain stage are similar to those required for designing and installation of a floating solar power plant. Basic academic qualifications include an engineering degree in the civil, electrical, mechanical fields or Diploma/ITI or any other vocational certificate in a specific area of work. This is sufficiently and readily available in the current market; however, there is a need for specialists in areas such as marine and hydro engineering. Further, for the existing skills there is a need for advanced level of specialization in areas such as O&M of under and over water civil structures, electrical and mechanical works, knowledge and proficiency in offshore first aid, fire-fighting, and knowledge to maintain personal health and safety at project site.

While existing skills required to install a solar PV on land or rooftop will be still required for FSPV, there is a need to build capabilities around some of the emerging skills. **Table A.5 in Appendix A** lists the skills required for the key roles at the O&M stage.

## 2.6. Decommissioning

When the floating solar project reaches the end of its operational life, the component parts are dismantled and recycled. All waste resulting from the decommissioning of the floating solar plant are transported and taken to a landfill/recycling facility in accordance with laws and rules. There are two parts to the decommissioning: Disassembling and Restoration.

### 2.6.1. Occupation Skills and Key Roles

The key activities and plan for decommissioning are generally conducted by existing construction and commissioning workers/roles. The skill set required would be similar to the roles identified including engineers (Civil, Electrical), technicians, roustabouts, quality assurance, divers, and marine fitters. The roles of restoration shall include two additional roles which are important from the perspective of recycling, restoration and overall project management to ensure adherence to laws, and creating an environment-friendly ecosystem. The list of roles is presented in **Table 2.6** below.

**TABLE 2.6: Roles identified at Decommissioning stage**

Sub-stage	Roles
<b>Project Management</b>	Decommissioning Program Manager (M/S)
<b>Restoration</b>	Recycling specialist (J/M)

### 2.6.2. Skill Requirements

Decommissioning skill needs are fulfilled in multiple ways. The most common way is, where possible, re-deploying existing staff with spare capacity who also work on development and production activities. A range of new skills and job roles are also likely to be required for future decommissioning. These include skills in robotics and mechanisation, digital skills and innovative design and systems engineering skills to simplify decommissioning. **Table A.6 in Appendix A** details the key skills required at this final stage of the value chain.

While technical skills are important for performing jobs, behavioural skills help determine how the work is done. With time there has been greater emphasis on behavioural skills in addition to technical skills and qualifications to ensure success in workplace. Certain key behavioral skills identified across levels for FSPV are:

- Communication
- Stakeholder Management

- Problem solving
- Decision making
- Analytical skills
- Teamwork
- Flexibility/Adaptability
- Attention to detail

**Table 2.7** below details these behavioural skills.

**TABLE 2.7: Behavioural Skills**

Behavioural Skills	Description
<b>Communication Skills</b>	<ul style="list-style-type: none"> <li>▪ Good verbal and written communication skills</li> <li>▪ Present information in a clear and concise manner</li> <li>▪ Negotiate with key stakeholders</li> </ul>
<b>Stakeholder Management</b>	<ul style="list-style-type: none"> <li>▪ Interaction across different levels in the organization</li> <li>▪ Building relationships</li> </ul>
<b>Problem Solving</b>	<ul style="list-style-type: none"> <li>▪ Root cause analysis</li> <li>▪ Identify recurrent problems and find solutions</li> <li>▪ Leverage resources to arrive at solution</li> </ul>
<b>Decision making</b>	<ul style="list-style-type: none"> <li>▪ Timely decision making</li> <li>▪ Evaluate impact of decisions</li> </ul>
<b>Analytical Thinking</b>	<ul style="list-style-type: none"> <li>▪ Interpret data/information</li> <li>▪ Derive patterns</li> <li>▪ Logical and organized representation</li> </ul>
<b>Attention to Detail</b>	<ul style="list-style-type: none"> <li>▪ Thoroughness and accuracy</li> <li>▪ Provide accurate and consistent outputs in paperwork</li> </ul>
<b>Teamwork</b>	<ul style="list-style-type: none"> <li>▪ Collaboration</li> <li>▪ Cross-functional teaming</li> <li>▪ Team Management</li> </ul>
<b>Flexibility/Adaptability</b>	<ul style="list-style-type: none"> <li>▪ Adapt to changing circumstances</li> <li>▪ Create opportunities for change through active participation</li> </ul>

# 3. BRIDGING THE SKILL GAPS AND BUILDING CAPACITY



# 3 BRIDGING THE SKILL GAPS AND BUILDING CAPACITY

Skill development has long been a focal point for the government. Skill India was launched in 2015 to train over 40 crore people in India in different skills by 2022. To date, Skill India has trained 2.5 crore people on more than 2,500 job roles under 37 sector skill councils. Also, Suryamitra Skill Development Programme was launched to develop the skills of youth, considering the opportunities for employment in the growing solar PV power projects' installation, O&M in India and abroad.

Skills training for various trades related to the power industry are being offered in both public and private institutions including ITIs (Industrial Training Institutes), ITCs (Industrial Training Centres) and VTIs (Vocational Training Institutes). However, there is a need to strengthen and offer new courses and curriculum around RE, floating solar, and tidal energy, hence, provision for specialized skill is required in the industry.

As outlined earlier in the report, apart from the traditional skills and qualifications there is a need for specialists in areas such as geology, geophysics, oceanography, hydrography engineering, marine biology, environmental monitoring, meteorology etc. Further, for the existing skills, there is a need for an advanced level of specialization in the areas such as design, construction, operation and maintenance of under and over water civil structures, electrical and mechanical works. High level of knowledge and proficiency in offshore first aid, fire-fighting and prevention and personal survival techniques is a critical skill across stages in the FSPV value chain.

To meet the skill gaps, organizations can look to allied fields such as offshore wind, marine and naval operations or rig operations to acquire the necessary personnel. However, as the clean energy portfolio grows, some of the existing skills/manpower may become obsolete. To ensure manpower continuity, organizations must re-train their existing talent to build a future-ready workforce. This will reap multi-fold benefits for the organizations including eliminating cost and time invested in hiring fresh talent, improved employee morale, operations continuity, and balance between traditional and RE portfolios.

Organizations and policy-making bodies (such as MNRE, SECI etc.) can collaborate with institutes (for example, power training institutes in India and partner institutions with sector skill councils) to impart the necessary trainings to workers and bridge the skill gap. Some of the institutes in India offering generic and specialised courses in floating solar technology and allied disciplines are National Power Training Institute (NPTI), Institute of Solar Design, National Institute of Hydrology, National Institute of Wind Energy (NIWE), Central Institute of Plastics Engineering & Technology (CIPET), Indian Institute of Tropical Meteorology and Council of Scientific and Industrial Research (CSIR)-National Institute of Oceanography.

The **Table 3.1** on next page highlights some of the training courses available for bridging the skill gaps emerging in FSPV.

**TABLE 3.1: Training Courses**

Skills	Trainings/Courses	Institute
<b>General Courses</b>	Post Graduate Diploma Course (PGDC) in Renewable Energy and Grid Interface Technologies	NPTI
	PGDC in Energy Market Management	National Power Training Institute
	Sustainable Energy Systems	School for Environment & Safety (University of Michigan)
	Skill Development Training Program on Renewable Energy	NPTI
	Floating Solar Plant Design Course	Advance Electrical Design and Engineering Institute
	Clean Energy Technologies	NPTI
	Master of Science in Energy Management	University of Texas
	Development of FSPV in India	NPTI
	Renewable Energy Grid Interface Technology & Regulatory Framework	NPTI
	Renewables Certification training courses	Det Norske Veritas (DNV)
<b>Equipment Manufacturing</b>	B.E/B. Tech (Plastics Engineering/ Technology)	CIPET
	M.E/M. Tech (Plastics Engineering/ Technology)	CIPET
	M.Sc. Tech. (Material Science & Engineering)	CIPET
	Diploma in plastic technology	CIPET
	Post-graduate diploma in plastic processing and testing	CIPET
	Diploma in plastic mould technology	CIPET
	Economic and environment issue in material selection	Massachusetts Institute of Technology
	Diploma in Plastics Technology	CIPET
<b>Business Planning</b>	Design, Operation, Economic Evaluation of Floating Solar and Wind Integration	NPTI
	Hybrid Renewable Energy Systems	NPTI
	RE – Solar Financial Modelling	Corporate Finance Institute
<b>Design &amp; Pre-Construction</b>	Certificate in Floating Solar Project Design	Institute of Solar Design
	Geo Spatial Technologies	NPTI
	National Training Course on Wind Resource Assessment	NIWE



Skills	Trainings/Courses	Institute
	M.E Computer-aided design/Computer-aided manufacturing (CAD/CAM)	CIPET
	Certificate in Hydrogeology	DNV
	Hydrodynamics and Wave-Structure Interactions	Solar Energy Research Institute of Singapore (SERIS)
	Offshore Structural Systems	SERIS
	e-Course on Hydro-Meteorological and Climate Data Analysis: Basic and Advanced Techniques	National Institute of Hydrology
	Hydrological Investigations for conservation and management of springs, lakes and wetlands	National Institute of Hydrology
	Advanced Tools and Techniques for Hydrological Investigations	National Institute of Hydrology
	Climate Change and Hydrological Impact Assessment	National Institute of Hydrology
	Hydrological Modelling using Soil & Water Assessment Tool	National Institute of Hydrology
	Assessment of Reservoir Sedimentation Using Geo-Spatial Technique and Quantum Geographic Information System	National Institute of Hydrology
	Data Processing for Water Quality	National Institute of Hydrology
	Hydrological Modelling using HEC-RAS & HEC-Root Mean Square	National Institute of Hydrology
	Groundwater Modelling Using Visual Modflow	National Institute of Hydrology
	Advanced Hydrology	National Institute of Hydrology
	MSc. In Oceanography	National Institute of Hydrology
	Training on Biological Oceanographic Process	CSIR-National Institute of Oceanography (NIO)
	Geological Oceanography	CSIR-NIO
	Diploma in Meteorology and Atmospheric Sciences	Indian Institute of Tropical Meteorology
	M.Sc. in Meteorology	Indian Institute of Tropical Meteorology
<b>E&amp;S Impact Assessment</b>	Environmental Impact Assessment and Environment Management Plan	NPTI
	Post Graduate Diploma in Environmental Pollution Control Technology	Indian Institute of Environment Management
	Post Graduate Diploma in Sustainable Environment Management	Indian Institute of Environment Management

Skills	Trainings/Courses	Institute
<b>Construction &amp; Commissioning</b>	HVDC Submarine power cable course	DNV
	HVDC power cable course	DNV
	Ageing, QA, Testing, Diagnostics and Failures of MV and IT ISHV Power Cables course	DNV
<b>Health &amp; Safety</b>	Fire Prevention and Firefighting (Basic)	Standards of Training, Certification and Watchkeeping (STCW)
	Elementary First Aid	STCW
	Personal Survival Techniques	STCW
	Personal Safety and Social Responsibilities	STCW
	Proficiency in Security Awareness	STCW
	Emergency Preparedness and Crisis Management	DNV
	Open Water Diver Course	Professional Association of Diving Instructors
<b>Information &amp; Communication Technology</b>	Cyber Security in Power Sector	NPTI
	Adoption of Big Data and Analytics – Towards Utilities Transformation	NPTI

Besides the gaps in skills, there are other roadblocks that limit the skill development interventions for floating solar in India. The following section details some of these challenges and corresponding mitigation plans in detail.

