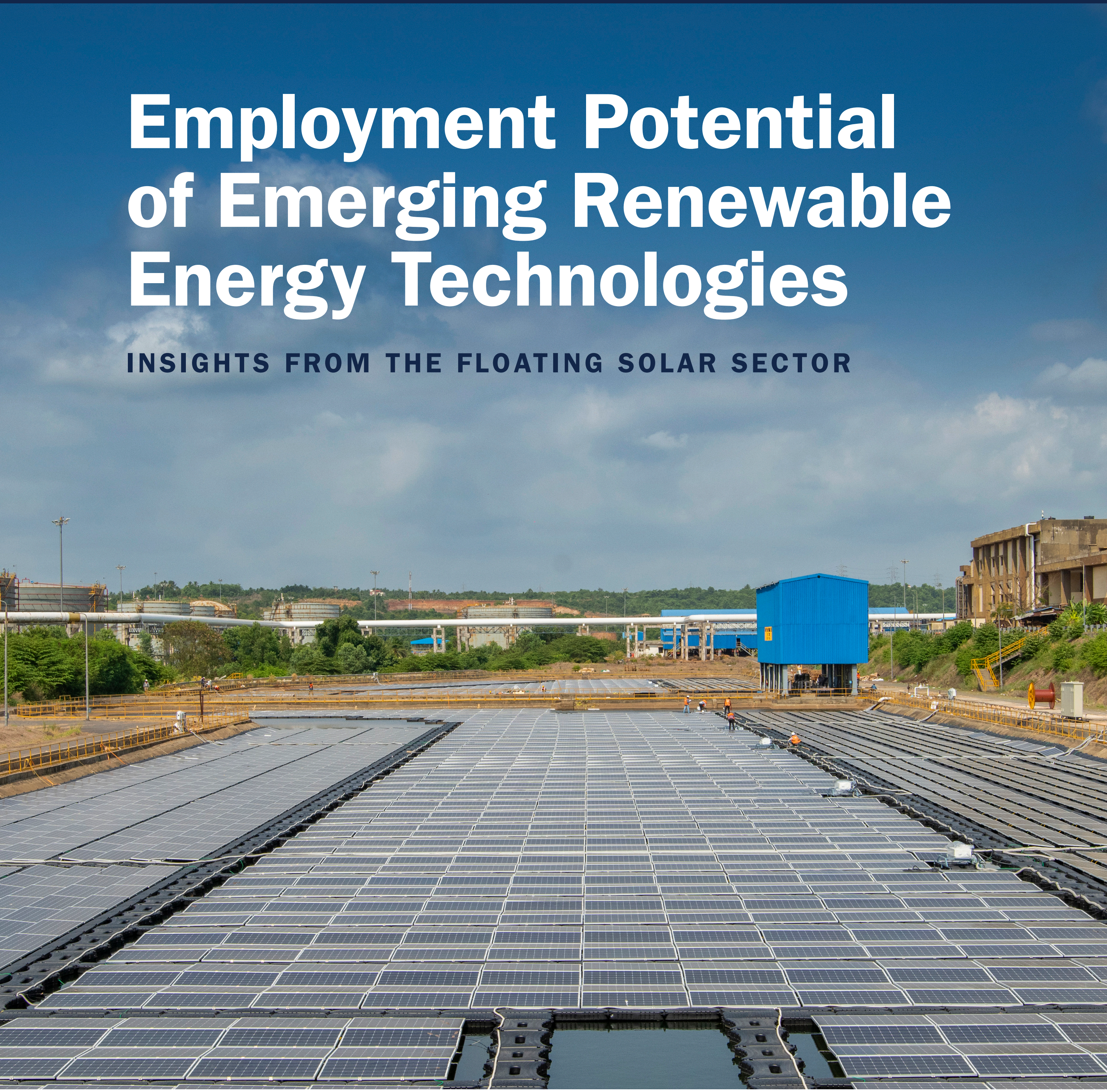
ISSUE BRIEF

March 2021

Employment Potential of Emerging Renewable Energy Technologies

INSIGHTS FROM THE FLOATING SOLAR SECTOR



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ACRONYMS

CdTe	cadmium telluride
DPR	detailed project report
EPC	engineering, procurement, and construction
FPV	floating photovoltaic
FRP	fibre-reinforced plastic
FY	financial year
GW	gigawatt
HDPE	high-density polyethylene
IEC	International Electrotechnical Commission
INR	Indian National Rupee
kW	kilowatt
MNRE	Ministry of New and Renewable Energy
MW	megawatt
O&M	operation and maintenance
PV	photovoltaic
RE	renewable energy
SECI	Solar Energy Corporation of India
USD	United State dollar
UV	ultraviolet

EXECUTIVE SUMMARY

Floating solar photovoltaic (FPV) technology offers a new and additional pathway to realize India's clean energy ambitions. It taps the country's large water reservoirs to overcome some of the persisting issues of ground-mounted solar, such as the lack of levelled land, evacuation infrastructure and performance degradation due to high operating temperatures. Concurrently, FPV provides additional employment opportunities.

The Council on Energy, Environment and Water (CEEW), the Natural Resources Defense Council (NRDC), and the Skill Council for Green Jobs (SCGJ) have undertaken periodical studies to estimate the direct jobs created in the solar and wind industry since 2014. In this study, we estimate the direct employment potential across the project deployment cycle in the FPV sector. This estimate is drawn from project-based case-studies generated through surveys and interviews with manufacturers, developers, and EPC (engineering, procurement, and construction) providers. We also provide an insight into the operational strategies and team structure in addition to discussing the typical duration of different phases of project development and the corresponding workforce employed.

KEY FINDINGS

- A small-scale FPV plant (capacity <1 MW) directly employs 58 workers while a mid-scale (capacity <10 MW) plant 45, over the course of their deployment.
- The FPV sector generates indirect job opportunities through manufacturers of specialized components like floats, anchors, and mooring system as well as domestic module manufacturers.
- The FPV sector offers opportunities for people qualified in hydraulic engineering, marine architecture, and plastic blow-moulding techniques, some of the key skills required for bringing an FPV plant to life, in addition to those required in ground-mounted solar operations.
- By setting time-based targets for FPV capacity, the government could widen the employment potential of this sector, which would bolster efforts to drive India's COVID-19 economic recovery and achieve its Paris Agreement goals.

KEY RECOMMENDATIONS

- We recommend to the Ministry of New and Renewable Energy (MNRE) to specify standards for photovoltaic (PV) modules used in the FPV sector.
- We suggest that the Ministry of Skill Development and Entrepreneurship comes up with training programs on specialized topics relevant for the FPV industry such as marine architecture and hydraulic engineering.
- We call upon FPV industry to regularly release data on employment and skill in the sector.
- We request the MNRE to announce periodic targets for FPV capacity.
- We also advise the Solar Energy Corporation of India (SECI) to initiate hydropower-linked FPV project tenders.

