COBENEFITS STUDY

October 2019

Future skills and job creation with renewable energy in India

Assessing the co-benefits of decarbonising the power sector

Executive report

teri IASS POTSDAM IET International Energy Transition COBENEFITS

This study has been realised in the context of the project "Mobilising the Co-Benefits of Climate Change Mitigation through Capacity Building among Public Policy Institutions" (COBENEFITS). This print version has been shortened and does not include annexes. The full version of this report is available upon request.

This project is part of the International Climate Initiative (IKI). The Federal Ministry for the Environment, Nature Conservation and Nuclear Safety (BMU) supports this initiative on the basis of a decision adopted by the German Bundestag. The COBENEFITS project is coordinated by the Institute for Advanced Sustainability Studies (IASS, Lead) in partnership with the Renewables Academy (RENAC), Independent Institute for Environmental Issues (UfU), International Energy Transition GmbH (IET) and in India The Energy and Resources Institute (TERI).

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Editors: David Jacobs, Ayodeji Okunlola, Laura Nagel, Sebastian Helgenberger and Arunima Hakhu – IET, IASS and TERI

Technical implementation: Neeraj Kuldeep, Poonam Nagar Koti, Arjun Dutt, Tanmay Bishnoi, and Abhishek Dalal — Council on Energy, Environment and Water (CEEW), Skill Council for Green Jobs (SCGJ), India

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INTERNATIONAL CLIMATE INITIATIVE (IKI)

COBENEFITS of the new energy world of renewables for the people of India

India is in the midst of an energy transition, with important social and economic implications depending on the pathways that are chosen. India's energy pathway will define the basis for its future development, including economic prosperity, business and employment opportunities as well as health impacts. At the same time, current investment decisions in India's energy sector will have a substantial impact on combatting global warming and securing the livelihoods of people in India and elsewhere.

With its bold decision to substantially ramp up renewable energy generation capacity, from 80 gigawatts as of May 2019 to 175 GW by 2022, the Government of India has sent a strong signal on both the direction and pace of India's energy transition. Political decisions on India's energy future link the missions and mandates of many government departments and agencies beyond energy and power, such as environment, industrial development and labour. Hence, the timely debate on India's energy future boils down to assessing how renewables can improve the lives of Indian people.

Employing scientifically rigorous methodologies and the most recent technical data, the study at hand contributes to estimating such co-benefits associated with the shift to renewables. It also provides guidance to government agencies on further shaping an enabling political environment to unlock the social and economic co-benefits of the new energy world of renewables for the people of India.

The Energy and Resource Institute (TERI), as the India Focal Point, together with the Institute for Advanced Sustainability Studies (IASS) invited ministries and government agencies such as the Ministry of New and Renewable Energy, Ministry of Environment, Forests and Climate Change, Ministry of Power, Ministry of Finance and NITI Aayog to join the COBENEFITS Council India, to provide their guidance to the COBENEFITS Assessment studies along with the COBENEFITS Training Programme and Enabling Policies Roundtables. Since its constitution in November 2017, the COBENEFITS Council India has guided the programme in framing its assessment topics for India and ensuring their direct connection to the current political deliberations and policy frameworks of their respective ministries.

We are also indebted to our highly valued research and knowledge partners, for their unwavering commitment and dedicated work on the technical implementation of this study. This COBENEFITS study was facilitated through financial support from the International Climate Initiative (IKI) of Germany.

India, among 185 parties to date, has ratified the Paris Agreement to combat climate change and provide current and future generations with opportunities to flourish. With this study, we seek to contribute to the success of this international endeavour by offering a scientific basis for harnessing the social and economic co-benefits of building a low-carbon, renewable energy system while facilitating a just transition, thereby **making the Paris Agreement a success for the planet and the people of India.**

We wish the reader inspiration for the important debate on a just and sustainable energy future for India!

Ajay Mathur
Director General, TERI, India
COBENEFITS
Focal Point India

Sebastian Helgenberger
IASS Potsdam, Germany
COBENEFITS
Project Director

Executive Summary

COBENEFITS

Future skills and job creation with renewable energy in India

Assessing the co-benefits of decarbonising the power sector

India has made significant progress in utilising its abundant renewable energy (RE) resources. The country has emerged as one of the leaders of the global energy transition, with a cumulative renewable energy installed capacity of 74 gigawatts (GW) at the end of 2018, and has ambitions to meet a target of 175 GW by the year 2022. Further, as recently announced by India's Ministry of New and Renewable Energy (MNRE), the government seeks to procure approximately 500 GW of additional RE capacity by the year 2028, resulting to a 40 percent share of installed capacity of non-fossil fuel sources in the power sector by 2030. Notwithstanding these targets, the employment effects of the resulting changes in the power sector still need to be properly understood.

This study analyses the employment effects of different plans for expanding power generation in India; this was carried out in the context of the COBENEFITS project with the aim of assessing the co-benefits[1] of a low-carbon energy transition in the country. Four different scenarios[2] are analysed for future development of the power sector in India with varying shares of renewable energy: **Business-as-usual** (BAU) scenario, which represents India's climate policy until 2016; **Nationally Determined Contribution** (NDC) scenario, which maps the strategies required to achieve India's NDCs targets; **NDC PLUS** (NDC PLUS) scenario, which is a deeper decarbonisation plan above the NDC scenario; and the **International Renewable Energy Association** (**IRENA**) **REmap** (REmap) scenario, which provides a power sector decarbonisation pathway for India to contribute towards limiting global temperature rise to well below 2° Celsius by 2100.

The study presents a value-chain-based approach by developing employment coefficients (full-time-equivalent jobs/MW/year) to analyse the workforce involved at various stages of the entire life cycle of different power generation technologies. The study also provides an initial assessment of the skill requirements, attainment levels and technical training required for India's present power sector plans and future low-carbon power sector ambitions. The four scenarios assessed considered a consistent timeline between 2020 and 2050.

- **Key policy message 1:** India can significantly boost employment through the power sector by increasing the share of renewables. With the government´s pledge under the NDC to scale up renewables in the country, net employment (measured in full-time employees) can be expected to increase by an additional 30 % by 2030. But there is abundant room to achieve more; by following IRENA's ambitious REmap pathway, this can be almost doubled.
- **Key policy message 2:** By electrifying the rural areas in the country with distributed renewable energy technologies, such as small hydro, rooftop solar and biomass, the employment impact per installed capacity of these technologies is about 25 times greater than fossil-fuel based power generation.
- **Key policy message 3:** Following the historical development in India's coal sector, with a shift towards an ambitious decarbonised power sector in India, coal-sector-based employment is expected to decline by about 52 % between 2020 and 2050. This transition, however, needs to be efficiently managed politically to mitigate negative impacts on displaced workers and communities.

[1] The term 'co-benefits' refers to simultaneously meeting several interests or objectives resulting from a political intervention, private-sector investment or a mix thereof (Helgenberger et al., 2019). It is thus essential that the co-benefits of climate change mitigation are mobilised strategically to accelerate the low-carbon energy transition (IASS 2017a).

[2] The Energy and Resources Institute (TERI) applying the MARKAL model developed the first three scenarios. The International Renewable Energy Agency (IRENA) developed the fourth scenario.

KEY FIGURES:

- Up to 3.5 million people can be employed in the Indian power sector by 2050.
- More than 3.2 million people can be employed in the renewable energy sector by 2050.
- The renewable energy sector could employ five times more people by 2050 than the entire Indian fossil-fuel sector employs today.

