REPORT

JANUARY 2022

INDIA'S EXPANDING CLEAN ENERGY WORKFORCE

OPPORTUNITIES IN THE SOLAR AND WIND ENERGY SECTORS

CEEW THE COUNCIL

NRDC NATURAL RESOURCES DEFENSE COUNCIL

SCGJ SKILL COUNCIL FOR GREEN JOBS ISO 9001 : 2015 CERTIFIED

About this Report

This report is a part of series of issue briefs, reports, case studies, and fact sheets on clean energy in India. This employment discussion builds on three earlier issue briefs on clean energy jobs, *Powering Jobs Growth with Green Energy* (2019), *Greening India's Workforce* (2017) *and Clean Energy Powers Local Job Growth in India* (2015).

About Council on Energy, Environment and Water

Council on Energy, Environment and Water (CEEW) is one of Asia's leading not-for-profit policy research institutions. The Council uses data, integrated analysis, and strategic outreach to explain – and change – the use, reuse, and misuse of resources. It prides itself on the independence of its high-quality research, develops partnerships with public and private institutions, and engages with the wider public. In 2021, CEEW once again featured extensively across ten categories in the 2020 Global Go To Think Tank Index Report. The Council has also been consistently ranked among the world's top climate change think tanks. CEEW is certified as a Great Place To Work® . www.ceew.in Twitter @CEEWIndia

About Natural Resources Defense Council

Natural Resources Defense Council (NRDC) is an international non-profit environmental organization with more than 3 million members and online activists. Since 1970, our lawyers, scientists, and other environmental specialists have worked to protect the world's natural resources, public health, and the environment. NRDC's India Program on Climate Change and Clean Energy, launched in 2009, works with local partners to help build a low-carbon, sustainable economy. www.nrdc.org Twitter @NRDC_India

About Skill Council for Green Jobs

Skill Council for Green Jobs (SCGJ) is the sector skill council supporting National Skill Development Mission, National Solar Mission, Make in India, Smart City Mission, AMRUT and Swachh Bharat Abhiyan. SCGJ has been created under the Ministry of Skill Development and Entrepreneurship (MSDE) and promoted by Ministry of New and Renewable Energy (MNRE) with the mandate to undertake industry skills gap analysis, develop National Occupational Standards along with course curriculums and certification of trainers and candidates to support skill development activity in India. www.sscgj.in

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Acknowledgements

The authors would like to thank Dr. Praveen Saxena, SCGJ; Ms. Amanda Maxwell, NRDC; Mr. Nitish Arora, NRDC; Mr. Neeraj Kuldeep, CEEW; Ms. Madhura Joshi, E3G; and Mr. Tanmay Bishnoi, Clean Energy Specialist for all for their review comments. We sincerely value the contributions of the following NRDC staff: Kim Knowlton, Sameer Kwatra and Kriti Sehgal, NRDC. The authors are grateful to the funders of our work for their generous support.

Suggested Citation: Akanksha Tyagi, Charu Lata, Jessica Korsh, Ankit Nagarwal, Deepak Rai, Sameer Kwatra, Neeraj Kuldeep, and Praveen Saxena. 2022. India's Expanding Clean Energy Workforce. Council on Energy, Environment and Water, Natural Resources Defense Council, and Skill Council for Green Jobs.

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Foreword

सत्यमेव जयते

इन्दु शेखर चतुर्वेदी
INDU SHEKHAR CHATURVEDI

सचिव
भारत सरकार
नवीन और नवीकरणीय ऊर्जा मंत्रालय
SECRETARY
GOVERNMENT OF INDIA
MINISTRY OF NEW AND RENEWABLE ENERGY

Foreword

India's renewable energy (RE) targets are rightly ambitious. While enabling a sustainable future, these targets also provide the opportunity of creating quality jobs for the growing population.

Harnessing the full employment potential of India's targets requires development of human resources in adequate numbers and skill sets. The Ministry of New and Renewable Energy has undertaken various initiatives in this direction. Some of these include conducting short term training programmes including Solar PV technician (Suryamitra) training , providing scholarships/ fellowships to students for pursuing higher studies and advanced research (National Renewable Energy Fellowship Scheme), internships to students / working professionals in renewable energy (National Renewable Energy Internship Scheme) and supporting educational and research institutions with RE based infrastructure facilities like upgradation of laboratories. The ministry recognises the importance of skilled manpower at all levels in RE sector and update the training curriculums as per industry requirements to bridge the workforce and skill gap. This becomes more critical with the India's renewed target of installing 450 GW of renewable energy by 2030.

I am therefore pleased to introduce the latest CEEW-NRDC and SCGJ report on RE employment in India which assesses prospects of creating new jobs in achieving the 450 GW target by 2030. The analysis on 450 GW capacity target highlights the importance of distributed RE technologies like rooftop solar to maximise the total employment. Information on employment potential and skill requirements in emerging sectors like floating solar, mini-grids and solar-wind hybrid systems would be useful in creating relevant training programmes to support capacity deployments. This year, the report also presents the impact of COVID-19 pandemic on employment in the Indian solar and wind energy sectors and underlines the importance of special provisions made for these sectors amid the nationwide lockdown.

I congratulate the CEEW, NRDC, and SCGJ team in putting out the latest analysis on RE employment in India. This report serves as a useful resource for us to stay informed on the current workforce in the sector and provides information on the industrial skilling requirement.

21/10/2021

[Indu Shekhar Chaturvedi]

New Delhi
October 21, 2021

अक्षय ऊर्जा से देश विकास
गांव गांव बिजली, घर घर प्रकाश

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List of Abbreviation

CAD	Computer Aided Design
CAGR	Compounded Annual Growth Rate
CEA	Central Electricity Authority
CEEW	Council on Energy, Environment and Water
CMS	Conditional Monitoring System
CNG	Compressed Natural Gas
COP	Conference of the Parties
COVID-19	Coronavirus Disease 2019
DISCOM	Distribution Company
DRE	Distributed Renewable Energy
E&C	Engineering & Construction
EPC	Engineering, Procurement and Construction
E-waste	Electronic-Waste
FPV	Floating Photovoltaics
FTE	Full-time equivalent
FY	Financial Year
GHG	Greenhouse Gas
GW	Gigawatts
HSE	Health, Safety and Environment
IEA	International Energy Agency
INDC	Intended Nationally Determined Contributions
IPP	Independent Power Producer
IRENA	International Renewable Energy Agency
ITI	Industrial Training Institute
MBED	Market-Based Economic Dispatch
MD	Managing Director
MW	Megawatts
NOS	National Occupation Standards
NRDC	Natural Resources Defense Council
NSQC	National Skills Qualifications Committee
NSQF	National Skills Qualifications Framework
O&M	Operations & Maintenance
PM-KUSUM	Pradhan Mantri Kisan Urja Suraksha evam Utthaan Mahabhiyan
PV	Photovoltaics
QA	Quality Assurance
QP	Qualification Pack
RE	Renewable Energy
REmap	Renewable Energy Roadmap
SCGJ	Skill Council for Green Jobs
SEWA	Self-Employed Women's Association
TOT	Terms of Trade
UN	United Nations
WSH	Wind-Solar Hybrid

Executive Summary

Introduction

Job creation, skill development and COVID recovery are key priorities for the Indian government. Jobs created in the renewable energy (RE) market offer a significant opportunity to meet the government's multiple goals of employment generation, clean energy expansion, and economic development. As of August 2021, India reached a total installed capacity of 100 GW of RE, excluding large hydro.

This report provides an updated analysis on direct jobs created from solar and wind in financial year 2020 (FY20) and 2021 (FY21), building on earlier analyses by the Council on Energy, Environment and Water (CEEW), the Natural Resources Defense Council (NRDC), and Skill Council for Green Jobs (SCGJ).

This analysis uses the workforce numbers, job-years per megawatt (MW), and full time equivalent (FTE) coefficients calculated in earlier reports from data collected in 2017. This report provides updated findings and recommendations geared toward India's goal of 500 GW of non-fossil fuel electricity generation capacity, including 450 GW of RE, by 2030.

Key Findings

- **India can potentially create about 3.4 million jobs (short and long term) by installing 238 GW solar and 101 GW new wind capacity to achieve the 500 GW non-fossil electricity generation capacity by 2030 goal.** These jobs represent those created in the wind and on-grid solar energy sectors. **A workforce of about one million can be employed to take up these green jobs.** Jobs created are different from the workforce needed, as one worker can perform more than one job.
- **As of FY21, the wind and solar energy sectors employ a workforce of 111,400.** The solar sector (utility-scale and rooftop solar) continued to employ the majority of this workforce with a 77 percent share (85,900) whereas wind accounted for 23 percent share (25,500).
- **COVID-19 impacted the Indian RE sector which created 48 percent fewer jobs in FY21 compared to FY19.** A new workforce of only 6,400 was added in FY21 as compared with 12,400 in FY19. Furthermore, the total workforce addition in FY20 and FY21 combined (11,600) is six percent lower than FY19 alone (12,400).
- **More than 78,000 trainees have been certified under the national-level solar energy Suryamitra training program** between 2015 and July 2021.
- With a focus on enhancing environmental awareness and integrating greening attributes across all job profiles and skill levels, **SCGJ developed two Greening National Occupation Standards (NOS)** "Optimize resource utilization at workplace" and "Adopt sustainable practices at workplace." These are being effectively mainstreamed in the training delivery across all job roles, with a specific focus to inculcate 'green knowledge' and 'green methods' for developing skills in all relevant sectors.

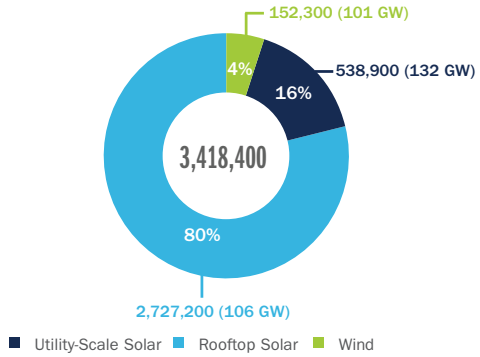
Recommendations

There is significant opportunity to combine the government's job creation and energy transition goals. The following recommendations can help:

- **Higher focus on decentralized renewable energy (DRE) sources like rooftop solar, mini- and micro-grid systems can significantly increase the employment opportunity potential of India's 500 GW of non-fossil fuel electricity generation capacity target.** The distributed nature of these projects makes them more labor intensive than utility-scale projects thereby increasing the jobs created across the project deployment cycle.
- **Ensure continuous deployment of RE capacities to restrain job loss through periodic tendering, provide relaxations to continue construction activities with necessary precautions even in special cases like pandemics** to ensure that the tendered projects meet the timeline, and support the investments in the sector through streamlined processes, payment securities, etc.
- **Strengthen domestic manufacturing of various technology components** to exploit the untapped employment potential and meet the requirements of the 500 GW of non-fossil fuel electricity generation capacity.
- **Promote rural skill development programs to take the transition closer to the community.** Our research indicates that the availability of skilled local workforce can accelerate the deployment of solar parks and mini/microgrid projects.
- **Regularly update the skilling curriculum through periodic industrial engagements** to bridge the skill gap and ensure timely availability of skilled workforce.
- **Reskill and upskill existing workforce** moving from conventional energy to renewable energy sector and to ensure continuous alignment with the evolving requirements of the industry.
- **Develop skilling and training programs for indirect and induced jobs** created from allied sectors like expansion of transmission and distribution network and battery storage industry.

3,400,000 New Jobs (short and long term) can be created by achieving **238 GW solar and 101 GW wind targets** of the 500 GW non-fossil fuel electricity generation capacity by 2030.

Sector-wise jobs creation potential by achieving 101 GW wind and 238 GW solar targets of non-fossil fuel capacity by 2030.



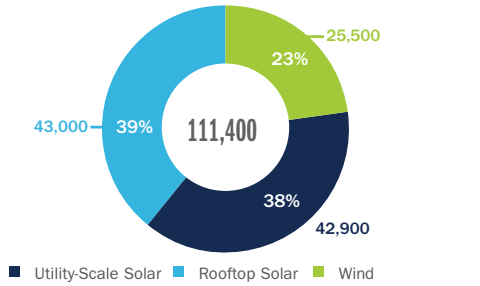
1,000,000 Workforce

can be employed to take up these jobs from the solar and wind targets of the 500 GW of non-fossil fuel capacity by 2030.

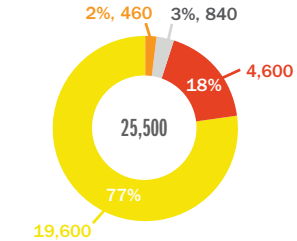
111,400 Workforce

Employed by wind and solar energy sectors as of FY21.

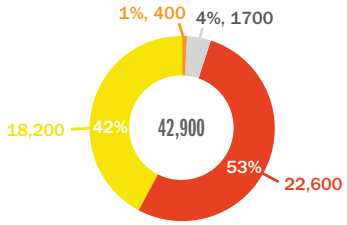
Cumulative workforce employed by wind and solar energy sectors as of FY21



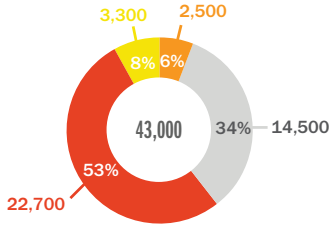
Cumulative Jobs Created for 39.2 GW of Installed Wind Capacity until FY21



Cumulative Jobs Created for 35.6 GW of Installed Utility-Scale Solar Capacity until FY21

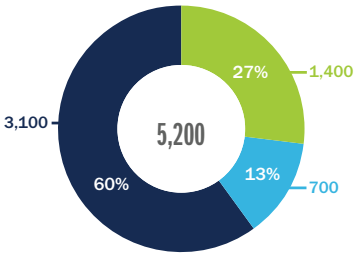


Cumulative Jobs Created for 6.5 GW of Installed Rooftop Solar Capacity until FY21

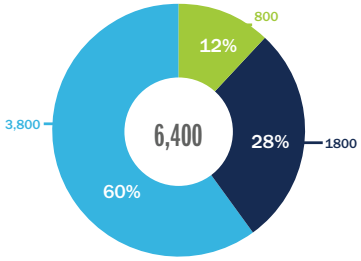


Business Development | Design | Construction and Commissioning | Operation and Maintenance

Solar and wind energy workforce added in FY20



Solar and wind energy workforce added in FY21



Utility-Scale Solar | Rooftop Solar | Wind

Total 100,000 Workers

Trained by SCGJ between **FY16 and FY21** out of which

78,000

were certified under the national-level Suryamitra program

Introduction

India announced a transformational target of 500 GW of installed non-fossil fuel electricity generation capacity by 2030 at the United Nations' 26th session of the Conference of the Parties (COP26) in November 2021. A majority of this share would come from renewable energy (RE) technologies like solar and wind. Reaching a capacity of 500 GW is vital for India to meet its rising energy needs in a sustainable manner while also achieving its climate commitments, both domestic and international. As of November 2021, India reached a total installed capacity of 104 GW of RE, excluding large hydro, and is working toward its near-term target of 175 GW RE by 2022.[4] The potential for employment and job creation by reaching 500 GW of non-fossil fuel capacity by 2030 is tremendous, as discussed in this report.