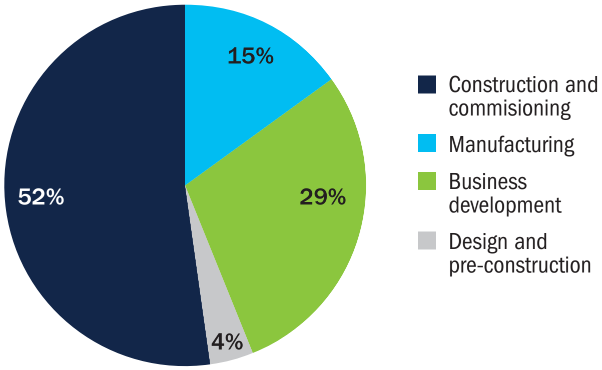
Table ES1 Overview of Operations in Deploying a Floating Solar Photovoltaic Plant of Different Capacities

Project phase	Duration (days)		Number of people engaged	
	Small-scale	Mid-scale	Small-scale	Mid-scale
Business development	30	110	11	12
Design and pre-construction	15	14	6	2
Construction and commissioning	53	195	36	27
Maintenance	30*	Not available	5**	4**

** Typical duration of one periodic maintenance*
*** The number of permanent employees overseeing these activities. In addition, temporary staff is also sourced during each maintenance cycle, who carry out the maintenance activities like module cleaning.*
Source: CEEW-NRDC Analysis, 2020.

Employment Insights from the Development of a Mid-Scale Plant

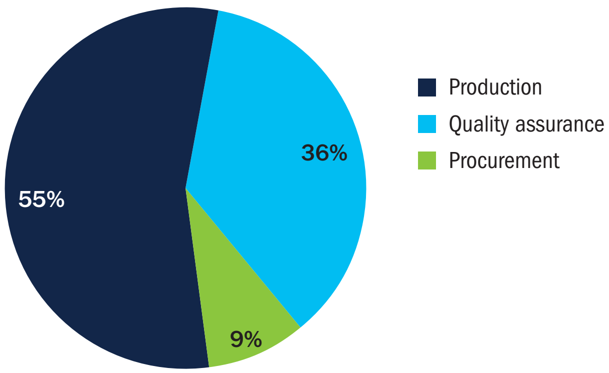
Figure ES1 Time-Share (days) of Project Development Cycle Phases for a Mid-Scale FPV Plant



Location: Mudasarlova Reservoir, Vishakhapatnam, Capacity 2 MW
Source: CEEW and NRDC analysis

Employment and Skill Data

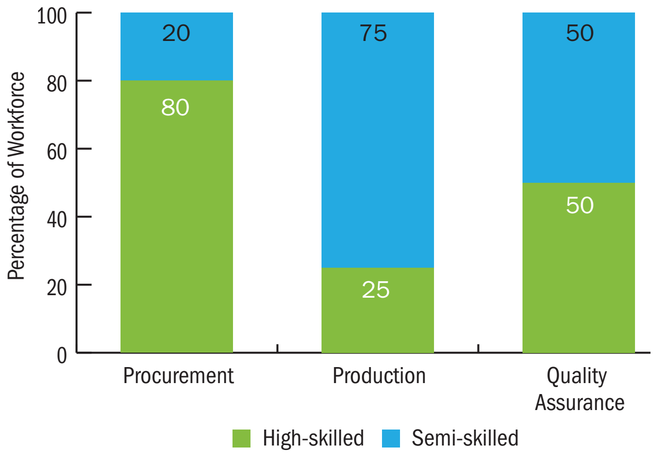
Figure ES2 Percentage of Workforce Engaged in Production of Different FPV Components (includes floats, anchors and moorings) for a Mid-Scale FPV Plant



Location: Mudasarlova Reservoir, Vishakhapatnam, Capacity 2 MW

Source: CEEW and NRDC analysis

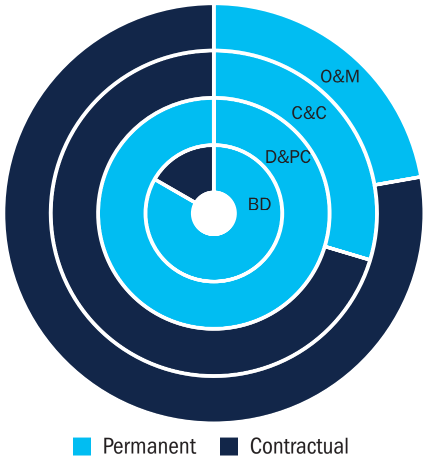
Figure ES3 Relative Proportions of High-Skilled and Semi-Skilled Workers Engaged in Production of a Mid-Scale FPV Plant



Location: Mudasarlova Reservoir, Vishakhapatnam, Capacity 2 MW

Source: CEEW and NRDC analysis

Figure ES4 Overview of Share of Permanent and Contractual Workers Employed at Various Project Stages in a Mid-Scale FPV Plant

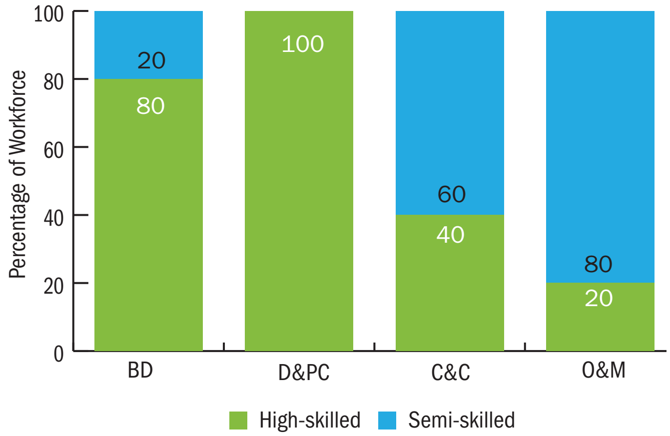


BD: Business development; D&PC: Design and pre-construction; C&C: Construction and commissioning; O&M: Operation and maintenance

Location: Mudasarlova Reservoir, Vishakhapatnam, Capacity 2 MW

Source: CEEW and NRDC analysis

Figure ES5 Relative Proportions of High-Skilled and Semi-Skilled Workers Employed in Different Project Stages of a Mid-Scale FPV Plant



BD: Business development; D&PC: Design and pre-construction; C&C: Construction and commissioning; O&M: Operation and maintenance