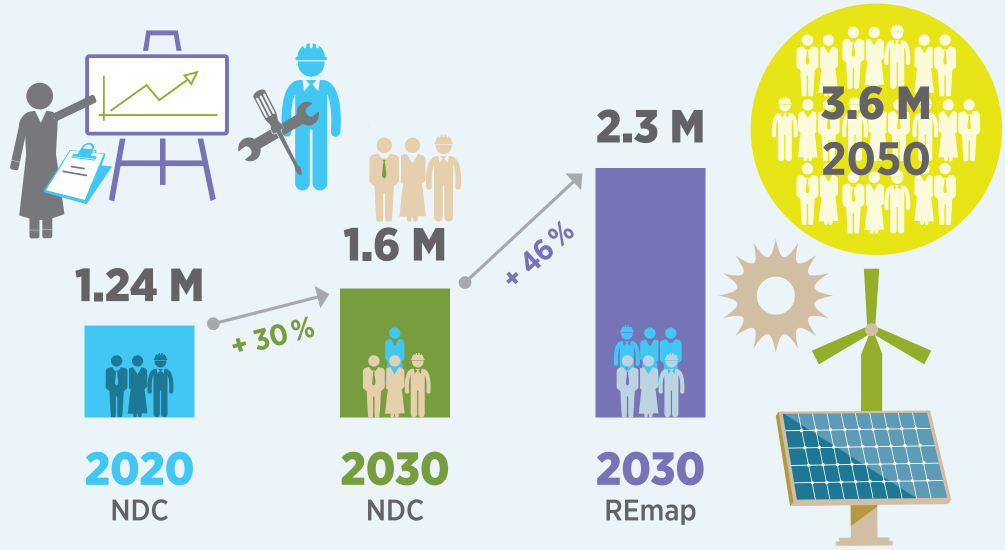
COBENEFITS
Future skills and job creation with renewable energy in India. Assessing the co-benefits of decarbonising the power sector

available on www.cobenefits.info

KEY FINDINGS:

- In all scenarios, the workforce required in the Indian power sector will increase considerably and may reach 3.5 million by 2050.
- Renewable energy technologies tend to be more labour intensive than conventional energy technologies. At the same time, distributed renewables such as small-scale hydro, rooftop solar and biomass create maximum employment for every MW of installed capacity. Rooftop solar employs 24.72 persons, small hydro employs 13.84 persons and biomass employs 16.24 persons for constructing and running a one-megawatt plant.
- The renewable energy sector will be the largest employee in the future Indian power sector. Already in 2020, 264,000 supplementary renewable energy jobs can be created by shifting from BAU to the NDC scenario. Under the REmap scenario, more than 3.2 million people would be employed in the renewable energy sector by 2050.
- Biomass and solar energy will be the major drivers of employment, with up to 2 million and 1.1 million employees, respectively, by 2050.
- Skilling is the primary future challenge. According to the NDC PLUS scenario, India would require 143,000 skilled experts and approximately 410,000 semi- and low-skilled technicians in the solar sector. This number would increase to 250,000 skilled jobs and more than 850,000 semi- and low-skilled technicians under the REmap scenario.
- The number of employees in the coal sector has already decreased considerably in past decades due to increasing mechanisation. In the coal-mining sector alone, approximately 105,000 jobs have been lost due to mechanisation between 2000 and 2015.

India can almost double the number of jobs through the power sector by 2030 by following an ambitious decarbonisation pathway.



NDC: Scenario that highlights the strategies necessary for achieving the targets laid out in India's international climate commitment (NDC)

REmap: High ambition renewable energy roadmap for India by the International Renewable Energy Agency (IRENA)

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1. Pathways towards decarbonisation: A rapidly changing power sector in India

KEY POINTS:

- In recent years, India has emerged as one of the leaders of the global energy transition, with a cumulative renewable energy installed capacity of 74 gigawatts (GW) at the end of 2018.
- India is targeting a 40 percent share of cumulative installed power generation capacity from non-fossil fuel sources by 2030. In early 2019, the Ministry of New and Renewable Energy (MNRE) announced that procuring 500 GW of additional RE capacity might meet this objective earlier, by 2028.
- Consistent with India's move towards renewable energy deployment, the share of coal-based installed capacity has declined from around 60 % at the end of 2015 to an expected 56 % at the end of 2019.

The decarbonisation of the power sector has gathered momentum with new investment flows into the renewable energy (RE) sector. With electricity and heat generation collectively accounting for 25 percent of global greenhouse gas (GHG) emissions, decarbonisation of the power sector is critical for climate change mitigation efforts envisioned under the Paris Agreement. In addition, renewable deployment also offers several co-benefits, such as improving energy access, reducing air pollution as well as generating employment (CEEW- NRDC, 2016). Investments in the renewable energy sector presently far exceed those pertaining to thermal generation at the global level (UNEP, 2018). The decisive global shift in the direction of investment flows in power generation reflects the improved cost competitiveness of renewable energy sources (IRENA, 2018). Besides declining equipment costs for prominent renewable technologies such as solar and wind (IRENA, 2019), the renewable sector has benefitted from favourable policy support in several countries, aimed at incentivising and de-risking investment in renewables.

While emission mitigation is an important objective of renewable energy deployment, the employment generated from the renewable sector is of considerable significance for a developing country like India in order to improve the standard of living of its people. The creation of full and productive employment has been acknowledged as an important global objective as goal 8 (SDG-8) of the United Nations' Sustainable Development Goals (UN, 2019). SDG-8 promotes sustained, inclusive and sustainable economic growth; and full and productive employment and decent work for all. With a rapidly growing renewable energy sector in India, the renewable-based power sector offers considerable employment potential, which can help towards the fulfilment of SDG-8 in an environmentally sustainable manner. At the same time, India's energy transition requires labour spanning a broad spectrum of skill levels in order to sustain the planned trajectory of deployment. Labour requirements span various stages of the value chain for power generation, including: fuel supply; the manufacturing of power plant equipment; project bidding; land acquisition; planning and design; construction and commissioning; and operation and maintenance.

1.1 Recent trends in the Indian power sector

By March 2019, India had an installed power generation capacity of 356 GW; 17% of this capacity was installed in the past three years (CEA, 2019). Consistent with India's policy towards renewable energy deployment over this period, the share of coal-based installed capacity declined from around 60% to 56% between the year 2015 and mid-year 2019 (cf. Figure 1). Also within this period, the share of installed REs in the power system increased from 14% to 22%.

The combination of a favourable policy framework aimed at incentivising and de-risking renewable generation, coupled with declining equipment costs globally, has translated considerable improvements in the competitiveness of renewable energy tariffs in India. Solar PV tariffs declined from 7.49 Rupees (INR) per unit of electricity in 2012 to INR 2.44 in 2017. Wind energy tariffs have also declined considerably with the commencement of reverse-auction bidding in February 2017. The first competitive wind tender resulted in a tariff of INR 3.46 in February 2017. This declined further to INR 2.43 by December of the same year. However, in the absence of any dedicated decarbonisation policies, future power generation is expected to still be dominated by the thermal power sector with coal remaining the largest source of power production.[3]