Growth in the RE sector has already created thousands of jobs in India. A 2019 report by NRDC-CEEW-SCGJ estimated that nearly 99,900 workers were employed in solar and wind projects of 65.7 GW of installed capacity until FY19 with a split of 76,600 workforce in on-grid solar sector and 23,300 in wind sector.[5] The same report estimated that achieving the solar (100 GW) and wind (60 GW) targets in the 175 GW RE target by 2022 could employ over 330,000 workers to take up nearly one million job opportunities in the short- and long-term.[6]

Under the Paris Agreement, India committed to reduce its greenhouse gas (GHG) emissions intensity by 33 to 35 percent by 2030 from 2005 levels and achieve 40 percent of installed power capacity from non-fossil fuels by 2030.[7] India is on track to meet these targets with renewables (solar, wind, biomass, and hydro) constituting 27 percent of India's total installed generation capacity by end of November 2021.[8] India has massive solar and wind energy potential. The country's solar potential is estimated at about 748 GW, assuming three percent of waste land area is covered by solar PV modules, and wind potential is estimated to be more than 300 GW.[9]

At the COP 26 conference in November 2021, countries were expected to enhance their climate targets into greater alignment with those required to keep the level of warming below a catastrophic 1.5°C. Given the large RE potential and the likelihood that India will exceed 40 percent of installed power capacity from non-fossil fuels before 2030, India has enhanced its climate commitments at COP26 conference to include:[10]

1. India's non-fossil energy capacity to reach 500 GW by 2030
2. India will meet 50 percent of its energy requirements with renewable energy by 2030
3. India will reduce its total projected carbon emissions by one billion tonnes from now to 2030
4. By 2030, India will reduce the carbon intensity of its economy to less than 45 percent
5. By 2070, India will achieve the target of net zero emissions

Renewable Energy and Jobs

As a demographically young and growing economy, India's employment needs are large; approximately 67 percent of the country's population falls between the age of 15 and 64 years.[11] India's total labor force in 2020 was almost 472 million people.[12] Prior to COVID-19, the workforce was steadily increasing and India added an approximately five million people to the workforce in 2019. On average, prior to COVID-19, around 4.75 million people were added to the labor force in India each year.[13] The labor force participation rate, the proportion of the population ages 15 and older that is economically active, was about 48 percent in 2019.[14]

RE continues to bring socioeconomic benefits by creating numerous jobs worldwide. In many countries, renewables-based construction projects, equipment supplies, policy implementation (permitting, licensing, auctions) and financing have returned to near normal pre-pandemic levels.[15] RE has proven to be flexible, cost-effective, and resilient in the face of health and economic crises.

Globally, solar PV reached an estimated 3.8 million jobs and wind power employed an estimated 1.2 million people in 2019.[16] CEEW-NRDC-SCGJ estimate that the total workforce in India in on-grid solar and wind sectors, excluding manufacturing, grew from around 19,790 in financial year 2014 (FY14) to 99,900 by March 2019, a five-fold increase.[17]

This analysis highlights that the job creation potential of decentralized renewable energy (DRE) projects is higher than utility scale projects. DRE solutions have the potential to create up to five times more indirect jobs in local communities than direct, formal DRE employment.[18] Data from 2017 to 2018 show that DRE companies operating locally are already a large contributor to direct and indirect employment in India.[19] For example, based on a recent CEEW-NRDC-SCGJ analysis, a distributed RE provider's community mini-grid deployment efforts created an estimated average of 986 jobs.[20] These jobs include 180 direct full-time jobs, 131 full-time equivalent (FTE) jobs from contractual work, and 675 productive-use jobs through additional entrepreneurial activities.

This report considers 'workforce employed' and 'jobs created' as two different parameters though both the terms are interchangeably used in various other studies. Jobs created as per cumulative installed capacity may be higher, as multiple projects may employ the same set of trained workforce.

Jobs Versus Workforce: An Explainer

In our 2015 analysis, Clean Energy Powers Local Job Growth in India, we estimated that scaling up grid-connected solar and wind energy would add a cumulative one million jobs for solar construction workers, installers, maintenance works, engineers, technicians, and plant operators between 2015 and 2022.[21] These jobs include short-term jobs for business development, design and pre-construction, and construction and commissioning, as well as long-term jobs for operations and maintenance and performance monitoring.

Jobs created, however, are different from the workforce needed. One worker can perform more than one job because some of the jobs are short-term. As a hypothetical example, assume the country has an installed capacity of 5 GW that has been deployed in Year 1 with a workforce of 1,500 workers. To deploy an additional 15 GW in Year 2, we would need those 1,500 workers who have already been trained to deploy 5 GW in Year 1 as well as an additional 3,000 workers to deploy the remaining 10 GW. The workforce required in Year 2, therefore, is only the new 3,000 workers that would need training. However, the workers employed totals 4,500 (and not 6,000) for the entire 5 GW plus 15 GW of deployment over the two years.

The analysis in this report estimates workforce employed in the solar and wind sector due to the capacity addition in FY20 and FY21. For estimating the job creation potential of meeting 500 GW of non-fossil fuel capacity by 2030, results are shown for both the workforce employed and total jobs created.

Renewable Energy Market Growth

While RE is reshaping India's energy sector, growth within the RE sector has been uneven. Between April 2014 to January 2021, India's installed RE capacity increased by two-and-half times, and in the same period, the installed solar energy capacity increased 15 times. India is fourth in wind power capacity and fifth in solar power capacity in the world in 2021.[22]

Installed capacity of utility-scale solar reached 32 GW in FY20 and 36 GW in FY21. Installed capacity of rooftop solar reached 6 GW in FY20 and 7 GW in FY21. Installed capacity of wind reached 38 GW in FY20 and 39 GW in FY21 (Figure 1).

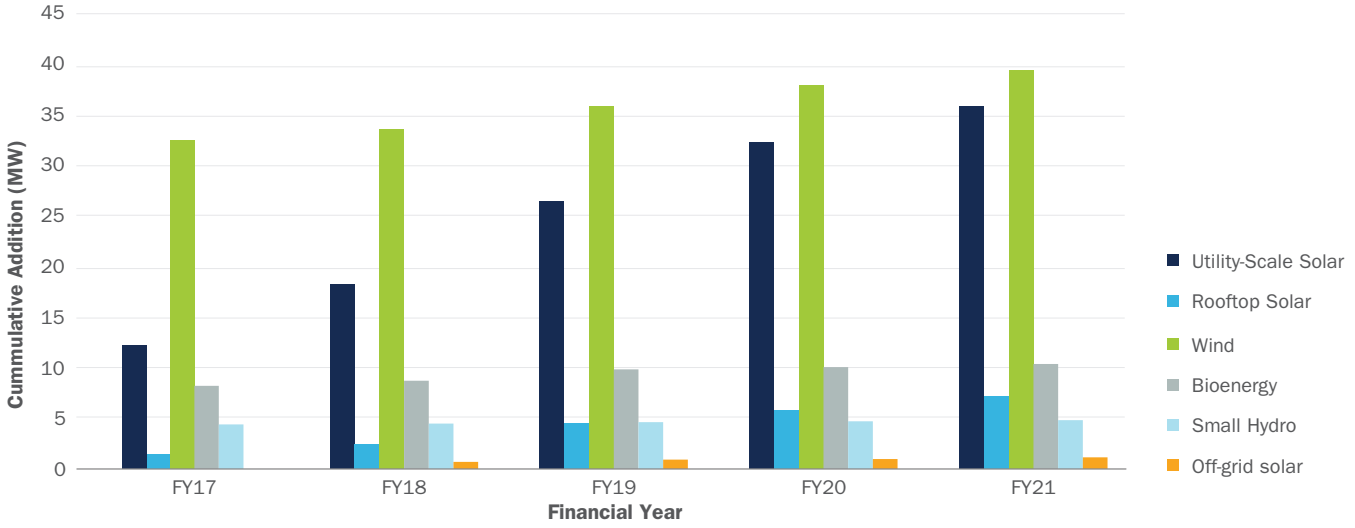
Utility-scale solar has achieved 65 percent of its 60 GW by 2022 target, while rooftop solar is at 17.5 percent of its target of 40 GW by 2022.[23] Wind, with a sectoral target of 60 GW by 2022, has achieved 66 percent of the target.

Evaluating policy and market choices and constraints regarding the share of clean energy projects, large utility-scale or decentralized RE, ensuring continuous growth in the sector and appropriate skilling and training can help in maximizing the workforce employed in the domestic renewable energy sector.

Impact of COVID-19 on Renewable Energy Sector

The RE sector proved to be resilient in the face of the COVID-19 pandemic, though there were some related supply chain disruptions and construction slowdowns.[25] RE generation was less impacted than the rest of the energy sector due to lower marginal costs of electricity generation and the fact that renewables are generally dispatched before other sources of electricity.[26] Overall, global renewable electricity showed strong resilience according to data on monthly installations, awarded auctions, financing of new projects and equity performance.[27] As electricity demand fell drastically during India's lockdown, there were some

Figure 1: Cumulative renewable energy capacity addition in india from FY17 - FY21 (Source: CEEW-NRDC analysis, 2022)[24]



positive market developments that benefited the RE sector, such as record low solar tariffs in late 2020.

The pandemic impacted the workers (including migrant workers), which led to workforce shortage in absence of better social protection measures. The pandemic exacerbated utility distribution companies' (DISCOMs) previously existing financial challenges. Overall, 24 percent and 39 percent less capacity was added in wind and utility-scale solar segments in FY21 over FY20. The rooftop solar segment, on the contrary, was more resilient as per internal estimates and the annual additions grew by nine percent over FY20.

RE market research by CEEW-NRDC-SCGJ showed that the largest reported impact of COVID-19 on employment was in the construction and commissioning phase. This phase includes activities like procurement, installation, grid integration and plant commissioning. The manufacturing phase reported the least amount of impact, which includes manufacturing of various technology components like PV modules, turbines, and balance of system. This is likely because the Indian solar market still relies heavily on imports of solar cells and modules. Trainings were impacted by COVID-19 lockdown. As employment options in the industry dwindled due to the pandemic, organizing training were impacted, besides restrictions on routine training activities.

Scope and Methodology

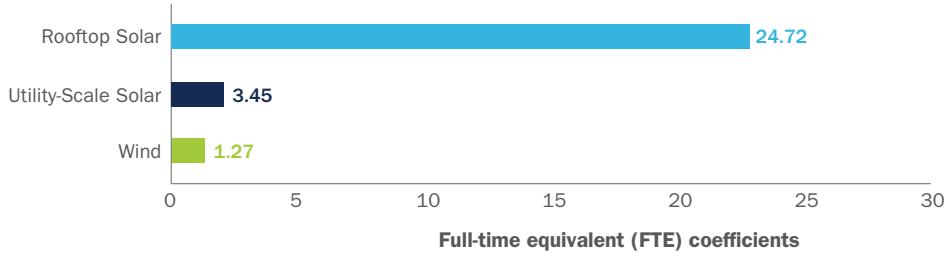
This issue brief analyzes the number of jobs created and the workforce required, i.e., the number of workers needed to perform the multiple tasks for implementing rooftop solar, utility-scale solar, and wind capacity, under the following two sections:

1. **Section 1:** Clean jobs created through renewable energy added to grid in FY20 and FY21.
2. **Section 2:** Potential clean energy jobs that can be created in the wind and solar sectors by meeting India's target of 500 GW of non-fossil fuel based capacity by 2030.

For estimating the number of jobs, each project is divided into four phases: business development, design, construction and commissioning, and operation and maintenance (O&M). Each phase creates direct, indirect, and induced jobs (Appendix 1). The analysis here is restricted to direct jobs created during the planning, construction, and maintenance of solar and wind projects. Indirect and induced jobs, created through manufacturing, financing or earnings of the engaged workforce, are not covered in the analysis.

All job numbers correspond to full-time equivalent employment and are estimated using the full-time equivalent (FTE) coefficients previously developed by CEEW-NRDC (Figure 2).[28] The full-time equivalent or job-year is simply a ratio of the time spent by an employee on a particular task/project in a given year to the standard total working hours in that particular year. The FTE formula translates short-term or one-time employment into a full-time equivalent or job-year. These coefficients are derived from the primary surveys conducted in 2014 across the solar and wind energy companies that included developers, engineering construction and procurement (EPC) contractors and solar PV module manufacturers. The capacity data for the various sectors is taken from government and market reports. As it can be observed, the wind sector is much less labor intensive compared to utility-scale solar or rooftop solar which required more workforce during design, construction and commissioning phases.

Figure 2: Full-time equivalent (FTE) coefficients for RE projects in different sectors (Source: CEEW-NRDC analysis, 2017)[29]



Clean Jobs Generation in FY20 and FY21

Employment in the Wind and Solar Energy Sectors

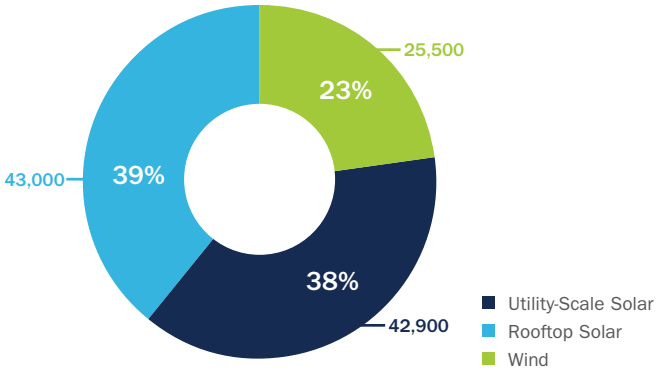
Between FY19 and FY21, the RE sector (wind, utility-scale solar and rooftop solar segments) grew by 23 percent.[30] At the end of FY21, the cumulative installed capacity of wind and solar energy stood at 81 GW (39 GW wind and 42 GW solar).[31] Within solar, the utility-scale segment continued to dominate over rooftop solar segment with 84 percent share (35.6 GW), the latter contributing 6.5 GW.[32]

This section assesses the workforce added to the wind and solar (ground mounted/utility-scale solar and rooftop solar) energy sectors commensurate to the capacity in FY20 and FY21. First, it presents the cumulative jobs created across the sectors. Then, it delves into the individual sectors to discuss the trends over the past two years.