Location: Mudasarlova Reservoir, Vishakhapatnam, Capacity 2 MW

Source: CEEW and NRDC analysis

1 INTRODUCTION

Floating photovoltaic (FPV) solar is an emerging technology in which solar photovoltaic (PV) modules are installed (floated) on a water body. Asia has taken a lead in FPV solar deployments, driven by rapid capacity deployments in China, India, South Korea, Taiwan, Thailand, and Vietnam, and is expected to host two-third of the global capacity. FPV's global installed capacity was 2.6 GW by August 2020 and a study projects a 20 percent annual growth till 2025.[1] A conservative estimate puts the global FPV potential at 400 GW, which indicates enormous opportunities for this sector's growth.[2]

For clean energy transition, FPV technology offers immense opportunities for India, as water bodies are spread across its vast landscape. By the middle of 2019, India had about 2.7 MW of installed FPV capacity and projects with a combined capacity of 1.5 GW capacity are under development.[3] The Government of India has set a target of achieving 10 GW of FPV capacity by 2022.[4] According to someestimates, India can build 280 GW of FPV capacity by by utilizing about 30 percent area (nearly 1,800 square kilometres) of its medium and large water reservoirs.[5] The bid prices for FPV tenders are also steadily declining, registering a 45 percent drop in prices between 2016 and 2018. As a result, India has achieved the lowest cost for FPV projects at ₹ 35 ($0.5)/watt, which was offered during the bid for 70 MW FPV capacity in Kerala.[6]

1.1 OPPORTUNITIES FOR FPV IN INDIA

FPV offers a promising option for supporting India's clean energy transition. FPVs face fewer challenges compared to ground-mounted solar plants which are often confronted with issues such as unavailability of levelled land for installation, lack of power evacuation infrastructure in proximity to the installation site, and performance losses due to high operating temperatures.[7] FPV eliminates the need for land by exploiting the existing artificial and natural water bodies like reservoirs and lakes. When these water bodies are in close proximity to an electricity generation site (e.g. hydropower dams or thermal power plants), an easy access to the transmission network is assured. The efficiency of solar generation is also enhanced by cooling effect of the water beneath and reduced soiling of the module surface.

Concentration of solar installations in states with high insolation and land availability is currently high.[8] The geographical coverage of solar capacity in the country could be improved by building FPV capacity as areas, even hills, with expansive water bodies become captive sites for FPV installations.

Despite its many advantages, FPV technology has some barriers which hinder its faster scale-up. For instance, FPV investment cost is about ₹ 7 ($0.1)/watt higher than its ground-mounted counterpart.[9] The cost is enhanced by additional structural auxiliaries such as floats, anchors, and mooring system. Contamination of the water body during the project construction or operation is also a concern.[10] Lastly, additional research is needed to study the real impact of FPV installations on water bodies.

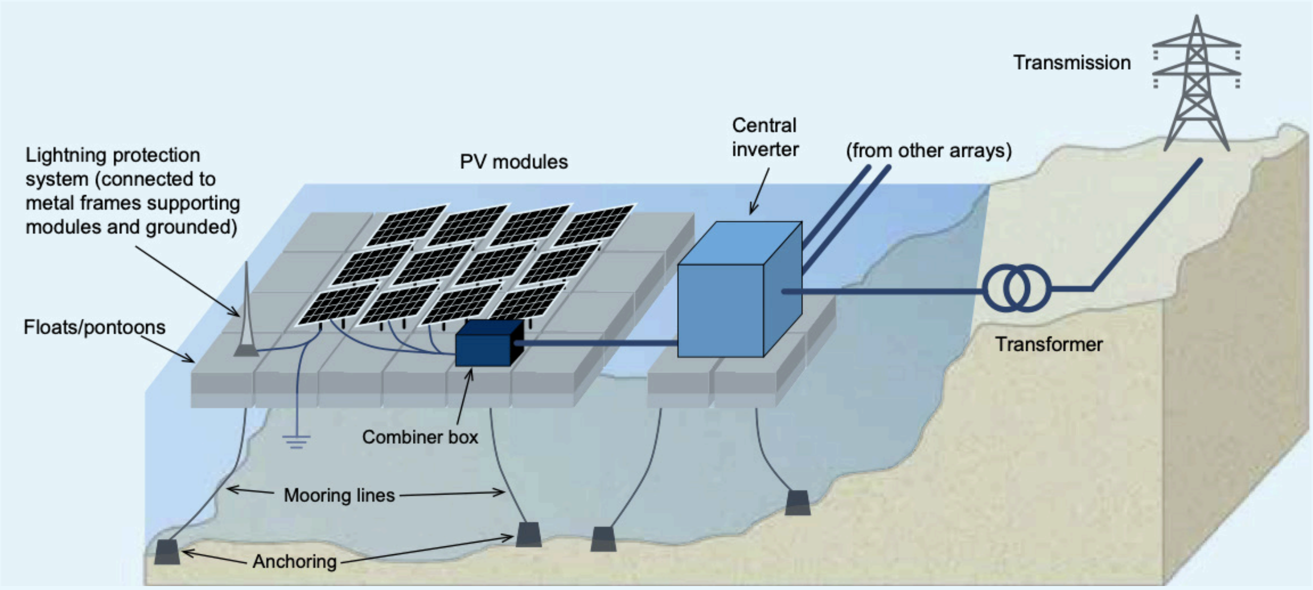
New FPV installations generate additional employment opportunities. In an economic slowdown because of the COVID-19 pandemic, this emerging sector can be help boost employment and reinvigorate the economy. We focus on the potential for direct employment across various project phases in the FPV sector in this issue brief.[11] We use a case-study based approach to identify specific skills required in the sector and draw a comparison with the ground-mounted solar sector. This study is part of the continued efforts of The Council on Energy, Environment and Water (CEEW) and Natural Resources Defense Council (NRDC) in estimating the direct jobs created in the solar and wind industry since 2014.[12]

Overview of floating solar technology

An FPV system consists of PV modules mounted on a floating structure, supported by mooring lines and anchors embedded in the water bed. The floating structure consists of a float, commonly made of high-density polyethylene (HDPE), designed to withstand water currents, local wind, and weight of the PV modules and auxiliaries. The floats are occasionally made of fibre-reinforced plastic (FRP) and metals. Cables connect the modules to the inverters, which are typically installed at the shore. Figure 1 shows a schematic representation of a typical FPV system with its main elements.

Two float designs are commonly used today: float and pontoon. In a 'float' system, modules are placed on a mounting structure, which rests on the buoyant float. The 'pontoon' type, besides hosting the modules, has an additional extra space in which other system components such as inverters can be installed. Anchoring and mooring systems stabilize the floating structure to withstand local changes in water currents and wind speed. These systems ensure that the buoyant structure provides stability to the floating structure and prevent it from drifting away with changing water current.