### 3.1. Key Challenges and Overview of Mitigation Strategies

**Limited focus on FSPV related skills as the sector is in a nascent stage:** To narrow the skills gap with respect to floating solar in the industry, there is a need to undertake robust training and skill development programs. Organizations must focus on retraining and upskilling their existing resources in collaboration with training academies, VTI, and participation in other public-private initiatives, Research & Development (R&D) efforts, and so on.

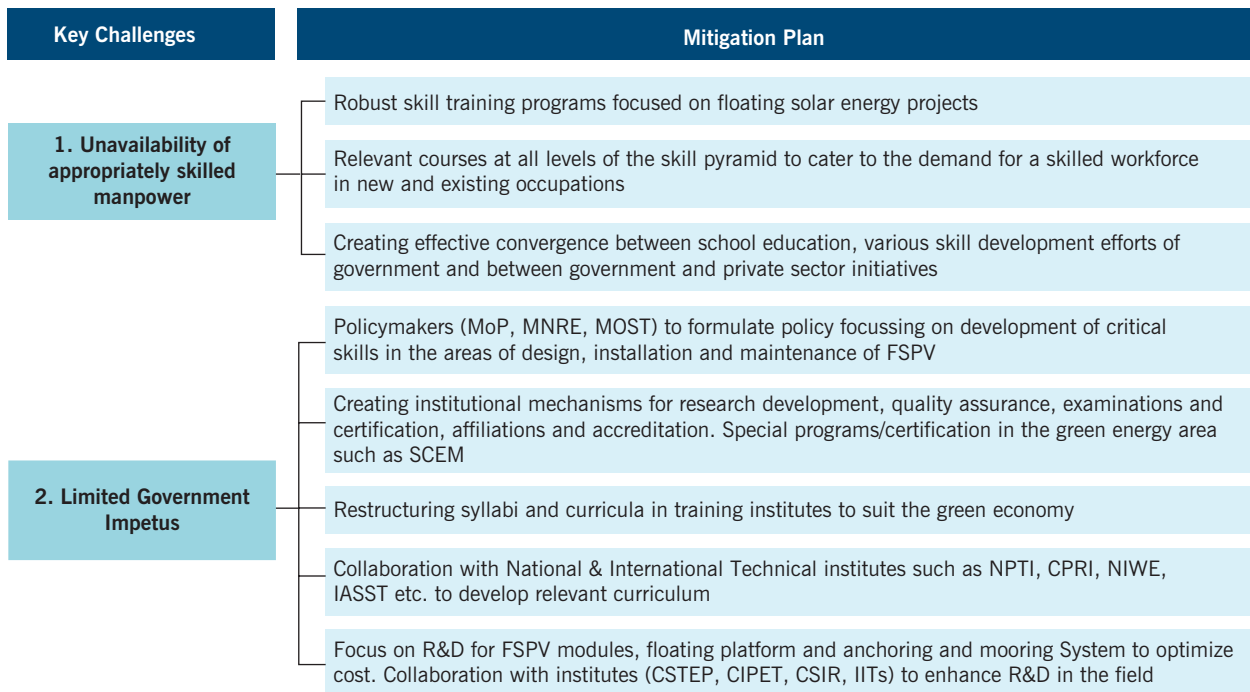
These training programs should cover employees at junior, middle and senior levels,

including blue-collared employees. Further, to build a pipeline of appropriate manpower, effective convergence must be created between school education, various skill development efforts by the government and between government and private sector entities.

**Limited Government Impetus:** Skill India recently established the Centre of Excellence for Skill Development in Power Sector on the campus of the National Institute of Solar Energy in partnership with Government of France. This Centre of Excellence will focus on creating a pool of highly skilled trainers and assessors for further training to increase the employability of candidates in the fields of electricity, automation, and floating solar.

There is a need to create institutional mechanisms (institutes, laboratories, research centres, testing centres with adequate resources for R&D, quality assurance, examinations and certification, affiliations and accreditation). Collaboration with institutes such as Centre

**FIGURE 3.1: Skill Development Challenges and Mitigation Plan (Part A)**



for Study of Science, Technology and Policy, CIPET, CSIR and Indian Institute of Technology (IIT) will help optimize cost by focusing on R&D for FSPV modules, floating platform and anchoring and mooring systems. Further, restructuring syllabi and curricula on the green economy through collaboration with National & International Technical Institutes such as NPTI, Central Power Research Institute (CPRI), NIWE, Renewable Energy Institute (Japan), SERIS, Massachusetts Institute of Technology Energy Studies, University of Michigan Renewable Energy Programs, University of Texas at Austin Renewable Energy Programs and other relevant colleges/institutes/universities will accelerate capacity building.

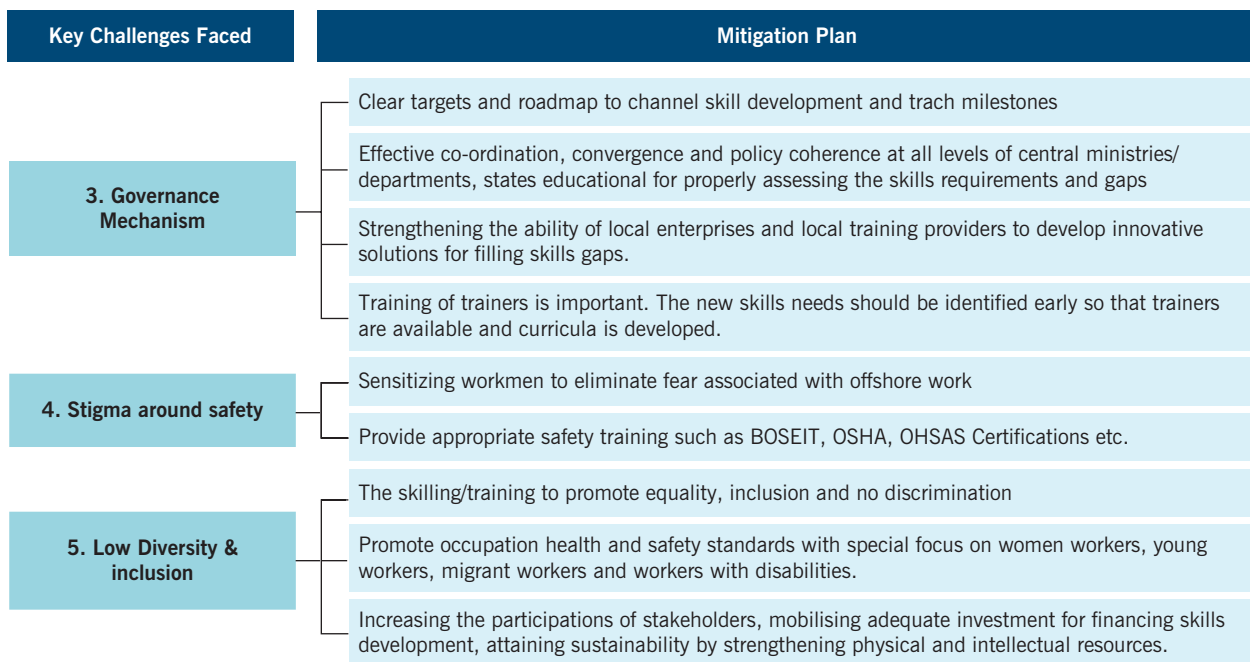
**Establish a Governance Mechanism:** To ensure continuous skill development and provide direction for future efforts, there is a need to create a roadmap for skill development in the FSPV sector (initiatives, targets, timelines, responsibility, financing, partners, risk and mitigation plan) and establish a governance mechanism. Effective co-ordination,

convergence and policy coherence at all levels of central ministries/departments and states are necessary to properly assess the skill requirements and gaps. Further, trainers must be trained and local enterprises and local training providers strengthened to develop innovative solutions that can fill skill gaps.

**Stigma around safety:** Unskilled and semi-skilled manpower are fearful while working on offshore areas. There is a need to sensitize the workforce and provide them with adequate expertise and training related to diving skills, survival, technical, and crisis management to help them feel confident and secure when working offshore.

**Low diversity and inclusion:** The energy sector remains one of the least gender diverse sectors. Despite making up 48 percent of the global labor force, women account for only 22 percent of the traditional energy sector. Developing internal policy frameworks, sensitizing people and incorporating trainings to promote equality, inclusion and zero discrimination will build

**FIGURE 3.2: Skill Development Challenges and Mitigation Plan (Part B)**



employee confidence and comfort in working in a diverse workplace. Promoting occupation health and safety standards should be done with special focus on women workers, young workers, migrant workers and workers with disabilities. Identifying roles that can be staffed by women and people with disabilities will enhance diversity in the sector. This, along with increased participation of stakeholders, mobilization of adequate investment for financing skills development and attaining sustainability by strengthening physical and intellectual resources, will help reduce the diversity gap in the energy sector.

### 3.2. Skill Implementation Framework

A skill implementation framework is necessary to ensure a nationwide skill enhancement for FSPV relevant skillsets.

The key skilling methodologies in green growth and sustainability were studied across nations such as Singapore, Australia, Korea and Thailand.

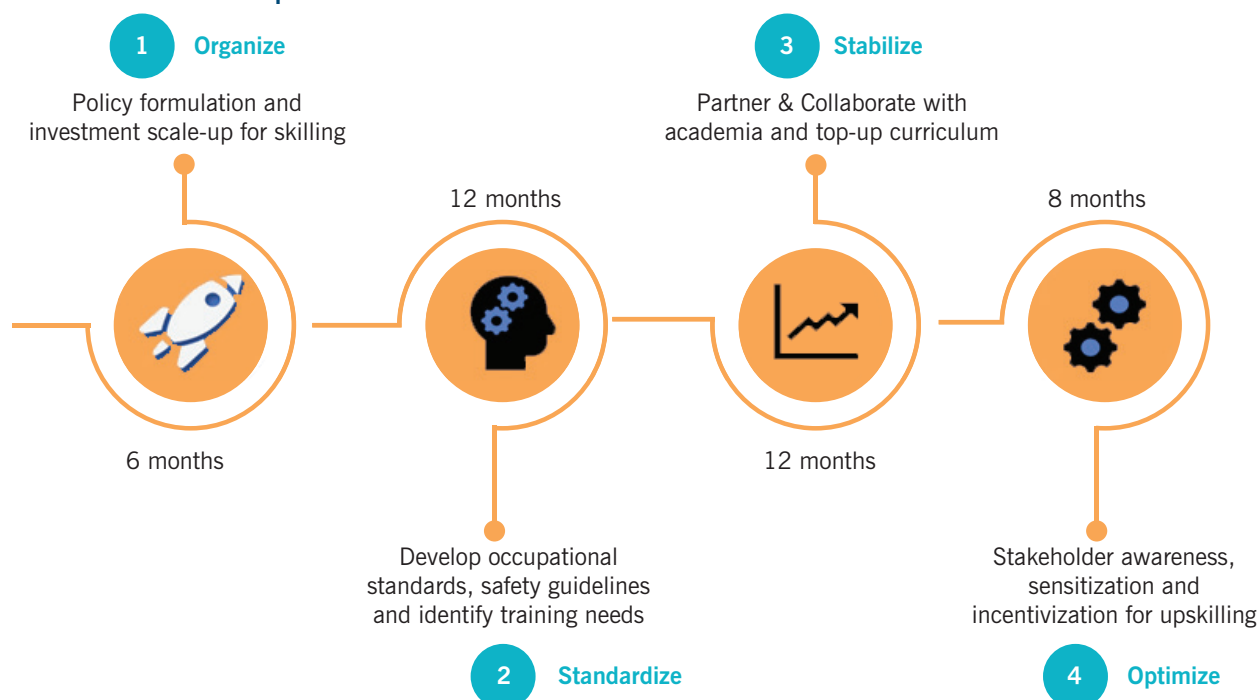
India’s National Action Plan on Climate Change focuses on the National Solar Mission to promote the development and use of solar energy for power generation and other uses. It also includes the establishment of a solar research centre, increased international collaboration on technology development, strengthening of domestic manufacturing capacity, increased government funding and international support. The adoption of greener technology in the sectors identified by the low-carbon strategy would bring about a change in the occupational structure and associated skill sets of the labour market. The quantity and quality of jobs, as well as the availability of skills to access those jobs, affects the transformation to the green economy at the local level, particularly when a large part of the workforce is engaged in the informal sector and does not have any skill training. Hence, for effective skilling, the framework in **Figure 3.3** can be explored.