Cumulative Employment

As of August 2021, the cumulative 81 GW renewable capacity addition has employed an estimated 111,400 workers across various RE project phases like business development, design, construction and commissioning, and operation and maintenance (Figure 3). 77 percent of these workers were in the solar sector (85,900) corresponding to 42 GW of installed capacity and remaining in wind sector (25,500) with 39 GW capacity. The rooftop solar segment, despite contributing 15 percent of the total solar capacity (6.6 GW), employed more workers (43,000) than utility-scale solar (42,900) with 35.6 GW. The distributed nature of rooftop solar makes these projects more labor intensive than utility-scale projects.

Figure 3: Cumulative workforce employed in the wind and solar sectors for 81 GW of installed capacity as of FY21 (Source: CEEW-NRDC analysis, 2022)[33]

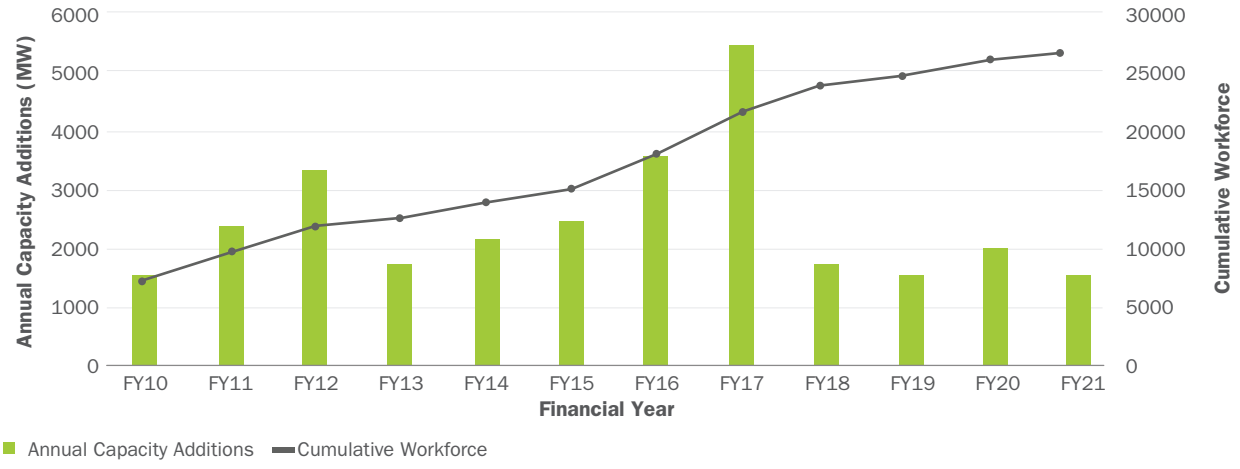


Wind Energy

Wind energy is one of the oldest and most mature RE sector technologies in India, having been around for almost two decades now. The nation has demonstrated global leadership in project development and technology transfer. As of FY 2008-09, India had deployed about 10 GW of wind capacity which created an estimated 6,500 workforce.[34] In 2015, India announced its ambition to install 175 GW of RE capacity by FY22, of which 60 GW would come from wind energy.[35] Supported by this renewed focus of the government, the growth continued in the next decade as well (Figure 4). Between FY10 and FY21, roughly 29 GW of new capacity was added. This capacity employed approximately 19,000 new workers, which raised the total to a little over 25,000 workers at the end of FY21.

Photo Credit : Prashanth Vishwanathan (IWMI)

Figure 4: **Employment trends in wind sector between FY10 and FY21 (Source: CEEW-NRDC analysis, 2022)** [36]



Solar Energy

Solar energy sector has seen stupendous growth in the last decade. With a cumulative capacity close to 15 MW in 2010, the sector has amassed about 40 GW in the last 11 years.[37] This capacity is distributed between utility-scale and rooftop solar segments, with the former taking the major share. The utility-scale solar segment has grown steadily since FY10 (2010). Between FY10 and FY21, about 35 GW of utility-scale solar capacity was deployed which employed an estimated 42,900 new workers (Figure 5). The rooftop solar segment, on the contrary, has seen a dismal growth over the last decade and could only install 6.5 GW capacity. However, this capacity employed about 43,000 workers, slightly greater than utility-scale solar (Figure 6).

Figure 5: **Employment trends in the utility-scale solar between FY10 and FY21(Source: CEEW-NRDC analysis, 2022)**[38]

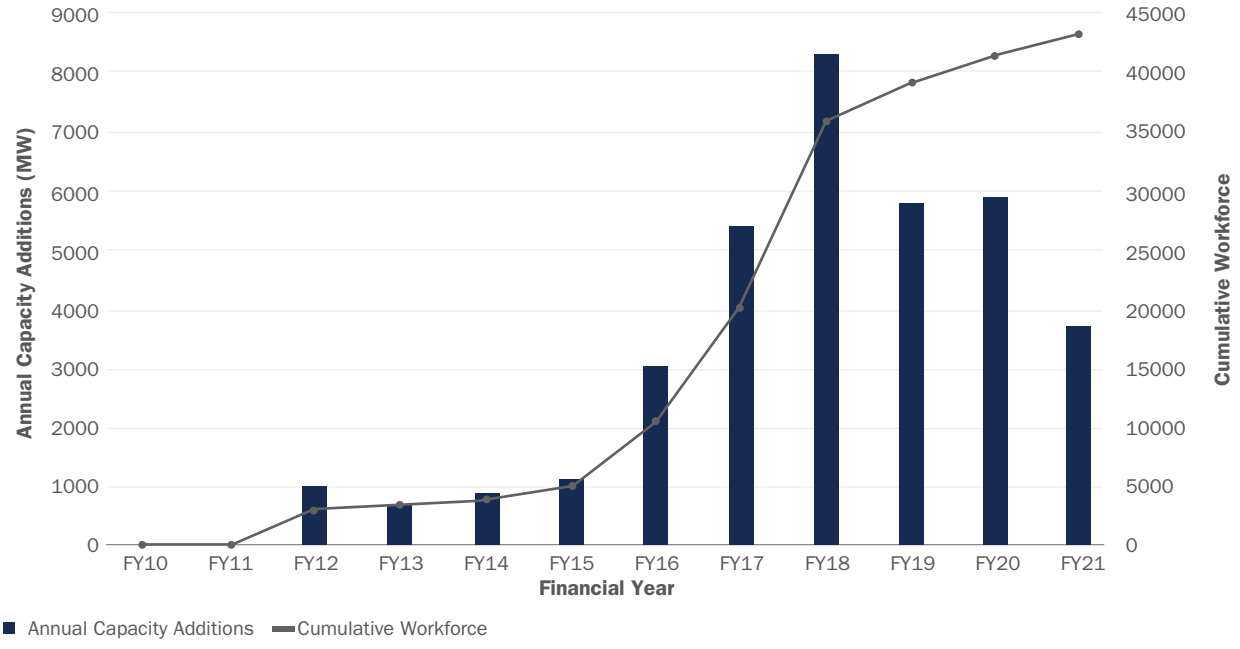
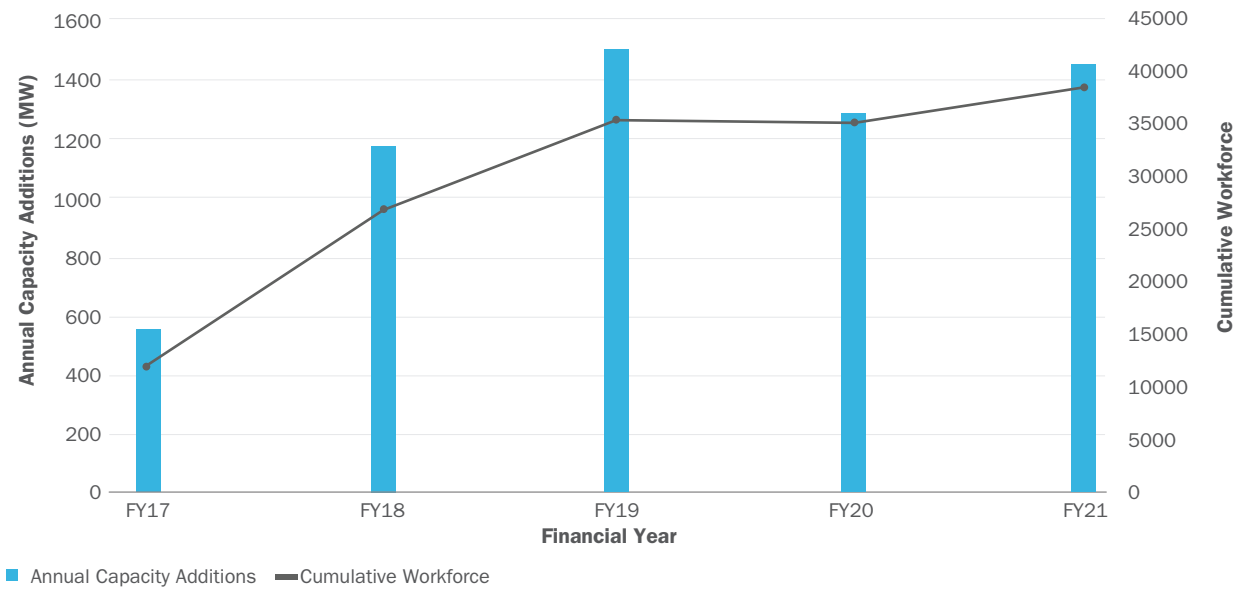


Figure 6: **Employment trends in rooftop solar between FY17 and FY21 (Source: CEEW-NRDC analysis, 2022)[39]**



Employment Addition in FY20 and FY21

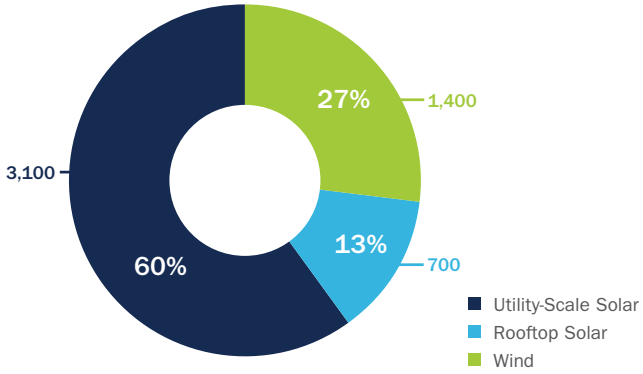
FY20: The annual capacity additions in FY20 for wind energy sector amounted to 2 GW and increased by 30 percent over FY19 figure of 1.5 GW.[40] As a result, with 1,400 new jobs, 78 percent more workers were employed in this sector in FY20 over FY19.[41]

The utility-scale solar segment saw an eight percent increase in annual capacity addition over FY19 from 5.7 GW to 5.8 GW; 3,100 new workers were added, a six percent increase over FY19. The rooftop solar segment, however, witnessed a 14 percent reduction in capacity addition over FY19 (reduced from 1.5 GW to 1.3 GW) leading to a 92 percent decline in workers.[42] Most of the contractual workers were laid off and an additional 700 workers were hired for the operation and maintenance of this new capacity. Multiple factors contributed to reduced capacity addition in rooftop solar during FY20. FY20 started with general elections in May 2019. On the policy side, many states withdrew net metering from commercial and industrial consumers which seemed to put them off. Lastly, the ripples of COVID-19 and nationwide lockdown contributed at onset of last quarter of FY20.

Overall, a total of 5,200 new workers were employed across the wind and solar sectors (Figure 7).

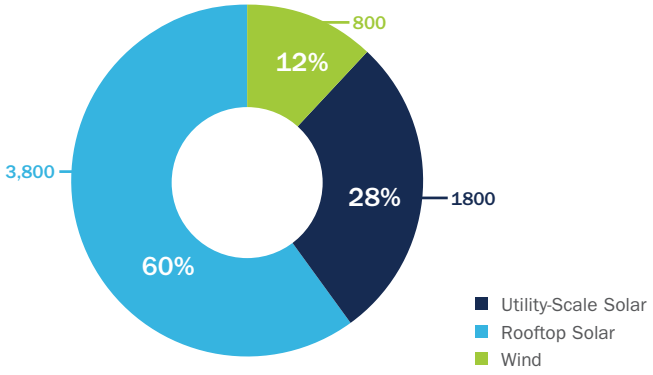
FY21: The repercussions of COVID-19 lockdown during late FY20 and mid-FY21 were seen in the RE sector as well. Overall, 24 percent and 39 percent less capacity was added in wind and utility-scale solar segments corresponding to 1.5 GW and 3.5 GW respectively in FY21 over FY20. The rooftop solar segment, on the contrary, was more resilient

Figure 7: **Solar and wind energy workforce added in FY20 (Source: CEEW-NRDC analysis, 2022)[43]**



and the annual additions grew by nine percent over FY20 and accounted for 1.4 GW capacity. Total of 6,400 new workers were employed in FY21 across these sectors (Figure 8). Individually, the wind and utility-scale solar sectors saw a 45 percent and 42 percent decline in workers in FY21 over FY20, respectively. Most of these workers were for one-time jobs under the business development, design, construction and commissioning phases. These wind and utility-scale solar employed 800 and 1800 new workers, respectively, for the operations and maintenance activities in FY21. The rooftop solar segment on the contrary saw a 480 percent increase in new workers over FY20 and employed 3,800 additional workforce in FY21.

Figure 8: Solar and wind energy workforce added in FY21 (Source: CEEW-NRDC analysis, 2022)[44]



Suryamitra Training Impact

To grow the clean energy sector workforce, it is key to equip workers with appropriate skills and training. The Suryamitra training program was launched by the Ministry of New and Renewable Energy in 2015. It is one such program that creates skilled technicians in the field of solar technology for installation, commission, and operation and maintenance.[45] To reach the country's 450 GW RE goal requires spreading awareness about the use of solar energy across all customers and calls for a massive pool of trained and skilled workers to support the growing and evolving demand in the solar sector.[46]

Since the program's inception to mid-2021, more than 78,000 trainees have been certified by Government of India under the Suryamitra training program supported by various central and state sponsored schemes. Based on its success, more recent programs like Vayumitra (wind energy installers) and Varunmitra (solar pumping system installers) have launched, keeping in mind the growing demand for skilled workers in these sectors. To determine the impacts of Suryamitra training delivery under all schemes, SCGJ supported Finnovation in carrying out a recent impact assessment study in 2020, which surveyed 1,004 certified Suryamitra trainees and 505 trainers in 11 states across the country.[47] Many of the surveyed trainees are under the age of 25 (age 18 to 25) and a large majority are under 30. Most of the surveyed trainers are over age 25 and roughly split between age group 26 to 30 and over 30. Also, almost all the trainees trained under the Suryamitra program are new to the sector.