Figure 1 Schematic Representation of Different Components of an FPV Plant



Source: World Bank Group, ESMAP, and SERIS 2019. Where Sun Meets Water: Floating Solar Market Report. Washington, DC: World Bank

2 METHODOLOGY

As FPV is a sunrise sector of the economy, we use a project-based analysis to assess the employment potential in the sector. We derived insights about operation strategies, organisational structure, and employed workforce at a project level through surveys and interviews with manufacturers, developers, and engineering, procurement, and construction (EPC) providers.

Out of seven companies we approached for our study, four of them came forward to provide information on three projects (names withheld on request). Of these projects, two are of small-scale capacity (<1 MW) The first project is located in a reservoir near Mumbai, is a technology demonstration pilot project (concentrated FPV) of 50 kW capacity. The second is a 450 kW FPV plant installed on a pond at CIAL golf course at Cochin airport. The third project is a mid-scale capacity (<10 MW) plant. This project, of 2 MW capacity, is located in Mudasarlova reservoir near Vishakhapatnam.

We reached out to stakeholders, each of whom has a distinct role in project deployment cycle that reflects their activities, team composition, and skill set of the employed workforce. A targeted questionnaire was given to each stakeholder to capture granular information and nuances of FPV operations. Further, we had telephonic conversations to get feedback and understand the working experiences of stakeholders.

Project development stages

A solar project deployment involves several activities for which varying number of people with different skill sets are needed and their work span depends upon the activity. We classify project activities into four stages to capture the employment potential of the FPV sector:

In Phase 1—business development—strategic decisions are made, such as assessing project viability, identifying potential off-takers, bidding, and obtaining several regulatory approvals such as securing water-body rights. Although these activities are undertaken by developers, EPC providers also perform them while submitting bids for the contract.

In Phase 2—design and pre-construction—different procedures are completed that are critical to ensuring a smooth plant construction such as site testing and acquisition, plant design, and site preparation. These activities are undertaken by EPC providers.

In Phase 3—construction and commissioning—various components are procured, such as modules, floats, and mounting structures, followed by field activities such as plant construction, component installation, and grid connection. A developer often outsources these activities to an EPC provider.

In Phase 4—operations and maintenance—regular plant operations and maintenance are performed, such as module cleaning, performance check, and troubleshooting. The developer undertakes these activities.

In our case study, we divide FPV project deployment into four phases grouping different activities performed in each phase. We also include insights from the manufacturing industry, which supplies various structural components such as modules, floats, and anchoring and mooring system for the FPV project. Figure 2 gives an overview of the value chain of the FPV sector. The survey questionnaire captures data across these different stages of an FPV project. It focuses on understanding the duration of particular activities and assessing the number of people employed in these activities across each phase.

3 KEY FINDINGS AND DISCUSSION

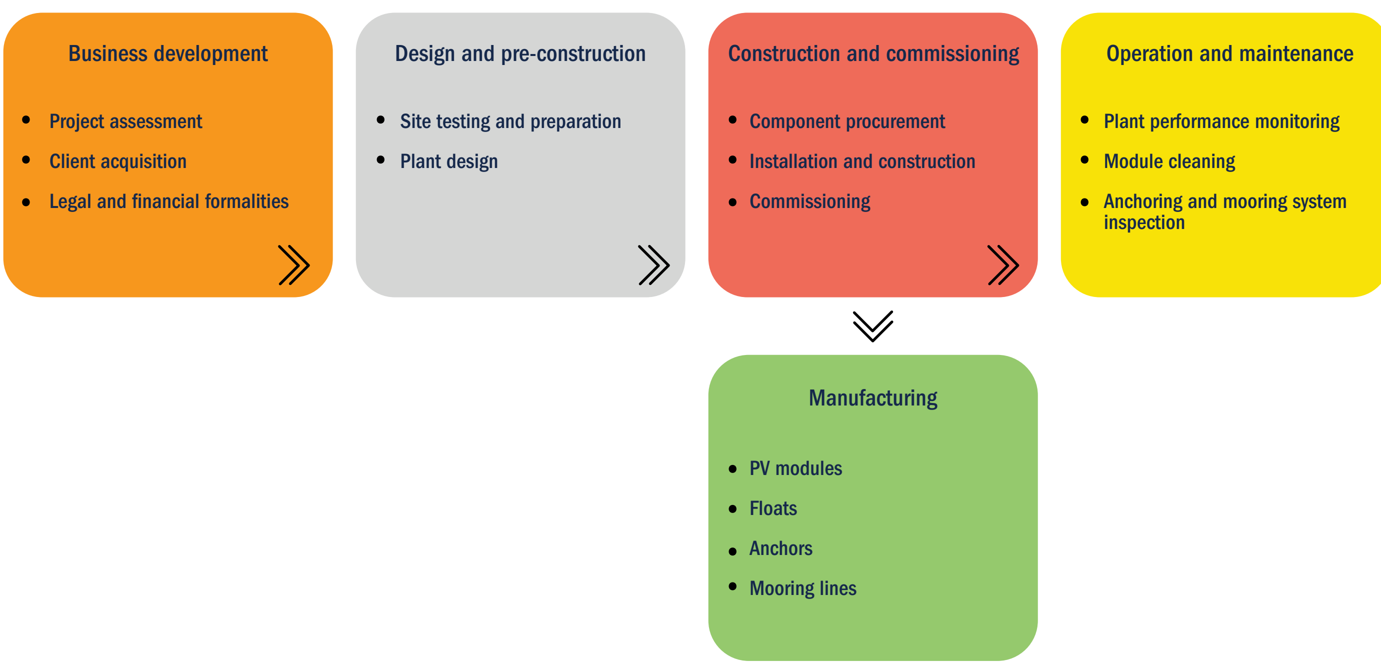
We provide insights from the survey responses and telephonic discussions in this section. We have gathered details on the average duration of activities and number of people employed along with how the duration of activities and workforce employed change based on the project size and company profile. These are indicative numbers based on the limited responses. A more comprehensive study undertaken when the sector matures would provide a clear picture of overall employment created over the course of an FPV project.