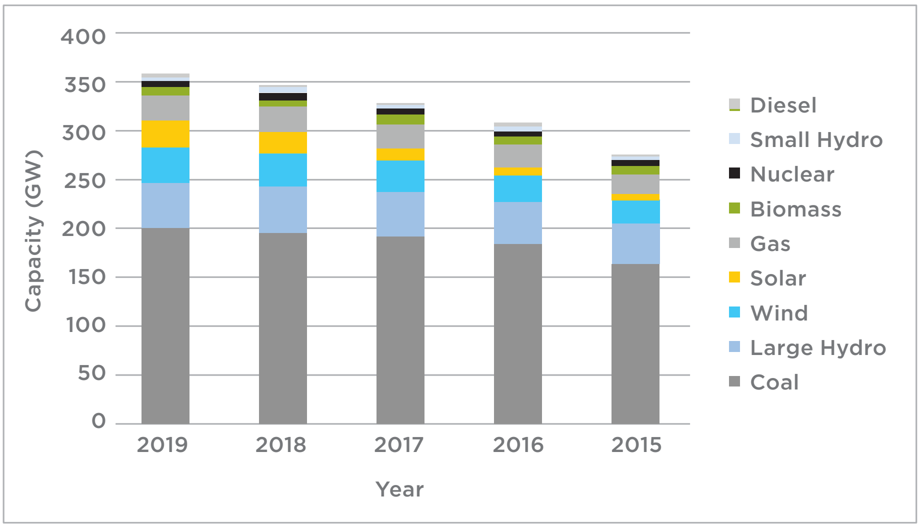

Figure 1: Installed generation capacity in India

Source: CEA, 2019

[3] A recent CEEW study on "Sustainable Development, Uncertainties, and India's Climate Policy" concludes that 50 GW of under-construction coal capacity, which is expected to come online by 2019, will lead to overcapacity up to 2025. Conversely, a different analysis, which assumed higher economic growth of CAGR 7.4 per cent from 2015 until 2050, found this would not lead to over capacity as the economic conditions in India improves (Chaturvedi, Nagar Koti, & Chordia, 2018). Overcapacity could lead to stranded assets in future, resulting in loss of employment in the sector.

1.2 Developing employment coefficients and calculating net employment effects

While existing studies of a particular power sector technology do capture some aspects of the jobs and skills dimensions pertaining to renewable generation, these are characterised by certain shortcomings (SCGJ, 2016; MNRE & CII, 2010; PSSC, 2017).

- Firstly, there is a lack of credible information on the number of jobs that have been created so far in both the RE and non-RE value chains and possible number of jobs to be created in the RE sector in the future.
- Secondly, existing studies do not capture the net impact of renewable generation on employment.
- Thirdly, there is a dearth of reliable information on different types of jobs, such as direct, indirect and induced jobs, across the value chains of all power generation technologies, including conventional generation.

Building on existing studies of employment as a co-benefit pertaining to the power sector, this study aims to address key gaps in the existing literature. Encompassing both renewable and conventional generation technologies, the study aims to:

- Develop employment factors in the power sector (gross analysis of the evolution of jobs created in the RE sector with expected net job effects in other sectors such as coal mining).
- Analyse potential job creation (employment effects) through the power sector over time. The employment effects are analysed at 5-year intervals until 2050. For the purpose of simplicity and clarity, the results are presented in ten-year intervals, i.e. years 2020, 2030, 2040 and 2050.

2. Methodology

2.1 Value-chain assessment and employment coefficients

The study undertakes a value-chain-based analysis to estimate *Full Time Employment (FTE)* in the Indian power sector. A value-chain analysis provides a comprehensive way of assessing various interlocking stages in the power sector, starting from the conception of a product or service, through the intermediary phases of production, and then to the delivery of electricity to consumers (cf. Figure 2). The value chain in the power sector comprises the fuel supply stage, equipment manufacturing, generation stage and the transmission and distribution stage.

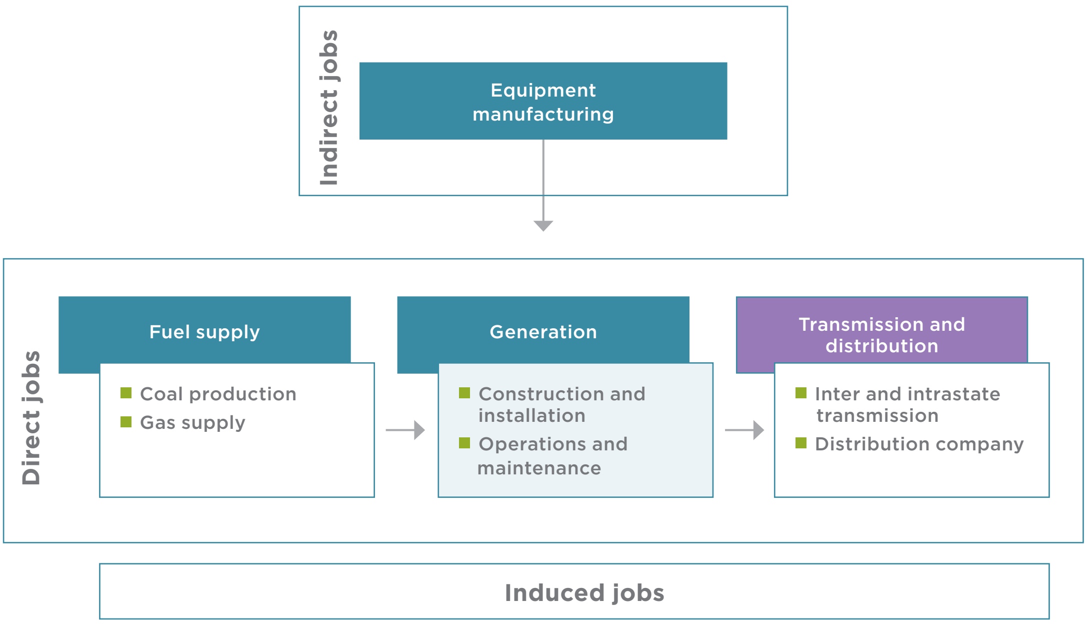

Figure 2: Power sector value chain and job classification

Source: own

The fuel supply stage is only relevant in the context of conventional technologies such as coal- and gas-powered plants that require primary sources of energy to generate electricity. Biomass-based generation technologies also create jobs in the fuel supply stage, since they use biomass as fuel. Other renewable technologies harness natural resources that are freely available. Employment per unit of generation is calculated from the total employment per tonne of coal and the specific coal consumption in thermal power plants, as shown in the equation below.

$$FTE\ per\ GWh = \frac{Total\ employment\ in\ coal\ mining}{Total\ coal\ production\ (tonnes)} \times \frac{Specific\ coal\ consumption\ (kg/kWh) \times 10^6}{1000}$$

The equipment manufacturing stage involves companies operating in the electrical equipment sector. Boilers, steam or gas turbines, generators, solar modules and wind turbines, among others, are the major types of power equipment offering indirect jobs in the manufacturing sector. Job creation during the generation stage has been broadly categorised as engineering, procurement, construction (EPC) and operations and maintenance (O&M). The EPC phase plays a big role in providing jobs for setting up new power plants, including job roles under system design and project execution.[4]

Employment factors for any generation technology are calculated considering all job types, ranging from pre-investment approval to contract closure and commissioning of a power plant. The formula for estimating the employment coefficient during the construction and installation phase considers the total number of working days contributed by the workforce over the project duration.

$$FTE\ per\ MW\ per\ year\ (Construction\ phase) = \frac{Total\ workdays\ contributed}{Capacity\ (MW) \times Construction\ duration}$$

Similarly, the employment factor during the operations and maintenance phase is calculated on an annualised basis, considering the total workforce deployed to ensure smooth plant operation. The labour intensity differs according to the plant capacity. Thus, the FTE coefficients are calculated for the individual power plant. The weighted average across different power plant capacities (of the same technology type) provides the FTE per MW for a particular technology.

$$FTE\ per\ MW\ per\ year\ (O\&M\ phase) = \frac{Total\ workdays\ contributed\ in\ a\ year}{Capacity\ (MW)}$$

The study captures employment created by different electricity generating technologies comprising coal, gas, nuclear, large and small hydro, utility- and rooftop-scale solar, wind, and biomass. Primarily, the data collected from official sources are used to calculate employment coefficients (FTE Jobs/MW/Year). The employment coefficients are calculated on a full-time-equivalent basis, which normalises the employment variations during the construction phase. The data used to calculate the FTE coefficients were sourced from multiple skill councils, industry and workforce datasets published by public sector undertaking organisations.