Self-reported survey findings: 95.7 percent of the certified trainees and 78.6 percent of the trainers reported to have improvement in their technical knowhow post training; 88.5 percent of the trainees and 53.9 percent of the trainers reported to have increased job opportunities/employability post training; 96.1 percent of the trainees and 93.3 percent of the trainers reported to have improvement in their performance post training; 80.5 percent of the trainees and 45.7 percent of the trainers reported to have increased income post training; and 99.3 percent of the trainees and 51.9 percent of the trainers reported to have experienced improvement in their quality of living post training.

500 GW by 2030: Job Creation Potential

Job creation, skill development and COVID recovery are key priorities for the Indian government. Jobs created in the renewable energy market offer a significant opportunity to meet the government's multiple goals of employment generation, clean energy growth, and economic development. Enhancing the clean energy target from 175 GW of RE by 2022 to 500 GW of non-fossil fuel capacity by 2030 will not only help in tackling climate change, but also in increasing green jobs in the country. However, RE development would need to go hand in hand with building the transmission and distribution network, developing energy storage technologies, identifying land for new RE plants, undertaking electricity distribution reforms, scaling up indigenous manufacturing and making low-cost finance accessible for the sector. Clean energy technologies like rooftop solar, floating photovoltaic systems, offshore wind and agrivoltaics can help minimize the total land requirement for renewable energy.[48]

Emphasizing on decentralized renewables and boosting domestic manufacturing have the potential to create more employment opportunities and ease land availability constraints. In addition to job creation, off-grid RE projects, though smaller in size, have greater scalability potential and avoid the long lead times and execution bottlenecks associated with public-sector offtake procurement projects.[49] The job creation opportunity of DRE is especially large. An advantage of DRE over large-scale renewables is that its biggest beneficiaries have been poor and marginalized communities, especially for mini-grids and bioenergy projects. Its decentralized nature creates employment in remote regions, where job opportunities are more likely to be scarce.

This section analyzes the potential number of direct jobs that can be created by 2030 if India meets its target of installed 500 GW of non-fossil fuel capacity. When India announced its 175 GW RE target, it included a breakdown of the target among all the states. This breakdown made states accountable for reaching their targets and enabled them to align the national targets with their state RE and climate policies. However, no such breakdown has been reported for the 500 GW target. For the current analysis, three different scenarios with different splits between technologies has been considered to meet the 500 GW target.

Methodology

Three scenarios are designed to estimate the job creation potential of the 500 GW of non-fossil fuel capacity target: government ambitions, forward- looking and market-driven. These scenarios are based on various national and international studies that have projections of India's energy mix for FY30 as briefed below:

- **Scenario 1 Government ambitions:** This scenario is based on Central Electricity Authority's (CEA) study on "Optimal Generation Capacity Mix for 2029-30," which indicates that India can reach 420 GW of solar and wind capacity in FY30.[50] This scenario is further modified to take the cumulative capacity to 450 GW of RE. Keeping the solar and wind capacity constant, the remaining 30 GW capacity is attributed to off-grid solar systems (especially mini and microgrids), small hydro, and bioenergy based on the government's constant focus on these segments.[51]
- **Scenario 2 Forward looking:** The second scenario is derived from the 2017 International Renewable Energy Agency (IRENA)'s REmap program for India.[52]
- **Scenario 3 Market driven:** The third scenario is derived from International Energy Agency's (IEA) 2020 market update that considers the impact of COVID-19 pandemic on RE deployment in the year 2020 and 2021.[53]

Refer Appendix 5 for detailed assumptions considered in the three scenarios.

The broader approach for framing these three scenarios is as follows:

- The 500 GW non-fossil fuel based capacity by 2030 includes RE, nuclear and large hydro. In this, the 450 GW RE capacity by 2030 consists of six RE technologies: wind, utility-scale solar, rooftop solar, bioenergy, small hydro, and off-grid solar (mini/microgrids, solar pumps, etc.). The share of these technologies is different in each scenario.
- The base year for all scenarios is FY21 and the capacities for different technologies are collated from government and market reports.[54]
- The year-on-year additions forecasted from FY22 to FY29, in each scenario are derived from different growth rates based on the capacity additions from FY17 to FY21 or as mentioned in the original sources and depending on the technology.[55]

Table 1 shows the final technology mix for the identified technologies in the three scenarios.

Photo Credit : Pxfuel

Table 1: Renewable energy technology mix in the three scenarios by 2030 (Source: CEEW-NRDC analysis, 2022)[56]

Technology	Scenario 1: Government ambition		Scenario 2: Forward looking		Scenario 3: Market driven	
	New addition (2022-2030)	Cumulative capacity	New addition (2022-2030)	Cumulative capacity	New addition (2022-2030)	Cumulative capacity
Wind	101	140	148	187	52	91
Utility-scale solar	132	168	125	161	204	240
Rooftop solar	106	112	29	35	89	95
Bioenergy	7	17	18	28	9	19
Small hydro	0	5	18	23	1	6
Off-grid solar	6	7	18	19	10	11
Total		**449**		**453**		**462**

*Higher capacity for bioenergy has been considered in Scenario 1 because CEA target of 10 GW in Optimal Generation Mix Report has already been achieved.

Jobs Created and Workforce Added in Wind and Solar Energy Sector by 2030

Table 2 presents the new jobs created from the wind and solar sectors in the three scenarios. Meeting the government ambitions, as depicted by scenario 1, to deploy 339 GW of new solar and wind capacity can create 341,8400 new jobs between FY22 and FY30. 80 percent (2,727,200) of these jobs would be created in the rooftop solar sector, followed by 16 percent (538,900) in utility-scale solar and remaining (152,300) in wind.

The new jobs created decrease to 1,548,600 in Scenario 2 through the deployment of 302 GW of new solar and wind capacity. These numbers are derived from IRENA's 2017 REmap study. It assigns a miniscule capacity share to rooftop solar (29 GW) while wind takes a precedence (148 GW) over its share in Scenario 1 (101 GW). More than half of these jobs would be created in rooftop solar sector (53 percent, 822,200), followed by utility scale solar (514,400) and wind (212,000).

Market driven Scenario 3 could deploy slightly above 450 GW within the stipulated time (FY30) and hence would create more number of employment opportunities than Scenario 2. This scenario is based on IEA's research on the Indian market to understand the impact of COVID-19 pandemic. It concluded that the sector was resilient to the impact of the pandemic than expected. Further, based on the learning from the last decade and maturity of these technologies, the sector would continue to grow at a faster rate between FY26 and FY30. Hence, about 345 GW of solar and wind capacity could be deployed between FY22 and FY30 and commensurate to this about 3,194,700 jobs could be created. Rooftop solar would continue to create maximum employment with 73 percent (2,317,100) jobs followed by utility-scale solar (25 percent, 787,800) and wind (three percent, 89,800).

The greater share of DRE technologies like rooftop solar in Scenario 1 (106 GW) boosts the employment opportunities over Scenarios 2 and 3 (29 GW and 89 GW, respectively).

the deployment of 339 GW of wind and grid-connected solar systems (utility-scale solar and rooftop solar). The new workforce decreases to 340,000 in Scenario 2 as the capacity of wind and grid-connected solar is 302 GW and in particular, the rooftop solar capacity is only 29 GW. Scenario 3 could employ 858,300 new workers from the deployment of 345 GW of wind and solar capacity.

Table 2 represents the new jobs that will be generated if India achieves its solar and wind installation target of 500 GW of non-fossil fuel capacity by 2030. On the other hand, Table 3 lists the workforce that would be needed to achieve these targets. The total required workforce is lower than the number of jobs created as one worker will be able to perform more than one job because some of the jobs would be short-term. Figure 9 presents the snapshot of India's RE capacity mix in 2030 and the cumulative jobs created by the solar and wind sectors.

Photo Credit : Pixabay

Table 2: New jobs created in solar and wind sector between FY22 and FY30 in various scenarios (Source CEEW-NRDC analysis, 2022)[57]

Technology	Scenario 1: Government ambition	Scenario 2: Forward looking	Scenario 3: Market driven
Wind	152,300	212,000	89800
Utility-scale solar	538,900	514,400	787,800
Rooftop solar	2,727,200	822,200	2,317,100
Total	**3,418,400**	**1,548,600**	**3,194,700**

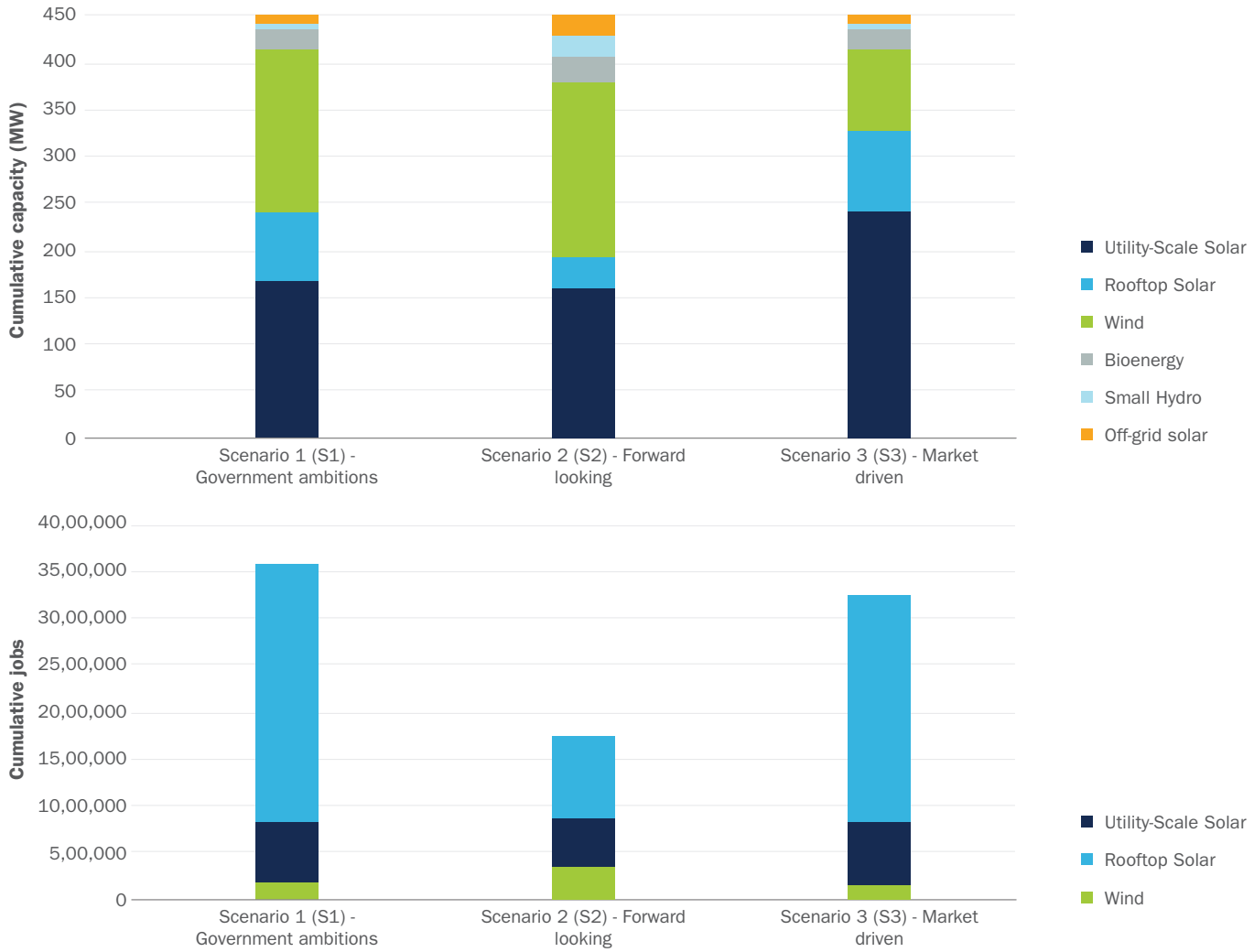
Table 3 presents the new workers added between FY22 and FY30 in the wind and solar sectors in the three scenarios. These estimates are based on the annual additions from FY22 to FY30. Scenario 1 which represents the government ambitions could employ 931,900 new workers through

These results indicate that while the government's intentions are to achieve 500 GW of non-fossil fuel capacity or 450 GW of RE capacity by 2030, it can go beyond to achieve at least 462 GW of RE. The strategy to create maximum jobs from the available technology options is to focus more on DRE.

Table 3: **New workforce added in solar and wind sector between FY22 and FY30 in various scenarios (Source CEEW-NRDC analysis, 2022)[58]**

Technology	Scenario 1: Government ambition	Scenario 2: Forward looking	Scenario 3: Market driven
Wind	63,400	95,600	30,900
Utility-scale solar	1,35,800	1,26,900	2,29,900
Rooftop solar	7,32,700	1,17,500	5,97,500
Total	**9,31,900**	**3,40,000**	**8,58,300**

Figure 9: **Snapshot of the technology mix (top) and job creation potential (bottom) of RE by 2030 (Source: CEEW-NRDC-SCGJ analysis, 2022)[59]**



Missed Opportunities

The number of jobs created in the RE sector is greatly dependent on the annual RE capacity additions. A decline in the annual capacity addition can lead to loss of workforce engaged in one-time activities like project design, construction and commissioning. As mentioned before, the annual capacity additions in the rooftop solar sector in FY20 decreased by 14 percent that led to six percent decline in the workforce added in this sector in FY20. While the capacity addition in this sector improved in FY21, those in wind and utility scale solar decreased by 24 and 39 percent. Hence, these two sectors employed 44 and 42 percent less workforce over FY20.