3.1 Manufacturing

3.1.1 PV modules manufacturing

PV modules are the backbone of solar technology, both on ground and water. These two systems differ in humidity and salt mist, which induces module corrosion. The current national and international standards for PV modules such as IS 14286-1-1: 2019/IEC 61215-1-1:2016 and IS 14286-1-Sec 2: 2019/IEC 61215-1-2:2016 describe test sequences for determining the effect of long-term exposure on the electrical and thermal characteristics of crystalline and thin film (made of cadmium telluride

Figure 2 **An FPV Solar Project Traverses Four Stages for a Successful Deployment**



Source: Modified from CEEW-NRDC 2014, Solar Power Jobs: Exploring the Employment Potential in India's Grid-Connected Solar Market

[CdTe]) modules installed in terrestrial open air environments.[13] Further, the IEC 61701:2020 describes test sequences to determine the resistance of different PV modules to corrosion from salt mist containing chlorides, such as sodium chloride and magnesium chloride.[14] As there are no similar standards for floating solar PV panels, the panels used for terrestrial environments are used for floating applications as well.[15] Until the new standards for floating PV modules are specified, the current module industry would continue to meet the demand from the FPV sector as well.

A typical PV module manufacturing unit has divisions such as management, administration and finance, purchasing, technical, and production. We estimate the employment coefficient (job-year/MW) of manufacturing industry to be 2.60 in 2017.[16] In a typical module manufacturing unit the production division houses more than 70 percent of the employees. Our survey for financial year 2017 revealed the domestic production of solar modules to employ 2,900 people per 1.5 GW of manufacturing capacity. For achieving 100 GW of solar capacity, 45,000 additional employees would be needed.[17]

If the FPV industry takes off in India, it would increase the demand for PV modules. We foresee only a marginal impact of the FPV industry on the employment coefficients and additional jobs created in solar PV module manufacturing. Because after a certain production capacity expansion, the same workforce can manage production to meet the additional demand.[18]

3.1.2 Design and manufacturing of floats, anchors, and mooring system

Floats hold the PV modules on water surface. According to the respondents in the FPV industry, floating structure (floater) manufacture involves extensive research. The material used to build the float needs to be buoyant and strong enough to host PV modules, inverters, and the weight of maintenance staff. Further, resistance to degradation under ultraviolet (UV) radiation is important. Quality of the raw material also affects the environmental impact and durability of the floaters. Hence, pure virgin raw materials are preferred over recycled materials to manufacture floaters. Different tests are conducted to validate the tensile strength, floatability, and mechanical resistance of the raw materials to ensure that it meets high quality standards.

The industry's understanding of the materials and system requirements for floats has improved over the years. Many Indian companies are investing in research and domestic manufacturing of floats. There are some international float manufacturers as well who import their patented technologies for operations in India. To maintain the same quality standards, the licensee companies import the machines, float moulds, and UV stabilizers to the local manufacturing facility.

Float design

The key considerations for customizing the design of floating structures to suit the project requirements are: [19]

- project scale, which determines the possible coverage of water surface;
- compatibility of the structure with PV modules and other electrical components;
- wind speed, water waves, and current;
- nature of waterbed or its bank, which holds the floating structure; and
- ease of deployment considering site conditions and the access to water.

As floats are manufactured usually in bulk, manufacturers consider all these aspects to develop robust floats. Developing the prototype is time-consuming and takes little over a month. Then the same design (float mould) is replicated for future projects. The process usually involves highly skilled civil and marine engineers, among others.[20]

Anchors and mooring system design

Unlike the float design, anchoring and mooring system is site-specific. This system's design depends on the nature of the water bed, soil composition, wind speed, and water level. Evenly distributing the weight of the floating structure and ensuring that the structure remains steady amid turbulence are critical to designing these systems. Highly skilled marine architects undertake the design and installation of these systems.

Although these products are used in offshore industry as well, they need to be customized for FPV installations. Therefore, dedicated manufacturing of anchors and mooring lines for FPV projects would generate additional job opportunities.

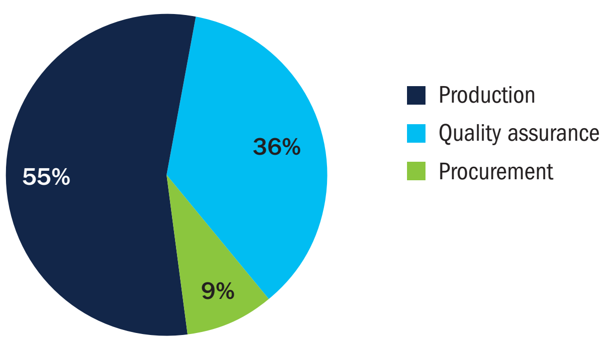
Manufacturing

Components such as floats, anchors, and mooring lines can be manufactured in-house by the developer or outsourced to a manufacturing company. If the manufacturing is outsourced, the developer invites bids, selects vendors, procures material, monitors manufacturing, and performs quality checks. The precise duration of the entire process depends on the project scale.

For a small-scale plant (capacity < 1 MW), the manufacturing phase could last for a month. For outsourced manufacturing, after finalizing the vendor, it usually takes about two weeks to complete the production of components, which comprises three to four days to procure the materials, a week to manufacture, and three days for quality check. The entire float manufacturing process usually involves contracted labourers and some company supervisors.

For a mid-scale plant (capacity < 10 MW), the entire manufacturing process takes two months, or slightly less, and involves 55 permanent staff (with a slight variation) with different skill levels (see Figures 3 and 4). Almost 90 percent of the time goes into float manufacture and the rest in the production of anchors and mooring system. Material procurement takes about five days and employs five highly skilled people. Production and planning of the manufacturing operations involve 30 people, majority of whom are semi-skilled, working in shifts over the production period. Highly skilled people are in-charge of operations. It is desirable to have a workforce with knowledge and prior experience in technologies like plastic blow moulding in operations. This aids the manufacturing process and troubleshooting of operations or production errors. Companies are currently investing considerable time in employee training, which reduces operation efficiency, as skilled people are in short supply. More than 50 per cent of workforce in a mid-scale plant is engaged in production of different FPV components (Figure 3). Close to 80 percent of the total workforce engaged in component production for a mid-scale plant is semi-skilled (Figure 4). Once production is completed, 20 people are involved in quality assurance activities, which take up to 20 days. The quality team is a homogeneous mixture of high- and semi-skilled people (Figure 4).