The study also considers the job losses due to in creasing mechanisation of coal mining activities. Derating factors are applied for the impact of increasing mechanisation in the power sector; this is based on historical data over approximately 30 years.

Furthermore, the study examined the labour intensity trends during the EPC and O&M phases to understand any change in intensity over time. However, the historical data indicate that labour intensity has remained consistent. Hence, the derating coefficients are not used to assess net employment during the EPC and O&M phases.

[4] Transmission and distribution include the construction of transmission lines to transfer power from the source of generation to consumers. This also includes employment provided by electricity distribution companies. However, since the transmission and distribution sector is agnostic to any particulate technology type, the report does not capture employment during the transmission and distribution phase.

DEFINING EMPLOYMENT EFFECTS

Employment through the sector could be broadly classified into three categories: Direct, Indirect and Induced jobs (CEEW-NRDC, 2017; Cartelle Barros, 2017)

- **Direct jobs:** This includes employment in the project deployment phase. Various associated activities include plant design, site development, financial closure, project management, fuel supply, construction/installation and the operation and maintenance of power plants.
- **Indirect jobs:** This includes jobs in the secondary industries that supply equipment to the primary industries. This relates to the manufacturing of equipment and materials used for the direct functioning of a power plant, which includes manufacturing of turbines, generators, boilers, solar PV panels and wind systems for power plants. It also includes jobs created at facilities that fabricate structural hardware, foundations and electrical components for power plants.
- **Induced jobs:** Induced jobs are created when the salaries earned in the primary and secondary industries are spent. For instance, earnings spent by the power plant's workers on purchasing food at grocery stores and restaurants, house rents, etc., induce additional employment in these respective industries.

2.2 Four long-term scenarios for the Indian power sector

Four scenarios are analysed for the future development of the power sector in India. These are used to compare the impacts of various capacity additions for different power generation sources over the next 32 years, until the year 2050. The Energy and Resources Institute (TERI) developed three of the scenarios: BAU, NDC and NDC PLUS. The scenarios are based on partial end-use methods and/or econometric models of the basic drivers of population and GDP growth in the country across sectors. The fourth scenario (REmap) is developed by IRENA.

The **Business as Usual** (**BAU**) scenario assumes the uptake of more efficient technologies based on past trends, existing policies and targets rolled out by 2016. As a result, the current renewable energy targets are partially achieved; coal remains the dominant source with an installed capacity of 888 GW in 2050. Solar and wind installations stand at 156 GW and 126 GW respectively. Total generation capacity reaches 1409 GW in 2050.[5]

The **NDC scenario** (**NDC**) highlights the strategies necessary for achieving the targets laid out in India's NDCs. The major targets accounted for in the scenario are emissions intensity reduction of GDP by 33–35 percent of 2005 levels, and developing a 40 percent non-fossil-based capacity by 2030; however, achieving these goals requires a multi-dimensional development action plan. Coal has the highest installed capacity in 2050, at 739 GW. The decline in coal is substituted by cleaner sources of generation, with 250 GW solar and 135 GW wind installed capacities. Gas-based generation capacity also increases to 134 GW in this scenario.[6]

[5] Improved industrial efficiency as part of the BAU scenario is seen mainly in PAT-designated consumers. The penetration of efficient appliances is slow, as is the phase-out of traditional fuels and the electrification of households. There are few GRIHA-rated buildings in the commercial sector, and their penetration is constrained by their higher costs and lack of appropriate policies; past trends continue in the share of railways, vehicular efficiency improvement and the share of electric pumps in the agriculture sector.

[6] The NDC scenario considers options for enhanced technological efficiency across all sectors; sustainable and efficient urbanisation patterns based on smart cities; fuel substitution in the transport and agricultural sectors, from petroleum-based fuels to increasing share of decarbonised electricity; increased penetration of energy-efficient buildings in the commercial sector; and a swifter phase-out of traditional fuels.

The **NDC PLUS scenario** (**NDC PLUS**) takes up strategies for deeper decarbonisation over and above the NDC scenario. Consequently, it assumes rapid uptake of efficient technologies across all sectors, accelerated efficiency improvements for both appliances and vehicles, and aggressive efforts towards improvement of specific energy consumption (SEC) across the industrial sector. This scenario therefore assumes greater penetration of efficient and low-carbon options such as electric vehicles over petroleum-based vehicles; use of public modes of transportation over private vehicles; use of five-star-rated air conditioners; and enhanced renewables capacity. In this scenario, with deep decarbonisation priorities, installed solar capacity reaches 557 GW in 2050, followed by coal at 478 GW and wind at 222 GW.

The **IRENA REmap scenario** (**REmap**) assesses the renewable energy potential assembled from the bottom-up, starting with country analyses conducted in collaboration with country experts.. In this scenario, the share of coal in the Indian power system is reduced from more than 70% today to less than 8% of power generation in 2050. At the same time, the installed solar PV capacity would reach 940 GW in 2050. This is based on the sum of both utility- and rooftop-scale capacities, while ensuring technical feasibility (i.e., that the total installed capacity of utility-scale solar PV proposed in the scenario remains well below the technical potential limit of 750 GW). The IRENA REmap model applies a simplified approach to assess power generation adequacy and flexibility requirements.

2.3 Study limitations

This study utilises employment coefficients to compute the direct and indirect employment effects in the Indian power sector. An alternative research methodology would involve an input–output (IO) model framework. The advantage of using an I O model is that it enables understanding the linkages between sectors and ripple effects in other sectors due to increasing economic activity in the renewables sector. For instance, by integrating higher shares of low-cost renewable energy technologies into the Indian power sector, industrial and commercial activities could increase in the long term and thus create additional economic growth. In addition, further research is required concerning emerging and future technologies. In particular, Indian employment coefficients still need to be developed for concentrated solar power (CSP) and battery technologies; these are crucial elements of efforts to entirely decarbonise the country's power sector.

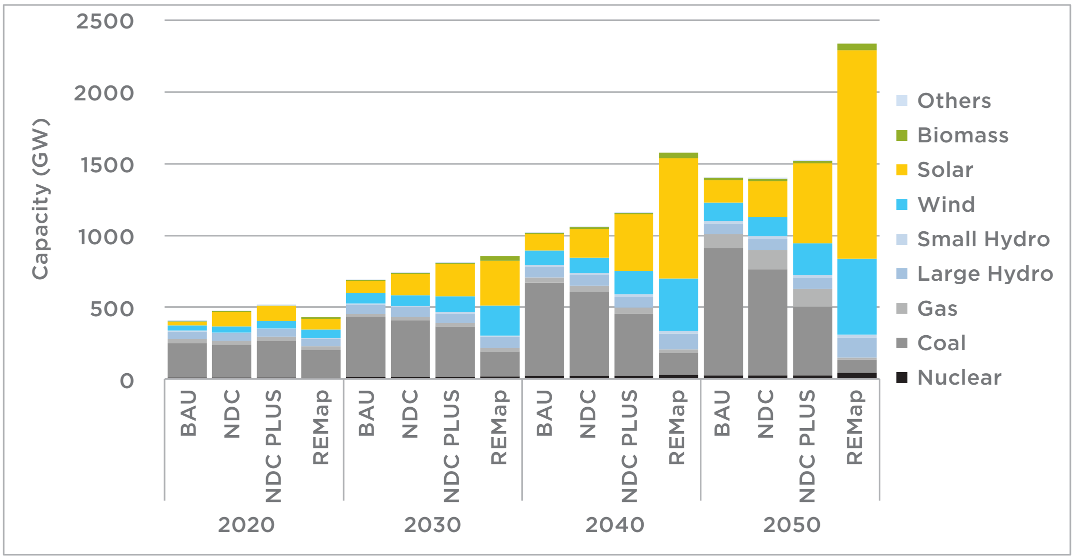

Figure 3: Generation capacity (GW) forecast under different scenarios

Source: TERI, 2019

3. Harnessing employment potential by deploying renewables

KEY POINTS:

- Renewable energy technologies tend to be more labour intensive than conventional energy technologies. Distributed renewable projects such as small hydro, rooftop solar and biomass create maximum employment for every MW of installed capacity. Rooftop solar employs 24.72 persons, small hydro 13.84 and biomass 16.24 persons for constructing and running a one-megawatt plant.
- Skilling is the major need of the hour. According to the NDC PLUS scenario, India would require 143,224 skilled experts and 410,126 semi- and low-skilled technicians in the solar sector. This number would increase to 256,781 skilled jobs and 878,998 semi- and low-skilled technicians under the REmap scenario.
- In the long term, deep decarbonisation scenarios will have an effect on the share of coal in the power mix and thus on employment opportunities within this sector.