Job creation by a RE technology also depends on the evolution of its value chain. India's component

manufacturers did not grow in line with the power producers and largely remain assembly units of solar modules mainly imported. The government recently put restrictions on imports and simultaneously introduced a production-linked incentive program to give local production a boost. As the workforce required for manufacturing and assembling is different, an underdeveloped manufacturing industry reduces potential employment opportunities in solar energy sector. The ₹4,500 crore ($600 million) production-linked incentive scheme for solar photovoltaic (PV) modules will help India ramp up its domestic manufacturing capacity and is expected to add 10 GW capacity of integrated solar PV manufacturing plants. The wind sector has already seen leading equipment manufacturers open factories to supply the national and international markets. To achieve the full job creation potential in a RE technology, local manufacturing is crucial. A dated estimate indicates that domestic manufacturing for an earlier target of 100 GW solar capacity could employ 45,000 additional workforce over the 290,000 workers employed across the project deployment cycle.[60]

The National Electricity Plan of 2018 aims for 275 GW of RE by 2027, reinforcing the government's commitment to transforming the electricity sector.[61] However, there is also the need to shift the focus of policy away from capacity targets for renewables, toward a comprehensive strategy for integrating renewables into the power system. The introduction of variable renewables like wind and solar into the Indian power mix creates new challenges of balancing these variable sources of supply. This variability highlights the importance of battery storage systems, and energy storage technology will be a crucial option to integrate variable renewables into the power system. It would be beneficial to define targets and policy frameworks for battery storage out to 2030. Lessons from around the world highlight the importance of demand-side measures, grid investments, and market reforms for India.

Another step in this direction would be to review the current economic dispatch regime where self-scheduling often constrains optimum utilization of renewable sources of energy. The proposed market-based economic dispatch (MBED) of power by the Ministry of Power is expected to enhance greater RE integration with the balancing area increasing from state to national level leading to a huge drop in RE curtailment.[62] Retiring old and expensive coal power plants has the potential to reduce the cost of electricity to consumers by reducing the cost of power purchase for DISCOMs.[63]

Rooftop solar sector that has a very high potential of creating clean jobs compared to utility-scale solar or wind sector, has not picked up as expected. By FY21, the rooftop solar sector accounted for only 6.5 GW of installed capacity, against the target of 40 GW by 2022. The change in gross and net metering policies has hampered the segment's growth.[64] With bigger commercial and industrial consumers being denied the benefit of net-metering, a large chunk of the prosumers are discouraged by the move.[65]

With regard to decentralized renewable energy policies, a recent report by CLEAN has highlighted the need for provision of longer tenure loans for DRE products, capital subsidies for high-cost products and sector-specific financial solutions.[66] The report also highlights that while the focus for DRE energy access has largely been on solar-based applications, there is a wide scope for bioenergy, wind, pico-hydro, and other hybrid technologies.

Opportunities for Skill Development in Renewable Energy Sector in India

With the 500 GW target announcement by the Indian government, the clean energy sector is poised to grow tremendously over the next decade. This growth will need to be met by newer technologies other than wind, utility-scale solar, and rooftop solar. Additionally, the renewable sector's growth cannot be limited to urban areas. In recent years, upcoming clean energy technologies emerged in the Indian market, such as mini and micro grids, floating solar plants, solar-wind hybrid plants, off-shore wind plants and battery storage. The technologies are essential for clean energy development, particularly across rural areas, and to meet the 500 GW target. The time is ripe to review these technologies for skill development of local rural workers.

Mini Grids

Solar mini grids can create jobs, help reduce energy poverty, and improve electricity quality.[67] A solar mini grid is an integrated system that includes generation, energy storage devices, power conversion equipment, and distribution infrastructure. It provides both generation and distribution of energy and can be independent or connected to the grid.

Mini Grid Case Study: Mlinda

Mlinda is a distributed RE provider across India that combines energy services with capacity-building initiatives. Its community mini-grid deployment efforts have created an estimated 986 jobs from 2016 to 2020, on average, with the number of jobs created for each mini-grid ranging from 15 to 28.[68] These jobs are created through direct employment or by creating entrepreneurial jobs from productive use electricity loads such as mills and electrified businesses. The approximate 986 jobs include 180 direct full-time jobs, 131 FTE jobs from contractual work, and 675 productive-use jobs through additional entrepreneurial activities.

The Ministry of New and Renewable Energy launched the PM-KUSUM scheme in 2019 to ensure energy security for farmers and honor India's commitment to increase the share of installed capacity of electric power from non-fossil-fuel sources.[69] One component of the PM-KUSUM scheme (Component-A) aims to add 10,000 MW of decentralized ground mounted grid-connected small/micro solar or other renewable source-based generation by 2022, with an initial target of 1,000 MW.[70] If the initial 1,000 MW capacity target is met through the deployment of mini-grids that follow Mlinda's "energy services and development-based" business model an estimated average of 877,000 jobs could be created (619,000 to 1,134,000 direct and productive use jobs).[71] The number of jobs, particularly productive use jobs, will differ slightly based on the type of business model, uptake of productive use loads, and geography. Pairing energy services with capacity development ensures that communities can utilize electricity to improve their livelihoods.

Floating Solar

Floating solar photovoltaic (FPV) is an emerging segment in which PV modules are installed (floated) on a water body of water. Asia leads globally in FPV solar deployments.[72] While the FPV and ground-mounted solar sectors have many functions in common, the FPV sector can create additional employment opportunities in India. An FPV solar project includes four stages; each phase involves activities for which a varying number of people with different skill sets are needed for different work spans. A small-scale FPV plant (capacity <1 MW) directly employs 58 workers, while a mid-scale (capacity <10 MW) plant employs 45, over the course of their deployment.[73] 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-molding techniques, some of the key skills required for bringing an FPV plant to life, in addition to those required in ground-mounted solar operations. FPV can generate additional employment opportunities in domestic manufacturing, research, and product design.

Wind-Solar Hybrid Projects

Wind-solar hybrid (WSH) power plants are new and upcoming players in the Indian RE landscape. These systems are complementary in nature as during the day, solar radiation is high during the day and the wind picks up in the evening and during the night. Therefore, it can generate energy almost throughout the whole day which can help take care of the problems of variability related to standalone solar and wind plants. The constant power supply due to the complementary nature would therefore make them economically viable in the longer run. India's Wind-Solar Hybrid Policy provides a framework for promoting grid-connected WSH power plants for efficient utilization of transmission networks and incentive to large developers and as a result, an increasing number of hybrid plants are in the pipeline. Over 11 GW and 15 GW of WSH capacity is expected to be installed by 2023 and 2025 respectively because of support from state governments and the Solar Energy Corporation of India.

According to CEEW's case study on WSH power plants, a 61 MW project employs 250 workers over the course of deployment. This comprises 13 percent of permanent workers and 87 percent of contractual workers.[74] At present, WSH developers are making their projects hybrid by adding solar or wind to their already already-deployed standalone solar or wind plants to meet the increasing consumer demands. Currently, developers are not looking to co-locate because most states don't have a dedicated wind-solar hybrid policy in place. However, there are states like Andhra Pradesh, Rajasthan, and Gujarat that have already come up with their own WSH policies. As more states come up with their own WSH policies, the deployment of WSH plants is only going to increase and so are the employment prospects for WSH.

Skill Development for Rural India

Millions in rural India are looking to recover their livelihoods after the devastating impact of COVID-19. Clean energy skills and trainings can be a lifeline, especially given the worsening extreme weather events fueled by climate change. Entrepreneurial opportunities for the village populations can dramatically improve livelihoods, accelerate the transition to clean energy, and reduce poverty. To realize the country's massive clean energy potential, there is a significant need for skill development, especially for women in India's villages. SCGJ's network of training partner covers almost the entire length and breadth of the country. However, due to the nature of skilling as a business operation, in most cases, the training centers are in the capital city or tier I, II cities (cities with higherpopulation densities). Interested candidates from rural areas usually attend skill trainings at an urban location.

Skill gaps are usually most pronounced in remote and rural areas. For example, there may be a talent shortage to develop, install, operate, and manage mini-grids and solar pump projects. Scheduling tailormade training and skilling programs at regular intervals is key to addressing the scarcity of skilled workers in rural areas. On-field experience from various decentralized energy projects reveal that the level of capacity development varies for different stakeholders engaged in project development, operation, and management. To meet these needs, various training programs are organized by project implementation agencies, project developers, state renewable energy development agencies, and training institutions.

Local capacity-building of stakeholders ensures better project performance. This approach consists of training rural people, particularly youth, on issues of plant operation and maintenance and various other aspects of electricity use for rural consumers. Inputs from mini grid operators suggest that there is a continuous need to train plant operators and provide refresher-training programs across the project life cycle. While training programs improve skilling of many rural youth engaged in projects, they also significantly increase prospects of employability in associated sectors.

Given the potential for large rural/off- grid clean energy deployment, SCGJ has developed skilling qualifications. The qualifications focus on rural women and youth to help them leverage business opportunities in the off-grid market. Women must be at the forefront of energy transitions.[75] A 2019 report by NRDC-SEWA-SCGJ on building skills and improving livelihoods of women salt farmers in Gujarat provides a great example of how the focus on developing the necessary skills for the solar pumps has played a critical role in expanding the use of clean energy for salt-farming.[76] SCGJ has also developed a few relevant qualifications including trainings on solar lighting for home lighting systems and streetlights, improved cookstoves, and appliance assembly, sales and maintenance.[77]

Solar water pumps and solar mini grids also provide significant opportunities for rural skilling and subsequent employment. Qualifications developed by SCGJ offer opportunities for training on various aspects of mini grid installation and associated entrepreneurship across various levels.[78] Mini-grid operators have also extensively focused on continuous capacity enhancement of the communities as one of the key drivers for promoting ownership and thus delivering successful projects.

Mini-grid projects have the potential to create new jobs in India's rural areas, which go beyond the agricultural sector. However, suitable incentives along with skilling and training opportunities must be provided to ensure that jobs are also offered for unskilled and low-skilled workers from the communities where such projects shall be located. It is also observed that in many cases, skilled plant operators switch to other jobs due to the acquired project experience and technical skills. With the transition towards productive and livelihood applications, it has also become important to understand the capacity building needs of the enterprises and individuals utilizing such applications. In this context, capacity building requirements for all stakeholders for the development of the off- grid sector is also being assessed regularly by SCGJ and subsequently customized training delivery programs are also being explored.

Expanding Green Business Portfolios

The transition to a green economy requires workers with the appropriate skills. This includes the need to help all businesses and industries mitigate climate change and use natural resources efficiently. Greening should not be considered as an endpoint, but rather a continuous and evolving process as new environmental demands and opportunities arise. To reduce the environmental impact of production and services, it is key to build and strengthen new and existing greening competencies across all job profiles and all skills levels. This includes enhancing environmental awareness and integrating green attributes into work areas to change consumption and production patterns.

SCGJ developed two Greening National Occupation Standards (NOS): namely "Optimize resource utilization at workplace" and "Adopt sustainable practices at workplace." These two NOS include competencies on energy and material conservation, resource audit and waste management, pollution control, etc. with a specific focus to inculcate 'green knowledge' and 'green methods' for developing skills in all relevant sectors such as agriculture, manufacturing, services, construction etc. In line with the Greening Framework developed for "Technical and Vocational Education and Training," these greening NOS are being effectively mainstreamed in the training delivery across all job roles.

To ensure that greening components are adequately reflected across all job roles, it has been made mandatory for all Skill Councils to incorporate suitable greening attributes in their new and existing qualifications (during revision or rationalization). Qualifications do not get required approval unless greening attributes in alignment with the concerned job roles are suitably reflected. Further to the greening NOS, SCGJ is developing Model Curriculum, supported with Participation Handbooks and Facilitator Guides to help all stakeholders including trainee and trainers across all the sectors to effectively align greening aspects with their job roles and accordingly conduct their trainings and assessment. Opportunities for green business and skilling interventions in India are enormous as there are over 2,400 job roles. This number is expected to increase significantly as the economy recovers from the pandemic.

For India to meet its 500 GW of non-fossil fuel based capacity target by 2030, contribution from existing and upcoming DRE technologies (rooftop solar, floating solar, off-grid wind, bioenergy etc.) will be crucial. As businesses and industries galvanize action on sustainability, workers will also need the competencies and knowledge to respond effectively to shift to greener business practices and to learn the skills required for DRE projects.

Recommendations

Below are recommendations that can support India develop a trained and skilled workforce to help achieve its 500 GW goal, boost and diversify employment opportunities and develop a robust skilling ecosystem that can cater to the evolving industry needs.

Higher focus on decentralized renewable energy sources

Decentralized RE projects like rooftop solar, mini and micro-grids, biomass and small hydro systems, though smaller in size, have greater scalability potential and avoid the long lead times and execution bottlenecks associated with public-sector offtake procurement projects.[79] DRE projects not only create direct employment jobs, but also lead to creation of entrepreneurial jobs from productive use electricity loads such as application of RE in agro-processing, communications, commerce, education, and other fields. Challenges to expanding off-grid renewables or DRE in India include unclear policy direction, such as on net-metering and import duties on solar modules, information about available technology options, affordable and innovative financial solutions for micro businesses and small consumers, as well as information asymmetry among equity/debt investors constraining companies' ability to access finance. While rooftop solar remains the mainstay, emergence of diverse business models such as mini and micro-grids, floating solar systems, and biomass to energy projects have expanded the gamut of clean energy applications. These projects can increase the employment opportunities in rural areas to achieve India's 500 GW non-fossil fuel capacity target. The distributed nature of these projects makes them more labor intensive than utility-scale projects thereby increasing the jobs created across the project deployment cycle. Supporting these businesses with both technical assistance and development (and commercial) finance is crucial to realize India's off-grid RE potential.

Ensure continuous deployment of RE capacities to restrain job loss

Steady and continual installation of RE projects through periodic tendering can help in retaining the existing clean energy jobs and create new jobs across the RE landscape. Providing relaxations to continue construction activities even in special cases like pandemics, supporting the investments in the sector through streamlined processes, payment securities etc. are other ways to reduce job loss in the sector while ensuring appropriate worker benefits (healthcare, housing, sanitation) and health and safety precautions.

COVID-19 had a higher impact on migrant workers compared to the local workforce. While continuing construction activities during situations like a pandemic, improvements can be made in the working and living conditions of migrant workers.

Strengthen domestic manufacturing

By June 2021, India had a domestic manufacturing capacity of only 3 GW for solar cells and 15 GW for solar modules. To leverage its growing green energy market in line with the 500 GW target as well as to play a larger role in global supply chains, India needs to create global manufacturing champions by removing sectoral disabilities and creating economies of scale to develop complete component eco-systems in the country. An added advantage of this would be to harness the untapped employment potential from such development.

Promote rural skill development programs

RE jobs and skill trainings need to be brought to rural areas outside of tier I and tier II cities. India's rural communities are not yet equipped with the necessary skill sets to access such jobs. To access these jobs, features such as providing access to under-educated youth, ensuring women's inclusion, and connecting trainees to job platforms need to be embedded in training programs and through industrial training institutions (ITI). Integrating skill training with academic curriculum in school as also envisaged in the National Education Policy would also create an efficient workforce particularly in rural and semi urban area which would drive the country's economic progress. Our research indicates that the availability of a skilled local workforce can accelerate the deployment of solar parks and mini/microgrid projects and increase uptake of DRE applications and productive use jobs.