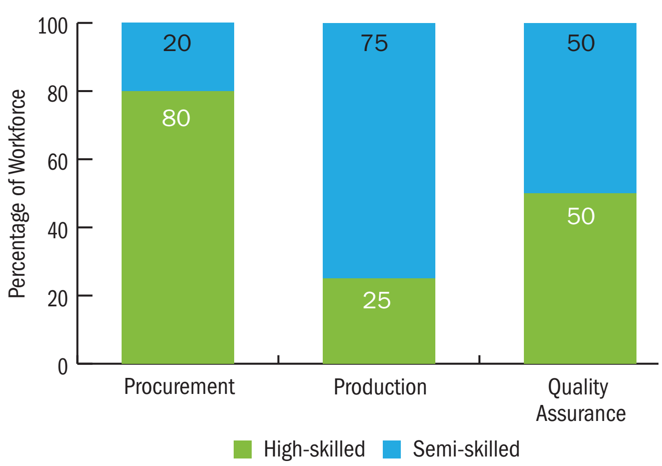
Figure 3 Percentage of Workforce Engaged in Production of Different FPV Components (includes floats, anchors and moorings) for a Mid-Scale FPV Plant



Location: Mudasarlova Reservoir, Vishakhapatnam, Capacity 2 MW

Source: CEEW and NRDC analysis

Figure 4 Relative Proportions of High-Skilled and Semi-Skilled Workers Engaged in Production of a Mid-Scale FPV Plant



Location: Mudasarlova Reservoir, Vishakhapatnam, Capacity 2 MW

Source: CEEW and NRDC analysis

Through FY21 to FY23, the domestic manufacturers are anticipating more than 100 percent scale-up in the production of different FPV components such as floats, anchors, and mooring lines.

3.2 BUSINESS DEVELOPMENT

In the business development phase, various strategic activities such as preparation of detailed project report (DPR), feasibility study, bidding, and liaising with government are undertaken. Both developers and EPC providers perform these activities for a project. For EPC providers, the business development phase starts much before submitting the bid for a project, and continues even after winning the bid. In the pre-bid phase, EPC providers submit a DPR containing details such as generation from plants, cost estimates, and feasible area for surface coverage. Based on these parameters, they submit a bid to the developers. After winning the bid, business development involves other activities mentioned in Figure 2.

We find two types of companies operating in the FPV sector: typically smaller or mid-sized companies offering only FPV-specific services and, usually, large ones that have a dedicated division for FPV projects. The business development phase creates new employment opportunities in both types of companies. A small- and mid-scale plant respectively requires 11 and 12 people for business development and this department is usually peopled by highly skilled staff with years of experience and formal degrees. Business development activities are accomplished in a month for a small-scale project and in 110 days for mid-scale project (Table 1, Figures 5 and 6).[21] EPC providers spend about 45–60 days for business development in the pre-bid phase, with a team of four people. The post-bid phase activities involve eight people, usually six permanent staff and two contractual. Majority of the contractual staff is hired for site acquisition and regulatory activities.

3.3 DESIGN AND PRE-CONSTRUCTION

Site studies and plant design, which are crucial for plant construction, are undertaken in this phase. Various types of water bodies such as reservoirs, ponds, and lakes are used for deploying FPV technology. The orientation and shape of the water body is important for FPV installation. As India is located in the northern hemisphere, south orientation is preferred for module installation to improve electricity generation.

Bathymetry and hydrographic studies are a pre-requisite before finalizing the plant design and commencing the installation process. Bathymetry estimates water body's depth and helps understand the water body's topography so as to know the bedrocks and other hindrances in the waterbed. Hydrographic studies also include bathymetry but extend to ascertaining the shape and features of the shoreline, the characteristics of tides, currents, and waves as well as the physical and chemical properties of water.

Soil testing and water variations are also an integral part of the pre-design studies. Collectively, these studies determine the plant design, including placement of anchoring and mooring systems. Therefore, these activities involve highly skilled expert staff. If the type of water body is known, say reservoir of a hydroelectric dam, then necessary data for these studies are typically available from primary project documents. So, the whole process can be completed in about two weeks. However, if the water body is new and unexplored, then data collection and other requisite studies take considerable time. In some cases, it can extend to a few months.

The plant design is conceptualized based on the pre-design study results. Irrespective of plant capacity, this phase requires a small team of highly skilled civil, mechanical, hydraulic, and electrical engineers. The actual team size, however, depends on the organisation undertaking the project. One of our respondents employed six people for these activities, and the other organisation employed two people. Given the underlying complexities of the water body and the detailed studies required, plant design for an FPV project is more time-consuming than ground-mounted solar. The average duration of this phase is about 15 days for a small-scale plant and 14 days for a mid-scale plant (Table 1, Figures 5 and 6). Design and pre-construction of the plant requires high-skilled workforce (Figure 6).

After finalizing the plant design, project site is readied for construction. Site preparation is easier and faster in FPV compared to ground-mounted solar. On land, the foundation structure is made of concrete, which needs time to cure. Further, the land needs to be cleared and levelled for installation. FPV, on the other hand, doesn't have these hassles, shrinking the construction time.

3.4 CONSTRUCTION AND COMMISSIONING

This phase includes the procurement of different plant components and field activities for plant construction and installation. Once the installation is complete, the FPV plant is commissioned. Often these activities are outsourced to an EPC company. Many of these processes happen in parallel, and hence the timelines for sub-stages overlap. For instance, the components are procured in a phased manner. As soon as the first lot of these components arrives, the installation and construction process is initiated. Next, the team tests and commissions components such as inverters or even smaller plant capacities in phases.

As a first step, the EPC company procures various components such as modules, floats, anchors, and mooring from a manufacturer. Often, the EPC company is also a manufacturer of one or more of these components. Depending on the plant size, which alters the quantity of these parts, the procurement process can take anywhere between a few weeks and a few months. For a small-scale plant, the procurement team has three people, two skilled and one unskilled. For a mid-scale plant, the number of people employed remains similar, but the duration of procurement increases to about two months.

After procuring the components, the construction and installation process is kickstarted. For modules, the general implementation strategy is to make small modular blocks, called solar pods, and scale them up for the entire plant. A pod usually hosts a few kilowatts of capacity, which increases considerably for a large plant.[22]

As soon as a pod is ready, it is released into the water body. Depending on the location, the pod can be simply pushed into water (optimum for ponds or lakes) or lifted off the surface and neatly placed on the water body by using dedicated machinery. The latter is a preferred mode for installations on artificial reservoirs as pushing the pod through concrete surface of the dam can damage the pod.

Once the pod is on water, a team of technicians and labourers completes the installation by making final connections. The team includes engineers (civil, electrical, and hydraulic), labourers, and a boatman to carry them to the site. Based on the depth of the water body, external scuba divers are arranged to connect these pods with the anchoring lines. In a small plant, 33 people are involved in the construction and installation work, which lasts for a month. For a mid-scale plant, these activities take about 135 days requiring 25 people (6 permanent and 19 contracted staff).