3.1 Employment coefficients for all major power generation technologies

A major part of this project was to develop India-specific employment coefficients (Full-time-equivalent Jobs/MW/Year) for different electricity generation technologies. Employment coefficients are estimated across the entire technology value chain, capturing direct and indirect jobs.[7] The employment coefficients are summarised in Figure 4.

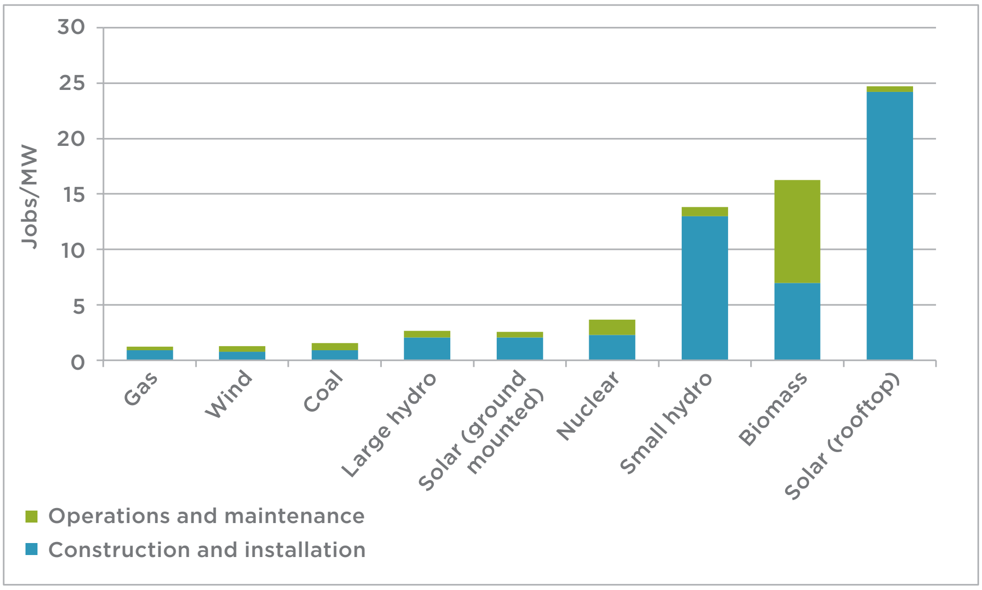

Figure 4: Employment coefficients for different electricity-generating technologies

Source: own

[7] Direct jobs include employment during pre-feasibility assessment, plant design, procurement, construction and the operations and maintenance activities. Indirect jobs are associated with manufacturing of plant machinery and equipment.

3.2 Gross employment effects in the Indian power sector

India has a unique opportunity to create millions of sustainable jobs in the power sector. To estimate the total employment potential in the sector in the coming decades, the above employment coefficients for each of the different technologies are used.[8] In all four scenarios, the workforce required in the Indian power sector will increase considerably. This is primarily triggered by the expansion of power generation capacity in order to power economic growth in India. However, moving towards a decarbonised power sector can provide additional benefits.

With a shift from BAU to the NDC scenario, about 220,000 more jobs are created by the year 2020 through the power sector (cf. Figure 5). A shift to the IRENA REmap scenario would create about 350,000 more jobs in comparison to BAU by 2020. With more ambition, with the REmap scenario, about 1.3 million supplementary jobs are created through the power sector by 2050, 43% more than the number of jobs created under the NDC scenario within this timeframe.

By the year 2020, 264,000 additional supplementary jobs can be created in the RE sector under the NDC scenario in comparison to BAU (cf. Figure 6). Nevertheless, India can achieve significantly greater employment by moving beyond the NDC commitment. Under the REMap scenario, more than 3.2 million people could be employed in the renewable energy sector by the year 2050. This is an increase of more than 150% compared with the NDC pathway. **To put this into perspective: The renewable energy sector could employ five times more people in 2050 than the entire Indian fossil-fuel sector (coal, gas, nuclear) employs in 2020.**

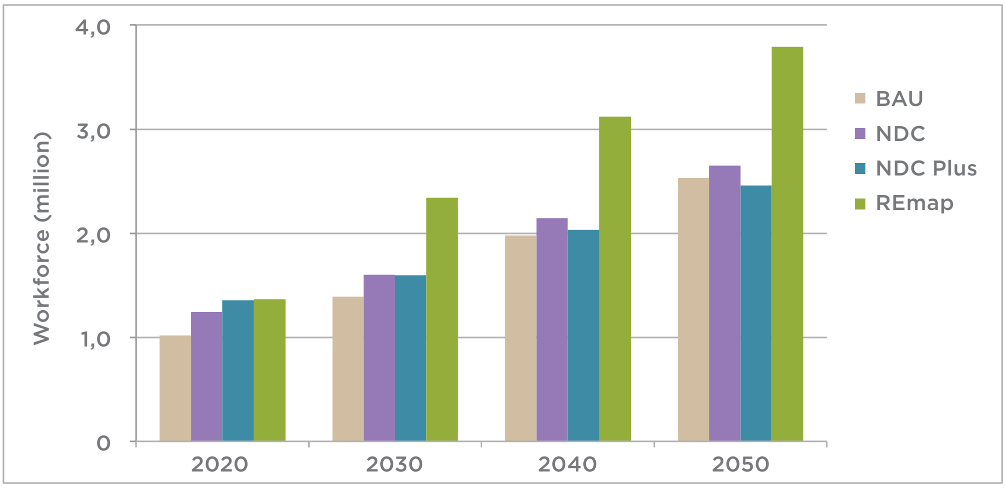

Figure 5: Net employment in the Indian power sector over time

Source: own

[8] The four different scenarios provide the total operational capacity in a particular year, which is used to calculate the total workforce requirement for that respective year.

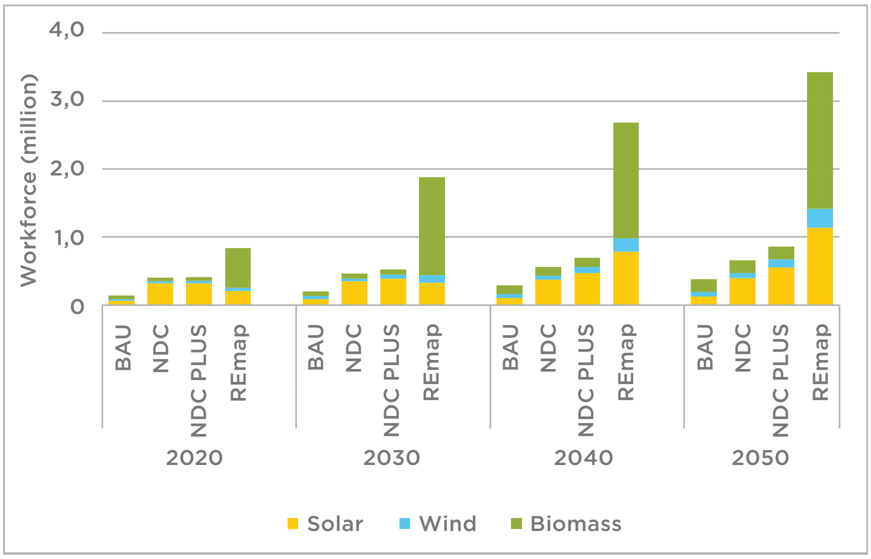

Figure 6: Workforce distribution within the Indian renewables sector

Source: own

3.3 Boosting jobs through the solar sector

From the analysis, the solar sub-sector creates the highest number of jobs in the power sector in India. Many of these jobs will occur during the construction phase, which accounts for 2.95 FTE/MW/Year, while the operations and maintenance phase creates about 0.5 FTE/MW/Year. More jobs will be created in the solar sector because rooftop solar is more labour intensive than any other (renewable) energy technology. Rooftop solar employs 24.72 person per MW installed capacity.