**Organize:** Effective coordination is required among central ministries/departments, along with a comprehensive skilling policy for

**TABLE 3.2: Leading Practices**

Country	Key initiatives/programs
<b>Singapore</b>	<ul style="list-style-type: none"> <li>▪ The Singapore Certified Energy Manager program offers formal training and certification in energy management.</li> <li>▪ Building and Construction Authority conducted courses on sustainability and green building, including the Master of Science programs, in collaboration with the University of Nottingham and University College London.</li> <li>▪ Singapore, National University of Singapore (NUS) and Deltares (Netherlands). NUS and Delft University of Technology have developed a double master’s program in Hydraulic Engineering and Water Resources Management.</li> <li>▪ Certified Sustainability Professional and Green Collar Worker Program by the Singapore Business Federation.</li> </ul>
<b>Australia</b>	<ul style="list-style-type: none"> <li>▪ Employment services providers are helping industry and business address the emerging skills challenges in green collar jobs.</li> <li>▪ The National Green Skills Agreement contributes to the advancement of training to incorporate skills, the development of national standards, and teaching in vocational training.</li> </ul>
<b>Korea</b>	<ul style="list-style-type: none"> <li>▪ Education programs for R&amp;D specialists for green technology development.</li> <li>▪ Training programs facilitate retraining existing workers to be green workers.</li> </ul>
<b>Thailand</b>	<ul style="list-style-type: none"> <li>▪ Skill Development Promotion Act 2002 promotes green workplace training and learning. Under this act, private enterprises can benefit from certain tax privileges if they undertake qualified human development training.</li> <li>▪ Tripartite cooperation among ministries, government agencies, and private sector for future skills in solar PV installations.</li> </ul>

**FIGURE 3.3: Skills Implementation Framework**



FSPV (similar to the National Training Policy for the Power Sector). Various educational levels of green jobs/occupations, associated competencies, competency levels and assessments shall be created to meet the skills requirements of FSPV sector in India. The government could play a critical role in scaling up investment in FSPV skilling. The investment in clean development and green jobs has been growing fast in India in recent years as is evident from government expenditure in some of the key ministries responsible for promoting a green economy. However, this investment could be scaled up both at the state government and private levels.

**Standardize:** There is a clear need for improved training and certification programs to be accessible to workers of varying backgrounds and skill sets across the country. The Skill Council for Green Jobs should formulate Qualification Packs, National Occupation standards, and ensure future training programs to scale FSPV projects. The Skill Council for Green Jobs has been instrumental in training at a large scale for solar skills (for example, Suryamitra) and should have the mandate, expertise, and capacity to drive FSPV skilling in India. The safety risks, design and aesthetics associated with FSPV systems should be clearly taught.

**Stabilize:** Strengthen the ability of local enterprises and local training providers (it is,

and training partners of the power sector skill council and the Skill Council for Green Jobs) to develop innovative solutions for filling skills gaps. Existing national institutions (IITs, National Institute of Technology, Indian Institute of Science, regional/state engineering colleges) providing science, technology, engineering, and mathematics (STEM) education can be strengthened by updating curriculum and syllabi with respect to floating solar related mechanical, electrical and civil systems, health and safety training and focus on marine institutes for inculcating skills relevant to the FSPV sector. Also, existing institutes in the power industry (such as NPTI, CPRI, National Institute of Solar Energy, Tata Power Skill Development Institute, Adani Power Training and Research Institute, Reliance Energy Management Institute, NTPC School of Business, The Energy and Resources Institute or TERI) may be leveraged to run FSPV specific programs to train the existing workforce.

**Optimize:** Stakeholders across different spheres of economic activities can be sensitized to FSPV, its safety and environmental concerns, through media campaigns, street plays, art forms, and school curricula. Educating workers, employers, civil society, and policy planners would help FSPV gain traction in India. The implementation of synchronous solutions for linking skills training to employment, fostering awareness and incentivization for diversity in workforce should be considered.

# APPENDIX





# APPENDIX A: ROLE-WISE SKILLS

## Manufacturing Skills

**TABLE A.1: Role-wise skills requirement-Manufacturing**

Roles	Skills & Knowledge
<b>Physicist (S/M)</b>	<ul style="list-style-type: none"> <li>▪ Mathematics and Computation knowledge</li> <li>▪ Research and data collation skills</li> <li>▪ Data analysis, integration, modelling, and testing skills</li> <li>▪ Able to conduct advanced research in FSPV</li> <li>▪ Physics related to floating PV</li> <li>▪ Working knowledge of Applied Marine physics (currents, air-water interaction, heat exchanges and circulation patterns)</li> </ul>
<b>Chemists (S/M)</b>	<ul style="list-style-type: none"> <li>▪ Semiconductor design and development</li> <li>▪ Ability to conduct data analysis, integration, modelling, and testing</li> <li>▪ Knowledge of FSPV related Material Sciences (HDPE, UV, corrosion resistance materials)</li> <li>▪ Knowledge of Marine/Ocean Chemistry (application-based design)</li> </ul>
<b>Materials scientists (S/M/J)</b>	<ul style="list-style-type: none"> <li>▪ Understanding of Material Science &amp; applied Metallurgy</li> <li>▪ Ability to conduct data analysis, integration, modelling, and testing skills</li> <li>▪ Knowledge of materials processing and fabrication for structures</li> <li>▪ Ability to conduct FSPV structural analysis</li> <li>▪ Up-to-date knowledge of solar-related technology innovation</li> <li>▪ Knowledge of Naval material science (application and testing)</li> </ul>
<b>Industrial production managers (M)</b>	<ul style="list-style-type: none"> <li>▪ Understand solar cell material type and characteristics</li> <li>▪ Analysis of application relationship between cell type and energy</li> <li>▪ Knowledge of process and packaging (materials) technology</li> <li>▪ Demonstration of working knowledge pertaining to cell manufacturing technology</li> <li>▪ FSPV process development</li> <li>▪ Knowledge of Assembly technology of solar products especially FSPV</li> </ul>
<b>Electrical Component Engineer (M)</b>	<ul style="list-style-type: none"> <li>▪ Understanding of Grid Connection studies for renewables</li> <li>▪ Working knowledge of SCADA – equipment working, procedures, data analysis, actions</li> <li>▪ Having working knowledge of High Voltage Substation Engineering, on technical activities in international context</li> <li>▪ Experience in Power System on RMS/Electromagnetic transient modelling</li> <li>▪ Understand international environment and design practices in electrical power industry including underwater/floating sea cabling</li> </ul>

Roles	Skills & Knowledge
	<ul style="list-style-type: none"> <li>▪ Ability to work on Solar Power Plant String Combiner Box/Alternate Current (AC) Distribution Board (ACDB)/MDB/Metering cubicle for FSPV related applications</li> <li>▪ Understanding and working knowledge of Inverters Selection and Sizing (Grid Connection and Off Grid) for FSPV applications</li> </ul>
<b>Semiconductor processors designers (J/M)</b>	<ul style="list-style-type: none"> <li>▪ Development and testing of Chemical Composition</li> <li>▪ Very large-scale integration/Large-Scale Integration Manufacturing knowledge</li> <li>▪ Usage of Electronics &amp; Computer Language</li> <li>▪ Knowledge of Device physics for solar cell</li> <li>▪ Knowledge of PV and material physics</li> <li>▪ Advanced Chemistry Cell Technology</li> </ul>
<b>Computer-controlled machine tool operators (J)</b>	<ul style="list-style-type: none"> <li>▪ Knowledge of Production procedures</li> <li>▪ Ability to read blueprints, schematics and manuals</li> <li>▪ Ability to handle Computer Numerical Control (CNC) equipment, moulds etc.</li> <li>▪ Working knowledge of repairing machines or systems using the needed tools</li> <li>▪ Operation Monitoring - Watching gauges, dials, or other indicators to make sure a machine is working properly</li> <li>▪ Quality Control Analysis - Conducting tests and inspections of products, services, or processes to evaluate quality or performance (with focus on effects of water quality, evaporation)</li> </ul>
<b>Electrical and electronic equipment assemblers (J)</b>	<ul style="list-style-type: none"> <li>▪ Knowledge of electrical standards</li> <li>▪ Evaluating information to determine compliance with standards</li> <li>▪ Development environment software</li> <li>▪ Working with Spreadsheet software</li> <li>▪ Working on Network connectivity terminal emulation software</li> <li>▪ Ability to read blueprints, schematics and manuals.</li> <li>▪ Conducting tests and inspections of products to evaluate quality or performance</li> </ul>
<b>Coating and painting machine operator (J)</b>	<ul style="list-style-type: none"> <li>▪ Ability to comprehend important documents like company's work instructions, quality policy, printed instructions and job specifications</li> <li>▪ Identify and mitigate Substrate/surface for oil/grease, dirt, salt or white patches/rust and imperfections</li> <li>▪ Knowledge of types of abrasive for blasting such as grits or shots</li> <li>▪ Selection of abrasives depending on substrate</li> <li>▪ Identify the factors (type of substrate/floor, type of contamination, desired cleaning grade, surface profile, etc.) for water borne equipment</li> <li>▪ Application of water resistant, and UV resistant paints/coats</li> <li>▪ Lamination techniques for water resistance</li> </ul>

Roles	Skills & Knowledge
<b>Welder (J)</b>	<ul style="list-style-type: none"> <li>▪ Setting up and taking down machine tools</li> <li>▪ Operating brazing and soldering equipment with high accuracy</li> <li>▪ Starting up, shutting down, monitoring and adjusting robotic welding tools</li> <li>▪ Usage of different tools to layout, fit and fabricate metal components</li> <li>▪ Usage of fillet and bull weld gauges</li> <li>▪ Experience in Tungsten Inert Gas, Metal Inert Gas and Arc welding</li> <li>▪ Dynamics and working knowledge of offshore welding techniques</li> <li>▪ Able to use of a range of grinders</li> <li>▪ Responsible for Coil testing for air leaks</li> </ul>