3.5 OPERATION AND MAINTENANCE

Operation and maintenance (O&M) of FPV plants are relatively smoother than ground-mounted solar. This is because installations on water do not give rise to issues like accumulation of dust and/or sand, common in ground-mounted installations. Therefore, periodic maintenance, which includes activities such as module cleaning and site cleaning, is done only four times a year for a small-scale plant and 28 times a year for a mid-scale plant.[23]

These O&M services are provided by EPC or developers and the project off-taker decides the exact duration of these activities. In a small-scale plant, each maintenance cycle lasts for about 30 days. For maintenance services, the service providers contract a team of semi-skilled people who assist their permanent staff. For a mid-scale

Table 1 Overview of Operations in Deploying a Floating Solar Photovoltaic Plant of Different Capacities

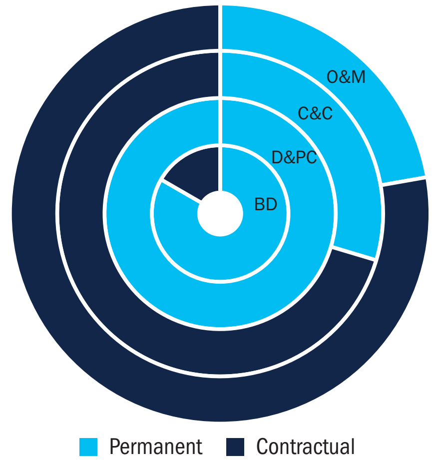
Project phase	Duration (days)		Number of people engaged	
	Small-scale	Mid-scale	Small-scale	Mid-scale
Business development (BD)	30	110	11	12
Design and pre-construction (D&PC)	15	14	6	2
Construction and commissioning (C&C)	53	195	36	27
Operation and maintenance (O&M)	30*	Not available	5**	4**

** Typical duration of one periodic maintenance*

*** The number of permanent employees overseeing these activities. In addition, temporary staff is also sourced during each maintenance cycle, who carries out the maintenance activities like module cleaning.*

Source: CEEW-NRDC Analysis, 2020

Figure 5 Overview of Share of Permanent and Contractual Workers Employed at Various Project Stages in a Mid-Scale FPV Plant

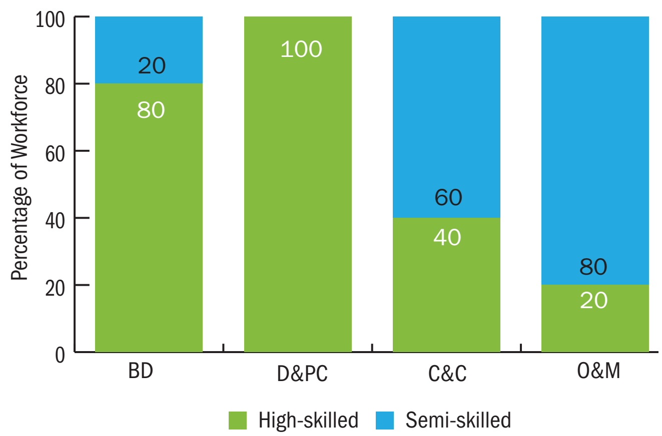


BD: Business development; D&PC: Design and pre-construction; C&C: Construction and commissioning; O&M: Operation and maintenance

Location: Mudasarlova Reservoir, Vishakhapatnam, Capacity 2 MW

Source: CEEW and NRDC analysis

Figure 6 Relative Proportions of High-Skilled and Semi-Skilled Workers Employed in Different Project Stages of a Mid-Scale FPV Plant



BD: Business development; D&PC: Design and pre-construction; C&C: Construction and commissioning; O&M: Operation and maintenance

Location: Mudasarlova Reservoir, Vishakhapatnam, Capacity 2 MW

Source: CEEW and NRDC analysis

plant, this team is made up of four permanent employees and 10 contractual workers. One of the permanent staff is assigned for real-time monitoring of the plant. The responsibilities of this person include module performance, observing the lateral flow of water, and taking necessary actions to restrain the movement of the installed system. Occasionally, this person also checks the anchors and mooring lines to ensure the stability of the system. As the installations are on water bodies, all personnel involved in operations should know how to swim to safety in case there is an accident in the water body. Largely, contractual workers are employed at various project stages in a mid-scale FPV plant (Figure 5).

3.5.1 Challenges

Despite some advantages, the FPV installations also pose challenges for the operators. First, the location of FPV plants makes their maintenance a comparatively tedious exercise compared to land installations. The site can be accessed only through boats, which are also used to carry all the required items to avoid delays. Second, damage and obstruction can be caused by natural habitat. Fouling by marine organisms such as algae, anthozoa, and tunicate, could have an impact on the system's buoyancy.[24] FPV installations serve as an excellent resting site for birds. But birds may damage the module surface by scratching or poking with their beaks. Bird droppings can cover the cell surface leading to hot spots, which can damage other cells in the module. To scare birds, operators often install auxiliaries like spikes or wind cones. Shading of water body by the floating structure can inhibit the growth of coral reefs and sea grass.[25]

4 CONCLUSION AND RECOMMENDATIONS

Scaling up of FPV technology in India can support its clean energy transition and and generate employment. The FPV and ground-mounted solar sectors have a majority of functions in common. But our study suggests that FPV sector can create additional employment opportunities. For instance, the FPV technology needs PV modules with improved humidity tolerance and corrosion resistance. Components such as floats and customized anchors and mooring lines are exclusive to FPV installations, and their manufacture creates job opportunities. Hence, existing domestic manufacturing of these project components would get a boost if FPV technology takes off in a big way in India. New employment opportunities, especially in research and product design, beckon when the FPV scales up in the country.

During its development cycle, an FPV project would create additional jobs for dedicated players and those transitioning from ground-mounted sector to FPV, although the magnitude would be different. For specialized companies handling FPV projects, new jobs would be created in all developmental phases, with the highest during the construction and commissioning phase. In case of transitioning or conglomerate companies, besides some skilled workforce needed for dedicated project phases, most of the existing staff would be sufficient. Therefore, the need for additional jobs would be low, as companies may prefer to use the existing workforce.

We are upbeat about the sector's potential to grow, and our respondents foresee an increase in employee strength in the coming three years. An interesting observation from our case-study is the possibility of additional employment prospects for local boatmen in project sites. Since the FPV project is primarily accessed by a boat, for carrying out installation and maintenance activities, the developers and EPCs can outsource these services to the local community living close to the water body. Although the number of jobs created would be small, it surely opens up an additional source of livelihood.

The FPV technology requires high engineering skills for execution. High-skilled people are needed in all stages and semi-skilled workers are also deployed in several stages. The FPV sector needs people with new skill sets, such as hydraulic engineering, marine architecture, plastic blow moulding, and swimming, in addition to those essential in the ground-mounted solar PV sector. Hydraulic studies are crucially needed for site selection and plant design. Marine architecture is critical for designing and installing anchoring and mooring system. Although courses of study are available for these skills, the FPV sector needs experts in different roles. Further, some of the necessary skills are learnt on-field and with experience. Knowledge and experience of plastic blow-moulding technology is very essential for accurate and smooth manufacturing of floats. Swimming, on the other hand, is a life-saving pre-requisite skill for people involved in FPV projects.