In the short-term, with a shift from BAU to the NDC scenario, about 260,000 new jobs can be created in the solar sector through ambitious mid-term targets via competitive procurement of new solar capacity by the year 2030; however, by shifting to NDC Plus, an additional 4,000 jobs can be created within this timeframe (cf. Figure 7). Over the long term, with a shift from BAU to the REmap scenario, over 1 million additional jobs[9] can be created through the solar industry by the year 2050, and over 700,000 additional jobs through REmap in comparison with the NDC scenario.

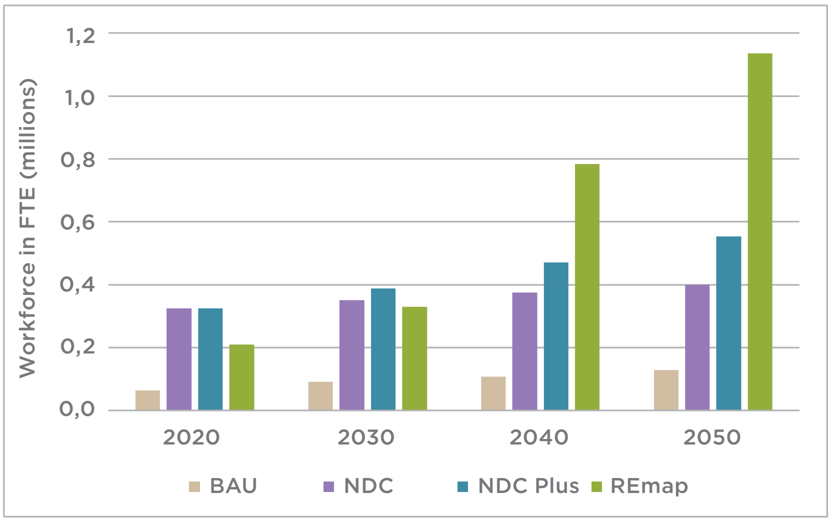

Figure 7: Workforce evolution in the solar industry, 2020–2050

Source: own

[9] The REMap scenario includes both solar PV and a substantial share of concentrated solar power (CSP). In this project, CSP employment coefficients are not developed. This is partly because CSP in India has not yet passed the pilot project phase. Therefore, an equivalent solar PV capacity is assumed, corresponding to annual CSP capacity.

3.4 Workforce evolution in the wind power sector

The wind industry is associated with the use of prefabricated components, greater mechanisation and lower land footprint per installed MW capacity. During the construction phase, wind power potentially creates 0.77 FTE/MW/Year. The components of a wind turbine, whether tower, nacelle, blades, etc., are manufactured at factories, whereas at the project site only assembly activities are undertaken. Nonetheless, the job-creation potential within the wind industry is compelling. Under the BAU and NDC scenarios, India's wind sector is predicted to account for approximately 22,000 and 25,000 FTE respectively by 2020. However, with forward-looking RE policies under the REMap scenario, up to 276,000 can be employed through the wind power sector by 2050 (cf. Figure 8).

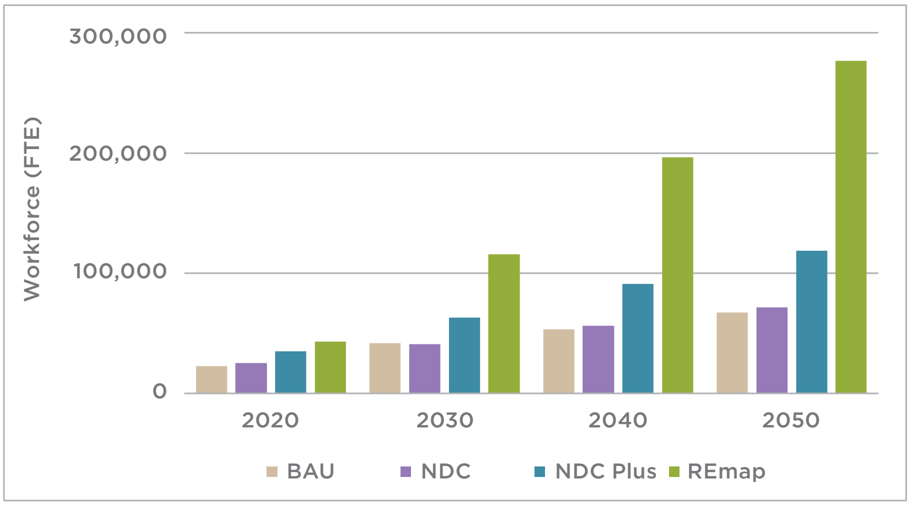

Figure 8: Workforce evolution in the wind power sector, 2020–2050

Source: own

3.5 Employment in the biomass sector

Unlike in the solar and wind power sectors, where the construction and O&M phases are more labour intensive, the biomass sector requires additional workforce to manage biomass fuel sourcing and processing. A biomass power plant consumes an average of 28.5 tons of waste per day for every MW of generation capacity and creates approximately 1.22 FTE jobs per ton of biomass feedstock.

In the first three scenarios (BAU, NDC and NDC PLUS) with similar shares of installed biomass power, employment in the biomass sector potentially creates 20,000 full-time jobs by 2020 and 850,000 full-time jobs by 2050 (cf. Figure 9). However, the REmap scenario with a significantly higher share of biomass creates about 2 million full-time jobs by the year 2050. Biomass under the REmap scenario is used for balancing purposes due to the accompanying rapid decline in the use of fossil fuels in the power sector.