## Feasibility Skills

**TABLE A.2: Role-wise skills requirement-Feasibility**

Roles	Skills & Knowledge
<b>Solar PV Business Development Executive (J)</b>	<ul style="list-style-type: none"> <li>▪ Understand Electrical concepts related to solar plants</li> <li>▪ Knowledge of typical specifications, functioning, maintenance requirements of solar PV components - modules, inverters, cables, junction box etc.</li> <li>▪ Understand Solar power plant design and do cost estimations</li> <li>▪ Exceptional customer interaction &amp; key account management</li> <li>▪ • Conduct Financial modelling methods - Capital Expenditure, Renewable Energy Service Company, Operating Expense. Tariff &amp; costing analysis (Estimated generation and payback period analysis - solar plants)</li> <li>▪ Understand typical specifications, functioning, maintenance of floating panels, cables etc.</li> <li>▪ Knowledge of Regulations, energy policies and exemptions for FSPV projects laid down by Government and Regulatory bodies</li> <li>▪ Technical, Commercial and legal knowledge of FSPV setups</li> <li>▪ Knowledge of Financial institutions and banks for solar plants and their terms and conditions of the loans</li> </ul>
<b>Solar Proposal Evaluation Specialist (M)</b>	<ul style="list-style-type: none"> <li>▪ Understanding and working knowledge of cell, module, string, array, module technologies, DNI, DHI, GHI</li> <li>▪ Functioning and operating principle of Solar PV power plants</li> <li>▪ Site surveying valuation parameters knowledge</li> <li>▪ Understand shading analysis &amp; its effect</li> <li>▪ Grid interconnection knowledge</li> <li>▪ Configuration of metering system, gross metering and net metering</li> <li>▪ Indian regulation on harmonics, flicker, frequency &amp; voltage range and its effect on quality of power</li> <li>▪ Lifecycle cost and capital cost of a Solar PV Power Plant</li> </ul>

Roles	Skills & Knowledge
	<ul style="list-style-type: none"> <li>▪ Knowledge of PV*SOL®, PVsyst, Meteonorm</li> <li>▪ Knowledge on legal provisions of environment &amp; wildlife</li> <li>▪ Understanding of permits and clearances requirement for floating solar</li> <li>▪ Offshore site surveying methods and evaluation parameters</li> <li>▪ Topography of the bank, bathymetry, water level variation, types of anchors</li> <li>▪ Knowledge of the impact of design parameters like tilt angle, orientation and shading for floating panels on array output</li> <li>▪ Typical specification, types, functioning and operating principle of FSPV plant</li> <li>▪ Basic understanding of grid interconnection and different configuration of metering system</li> <li>▪ Knowledge of performance evaluation indicators of a FSPV Power Plant</li> <li>▪ Government policies and incentives such as feed-in-tariffs, net-metering etc. for floating solar sector</li> </ul>
<b>Proposal development Specialist(M/S)</b>	<ul style="list-style-type: none"> <li>▪ Request for quote (RFQ) preparation</li> <li>▪ Proposal preparation</li> <li>▪ Devise and application of supplier auditing methodology</li> <li>▪ Knowledge of contract management procedures</li> <li>▪ Conducting cost analysis</li> </ul>
<b>Business Development Manager (M/S)</b>	<ul style="list-style-type: none"> <li>▪ Knowledge of land acquisition (policies, processes and methodology)</li> <li>▪ Ability to undertake Client Management and stakeholder interaction</li> <li>▪ Ability to conduct Tariff &amp; costing analysis</li> <li>▪ Knowledge of obtaining permits and clearances from local authorities. Waterbody acquisition/rental/permit - Permission for installation of FSPV project</li> <li>▪ In-depth understanding of floating solar power policies</li> <li>▪ In-depth understanding of RE policies, incentives and government mandates</li> </ul>

## Design & Development Skills

**TABLE A.3: Role-wise skills requirement Design & Development**

Roles	Skills & Knowledge
<b>Site surveyor (M)</b>	<ul style="list-style-type: none"> <li>▪ Solar energy system concepts and applications</li> <li>▪ Solar resource assessment -DNI, DHI, GHI and their interpretations</li> <li>▪ Understand functioning, operating principle &amp; efficiencies of solar PV plants</li> <li>▪ Knowledge of typical specifications, functioning, operating principle and efficiencies of different types of solar PV power plants, commercially available PV</li> <li>▪ Understanding of site surveying methods and conducting such surveys</li> <li>▪ Shading and its effect analysis</li> <li>▪ Local power loads/grid dispatch knowledge</li> </ul>

Roles	Skills & Knowledge
	<ul style="list-style-type: none"> <li>▪ Knowledge of environmental regulations, geological landscapes etc.</li> <li>▪ Conduct pre-feasibility study to identify opportunity and the potential difficulty in developing floating solar project</li> <li>▪ Experience of FSPV installation tools</li> <li>▪ Identify water patches and develop site plans</li> <li>▪ Natural calamities impact assessment (drought/flood)</li> <li>▪ Impact assessment on aquatic life, fishing &amp; farming</li> </ul>
<b>Atmospheric scientists// meteorologists (S/M/J)</b>	<ul style="list-style-type: none"> <li>▪ Mathematical and computational ability</li> <li>▪ Responsible for Urban planning and natural resource management</li> <li>▪ Knowledge of Remote sensing principles and methods</li> <li>▪ Compiling data from ground surveys, aerial photographs, satellite images and reports</li> <li>▪ Photographic images and patterns interpretation</li> <li>▪ Knowledge of waterbodies' impact on climate</li> <li>▪ Effects of climate change on FSPV</li> <li>▪ Knowledge of Marine meteorology</li> <li>▪ Knowledge of Acoustic and seismic technology</li> </ul>
<b>Wind Energy Analyst (J/M)</b>	<ul style="list-style-type: none"> <li>▪ Ability to work on Wind flow modelling packages- Meteodyn, Ansys</li> <li>▪ Conduct Onshore &amp; offshore wind analysis</li> <li>▪ Operational energy yield assessment- SCADA</li> <li>▪ Software/programming skills</li> </ul>
<b>Geotechnical Engineer (J/M)</b>	<ul style="list-style-type: none"> <li>▪ Design of marine/offshore systems</li> <li>▪ Understand Geotechnical analysis packages</li> <li>▪ Working knowledge of Geological maps and interpretation of aerial photographs</li> <li>▪ Knowledge of industry standard energy yield assessment methodologies</li> <li>▪ Understand ongoing innovation in technology and research</li> <li>▪ Working of analytical 2D and 3D modelling for foundation design and sub-surface view.</li> <li>▪ Application of software like GeoSlope, PLAXIS</li> </ul>
<b>Bathymetrist/ Hydrologist (J)</b>	<ul style="list-style-type: none"> <li>▪ Water measurement principles, practices &amp; standards knowledge</li> <li>▪ Experience of handling water monitoring equipment and specifications</li> <li>▪ Able to work on GIS and CAD software system</li> <li>▪ Know documentation techniques</li> <li>▪ Survey and design techniques' knowledge and usage</li> <li>▪ Knowledge of dredge operation and maintenance</li> <li>▪ Knowledge of National Hydrographic Organization/ International Hydrographic Organization standards</li> </ul>
<b>Hydrologic Engineer (J/M)</b>	<ul style="list-style-type: none"> <li>▪ Environmental law and Government policy knowledge</li> <li>▪ Usage of Statistical and hydrological modelling techniques</li> <li>▪ Knowledge of relevant software- Hydrologic Engineering Centre - River Analysis System, Hydrologic Engineering Centre - Hydrologic Modeling System (HEC HMS), Orcaflex, Ansys, Hypack, Hysweep etc.</li> </ul>

Roles	Skills & Knowledge
<b>Hydrologic Technician (J)</b>	<ul style="list-style-type: none"> <li>▪ Environmental law and Government policy knowledge</li> <li>▪ Statistical and hydrological modelling techniques</li> </ul>
<b>Soil Testing Technician (J)</b>	<ul style="list-style-type: none"> <li>▪ Ability to conduct boring investigations</li> <li>▪ Soil, bedrock &amp; groundwater elevation and quality data interpretation</li> <li>▪ Seismic risk assessment studies</li> <li>▪ Ability to use automated equipment for soil testing</li> <li>▪ Conduct Soil lab tests- Working knowledge of Permeability test, Triaxial Cells, Hydrometer Analysis, Sieve Analysis, Free Swell Index, Specific Gravity, Liquid Gravity, Plastic Limit, Shrinkage Limit test etc.</li> </ul>
<b>Environmental scientists (S/M/J)</b>	<ul style="list-style-type: none"> <li>▪ Understand theoretical foundations and the modelling of climate change</li> <li>▪ Understanding of Marine water quality, marine life and pollutants analysis</li> <li>▪ Working of GIS and other software</li> </ul>
<b>Environment &amp; Social Impact Assessment Specialist (M)</b>	<ul style="list-style-type: none"> <li>▪ Understand Central and Local Government environmental protection guidelines</li> <li>▪ Understanding of the process to conduct Socio economic survey</li> <li>▪ Able to do report writing and statistical tables</li> <li>▪ Designing of E&amp;S Management Framework</li> <li>▪ Deep understanding of socio economic and demographic patterns</li> </ul>
<b>Sociologist (S/M)</b>	<ul style="list-style-type: none"> <li>▪ Ability to conduct human and social behaviour analysis</li> <li>▪ Knowledge of data collection methods through observation, interviews or surveys</li> <li>▪ Understanding of social challenges and their mitigation methodologies</li> <li>▪ Develop materials for educating local population and communities</li> <li>▪ Expertise in social challenges, impacts and problems with regards to FSPV setup (irrigation, rivers, sea, lakes, forests)</li> </ul>
<b>Electrical Engineer (Design) (M)</b>	<ul style="list-style-type: none"> <li>▪ Knowledge of Design and validation standards</li> <li>▪ Experience for electrical systems design and manufacturing</li> <li>▪ Understanding of international standards for electrical systems for Solar plants</li> </ul>
<b>Energy Modeller (S/M)</b>	<ul style="list-style-type: none"> <li>▪ Conduct daylight/energy modelling and analysis</li> <li>▪ Ability to analyse loading patterns and optimize load and output</li> <li>▪ Designing of energy saving schemes associated with electrical and mechanical equipment, control sequences, operating schedules</li> <li>▪ Working knowledge of Energy Modelling software such as eQuest, Tas, Sefaira</li> <li>▪ Engineering analysis including thermodynamics, heat transfer, fluid dynamics and energy/mass balance</li> </ul>
<b>Structural Design Engineer (J/M)</b>	<ul style="list-style-type: none"> <li>▪ Module mounting structures &amp; foundation design</li> <li>▪ Conduct structural load analysis</li> <li>▪ Structural layout design for solar PV plant</li> <li>▪ Knowledge of materials and components specifications used for foundation &amp; mounting structures</li> <li>▪ Structural design report writing experience</li> <li>▪ Responsible for structural design of the floating solar PV and requirements such as - maintenance walkways between PV panel rows</li> </ul>