In addition to technology-specific trainings like Suryamitra, Vayumitra etc., focus should include soft skills and business development trainings to cover the entire value chain.

Regular update of the skilling curriculum

Periodic industrial engagements can be conducted to bridge the skill gap and ensure timely availability of skilled workforce. Another opportunity is to diversify trainings for upcoming technologies like FPV, solar-wind hybrid projects, mini- and micro-grids, battery storage etc. Training programs can also be designed in a manner to engage more women and rural communities. Training rural youth to empower them to access job opportunities also requires changes to training institutes' curricula and their approach to admissions. Work can be done on customizing trainings for the rural consumer and imparting them in the local languages.

Need for reskilling and upskilling of existing workforce

While a range of skilling interventions are being designed and implemented to facilitate thousands of trainees for a career in the renewable energy sector, reskilling and upskilling measures will also be crucial to ensure that employment benefits are made accessible across the wider economy.

As renewable energy (particularly solar) has become more competitive to conventional fuels, traditional fossil fuel companies have significantly diversified their portfolio and continue to invest in reskilling their workforce. In some cases, there might be a need for significant re-skilling and subsequently re-certification of skills, while in other cases there may be substantial overlaps with required skills. Similarly, a range of upskilling interventions are also being carried out under skill ecosystem to ensure that trained candidates are continuously aligned with the evolving requirements of the industry. Further, financial and technical support can be provided to training centers and vocational institutions to enhance the quality and pace of trainings while ensuring that certified trainees meet the requirements of a continuously evolving RE sector.

Additional training may also be needed to certify trainers to build their practical expertise and to ensure that they remain updated about the best practices in the industry. While some upskilling training programs are being implemented through bilateral support, building such capacity requires close partnerships and coordination between all stakeholders including governments and industry to ensure that training programs adequately prepare the workforce for energy transition.

Development of indirect and induced jobs

For renewable energy to prosper, India needs to strengthen its transmission and distribution network. A robust grid is essential to integrate 500 GW of non-fossil fuel energy capacity and serve end-users. And a flexible power system is needed to manage the daily and seasonal variations of RE. Bloomberg estimates that it will cost cumulatively $335 billion in investment in the grid by 2034 to cater for 450 GW of RE.[80] In addition to building a strong electrical grid, growth will be observed in battery storage industry to cater to the intermittent RE. Therefore, in addition to the direct jobs calculated in this report, indirect and induced jobs will also be created in allied sectors to support the 500 GW goal; and, skilling and training programs, if applicable, should be developed for the same.

Appendix

Appendix 1: Difference Between Direct Jobs, Indirect Jobs, Induced Jobs and Productive Use Jobs

The analysis in this issue brief is limited to direct jobs created through installation and maintenance of the additional solar or wind capacity. This issue brief does not include indirect jobs for example, those in the manufacturing, financing, and distribution companies, or induced jobs, such as jobs created by earnings of workers employed in the renewable energy sector, or productive use jobs like entrepreneurial jobs that have been enhanced due to the use of DRE applications.

Direct jobs, earnings, and output are the jobs associated with the design, development, management, construction/installation, and maintenance of projects and project facilities. For example, in installing a PV or large wind system, the direct impacts include the jobs for specialty contractors, construction workers, clean-up crews, truck drivers, and other specialists hired to permit, design, and install the system. It also includes management, business development and support staff.

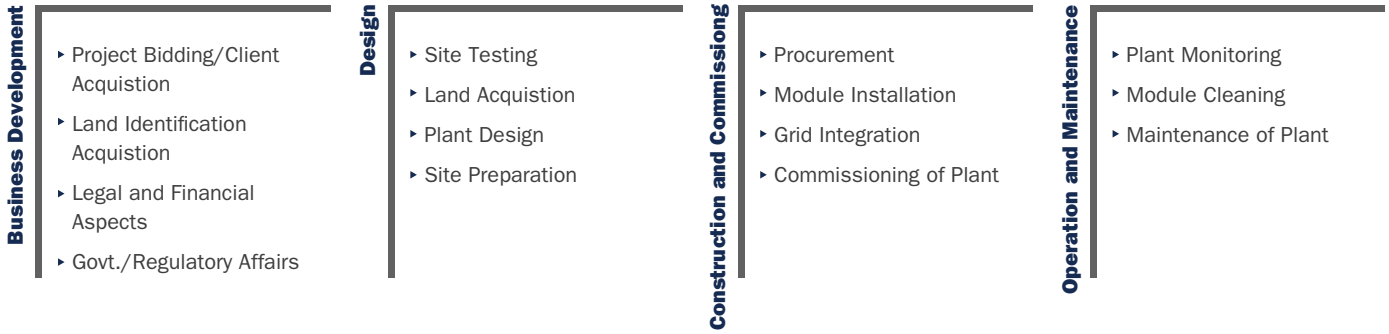
Indirect jobs are the jobs associated with the manufacturing of equipment and materials used for the facility, the supply chain that provides raw materials and services to these manufacturers, and the finance and banking sectors that provide services for the construction and operation of a facility. For example, for a wind facility, this would include jobs at wind turbine manufacturing plants and jobs at other manufacturing facilities that fabricate structural hardware, foundations, and electrical components for the wind facility's systems. It also includes the banker who finances the construction contractor, the accountant who keeps the contractor's books, and the jobs at steel mills and other suppliers that provide the necessary materials.

Induced jobs refer to the jobs created due to the spending of earnings by persons directly and indirectly employed by the projects (workers in the first two categories). For example, during the construction phase of a facility, jobs are induced when the workers hired to install a PV system spend their earnings to purchase food at grocery stores and restaurants, pay rent, and purchase clothes or other goods to meet their needs.

Productive use jobs refer to the existing and new entrepreneurial jobs that have been enhanced due to the use of DRE applications like mini-grid electricity. Some examples of productive use jobs include those from electrified rice hulling machines, cold storage units, oil expellers, grain-milling machines, air compressors, sewing machines, shops, and welding machines. Productive use jobs can vary significantly based on the geography, the business model of mini-grids, and operators.

Appendix 2: Project Phase and FTE Coefficients

Figure 10: **Solar and wind project deployment phases (Source: CEEW-NRDC, 2019)[81]**



An FTE coefficient is the 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. Figure 13 above provides information about the different project phases and Table 5 below shows the FTE coefficients for these phases for solar and wind energy projects.[82]

Table 4: FTE Coefficients for different phases of a wind and solar project (Source: CEEW-NRDC-SCGJ, 2019)[83]

Project phase	FTE Coefficient		
	Wind	Utility-Scale Solar	Rooftop Solar
Business Development	0.06	0.05	1.53
Design	0.1	0.2	8.85
Construction and Commissioning	0.6	2.7	13.84
Operations and Maintenance	0.5	0.5	0.5

The number of jobs created varies with the project phase and project type across wind and solar sectors. This difference arises due to the different types of business models for these two technologies. For example, for each MW of capacity added, wind energy creates uniform number of jobs in construction and pre-commissioning, and O&M stage of the plants. Most of the wind projects are of large capacity and owned by independent power producers (IPPs), which outsource the workforce for O&M.

The solar energy sector, on the other hand, creates far more employment opportunities in the construction and pre-commissioning stage than O&M. In rooftop solar, as the project scale is diverse, owners of the project often carry out the O&M themselves, eliminating the need to outsource these activities.

Rooftop solar projects are decentralized and more labor intensive, hence, create the maximum number of jobs across all segments, as indicated by a high FTE coefficient. These are followed by utility-scale solar and wind projects. Among the different segments, the construction and commissioning of a project creates the maximum number of jobs across all technologies. Further, irrespective of the technology, the least number of jobs are created in the business development phase.

Appendix 3: Employment Added in Different Renewable Energy Technologies in FY20 and FY21

Table 5: Project phase-wise employment added in different RE technologies in FY20 and FY21 (Source: CEEW-NRDC-SCGJ Analysis, 2022)[84]

Wind			
Installed Capacity Addition for Wind	**Cumulative Capacity addition until FY19 (MW)**	**Annual Capacity (MW)**	
		FY20	**FY21**
	35621.26	2068	1553
Change over previous year (MW)	-	488	-515
Project phase	**FTE Coefficient**	**Annual Additional Employment**	
		FY20	**FY21**
Business Development	0.06	29	0
Design	0.1	54	0
Construction and Commissioning	0.6	293	0
Operations and Maintenance	0.5	1034	777
Total		**1410**	**777**

Utility-Scale Solar			
Installed Capacity Addition for Utility-Scale Solar	**Cumulative Capacity addition until FY19 (MW)**	**Annual Capacity (MW)**	
		FY20	**FY21**
	26265	5847	3533
Change over previous year (MW)	-	51	-2314
Project phase	**FTE Coefficient**	**Annual Additional Employment**	
		FY20	**FY21**
Business Development	0.05	3	0
Design	0.2	10	0
Construction and Commissioning	2.7	138	0
Operations and Maintenance	0.5	2990	1807
Total		**3140**	**1807**

Rooftop Solar			
Installed Capacity Addition for Rooftop Solar	**Cumulative Capacity addition until FY19 (MW)**	**Annual Capacity (MW)**	
		FY20	**FY21**
	3847	1295	1422
Change over previous year (MW)	-	-218	127
Project phase	**FTE Coefficient**	**Annual Additional Employment**	
		FY20	**FY21**
Business Development	1.53	0	194
Design	8.85	0	1124
Construction and Commissioning	13.84	0	1758
Operations and Maintenance	0.5	648	711
TotalW		**648**	**3787**

Appendix 4: Qualification Packs

Skill Council for Green Jobs was launched by the Ministry of Skill Development and Entrepreneurship to supplement the Skill India Mission for the purpose of developing competencies/skills in the renewable energy, environment, forest, climate change and sustainable development domains.

SCGJ annually reviews and updates its qualification packs to capture the upcoming skill needs for both service users and manufacturers/service providers within the domains specific above. SCGJ has also developed two greening National Occupation Standards which are being integrated across all job roles in skilling ecosystem. Five new job roles in Small Hydro and Compressed Bio-CNG segments are in the approval process. Figure 14 provides a summary of the qualification packs and Table 7 provides detailed information about the latest list of sector-wise qualification packs developed by SCGJ. The table also provides information about the National Skills Qualifications Framework (NSQF) level. NSQF is a quality assurance framework, and the levels are defined in terms of learning outcomes which the learner must possess regardless of whether they were acquired through formal, non-formal, or informal learning.

Figure 11: Summary of SCGJ's Qualification Packs (Source: SCGJ, 2022)[85]

Job Roles developed so far

Sector - Wise Job roles	NSQF Job Level						QPs Developed	NSQC Approved
	Level 2	Level 3	Level 4	Level 5	Level 6	Level 7		
Solar Photovaltic	1	0	6	6	3	3	**19**	15
Solar Thermal	0	0	2	1	0	0	**3**	-
Biomass Energy	0	0	3	0	1	0	**4**	4
Waste Management	0	3	4	0	1	0	**8**	8
Waste Water Treatement	0	1	3	0	0	0	**4**	2
Clean Cooking	0	1	2	0	1	0	**4**	4
Wind Energy	0	0	6	1	1	0	**8**	-
Total	1	5	27	8	7	3	**50**	33

SCGJ has also developed 2 greening NOS which are being integrated across all job roles in skilling ecosystem. 5 new job roles in Small Hydro and Compressed Bio-CNG segments are also being approved.

Table 6: SCGJ's Qualification Packs for Green Jobs (Source: SCGJ, 2022)[86]

No.	Sector	Qualification Pack Title	QP Code	NSQF Level
1	Solar Photovoltaic	Solar PV Installer (Suryamitra)	SGJ/Q0101	4
2		Solar PV Installer – Electrical	SGJ/Q0102	4
3		Solar PV Solar PV Installer – Civil	SGJ/Q0103	4
4		Rooftop Solar Photovoltaic Entrepreneur	SGJ/Q0104	6
5		Solar Proposal Evaluation Specialist	SGJ/Q0105	5
6		Rooftop Solar Grid Engineer	SGJ/Q0106	5
7		Solar PV Business Development Executive	SGJ/Q0107	5
8		Solar PV Site Surveyor	SGJ/Q0108	6
9		Solar PV Structural Design Engineer	SGJ/Q0109	5
10		Solar PV Designer	SGJ/Q0110	7
11		Solar PV Project Helper	SGJ/Q0111	2
12		Solar PV Engineer (Option: Solar Water Pumping Engineer)	SGJ/Q0112	5
13		Solar Site In-charge	SGJ/Q0113	6
14		Solar PV Project Manager(E&C)	SGJ/Q0114	7
15		Solar PV Maintenance Technician - Electrical (Ground Mount)	SGJ/Q0115	4
16		Solar PV O&M Engineer	SGJ/Q0116	5
17		Solar Off Grid Entrepreneur	SGJ/Q0117	5
18		Solar PV Manufacturing Operator	SGJ/Q0118	4
19		Solar Lighting Assembler (Elective: Home Lighting System/Street Lights)	SGJ/Q0119	4

No.	Sector	Qualification Pack Title	QP Code	NSQF Level
20	Solar Thermal	Solar Domestic Water Heater Technician (Option: Manufacturing Technician)	SGJ/Q0601	4
21		Solar Thermal Plant Installation & Maintenance Technician	SGJ/Q0602	5
22		Solar Thermal Engineer – Industrial Process Heat (Option: Consultant)	SGJ/Q0603	5
23	Clean Cooking	Improved Cookstove Installer	SGJ/Q2101	4
24		Portable Improved Cookstove Assembler	SGJ/Q2102	3
25		Portable Improved Cookstove Sales and Maintenance Executive	SGJ/Q2104	4
26		Portable Improved Cookstove Distributor	SGJ/Q2105	6
27	Waste Management	Recyclable Waste Collector & Segregator	SGJ/Q6101	4
28		Safai Karamchari (Option: Wet Cleaning/ Mechanized Cleaning)	SGJ/Q6102	3
29		Waste Picker	SGJ/Q6103	3
30		Animal Waste Manure Aggregator (Option: Biogas Plant Operator / Compost Plant Operator)	SGJ/Q6302	4
31		Agri-residue Aggregator	SGJ/Q6201	4
32		Biomass Depot Operator	SGJ/Q6207	4
33		Manager- Waste Management Elective: Biomass Depot or Compost Yard or Dry Waste Center	SGJ/Q6501	6
34		E-waste Recycling Entrepreneur	SGJ/Q0202	6
35	Waste Water Treatment	Wastewater Treatment Plant Technician	SGJ/Q6601	4
36		Wastewater Treatment Plant Helper	SGJ/Q6602	3
37		Septic Tank Technician	SGJ/Q6402	4
38		Desludging Operator	SGJ/Q6403	4
39		Faecal Sludge Treatment Plant O&M Technician	SGJ/Q6404	4
40	Wind Energy	Assistant Planning Engineer – Wind Power Plant	SGJ/Q1201	4
41		Site Surveyor-Wind Power Plant	SGJ/Q1202	6
42		Construction Technician (Mechanical) - Wind Power Plant	SGJ/Q1401	4
43		Construction Technician (Civil) - Wind Power Plant	SGJ/Q1402	4
44		Construction Technician (Electrical) - Wind Power Plant	SGJ/Q1403	4
45		CMS Engineer- Wind Power Plant	SGJ/Q1501	5
46		O&M Mechanical Technician – Wind Power Plant	SGJ/Q1502	4
47		O&M Electrical & Instrumentation Technician – Wind Power Plant	SGJ/Q1503	4
48	Other Green Jobs	Technician-Paper Bag Manufacturing	SGJ/Q8701	3
49		Paper Bag Maker	SGJ/Q8702	5

Appendix 5: Scenario Assumptions for 500 GW of Non-fossil Fuel Capacity, Including 450 GW of Renewable Energy by 2030

Scenario 1: Government Ambitions

The final projection for this scenario has been taken from the Central Electricity Authority (CEA) report on Optimal Generation Capacity mix for FY30. The study considers the projected peak electricity demand and energy requirement to find out the optimal capacity mix for FY30.[87] The study considers FY22 as the base year and assumes that India achieves the Intended Nationally Determined Contribution (INDC) target of 175 GW installed capacity of RE. However, the present growth rate suggests that it would not be possible to reach the 175 GW target by FY22. Therefore, for this scenario, the final projections for each RE technologies except bioenergy and off-grid solar are considered. The following are detailed assumptions for scenario 1:

- The final figures for solar, wind, and small hydro are taken from the CEA report.