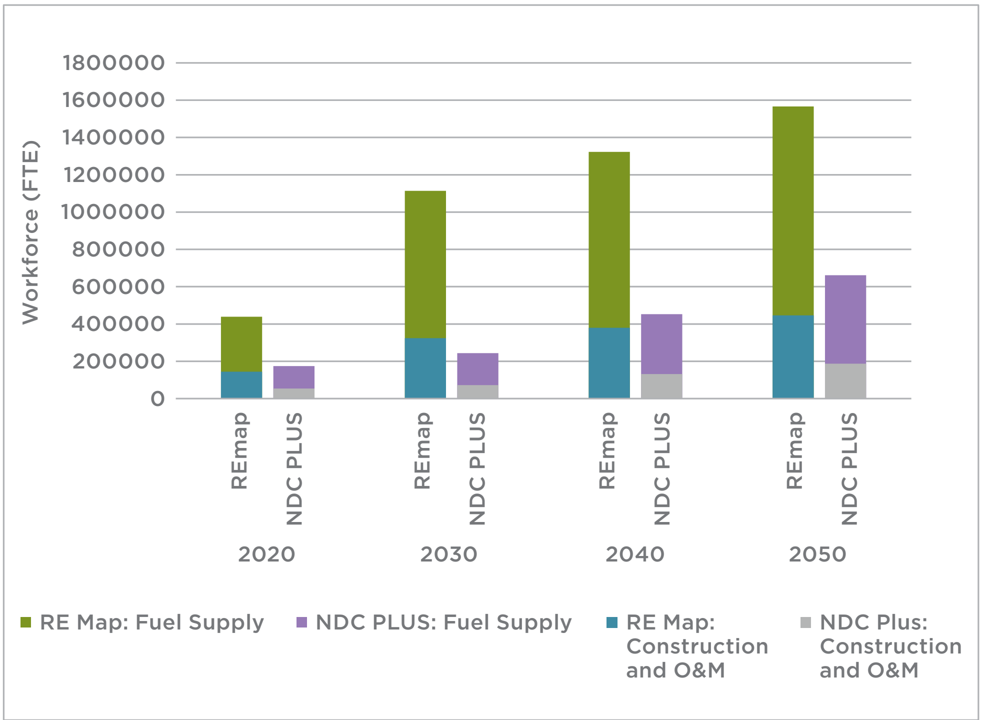

Figure 9: Workforce evolution in the biomass sector, 2020–2050 under the NDC PLUS and REmap scenarios

Source: own

3.6 Job declines in the coal sector

The coal sector in India presently employs about 350,000 FTE, The coal sector in India presently employs approximately 350,000 FTE, following record numbers of job losses during the past decade (more than 105,000 jobs were lost between the years 2000 and 2015, due to increasing mechanisation in the sector)[10].

Coal India Limited (CIL) one of the largest corporate employers in India, with 300,000 employees, is responsible for approximately 84% of total coal production in India. Using developments at CIL as a representative case of the employment trend in India's coal sector: Between 2000 and 2015, job losses in the industry averaged 2.48% annually (cf. Figure 10).

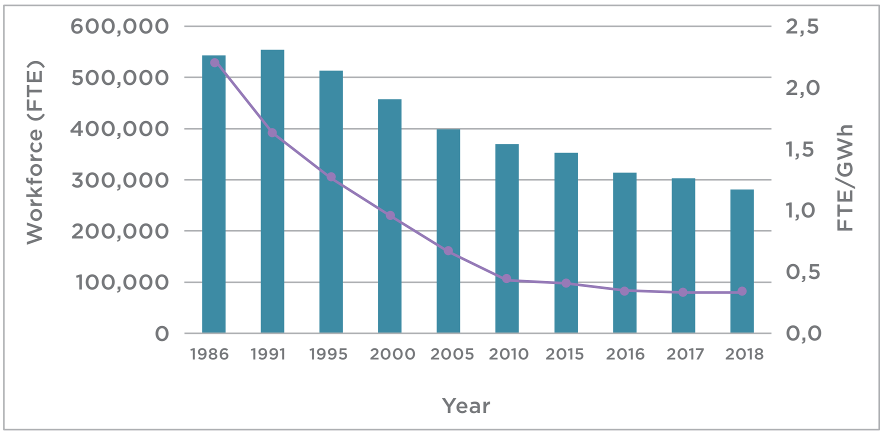

Figure 10: Employment trend at Coal India Limited

Source: CEEW-SCGJ analysis, 2019

[10] The employment numbers until 2015 are taken from the report *Statistics of Mines in India*, available at http://www.dgms.gov.in/writereaddata/UploadFile/Coal_2015.pdf. Numbers for recent years are from multiple CIL annual reports.

Past reductions in total workforce at CIL can be attributed to the company's continuous drive to improve productivity by increasing mechanisation. As per the data reported by the Directorate General of Mines Safety India, the total number of different machines and their aggregate horsepower used in coalmines has increased over time (DGMS, 2015). In the year 2015, CIL operated 17,500 machines, cumulatively amounting to 4.6 million horsepower. From estimates based on the primary data reported by CIL, the coal-mining sector today employs 0.33 people per gigawatt-hour generated at power plant level. Furthermore, to account for improved productivity as a result of increasing automation in coal mining, the report assumes an annual 3 per cent decrease in employment coefficient; A decline factor is calculated, based on historical trends in productivity at CIL. This suggests that employment coefficients will fall and hence overall employment will decline.

India's energy transition is unlike those in developed economies, which are characterised by muted growth in electricity demand and are largely replacing existing conventional generation capacity with renewable capacity. India is one of the world's fastest growing emerging economies, with electricity demand that is expected to rise rapidly with economic growth and the expanding access to electricity. India's electricity demand is expected to more than triple between 2014 and 2030 (UNFCCC, 2019). Given such a demand trajectory, in the near-term India is looking to augment existing power generation capacity (whether conventional or renewable generation), instead of replacing existing conventional generation capacity with new renewable capacity. Thus, increasing renewable generation will not directly lead to decline in employment in thermal generation.

However, in the longer term, deep decarbonisation scenarios will have an effect on the share of coal in the power mix and thus on employment opportunities within this sector. In 2050, the coal sector would employ 1.2 million people in the business-as-usual scenario, 1 million people in the NDC scenario and 670,000 people in the NDC PLUS scenario. In the REmap scenario, the number of employees would be further reduced to 130,000 full-time equivalents. As indicated in Figure 11, the job creation potential of renewable energy technologies is much greater than the job reductions anticipated in the coal sector.

It is estimated that the renewable energy sector could employ five times more people in 2050 than the entire Indian fossil-fuel sector (coal, gas, nuclear) employs in 2020. However, it is unclear how many workers from the coal sector could simply migrate to the renewable energy sector. The next section provides a brief overview of the skills required in the future Indian power sector.

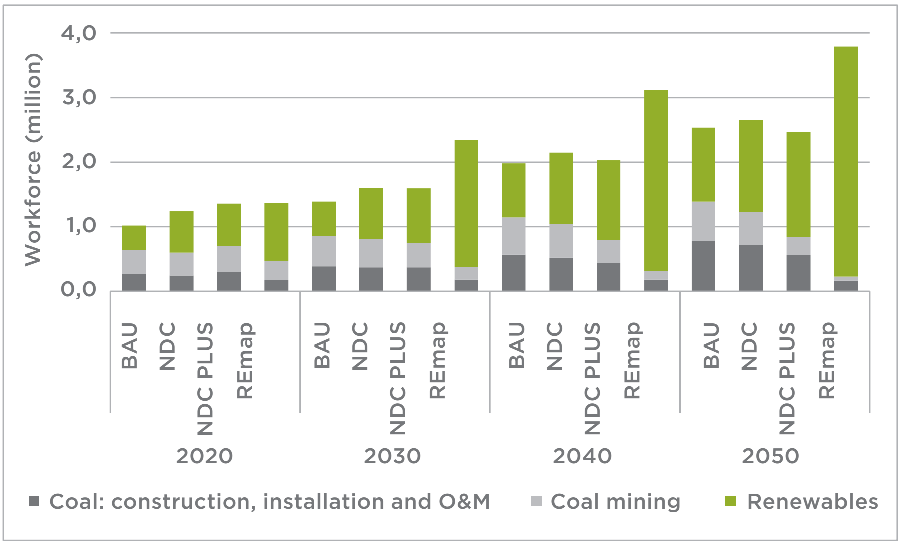

Figure 11: Net employment in the coal and renewable energy sector, 2020–2050

Source: authors

3.7 Skills development for a renewable energy future/the power system of the future

As the growing workforce in the power sector requires different skillsets, it is important to understand the requirements for skilled, semi-skilled or low-skilled workers in renewable energy power plant deployment and operations-related activities.[11] The National Skills Qualifications Framework (NSQF) is composed of ten levels, each representing a different level of complexity, knowledge and autonomy required to demonstrate the competence commensurate with each level (where level 1 represents the lowest complexity). The criteria, expressed as learning outcomes, define the levels.