Roles	Skills & Knowledge
	<ul style="list-style-type: none"> <li>▪ Ability to undertake water variations and water proximity analysis impacting electricity generation</li> <li>▪ Topography understanding- water salinity, high winds</li> <li>▪ Monitoring system and the related performance metrics for FSPV</li> <li>▪ Impact analysis on aquatic life, fishing &amp; farming</li> </ul>
<b>Switchyard Engineer – Civil (M)</b>	<ul style="list-style-type: none"> <li>▪ Structural Analysis of foundations and civil structures</li> <li>▪ Design of structures &amp; equipment support foundations</li> <li>▪ Understanding of Civil engineering design codes</li> <li>▪ Draft, prepare &amp; review of design &amp; documentation</li> <li>▪ Knowledge of Bill of Materials (BoM)/Bill of Quantities (BoQ) preparation</li> <li>▪ Understanding red mark drawings</li> <li>▪ Structural Analysis of foundations and civil structures for FSPV</li> </ul>
<b>Solar PV Designer (M/S)</b>	<ul style="list-style-type: none"> <li>▪ Understand the plant layouts, water distribution network inside the plant, water drainage system, civil design for mounting solar PV panel and support structure</li> <li>▪ Solar PV power generation technology knowledge</li> <li>▪ Detailed understanding of selection procedures</li> <li>▪ Detailed understanding of design and drawings for solar plant</li> <li>▪ Simulate estimated generation</li> <li>▪ Methods of financial modelling to find out levelized cost of generation</li> <li>▪ Knowledge of civil works i.e., construction of internal roads, foundations for mounting module support structures, combiner boxes, inverters, transformers, substation etc.</li> <li>▪ Knowledge of electrical works i.e., installation of inverters, transformers, earthing, Direct Current (DC)/AC power protection devices, lightning arresters, substation as per the grid codes and regulatory provisions</li> <li>▪ Understanding of efficiency, cost and specifications of commercially available PV cells and modules, inverters, transformers, charge controllers etc.</li> <li>▪ Functioning and operating principle of different types of solar PV plants</li> <li>▪ Understand electrical designs for the module/inverters and Balance of System</li> <li>▪ Understand various anchoring and mooring systems for floating solar panels</li> <li>▪ Knowledge of offshore and onshore electrical &amp; civil works</li> <li>▪ Knowledge of design software packages such as PVsyst, PV Sol etc.</li> </ul>
<b>Solar PV Installer (Electrical) (J)</b>	<ul style="list-style-type: none"> <li>▪ Knowledge of site assessment techniques before installation</li> <li>▪ Knowledge of solar PV components and procurement procedure</li> <li>▪ Methodology to test the solar PV electrical apparatus</li> <li>▪ Install electrical cables between floating PV arrays and the banks</li> <li>▪ Material specification knowledge- weight, Ingress Protection code, size</li> <li>▪ Inverter installation on floating PV arrays</li> </ul>

Roles	Skills & Knowledge
<b>Solar PV Installer (Civil) – Anchoring Designer (J)</b>	<ul style="list-style-type: none"> <li>▪ Site assessment before installation</li> <li>▪ Solar PV components and procurement procedure</li> <li>▪ Test and commission components</li> <li>▪ Install civil and mechanical components of the solar PV system</li> <li>▪ Understand civil maintenance requirements</li> <li>▪ Knowledge of mounting requirements- scaffolding</li> <li>▪ Topography of the banks, water level variations</li> <li>▪ Anchoring system knowledge- bottom, banks, hybrid anchoring</li> <li>▪ Understanding of various types of anchors- drilled anchors, percussive and concrete blocks</li> <li>▪ Floating PV plant movement calculation- control hitting banks</li> <li>▪ Environmental loads analysis for the anchoring system</li> <li>▪ PV modules requirement- water environment, corrosion, short circuiting</li> </ul>
<b>Substation Design Engineer</b>	<ul style="list-style-type: none"> <li>▪ Design of physical substation</li> <li>▪ Preparation of electrical drawings (layout, single line diagram, cable trench layout etc.)</li> <li>▪ Preparation of BoQ</li> <li>▪ Engineering oversight of substation physical designers, including bus design, equipment ratings, and safety/maintenance clearance</li> <li>▪ In-depth understanding of substation protection and control systems</li> <li>▪ Equipment specifications for procurement and/or factory acceptance testing</li> <li>▪ Knowledge of physical substation design elements including layouts, plans, sections and details, auxiliary AC/DC power systems, platform cabling systems, transformers switchgear, technical interfaces between offshore and onshore substations and, as required, harmonic filter(s), system studies and export/array cable interfaces and associated bills of material</li> <li>▪ Knowledge of electricity rules defined by relevant authorities</li> <li>▪ Knowledge of safety related aspects, especially handling of heavy electrical equipment</li> <li>▪ Technical expertise in offshore substation project engineering and management</li> <li>▪ Knowledge of various Sub Station Automation Systems including design of Smart Substations</li> </ul>
<b>Computer software developers (J/M)</b>	<ul style="list-style-type: none"> <li>▪ Programming &amp; Software</li> <li>▪ Working knowledge of Computational Fluid Dynamics, Orcaflex, Ansys programming</li> <li>▪ Application of Computer Vision/Image Processing</li> <li>▪ Point Cloud Processing</li> <li>▪ Knowledge of Linear Algebra &amp; Statistics</li> <li>▪ Knowledge of Computer Graphics</li> </ul>



## Construction

**TABLE A.4: Role-wise skills requirement-Construction**

Role	Skills & Knowledge
<b>Roustabouts</b>	<ul style="list-style-type: none"> <li>▪ Ability to do marine/offshore installation as per the standard procedures</li> <li>▪ Knowledge of QA &amp; Safety procedures</li> <li>▪ Ability to complete work in line with the safety guidelines and procedures</li> <li>▪ Expertise in installation of Anchoring &amp; Mooring systems for holding floats on waterbody</li> <li>▪ Possess basic diving skills in order to work on waterbodies</li> <li>▪ Basic level underwater maintenance works</li> </ul>
<b>Project Helper</b>	<ul style="list-style-type: none"> <li>▪ Basic understanding of mooring equipment such as mooring winches, anchor windlasses, chain stoppers, fairleads and capstans</li> <li>▪ Knowledge of mooring process and capable of connecting anchoring and mooring lines</li> <li>▪ Basic knowledge of maintenance procedures for solar panels</li> </ul>
<b>Solar PV Engineer</b>	<ul style="list-style-type: none"> <li>▪ Have basic understanding of types of anchors and suggestive mooring system</li> <li>▪ Ability to conduct solar resource assessment</li> <li>▪ Understanding of various types of anchors- drag embedment, suction and vertical load and mooring system</li> <li>▪ Ability to analyse the need and suggest the anchoring and mooring system required</li> <li>▪ Undertake impact analysis of current and voltage based on panels alignment, tilt angle on floats, shading etc.</li> <li>▪ Knowledge of simulation software and ability to work on software such as PVSol, PVsyst, ArcMap</li> </ul>
<b>Solar PV Technical Manager</b>	<ul style="list-style-type: none"> <li>▪ Working knowledge of floating PV island design, yield simulation, anchoring design, structural Drawings</li> <li>▪ Using packages like Helioscope and AutoCAD and software such as PVsyst, PVSOL, PvPlanner and Solar Pro for yield prediction</li> <li>▪ Knowledge of solar plant design elements</li> </ul>
<b>Solar PV Project Manager (E&amp;C)</b>	<ul style="list-style-type: none"> <li>▪ Knowledge of the permits and approvals required for construction on waterbodies in India</li> <li>▪ Understand and estimate construction requirements for a floating solar PV</li> <li>▪ Conducting commercial analysis for PV projects</li> <li>▪ Conduct financial modelling to find out the levelized cost of power generation using software such as System Advisor Model. Conduct analysis at different stages of floating solar power project and project requirements in terms of material, manpower and equipment at different phases</li> <li>▪ Knowledge of construction related civil work such as placement of anchors, mounting structures in waterbodies</li> <li>▪ Knowledge of electrical work for construction such as cabling routes, solar panel/ array, inverters, combiner boxes, lighting arrester connections etc on water surfaces</li> </ul>

Role	Skills & Knowledge
	<ul style="list-style-type: none"> <li>▪ Knowledge of safety and crisis management protocols (First-aid, survival techniques)</li> <li>▪ Knowledge of standards, HSE at site, regulation &amp; specifications required for solar PV projects</li> </ul>
<b>Project Engineer (Civil/Structural)</b>	<ul style="list-style-type: none"> <li>▪ Ability to conduct structural analysis of FSPV platforms and floats and determining the position of anchors onshore or offshore</li> <li>▪ Drafting, preparation &amp; review of design &amp; documentation related to civil works</li> </ul>
<b>Cable Installation Technician/Engineer</b>	<ul style="list-style-type: none"> <li>▪ Knowledge of using software packages like MakaiLay, 3D CAD</li> <li>▪ Understanding of marine regulatory processes and environment and work in adherence to these policies</li> <li>▪ Report writing for burial assessment study, cable burial risk assessment</li> </ul>
<b>Quality Assurance Executive</b>	<ul style="list-style-type: none"> <li>▪ Understanding of solar panel durability and conformance to reliability standards from a floating solar PV perspective</li> <li>▪ Understanding of QA process for FSPV</li> <li>▪ Understanding requirements for Management information system and documentation in compliance with International Organization for Standardization (ISO) standards (ISO 9001, ISO 14001, ISO 45001)</li> <li>▪ Check quality certifications such as ISO 9001, warranties from manufacturer, etc.</li> </ul>
<b>Quality Assurance (QA) Manager</b>	<ul style="list-style-type: none"> <li>▪ Understand nuances of QA processes</li> <li>▪ Working knowledge of QA, audit requirements and Quality Control (QC) compliances</li> <li>▪ Knowledge of ISO requirements and ability to maintain ISO documentation</li> <li>▪ Knowledge of assessment procedures &amp; testing parameters for a floating solar PV power plant</li> <li>▪ Knowledge of QA and QC report writing</li> </ul>
<b>Marine Fitter</b>	<ul style="list-style-type: none"> <li>▪ Working knowledge of conducting checks for flaws and needed repairs. Understand the checklist of activities required to be performed</li> <li>▪ Understanding various electrical &amp; electronic components and carryout testing and measurement to ensure functionality</li> <li>▪ Knowledge of mechanical aspects of floating solar platforms and carry out repairs and maintenance</li> <li>▪ Understanding engineering drawings</li> <li>▪ Ability to conduct chipping, scraping, grinding and usage of tools for carrying out these activities</li> <li>▪ Knowledge of repairing motors, pipes, connectors</li> <li>▪ Knowledge pertaining to usage of Personal Protective Equipment for safety</li> </ul>

## O&M

**TABLE A.5: Role-wise skills requirement - O&M**

Roles	Skills & Knowledge
<b>Solar PV O&amp;M Engineer (M)</b>	<ul style="list-style-type: none"> <li>▪ Knowledge of:               <ul style="list-style-type: none"> <li>◆ National Electrical Code and standard</li> <li>◆ Functioning, operating principle &amp; efficiencies of solar PV plants</li> <li>◆ Ability to interpret and evaluate soil test report</li> <li>◆ Type of foundations and components</li> <li>◆ Warranties of different types of solar PV components</li> </ul> </li> <li>▪ Adherence to safety and health standards for conducting underwater O&amp;M activities</li> <li>▪ Procedural knowledge to conduct shading analysis</li> <li>▪ Ability to identify:               <ul style="list-style-type: none"> <li>◆ Types of faults &amp; their corrective measures</li> <li>◆ Troubleshooting of electrical components</li> </ul> </li> <li>▪ Knowledge of different parameters to optimize energy yield of FSPV</li> <li>▪ In-depth understanding of different components of FSPV, design and installation</li> <li>▪ Measure and report relevant electrical and meteorological data such as humidity levels, wind direction, wind speed, irradiation, etc</li> <li>▪ Knowledge of the Standard operating procedure for module and float replacement</li> <li>▪ Knowledge and application of preventive measures to be taken for biofouling and its impact on the floats and cables</li> <li>▪ Knowledge of conducting mechanical integrity check of connecting parts (on and under water)</li> <li>▪ Diving skills</li> <li>▪ Knowledge of inspection of anchoring and mooring lines</li> </ul>
<b>Switchyard Engineer – Electrical (S/M)</b>	<ul style="list-style-type: none"> <li>▪ Significant knowledge of:               <ul style="list-style-type: none"> <li>◆ Substation design &amp; construction</li> <li>◆ Protective relay wiring &amp; settings</li> <li>◆ Industry standards and safety practices</li> <li>◆ Reading and analysing substation drawings &amp; technical specifications</li> </ul> </li> <li>▪ Knowledge and application of maintenance procedure for High Voltage equipment</li> <li>▪ Knowledge of SCADA systems</li> <li>▪ Conduct electrical fault analysis &amp; troubleshooting</li> </ul>