- Grid-connected Solar: Since CEA has not provided the split between grid connected solar, the percentage of utility-scale solar (60 percent) and rooftop solar (40 percent) for India's INDC target for FY22 has been considered for FY30.
- Bioenergy: since India has already achieved CEA projection of 10 GW of bioenergy for FY30, the same CAGR is considered for the remaining years.[88]
- To derive values for FY22 to FY29, CAGR is calculated for each technology from FY21 to FY30.
- To achieve the 450 GW RE target, the remaining 7 GW of capacity can be achieved through off-grid solar and especially with micro and mini grids. Several states like Uttar Pradesh, Odisha, and Bihar already have policies in place regarding micro and mini grids. In coming years, more states are expected to formulate policies on micro and mini grids, which has the potential to help achieve the 450 GW target.[90]

consider the INDC target for the year 2022. REMap options are technology options. Unlike other scenarios, this one doesn't focus just on solar or wind but other technologies like bioenergy (28 GW), off-grid solar (19 GW), and small hydro (23 GW). The large share of capacity for these technologies as compared to other scenarios suggests that India has a potential to diversify the RE technology mix. The assumptions taken for this scenario are:

- To derive values for FY 2022 to FY 2029, CAGR is calculated for each technology from FY 2021 to FY 2030.[95]
- Off-grid solar consists of solar home systems (8.7 GW) and solar for telecom towers (10 GW) for FY 2030.
- The share of utility-scale (80 percent) and distributed generation (20 percent) are estimated based on an IRENA assessment. The capacity of rooftop solar in FY 2030 shows that the INDC target of 40 GW is not achievable.

Table 7: Cumulative capacity (GW) for different technologies from FY22 to FY30 (Source: CEEW-NRDC-SCGJ Analysis, 2022)[91]

	FY22	FY23	FY24	FY25	FY26	FY27	FY28	FY29	FY30
Utility-scale Solar	42	50	60	71	84	100	119	141	168
Rooftop Solar	10	13	18	24	33	45	61	83	112
Wind	45	52	60	69	80	92	106	122	140
Bioenergy	11	12	12	13	14	15	15	16	17
Small Hydro	5	5	5	5	5	5	5	5	5
Off-grid Solar	1	2	2	3	3	4	5	6	7
Total	**113**	**132**	**155**	**182**	**216**	**256**	**306**	**367**	**449**

Table 8: Technology mix in FY30 in Scenario 1 (Source: CEEW-NRDC-SCGJ Analysis, 2022)[92]

RE technology	Capacity (GW) in FY30
Utility-scale solar	168
Rooftop Solar	112
Off-grid Solar	7
Wind	140
Bioenergy	17
Small Hydro	5
Total	**449**

Scenario 2: Forward Looking

The capacity mix for FY 2030 has been taken from IRENA REMap.[93] The Reference Case represents policies in place or under consideration and is based on the estimates from the Planning Commission of the Government of India and CEEW.[94] Since the reference case was prepared before India submitted its INDC, it does not consider the 175 GW target for the year 2022. For the forward-looking scenario, the projections of REMap options are used which are largely based on Low Carbon Inclusive growth scenario and

Table 9: Cumulative capacity (GW) for different technologies from FY22 to FY30 (Source: CEEW-NRDC-SCGJ Analysis, 2022)[96]

	FY22	FY23	FY24	FY25	FY26	FY27	FY28	FY29	FY30
Utility-Scale Solar	42	50	59	70	82	97	115	136	161
Rooftop Solar	9	10	12	14	17	21	25	29	35
Total Solar	51	60	71	84	100	118	140	166	196
Wind	47	56	66	79	93	111	132	157	187
Bioenergy	12	13	14	16	18	20	22	25	28
Small Hydro	6	7	8	10	11	14	16	19	23
Off-grid solar	2	2	3	4	5	7	10	14	19
Total	**115**	**135**	**160**	**188**	**223**	**263**	**311**	**367**	**453**

Table 10: Technology mix in FY30 in Scenario 2 (Source: CEEW-NRDC-SCGJ Analysis, 2022)[97]

RE Technology	Capacity in FY30
Utility-scale solar	161
Rooftop Solar	35
Off-grid Solar	19
Wind	187
Bioenergy	28
Small Hydro	23
Total	**453**

Scenario 3: Market Driven

IEA market update 2020 has provided an analysis that considers the impact of COVID-19 pandemic on RE deployment in the year 2020 and 2021. According to the analysis, although the growth rate as compared to the previous years is lower, the RE deployment has shown resilience.[98] The report provides the forecast for FY 2025 and net addition for each year from 2020 to 2025 for each technology except for small hydro. There are two cases for net addition provided by IEA, main case and the accelerated case. This scenario considers the accelerated case as the capacity deployment rate would not be enough to meet the 450 GW target in FY 2030. The detailed assumptions considered in the scenario are given below:

- The IEA dashboard has provided figures for the calendar year so the net addition values for each year is divided by four quarters and 1/4th of it is added to the previous FY and 3/4th is added to the next FY to keep consistency.
- For all the technologies except small hydro, after FY 2025, the capacity figures are extrapolated by calculating the CAGR of FY 2017 to FY 2025 and keeping the same CAGR from FY 2025 onwards till FY 2030.[99]
- For small hydro, the CAGR of FY 2017 to FY 2021 is calculated and the capacity figures are extrapolated keeping the same CAGR till FY 2030.[100]
- The net addition for all the RE technologies for FY 2020 and FY 2021 is lower than the net addition in FY 2019 (Table 12). The impact of Covid-19 pandemic is quite evident. For wind, the drop in deployment is caused due to lockdown as it delayed the construction and project commissioning. For solar, supply chain disruptions and delayed construction has resulted in low net addition. However, the net addition is expected to increase in the FY 2022 as IEA forecast suggests.

Table 11: **Net RE addition in FY19, FY20 and FY21 (Source: CEEW-NRDC-SCGJ Analysis, 2022)[101]**

	FY 2019	FY 2020	FY 2021
Utility-scale solar	8.2	5.8	3.5
Rooftop Solar	2	1.3	1.4
Off-grid Solar	0.2	0.1	0.2
Wind	2.2	2.1	1.6
Bioenergy	1.1	0.2	0.3
Small Hydro	0.1	0.1	0.1

Table 12: **Cumulative capacity (GW) for different technologies from FY22 to FY30 (Source: CEEW-NRDC-SCGJ Analysis, 2022)[102]**

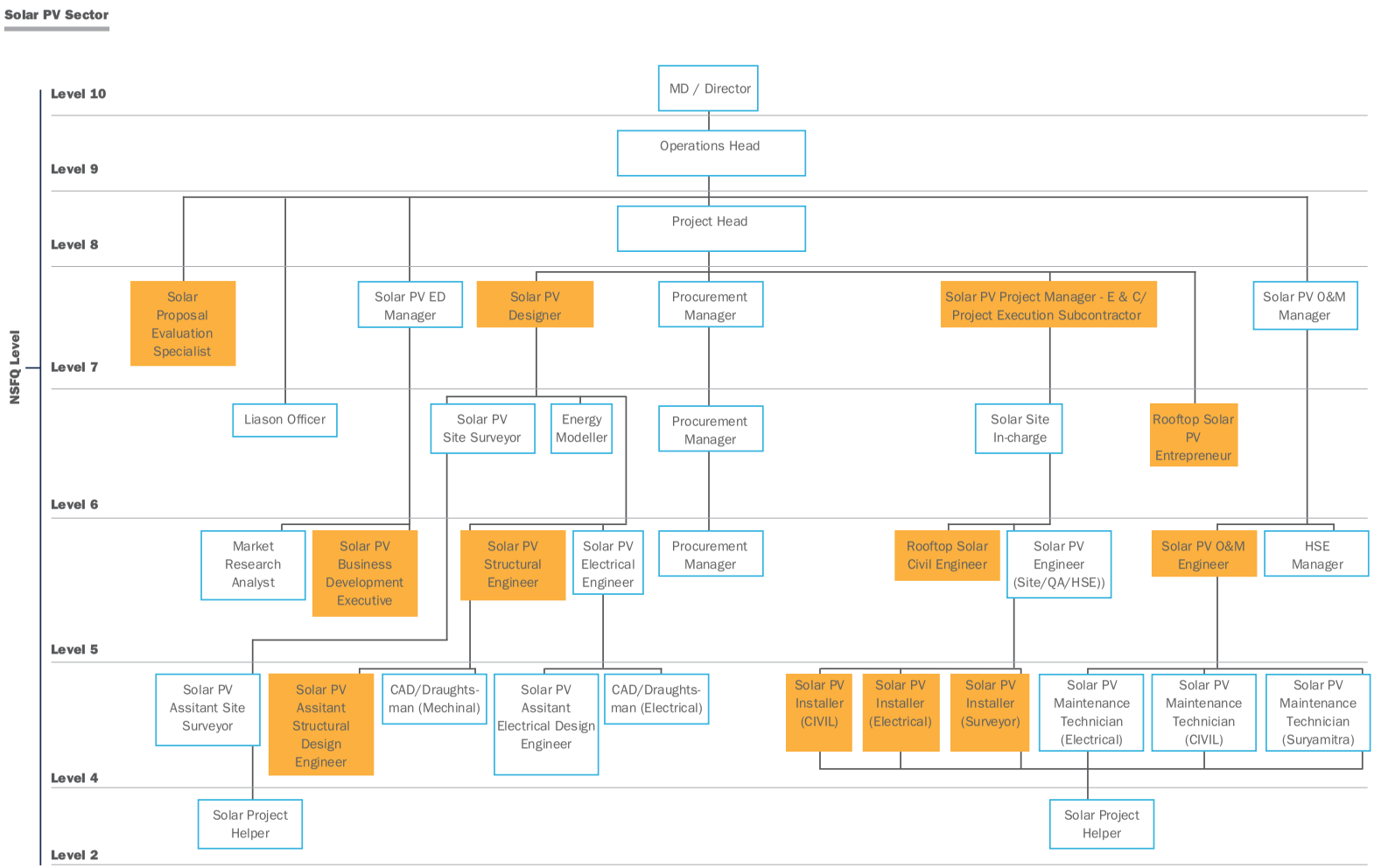
	FY22	FY23	FY24	FY25	FY26	FY27	FY28	FY29	FY30
Utility-Scale Solar	46	57	69	83	102	127	157	194	240
Rooftop Solar	9	12	16	21	29	39	52	71	95
Total Solar	55	69	86	104	131	165	209	265	335
Wind	44	50	56	63	68	73	78	84	91
Bioenergy	11	12	12	14	15	16	17	18	19
Small Hydro	5	5	5	5	5	6	6	6	6
Off-grid Solar	2	3	3	4	5	6	7	9	11
Total	**117**	**139**	**163**	**190**	**224**	**265**	**317**	**382**	**462**

Table 13: **Technology mix in FY30 in Scenario 3 (Source: CEEW-NRDC-SCGJ Analysis, 2022)[103]**

Renewable Energy Installed Capacity in FY 2030 (GW)	
Utility-scale solar	240
Rooftop Solar	95
Off-grid Solar	11
Wind	91
Bioenergy	19
Small Hydro	6
Total	**462**

Appendix 6: Occupational Map for Employment Opportunities in the Indian Solar Industry