RECOMMENDATIONS

Based on the insights obtained from our study, we propose the following recommendations.

1. **Standards for PV modules used in FPV industry**

   The Ministry of New and Renewable Energy (MNRE) should implement IEC Standards for PV modules used in FPV plants. As this technology requires high-humidity and corrosion-resistant PV modules, introduction of a standard would improve the performance and durability of FPV plants. Further, it would boost the domestic production of these modules, thereby increasing employment prospects.

2. **Training programs on specialized topics relevant for FPV industry**

   The Ministry of Skill Development and Entrepreneurship should design and offer training programs in hydraulics and marine architecture. FPV is an engineering-driven industry and needs highly skilled people in vital roles. So, it is important to introduce these new technologies and related topics in the existing curriculum at the undergraduate or post-graduate level. Besides, reskilling the existing workforce by providing short-term training on new skills would improve their employment prospects in the emerging technologies like FPV.

   To meet the demand of skilled workers in the float manufacturing industry, training programs covering the science and operations of plastic production technologies like blow moulding are essential. This could significantly improve operation efficiency of FPV installations.

3. **Better reporting of employment data**

   The FPV industry should periodically share employment figures for each project and report the gap in the desired skill level. This would guide concerned ministries to introduce relevant training programs and enable sectoral development and employment growth.

4. **Periodic targets for FPV capacity**

   We urge the MNRE to consider setting annual targets for FPV capacity deployment to open up employment opportunities and instil investor confidence in these technologies. Periodic targets would aid in the creation of jobs by supporting domestic manufacturing of different FPV components and utilisation of trained workforce. The capital cost of floating solar projects is higher than ground-mounted plants. Access to finance is a major barrier for this sector. Target setting by MNRE would go a long way in driving the investors towards the sector.

5. **Integration of FPV technology with hydropower generation stations**

   We also recommend to the Solar Energy Corporation of India (SECI) to initiate hydropower station–linked FPV tenders. FPV projects require shorter durations for site preparation and plant construction. However, construction of necessary infrastructure for electricity transmission takes time, which delays commissioning of FPV projects. Reservoirs used for hydropower generation can act as viable sites for FPV deployment as the power evacuation infrastructure is readily available. In this way, the FPV projects could be constructed and commissioned in a short time span.

Endnotes

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11 Jobs created by RE technologies are classified into direct, indirect, and induced. Direct jobs are associated with the design, development, management, construction/installation, and maintenance of projects. Indirect jobs are related to the manufacturing of equipment and materials used in the project, supply chain that provides these materials and services to the manufacturers, and the finance and banking sectors that provide services for construction and operation of a project. Induced jobs are those created due to expenses by people directly or indirectly employed by the projects.

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16 Job-year or full-time equivalent (FTE) is a ratio of the time spent by an employee on a particular project/task in a given year to the standard total working hours in that particular year. For example, a project requiring a person working for three years counts as 3 FTE. Workforce required to do these jobs is calculated by multiplying the FTE coefficients with capacity (in MW). Our 2017 survey indicated that FTE vary marginally with an increase in the production capacity above 200 MW. For instance, module manufacturing companies with <50 MW capacity employed 35 per cent more people than those with higher capacities. Kuldeep, Neeraj, Kanika Chawla, Arunabha Ghosh, Anjali Jaiswal, Nehmat Kaur, Sameer Kwatra, and Karan Chouksey. 2017. Greening India’s Workforce: Gearing Up for Expansion of Solar and Wind Power in India. New Delhi: Council on Energy, Environment and Water.

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18 Our 2017 survey indicated that FTE vary marginally with an increase in the production capacity above 200 MW. For instance, module manufacturing companies with <50 MW capacity employed 35 per cent more people than those with higher capacities.

19 World Bank, ESMAP and SERIS. 2019. Where Sun Meets Water: Floating Solar Handbook for Practitioners. Washington, DC: World Bank

20 Definition of different skill levels used in the study. High-skilled: engineering or advanced degree required; Semi-skilled: technical qualification or vocational skills required; Low-skilled: no formal education required.

21 This phase of the project can be marred by delays and hence it could last for a long time. However, the effective time spent by employees on these activities could be less.

22 A representative number is about 6 kW/pod, which translates to about 30 modules/pod for a readily available crystalline silicon PV module.

23 According to our respondents, the plant maintenance is on customer’s request. The requests are often made if the customer observes any change in the performance of the plant or other visible damage. The number reported here is based on the respondents visit for the mid-scale plant constructed by them.

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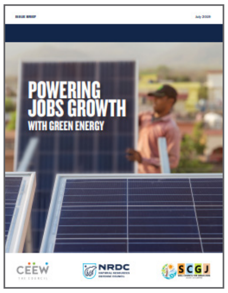
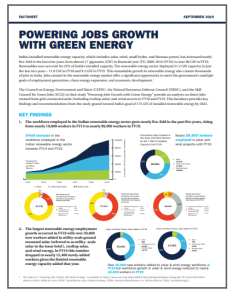
Highlighted Resources

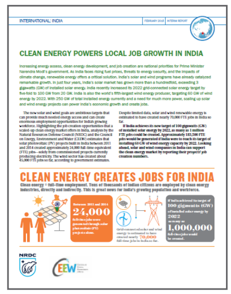


Powering Jobs Growth with Green Energy

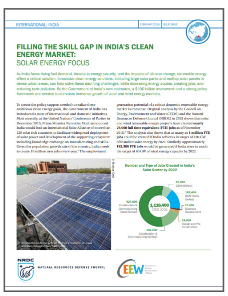


Powering Jobs Growth with Green Energy

Greening India's Workforce: Gearing up for Expansion of Solar and Wind Power in India

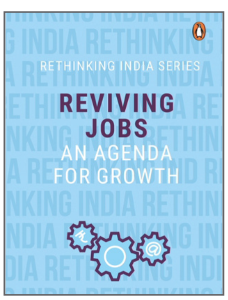


Clean Energy Powers Local Job Growth in India

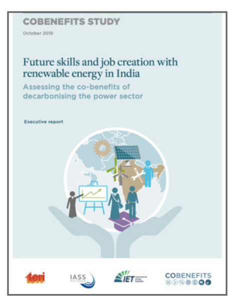


Filling the Skill Gap in India's Clean Energy Market: Solar Energy Focus

Creating Green Jobs: Employment Created by Kiran Energy's 20-Megawatt Solar Plant in Rajasthan, India



Chapter: Building the Workforce for India's Emerging Clean Energy in Reviving Jobs – An Agenda for Growth



Future Skills and Job Creation with Renewable Energy in India

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