Roles	Skills & Knowledge
<b>Solar PV Manufacturing Technician/Operator (M/J)</b>	<ul style="list-style-type: none"> <li>▪ Basic understanding of electrical concepts; their functioning and maintenance requirements</li> <li>▪ Maintenance requirements of various measuring equipment such as multi-meter, solar array tester and meggers, raw materials, shelf life, storage specifications of various equipment, cutting of Ethyl vinyl acetate encapsulant and back sheet</li> <li>▪ Expertise of soldering techniques</li> <li>▪ Understand procedure to carry out lamination of modules</li> <li>▪ Knowledge and adherence to safety and health standards</li> <li>▪ Understand different concepts of hydro or marine engineering with respect to the floating solar power plant</li> </ul>
<b>Solar PV O&amp;M Technician - Electrical (M/J)</b>	<ul style="list-style-type: none"> <li>▪ Understand solar PV technology and different components of solar PV plant</li> <li>▪ Basic understanding of electrical concepts; their functioning &amp; maintenance requirements</li> <li>▪ Understand the solar PV plant design/working drawings.</li> <li>▪ Undertake procedure to: <ul style="list-style-type: none"> <li>◆ verify the connections, cables and junction boxes</li> <li>◆ measure the string current and verify the connections between modules in each string periodically</li> <li>◆ check the integrity and working condition of all connections, fuses and circuit breakers</li> <li>◆ check the continuity of cables and wires</li> <li>◆ troubleshoot the identified faults</li> <li>◆ cleaning of modules/remove any shadowing objects</li> <li>◆ check the module frame for any deformation or defect</li> <li>◆ measure and record the readings from the inverter and the monitoring system</li> </ul> </li> <li>▪ Knowledge and application of parameters/checklists of Preventive, Corrective and Predictive maintenance</li> <li>▪ Understand the maintenance schedule and perform maintenance as per schedule</li> <li>▪ Knowledge of different components of floating solar PV</li> <li>▪ Procedure to clean PV modules, floating pontoons, inspection and management of soiling</li> <li>▪ Undertake mitigation of midges and vector control</li> <li>▪ Upkeep of the monitoring systems</li> <li>▪ Procedure to reset tripped inverters, replacing blown fuses, tightening cable connections or loose connectors due to float movement</li> <li>▪ Knowledge of procedure to repair equipotential bonding wires broken due to float movement and communication (transmission dropout)</li> <li>▪ Safety mechanisms for electric components while working underwater</li> </ul>

Roles	Skills & Knowledge
<b>Solar PV O&amp;M Technician - Civil (M/J)</b>	<ul style="list-style-type: none"> <li>▪ Understand solar PV technology and different components of Solar PV plant</li> <li>▪ Knowledge on warranties of different types of solar PV (civil components)</li> <li>▪ Understand the solar PV plant design/working</li> <li>▪ Responsible for procedures to: <ul style="list-style-type: none"> <li>◆ check the integrity of civil foundation for module mounting structures &amp; types of clamps</li> <li>◆ measure the thickness of galvanization and take immediate action in case of corrosion</li> <li>◆ check the module frame for any deformation or defect</li> </ul> </li> <li>▪ Should know how to maintain the internal access and pathways between the arrays and prevent water logging on floats</li> <li>▪ Adhere to safety norms as per industry standards</li> <li>▪ Understand different parameters/checklists of Preventive, Corrective and Predictive maintenance</li> <li>▪ Knowledge of different components of floating solar PV - anchoring system including wire or mooring chain, shackle and anchor and their warranties</li> <li>▪ Procedure to clean PV modules, floating pontoons, floats and management of soiling</li> <li>▪ Knowledge on: <ul style="list-style-type: none"> <li>◆ early signs of rust &amp; corrosion in the metal frame &amp; mounting structure</li> <li>◆ factors contributing to degradation of mooring system and floats</li> </ul> </li> <li>▪ Procedure to inspect for: <ul style="list-style-type: none"> <li>◆ marine growth, general fouling, chafing, surface damage or growth of algae and insect eggs/larvae, galvanic corrosion</li> <li>◆ condition of the float and their buoyancy</li> <li>◆ verify mooring tension lines</li> </ul> </li> </ul>
<b>Marine Operation Technician (J)</b>	<ul style="list-style-type: none"> <li>▪ Expertise in electrical equipment maintenance</li> <li>▪ Knowledge on the safety standards and quality control</li> <li>▪ Expertise in: <ul style="list-style-type: none"> <li>◆ Submarine cabling</li> <li>◆ Marine Equipment Maintenance</li> <li>◆ Mooring &amp; Anchoring maintenance</li> <li>◆ Dive Equipment maintenance</li> </ul> </li> <li>▪ Knowledge of: <ul style="list-style-type: none"> <li>◆ Local Waters</li> <li>◆ Safety &amp; Quality Control procedures</li> </ul> </li> <li>▪ Experience in Diving</li> </ul>
<b>Surface Supplied Air Diver (S/M)</b>	<ul style="list-style-type: none"> <li>▪ Diving skills</li> <li>▪ O&amp;M activities below the water depth of 55 m</li> <li>▪ Protocol to carry out emergency procedures</li> <li>▪ Experience of diving and swimming to perform underwater maintenance</li> <li>▪ Underwater safety protocols and measures to be taken</li> </ul>

## Decommissioning

**TABLE A.6: Role-wise skills requirement-Decommissioning**

Roles	Skills & Knowledge
<b>Decommissioning Program Manager (M/S)</b>	<ul style="list-style-type: none"> <li>▪ Conduct feasibility analysis</li> <li>▪ Knowledge of construction &amp; commissioning of solar PV plants</li> <li>▪ Dismantling of PV arrays</li> <li>▪ Reinstallation or recycling of arrays</li> <li>▪ Budget Management &amp; Project Management</li> <li>▪ Knowledge and prior experience in Brownfield modification projects,</li> <li>▪ Knowledge of industry design standards, QA &amp; QC</li> <li>▪ Dismantling of Moorings &amp; Floats</li> <li>▪ Removal of platforms and installed bays/maintenance tracks on waterbodies</li> <li>▪ Cable decommissioning</li> <li>▪ Management of e-Waste and suitable disposal</li> </ul>
<b>Recycling Specialist (M/J)</b>	<ul style="list-style-type: none"> <li>▪ Ability to coordinate the development and implementation of difficult and complex recycling projects</li> <li>▪ Perform studies and research on municipal recycling waste reduction and diversion projects</li> <li>▪ Plan, develop and implement recycling waste reduction and diversion projects</li> </ul>

## APPENDIX B: ROLE, DESCRIPTION & QUALIFICATIONS

Value Chain	Role	Brief Description	Academic Qualification
Manufacturing & Procurement	<b>Physicist (Scientific Research)</b>	<ul style="list-style-type: none"> <li>Works with chemists, material scientists, and engineers to improve the efficiency of solar panels</li> <li>Conduct research to identify new materials for solar panel generation</li> </ul>	A doctoral degree is a necessity for scientists who conduct original research and develop new products; however, some workers may enter the scientific fields with a bachelor's or master's degree
	<b>Chemists (Scientific Research)</b>	<ul style="list-style-type: none"> <li>Investigate the properties, composition, and structure of matter and the laws that govern the reactions of substances to each other</li> <li>Using this knowledge, chemists in the solar power industry are able to improve on solar cell design, develop new materials for making solar cells, or improve existing materials</li> </ul>	A doctoral degree is a necessity for scientists who conduct original research and develop new products; however, some workers may enter the scientific fields with a bachelor's or master's degree
	<b>Material scientists</b>	<ul style="list-style-type: none"> <li>Study the structures and chemical properties of various materials to develop new products or enhance existing ones</li> <li>Develop new materials and decreasing the cost of PV panels. They are also responsible to increase solar panel yield/efficiency</li> </ul>	A doctoral degree is a necessity for scientists who conduct original research and develop new products; however, some workers may enter the scientific fields with a bachelor's or master's degree
	<b>Semiconductor processors designer</b>	<ul style="list-style-type: none"> <li>Oversee the manufacturing process of solar cells</li> </ul>	Apprenticeship or Diploma (associate degree in a field such as microelectronics, bachelor's degree in engineering or a physical science)
	<b>Computer-controlled machine tool operators</b>	<ul style="list-style-type: none"> <li>Responsible to run CNC machines, a machine tool that forms and shapes floats, solar mirror or panel components</li> <li>Highly trained CNC workers also program the machines to cut new pieces according to design schematics</li> </ul>	Apprenticeship or Diploma

Value Chain	Role	Brief Description	Academic Qualification
Manufacturing & Procurement		<ul style="list-style-type: none"> <li>Use machines to mass-produce components that require highly precise cutting</li> <li>In the solar power industry, CNC operators manufacture precisely designed mirrors for Concentrated solar power plants and many of the components of PV panels</li> </ul>	
	Welder	<ul style="list-style-type: none"> <li>They are primarily responsible to apply heat to metal pieces during the manufacturing process, melting and fusing them to form a permanent bond</li> </ul>	Diploma or vocational certification
	Coating and painting machine operator	<ul style="list-style-type: none"> <li>They are responsible to apply coatings to solar panels, electrical panels, etc which require high level of precision</li> </ul>	Diploma or vocational certification
	Industrial production managers	<ul style="list-style-type: none"> <li>Plan, direct, and coordinate work on the factory floor. Determine which machines will be used, whether new machines need to be purchased, when overtime shifts are necessary, and how to improve the production process</li> <li>Ensure production runs on schedule and are responsible for solving problems that could jeopardize the quality of the components</li> </ul>	Degree in business administration, management, industrial technology, or engineering.
	Electrical Component Engineer	<ul style="list-style-type: none"> <li>Perform the grid connection studies for renewables (Solar + Wind+ Hybrid) which mainly includes Reactive Power Compensation, Harmonic, Flicker, Dynamic/RMS studies as per the Grid Code</li> <li>Perform Relay coordination, AC/DC Arc Flash and other studies</li> </ul>	B. Tech or M. Tech in Electrical or Power Systems Experience in engineering design & electrical power systems studies



Value Chain	Role	Brief Description	Academic Qualification
Feasibility		<ul style="list-style-type: none"> <li>Upgrade Electro-mechanical design templates for bus bars, conductor selection, loads on support structures, earthing and lightning protection design tools and templates etc.</li> </ul>	
	<b>Solar PV Business Development Executive</b>	<ul style="list-style-type: none"> <li>Ensure fundamental understanding and benefits of using solar power to develop and generate business for the organization</li> <li>Understanding of floating solar, rooftop market, ground mount market and decentralised solutions market to propose the right kind of solution to meet the specific needs of the respective clients</li> <li>Keep track of central and state solar policies/programs and has good understanding of the solar PV technology, its applications and economics</li> <li>Plan and deploy strategic business plan</li> <li>Identify leads, develop opportunities and generate sales</li> <li>Ensure exceptional customer interaction as well as key account management</li> </ul>	B.Tech/B.B.A./B. Com
	<b>Solar Proposal Evaluation Specialist</b>	<ul style="list-style-type: none"> <li>Review feasibility report of the site for installation, assess the techno-commercial feasibility and financial viability of setting up a solar PV power plant</li> <li>Provide techno-commercial advice, preparing lending or funding documents and write or review solar PV project reports</li> </ul>	B.E./B.Tech/BBA/B.Com/ B.Sc./CA Experience in project finance