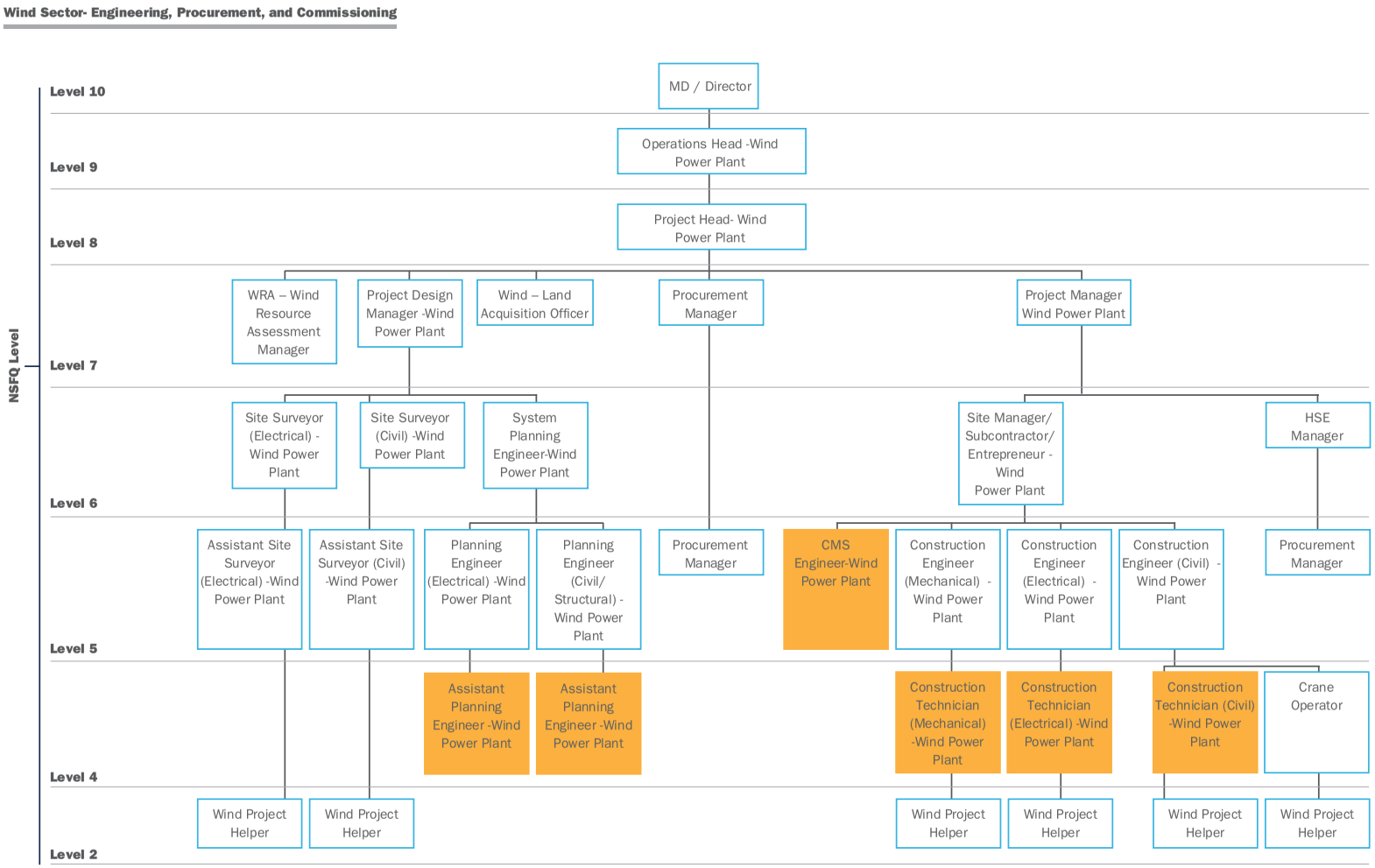
Figure 12: Occupational map and career progression for employment opportunities in the Indian solar industry* (Source: SCGJ, 2022)[104]



*The yellow boxes indicate that some of these jobs roles are included and are also in process to be included in the National Qualification Register, and that SCGJ has developed the corresponding qualification and course material for these roles.

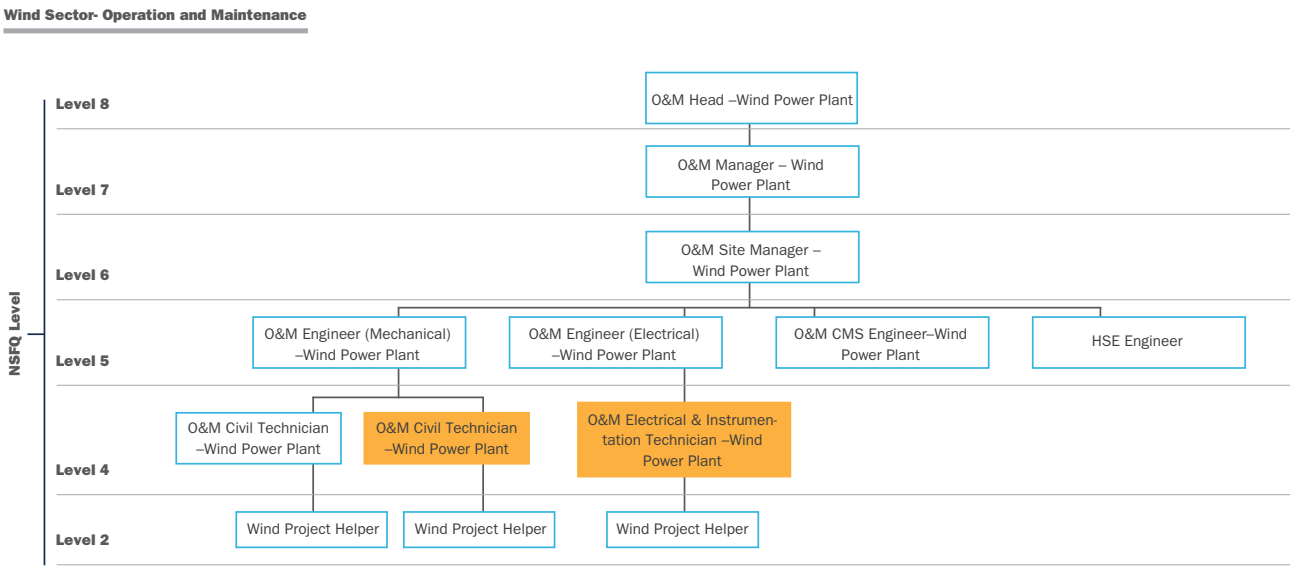
Appendix 7: Occupational Maps for Employment Opportunities in the Indian Wind Industry

Figure 13: Occupational maps and career progression for employment opportunities in the Indian wind industry: engineering, procurement, and commissioning* (Source: SCGJ, 2022)[105]



*The yellow boxes indicate that these job roles are being included in the National Qualification Register, and that SCGJ has developed the corresponding qualifications and course material for these roles.

Figure 14: Occupational maps and career progression for employment opportunities in the Indian wind industry: operations and maintenance* (Source: SCGJ, 2022)[106]



*The yellow boxes indicate that these jobs roles are included in the National Register, and that SCGJ has developed the corresponding qualification packs and course material for these roles.

Appendix 8: SCGJ's Skill Development Strategy

Figure 15: SCGJ skill development and training delivery strategy (Source: SCGJ, 2022)[107]

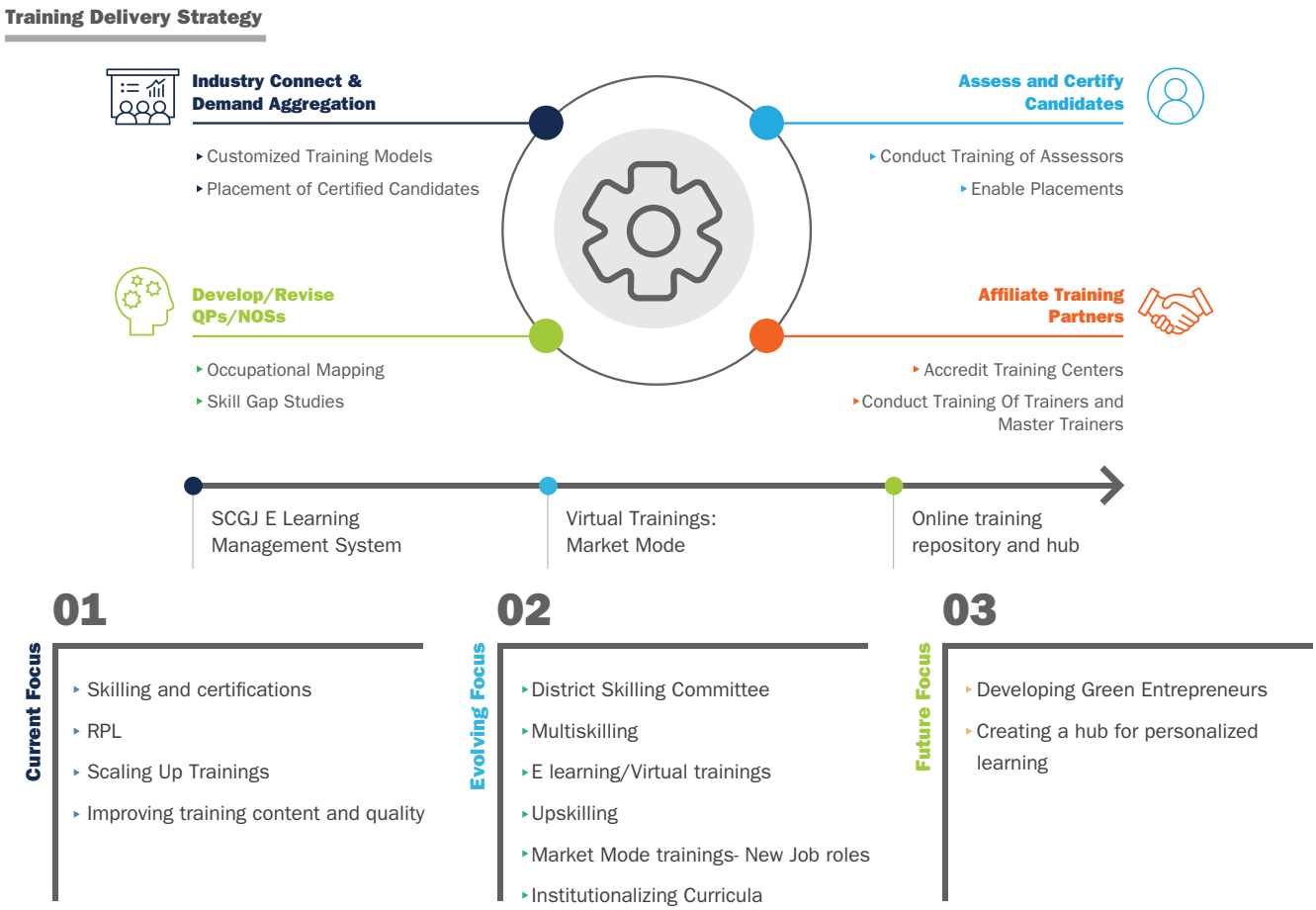
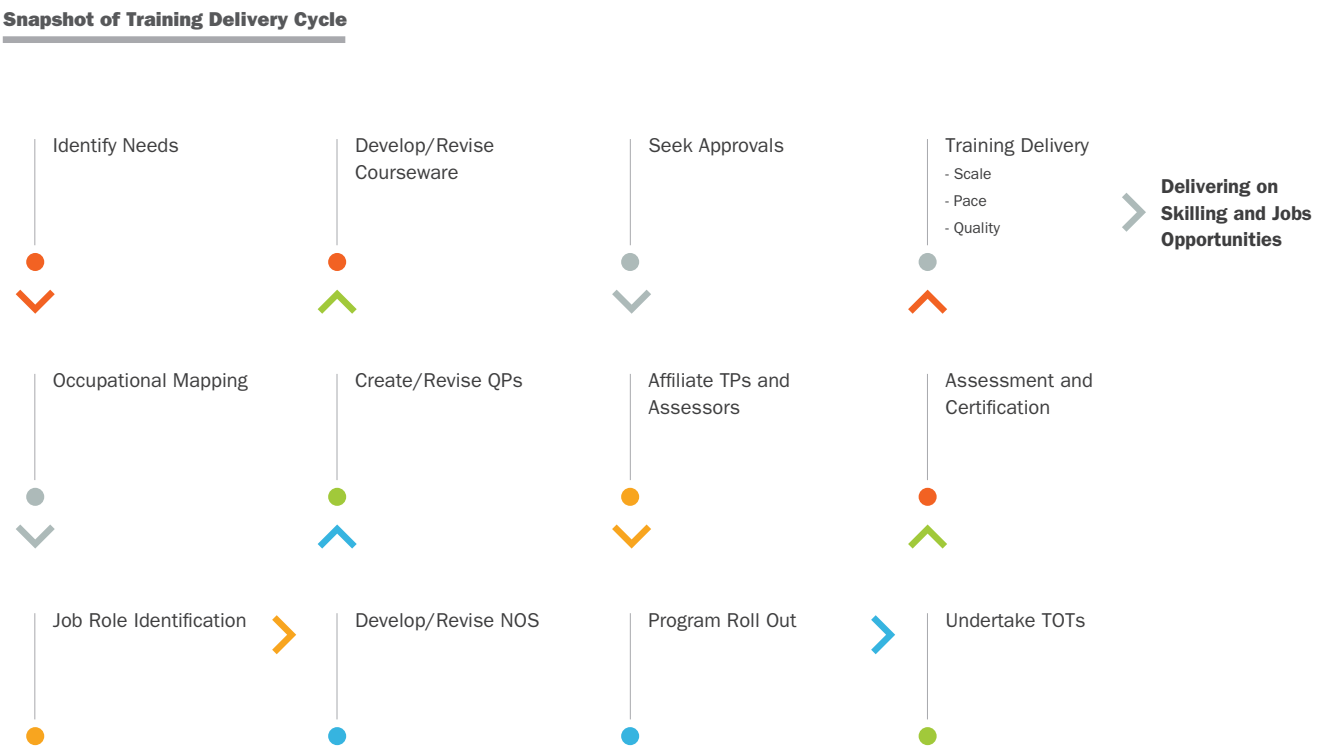


Figure 16: Snapshot of training delivery cycle (Source: SCGJ, 2022)[108]



ENDNOTES

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35.74%, Wind: 15.18%, Bioenergy: 5.96%, Small Hydro: 0.49%, Off-grid solar: 22.34%. These CAGR numbers are calculated from the initial and final capacities for the years FY21 and FY30 as reported by CEA. The CARG numbers are used to compute the annual deployments between FY22 and FY29.

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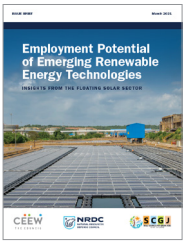
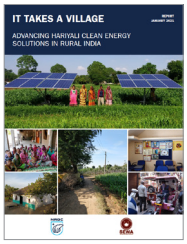
Highlighted Reports

Creating Jobs and Income: How Solar Mini-Grids Are Making a Difference in Rural India



Employment Potential of Emerging Renewable Energy Technologies



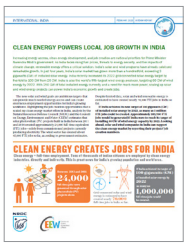
It Takes a Village Advancing Hariyali Clean Energy Solutions in Rural India

Powering Jobs Growth with Green Energy

Worth Their Salt Building Skills and Improving Livelihoods of Women Salt Farmers in Gujarat through Clean Energy Solutions

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

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



Clean Energy Powers Local Job Growth in India

Highlighted Blogs

- **India's New Climate Target Could Create 3.5 Million Jobs, Anjali Jaiswal, Charu Lata, November 2021**
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CEEW
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