Value Chain	Role	Brief Description	Academic Qualification
Feasibility	Proposal development Specialist	<ul style="list-style-type: none"> <li>▪ Select the right partners for manufacturing with a specific focus on metallic &amp; mooring parts</li> <li>▪ Negotiate pricing and terms and conditions of product supply</li> <li>▪ Act as the supplier's main interface for first contacts and for business matters</li> <li>▪ Identify new potential supplier for a given type of product</li> <li>▪ Assess whether it is preferable to make or buy products in a given situation based on internal method</li> <li>▪ Prepare RFQ based on product or tooling/equipment specification</li> <li>▪ Sign Non-disclosure agreement with new partners (review content with contract manager when needed)</li> <li>▪ Analyse quotation received from suppliers</li> <li>▪ Negotiate contract terms with suppliers and sign contract</li> <li>▪ Place Purchase Orders for tooling and equipment</li> <li>▪ Follow raw materials pricing evolution and news (London Metal Exchange Aluminium, Steel, Metal market indexes)</li> <li>▪ Draft a monthly report of key news that may impact the business</li> </ul>	<p>Bachelor or master's degree in business or in Mechanical engineering</p> <p>Experience in a purchasing environment of technical products (aluminium extrusion, steel extrusion, casting, forging, waterjet cutting, CNC, welding, fasteners), steel cables, polyethylene cables</p>

Value Chain	Role	Brief Description	Academic Qualification
Feasibility	Business Development Manager	<ul style="list-style-type: none"> <li>Interact and build long-term relationships with landowners, permitting authorities, engineers, consultants, investors and team members</li> <li>Develop projects and step in to support project managers in handling any challenging lease, permitting or construction related issues</li> </ul>	<p>Real estate development or solar project development experience</p> <p>Master's degree in any management</p>
Design & Development	Electrical and electronic equipment assemblers	<ul style="list-style-type: none"> <li>Assembling the complex electrical circuitry as well as assembling the components, such as inverters or controls, which connect to solar panels</li> </ul>	Diploma or vocational certification
	Electrical Engineer (Design)	<ul style="list-style-type: none"> <li>Accountable for the definition of insulation systems including dimensioning, BoM, manufacturing process definition and implementation and system validation</li> <li>Liaison with the suppliers and manufacturing sites</li> <li>Manage and mitigate the technical risks associated with designs through the project gates and products lifecycle using systematic methodologies such as Design failure mode and effect analysis and the creation and follow up of validation plans</li> <li>Define and follow up test plans to qualify the insulation systems according to international and internal standards</li> <li>Lead or participate in root cause analysis on fleet issues and incorporate the relevant lessons learned into next designs</li> </ul>	Bachelor's Degree in Electrical, Materials or equivalent

Value Chain	Role	Brief Description	Academic Qualification
Design & Development	Computer software developers	<ul style="list-style-type: none"> <li>Design and develop software used for a variety of purposes. In the solar power industry, computer software is used in forecasting weather and sunlight patterns to assess the feasibility and cost of generating solar power in a particular area</li> <li>Updating, repairing, expanding, and modifying existing programs</li> </ul>	Master's or doctoral degree Bachelor's degree in engineering
	Atmospheric scientists/meteorologists	<ul style="list-style-type: none"> <li>Study the atmosphere and weather patterns. In the solar power industry, they study particular areas being considered for development of a solar power plant and determine if solar power will be a cost-effective way to generate energy in a particular area by studying past weather patterns, assessing their impact and using computers to create models of expected weather activity</li> </ul>	Doctor's Degree Master's Degree Bachelor's Degree (Additional licenses/certifications in domain preferred)
	Environmental scientists	<ul style="list-style-type: none"> <li>Ensure that environmental regulations and policies are followed and that sensitive parts of the ecosystem are protected</li> <li>Minimize hazards to the health of the environment and surrounding population, fragile ecosystems and numerous protected species</li> </ul>	Doctor's Degree Master's Degree Bachelor's Degree (Additional licenses/certifications in domain preferred)
	Solar PV Site surveyor	<ul style="list-style-type: none"> <li>Survey of the proposed site, provide complete land map with elevations, arrange for soil testing &amp; test reports, provides details of approach to site, water table at site, quality of ground water, availability of water for module cleaning at site,</li> </ul>	Diploma/B.E./B.Tech. in Civil Engineering with prior experience of site survey

Value Chain	Role	Brief Description	Academic Qualification
Design & Development		availability of grid, location nearest substation where the solar power is to be delivered etc.	
	<b>Solar PV Structural Design Engineer (Civil &amp; Structural Design of Solar PV plant)</b>	<ul style="list-style-type: none"> <li>Design the module mounting structures/floats, foundations/anchoring for the module mounting structures/floats, inverters and transformers and the complete layout of the FSPV plant including pathways for accessibility</li> </ul>	Diploma in Civil Engineering/ Structural Engineering B.E/B.Tech/M. Tech in Civil Engineering
	<b>Switchyard Engineer - Civil</b>	<ul style="list-style-type: none"> <li>Design detailing of civil and structural works of switchyard</li> <li>Perform structural analysis and conduct calculations</li> <li>Determine cost and material estimates</li> <li>Preparing site working documentation, bar bending schedules</li> <li>Interdisciplinary coordination activities (including Firefighting, Electrical Services, Air Conditioning, Illumination systems etc.)</li> </ul>	B.Tech/B.E. in Civil Engineering
	<b>Solar PV Designer</b>	<ul style="list-style-type: none"> <li>Review the electrical design of the Solar PV power plant &amp; prepare the energy simulation report</li> </ul>	B. Tech/B.E. (Solar/Electrical, Electronics, Civil, Mechanical/ Energy Systems) M. Tech (Solar/Electrical, Electronics, Civil, Mechanical/ Energy Systems) Minimum 3 years of solar PV experience
	<b>Solar PV Installer (Electrical)</b>	<ul style="list-style-type: none"> <li>Install, test, and commission different electrical components of PV systems that meet the performance and reliability needs of customers by incorporating quality craftsmanship and complying with all applicable codes, standards and safety requirements</li> </ul>	10th Pass + ITI/Diploma (Electrical, Electronics, Civil, Mechanical, Fitter, Instrumentation, Welder)

Value Chain	Role	Brief Description	Academic Qualification
Design & Development	<b>Solar PV (Civil) - Anchoring Designer</b>	<ul style="list-style-type: none"> <li>▪ Install, test, and commission different civil components of PV systems, which meet the performance and reliability needs of customers by incorporating quality craftsmanship and complying with all applicable codes, standards and safety requirements</li> </ul>	10th Pass + ITI/Diploma (Electrical, Electronics, Civil, Mechanical, Fitter, Instrumentation, Welder)
	<b>Geotechnical Engineer</b>	<ul style="list-style-type: none"> <li>▪ Provide engineering analysis, design &amp; reporting for projects</li> <li>▪ Provide geotechnical input to the design and analytical functions of structures including gravity structures, piled structures, pipelines, cables and shore crossings</li> <li>▪ Meteorological aspect (to be measured above and below the FSPV system and at nearby areas that would represent ambient conditions): <ul style="list-style-type: none"> <li>◆ Solar radiation (net radiation or short and longwave radiation)</li> <li>◆ Air temperature</li> <li>◆ Wind speed and direction</li> <li>◆ Relative humidity</li> <li>◆ Cloud cover</li> </ul> </li> <li>▪ Specification and procurement support for site investigation works review of findings and development of design parameters</li> <li>▪ Develop construction and engineering cost estimates</li> <li>▪ Inspection and assessment of existing infrastructure</li> <li>▪ Assists in the collection and analysis of data from sampling, reports, maps, drawings, tests and aerial photographs to evaluate, plan and permit projects</li> </ul>	A relevant degree in Geotechnical, Civil or Geological Engineering (or equivalent)

Value Chain	Role	Brief Description	Academic Qualification
Design & Development	<b>Bathymetrist/ Hydrologist</b>	<ul style="list-style-type: none"> <li>▪ Provide technical assistance for water related activities by obtaining field measurements and collecting water samples including bathymetry surveying and mapping; designing and inspecting dredge operations in accordance with engineering standards and procedures; conducting water flow measurements and performing other related activities</li> <li>▪ Develop designs using computer drafting programs and models (e.g., CAD, GIS, etc.) for dredging</li> <li>▪ Conduct layout activities and construction oversight in accordance with appropriate standards and specifications</li> <li>▪ Develop as-built construction documentation for completed projects and certification</li> <li>▪ Perform measurements of water-level, stage and discharge</li> <li>▪ Verify the accuracy of data; prepare samples for lab analyses</li> <li>▪ Perform installation, maintenance, servicing, and troubleshooting of sensing, recording, and communications equipment and instrumentation</li> <li>▪ Observe and note hydraulic or environmental conditions; develop stage-discharge and velocity index curves and ratings</li> </ul>	Bachelor's Degree in Oceanography, Geology, Geophysics, Hydrography engineering, construction, industrial technology
	<b>Soil Testing Technician</b>	<ul style="list-style-type: none"> <li>▪ Evaluate and interpret subsurface data of soil to develop conclusions concerning the geologic site conditions</li> </ul>	Bachelor's degree in Geology, Hydrogeology or related field

Value Chain	Role	Brief Description	Academic Qualification
Design & Development	<b>Environment &amp; Social Impact Assessment Specialist</b>	<ul style="list-style-type: none"> <li>▪ Establish the environmental baseline in the study area and to identify any significant environmental issue</li> <li>▪ Analyse, quantify the impacts and design project activities keeping in mind E&amp;S impacts</li> <li>▪ Prepare an inventory of biodiversity (Flora and Fauna) in the region and those likely to be affected due to project activity</li> <li>▪ Socio economic survey and need based assessment study on the basis of secondary/ primary information</li> <li>▪ Prepare an E&amp;S Management Framework including well defined performance indicators for addressing the identified issues, through various activities/tasks under the proposed project, and strategy for its implementation to achieve sustainable environmental benefits</li> </ul>	Degree in biology, marine biology or environmental monitoring
	<b>Hydrologic Engineer</b>	<ul style="list-style-type: none"> <li>▪ Responsible to design and oversee the building of hydraulic engineering projects related to the flow and use of water in both natural and manmade settings</li> <li>▪ Use computer technology to calculate flow statistics</li> <li>▪ Oversee other types of engineers related to specific hydraulic projects</li> <li>▪ Study the construction of water-related structures and examine the flow patterns of water</li> </ul>	Bachelor's in civil engineering (Masters preferred with emphasis in hydrology/ hydraulics, water resources or related field)



Value Chain	Role	Brief Description	Academic Qualification
Design & Development	Hydrologic Technician	<ul style="list-style-type: none"> <li>Assist in the research, design, and implementation of systems that harness, utilize, conserve, and protect water resources</li> <li>Work with Hydrologists, Engineers, and Hydrogeologists on projects that support hydrology — the study of water, including its composition, distribution, and environmental impact</li> <li>Support plan and execute water research projects related to scientific and environmental issues such as drought, flood control, irrigation, hydroelectric power, and groundwater contamination</li> </ul>	Bachelors/Diploma in Civil Engineering
Construction	Roustabouts	<ul style="list-style-type: none"> <li>Perform general manual labour tasks including lifting &amp; moving construction materials, loading/unloading of materials, assisting with minor repairs to equipment, helping to test and maintain safety to ensure compliance with regulations</li> </ul>	ITI/Diploma/Vocational Certification
	Solar PV Project Helper	<ul style="list-style-type: none"> <li>Help the site surveyor in survey of site for power plant, installation technicians in erection and commissioning activities and maintenance technicians for maintenance of solar PV power plants</li> <li>Help in installation of solar power plants</li> </ul>	ITI/Diploma/Vocational Certification
	Solar PV Engineer	<ul style="list-style-type: none"> <li>Specializes in the erection and commissioning of the solar power plant, its quality assurance and its HSE issues</li> </ul>	B.Tech. (Civil/Mechanical/ Electrical/Electrical & Electronics/Instrumentation)

Value Chain	Role	Brief Description	Academic Qualification
Construction		<ul style="list-style-type: none"> <li>Apply appropriate surface preparation and protection techniques, based on surface material, operating conditions, and maintenance requirements, against exposure to marine environments</li> </ul>	
	<b>Solar Site-in charge</b>	<ul style="list-style-type: none"> <li>Responsible for all activities related to erection and commissioning of solar power plant at site</li> <li>Receive different components of the solar power plant procured as per the design department, check the components for specifications and quality, install the solar power plant as per the design, construct the substation and grid interface incorporating grid code and regulatory provisions incorporated in the design, commission the DC and AC parts of solar power plant and grid connection, data acquisition and monitoring equipment</li> </ul>	B.E. (Civil/Mechanical/Electrical & Electronics/Instrumentation/Construction Management) with experience in solar PV power plant installation and commissioning
	<b>Solar PV Technical Manager</b>	<ul style="list-style-type: none"> <li>Manage, train, animate and develop the technical department of the FSPV project development activity</li> <li>Manage and ensure the follow-up from the pre-project stage to completion</li> <li>Create and cultivate a relationship of confidence with external stakeholders</li> </ul>	Graduate from an engineering school, either generalist or specialized in renewable energies, with a minimum of an experience in project management in renewable energies (PV, wind power, etc.)
	<b>Solar PV Project Manager (E&amp;C)</b>	<ul style="list-style-type: none"> <li>Responsible for managing erection and commissioning of one/multiple solar power plants at one site or different sites</li> </ul>	Degree in Electrical Engineering/Construction Management or related discipline MBA degree preferred Experience in RE/power sector utilities/consulting firms/solar PV power plant installation and commissioning

Value Chain	Role	Brief Description	Academic Qualification
Construction		<ul style="list-style-type: none"> <li>Receive different components of the solar power plant (modules, inverter, transformers etc.) procured as per the design</li> <li>Check the components for specifications, quality, conduct erection and commissioning of the solar power plant as per the design, construct the substation and grid interface incorporating grid code and regulatory provisions incorporated in the design</li> </ul>	
	<b>Project Engineer (Civil)</b>	<ul style="list-style-type: none"> <li>Manage planning &amp; design of civil &amp; structural works including performing due diligence &amp; feasibility of construction site</li> <li>Evaluate cost estimates and monitor project budgets in coordination with the Site in charge</li> <li>Responsible for preparing work schedules and allocating resources for all civil construction activities for the project</li> <li>Ensure that project is commissioned in compliance with industry specifications and safety standards</li> </ul>	B.Tech/B.E. in Civil Engineering
	<b>Cable Installation Technician/Engineer</b>	<ul style="list-style-type: none"> <li>Assist with cable route design and engineering</li> <li>Undertake assessments relating to cable protection including stable seabed assessments and burial assessments/burial strategies</li> <li>Inspections of cable systems at each offshore location</li> </ul>	Degree in engineering or mechanical engineering. Higher diploma in technical engineering
	<b>Quality Assurance Executive</b>	<ul style="list-style-type: none"> <li>Execute formal inspections to ensure quality, safety and reliability, adhering with technical specifications and compliance requirements</li> </ul>	Bachelor's in engineering (mechanical, materials or electrical preferred) or equivalent

Value Chain	Role	Brief Description	Academic Qualification
Construction		<ul style="list-style-type: none"> <li>Verify correctness and usability of vendor products and services through specification matching and quality checks</li> <li>Manage project processes and deliverables, according to stakeholder requirements and objectives, to improve customer satisfaction levels</li> <li>Manage risks relating to specific projects as precaution against internal and external vulnerabilities</li> <li>Provide detailed evaluation of installation procedures</li> </ul>	
	Quality Assurance Manager	<ul style="list-style-type: none"> <li>Implement on-going efforts to improve products, services, and/or processes through leveraging opportunities to streamline work, increase quality and reduce waste</li> <li>Incorporate quality principles and methodologies into engineering processes, products, and services from concept to disposal</li> <li>Establish quality assurance policies and management systems for products and services to ensure compliance with internal quality requirements, client expectations, international quality standards and/or regulations</li> </ul>	Bachelor's in engineering (mechanical, materials or electrical preferred) or equivalent
	Marine Fitter	<ul style="list-style-type: none"> <li>Repairs service and overhaul of engines and accessories of ships, boats etc., under guidance of Marine Engineer/Engineer/another designated expert</li> <li>Examine drawings and other specifications</li> </ul>	Bachelor of vocation/Degree in Mechanical/Electrical/Electronic Engineering, from All India Council for Technical Education (AICTE)/University Grants Commission recognized Engineering College/university Diploma in Mechanical/Electrical/Electronic Engineering from AICTE recognized board of technical education or relevant

Value Chain	Role	Brief Description	Academic Qualification
Construction		<ul style="list-style-type: none"> <li>Check and measure parts for flaws and other accuracy of fit using gauges, micrometres etc., and removes defect by chipping, filing, scraping, grinding and does other supplementary tooling, as necessary</li> </ul>	<p>Advanced Diploma (Vocational) from Directorate General of Training (DGT) with two years' experience in the relevant field</p> <p>OR</p> <p>National Trade Certificate/ National Apprentice Certificate passed in the Trade of "Marine Fitter" with three years' experience in the relevant field</p> <p>Essential Qualification:</p> <p>Relevant National Craft Instructor Certificate in any of the variants under DGT</p>
O&M	Solar PV O&M Engineer	<ul style="list-style-type: none"> <li>Responsible for day-to-day management of a team of solar PV technicians and O&amp;M activities of the plant</li> <li>Ensure adherence to safety requirements at all times</li> <li>Monitor the operation of the solar PV power plant and ensure adherence to applicable safety, occupational health and environmental regulations.</li> <li>Monitor floating solar arrays, voltages at various levels, operational efficiencies of individual components, electricity generation, loss in generation due to grid disturbance and consumption pattern of electricity, if applicable, compute performance ratio and compares with simulated values.</li> <li>Identify electrical faults and get it rectified in the plant down to module string level</li> <li>Responsible for manpower deployment and maintenance schedule</li> </ul>	A degree/diploma in Electrical Engineering

Value Chain	Role	Brief Description	Academic Qualification
O&M		<ul style="list-style-type: none"> <li>Use and maintain a Computerised Maintenance Management System and other quality management tools as necessary</li> </ul>	
	<b>Solar PV O&amp;M Technician - Electrical</b>	<ul style="list-style-type: none"> <li>Periodically check and maintain all the electrical components of the solar PV power plant for proper electrical connectivity, incorporate quality craftsmanship and comply with all applicable codes, standards, and safety requirements</li> </ul>	ITI or Diploma in Electrical Experience in electrical wiring, equipment installation and maintenance
	<b>Switchyard Engineer - Electrical</b>	<ul style="list-style-type: none"> <li>Conduct preventive &amp; breakdown maintenance of high voltage switchyard electrical equipment including isolators, circuit breakers, CVT, CT, Wave Traps, Reactors, HV Transformers etc.</li> <li>Conduct system studies with respect to electrical faults in the switchyard</li> <li>Smooth remote monitoring &amp; operation of electrical equipment using SCADA.</li> <li>Coordinate with external authorities for smooth operation of solar park</li> </ul>	B.Tech/B.E. in Electrical or Electrical and Electronics Engineering
	<b>Solar PV O&amp;M Technician - Civil</b>	<ul style="list-style-type: none"> <li>Periodically check all the civil parts/mechanical parts of the solar PV for its stability and long-life incorporating quality craftsmanship and complying with all applicable codes, standards and safety requirements</li> </ul>	ITI or Diploma in Civil Experience in equipment installation and maintenance
	<b>Solar PV Manufacturing Technician/Operator</b>	<ul style="list-style-type: none"> <li>Inspect and test the module and pack it for transit</li> <li>Cleans the front glass cover for the PV module</li> </ul>	ITI or Diploma

Value Chain	Role	Brief Description	Academic Qualification
O&M		<ul style="list-style-type: none"> <li>Solder solar cells to make interconnection in strings</li> <li>Carry out lamination of modules, framing of solar PV module</li> </ul>	
	<b>Marine Operation Technician</b>	<ul style="list-style-type: none"> <li>Install and perform routine maintenance of buoy systems, anchoring &amp; mooring systems and other related components</li> <li>Perform underwater mechanical operations, disassembling and repairing related equipment</li> <li>Assist in establishing and tracking maintenance schedule for anchoring &amp; mooring, electrical equipment, service boats etc.</li> </ul>	Diploma/Vocational Certification
	<b>Surface Supplied Air Diver/Navy Diver</b>	<ul style="list-style-type: none"> <li>Underwater salvage and repair, maintenance and unique construction projects</li> <li>Execute search and rescue missions</li> <li>Commercial diving activities and underwater operations in inshore and offshore waters</li> </ul>	Certificate-National Skills Qualifications Framework (SCUBA <sup>1</sup> Diver) or 12th (08 years as Indian Naval Ships Diving Officer/Indian Naval Ship Diver/Indian Naval Clearance Diving Officer/ Indian Naval Clearance Diver Class II)
De-commissioning	<b>Recycling Specialists</b>	<ul style="list-style-type: none"> <li>Asset recovery and electronics recycling for the solar industry</li> <li>Plan disposal for excess, recalled, and end-of-life solar products such as panels and energy storage</li> </ul>	Master's Degree in Public Administration, Business Administration, Environmental Science, or a closely related field  Experience in resource recovery (e.g., waste disposal, recycling), or training
	<b>Decommissioning Program Manager</b>	<ul style="list-style-type: none"> <li>Responsible for evaluating strategy and planning for decommissioning of solar modules, tracking system (if any), Inverters &amp; Transformers, Electrical cabling</li> </ul>	B.E./B.Tech in Electrical or Electrical & Electronics or Civil Engineering with significant experience in construction, commissioning O&M of Solar PV plants

1. Self-contained underwater breathing apparatus

Value Chain	Role	Brief Description	Academic Qualification
De-commissioning		<ul style="list-style-type: none"> <li>▪ The manager will also be responsible for coordinating with local authorities for necessary agreements and project closure</li> <li>▪ Associated with transportation of assets to scrapyards or alternative project sites for recycling/reinstallation of materials</li> <li>▪ Associated with managing waste and disposal of materials and providing site clearance to relevant authorities</li> <li>▪ Restoration of waterbodies, if applicable</li> </ul>	