The demand for "skilling" varies across the value chains of different power-generation technologies. Project deployment can be categorised into four phases: Business development; design and pre-construction; construction and commissioning; and operations and maintenance. The business development phase primarily requires a skilled workforce in the areas of research and project development, market tracking, drafting bids, land selection, project finance and contracts, etc. (CEEW- NRDC, 2016; IEMR). The Skill Council for Green Jobs (SCGJ) classifies various job activities as shown in Figure 12.

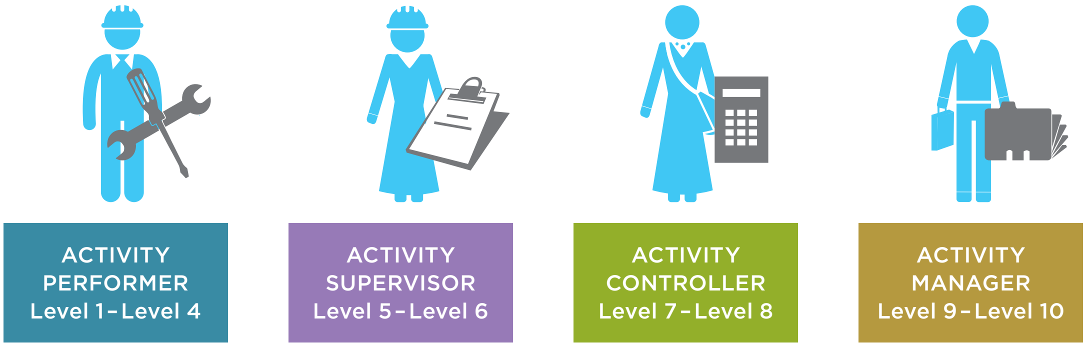

Figure 12: Job responsibilities and skill levels

Source: SGCJ, 2016

The plant design and pre-construction phase requires both skilled and semi-skilled workforce. Skilled workers are involved in preparing detailed plant-level engineering designs for electrical and mechanical systems as well as procurement of materials and equipment. Semi-skilled and low-skilled workers carry out work related to site preparation. The construction and pre-commissioning phase further requires a mix of skilled, semi-skilled and low-skilled workforce. During this phase, a large proportion of the workforce is either semi-skilled or low-skilled.

[11] The term 'skill' means the ability to apply knowledge and know-how to complete tasks and solve problems. Skills are described as cognitive (involving the use of logical, intuitive and creative thinking) or practical (involving manual dexterity and the use of methods, materials, tools and instruments).

Post-commissioning of a power plant, the operations and maintenance phase requires skilled workforce to operate the generators and monitor their performance. Plant maintenance activities also require semi-skilled as well as low-skilled workers to undertake repairs and facility management. The split between skilled, semi-skilled and low-skilled workforce across the value chain also varies for different technologies. As shown in Figure 13, the wind power sector requires a higher share of skilled workers even during the construction phase (the installation of the wind tower, nacelle, turbines, etc. requires experienced personnel). Solar projects, on the other hand, require more workers for installing modules, but this involves higher shares of semi- and low-skilled workers (cf. Figure 14).

Hiring appropriately skilled personnel has always been a major challenge in India. Among others, there is a shortage of platforms to advertise for solar jobs; salaries are often low; and existing training institutes are frequently too far away from the new workforce. Lack of training institutes and poor quality of existing training programmes have also been problems.

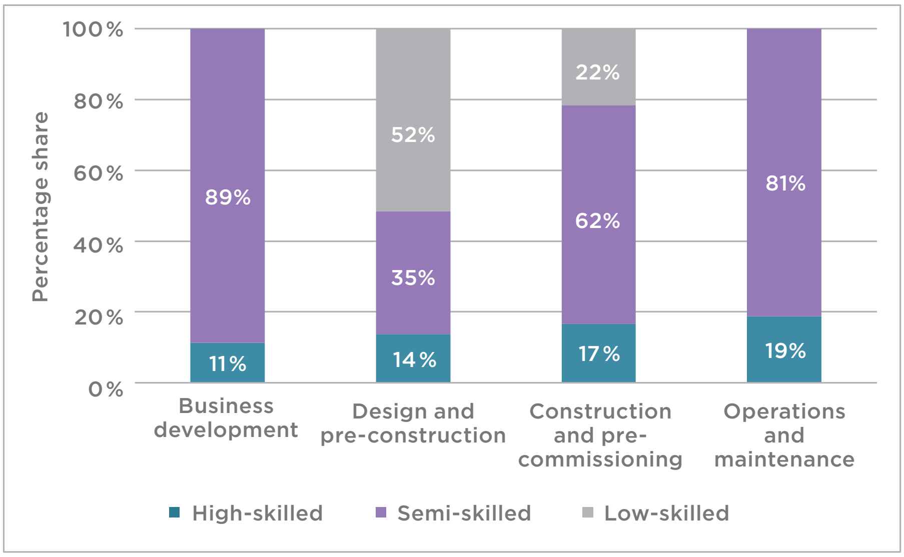

Figure 13: Shares of skilled, semi-skilled and low-skilled workforce for a wind project

Source: CEEW and NRDC, 2015

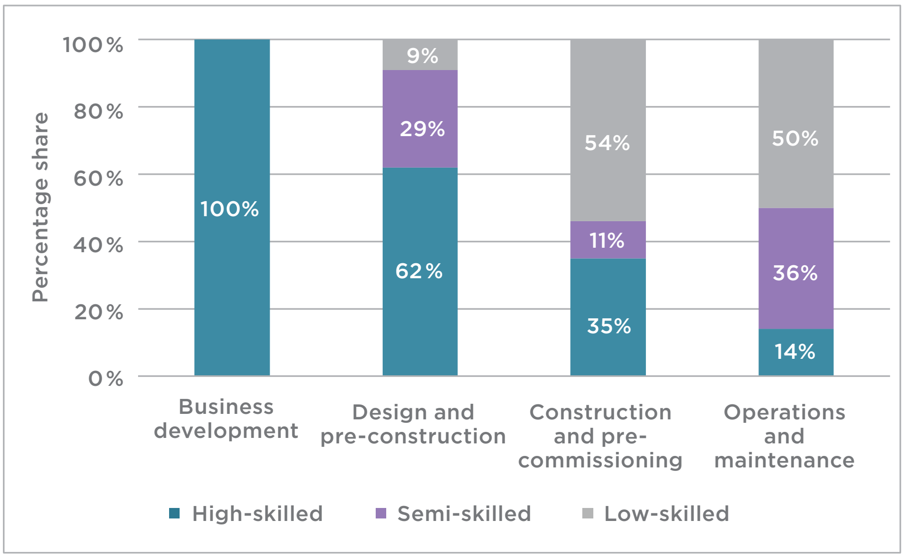

Figure 14: Shares of skilled, semi-skilled and low-skilled workforce for a solar project

Source: CEEW and NRDC, 2017

In order to install 250 GW of solar capacity by 2050 in accordance with the country's NDCs, India would need nearly 122,000 skilled plant design and site engineers and approximately 278,000 semi- and low-skilled technicians for construction (cf. Figure 15).[12] According to the NDC PLUS scenario, India would require 143,000 skilled experts and approximately 410,000 semi-skilled and low-skilled employees. Under the REmap scenario, this will further increase to 256,000 skilled jobs and 879,000 semi-skilled and low-skilled jobs in the solar sector by the year 2050.

The analysis of the wind sector suggests that it requires more semi-skilled labour at the business development stage, whereas solar required 100 percent skilled workforce at that stage. Wind power plant operation and maintenance requires the second-highest proportion of semi-skilled labour (81 per cent), followed by the construction phase.

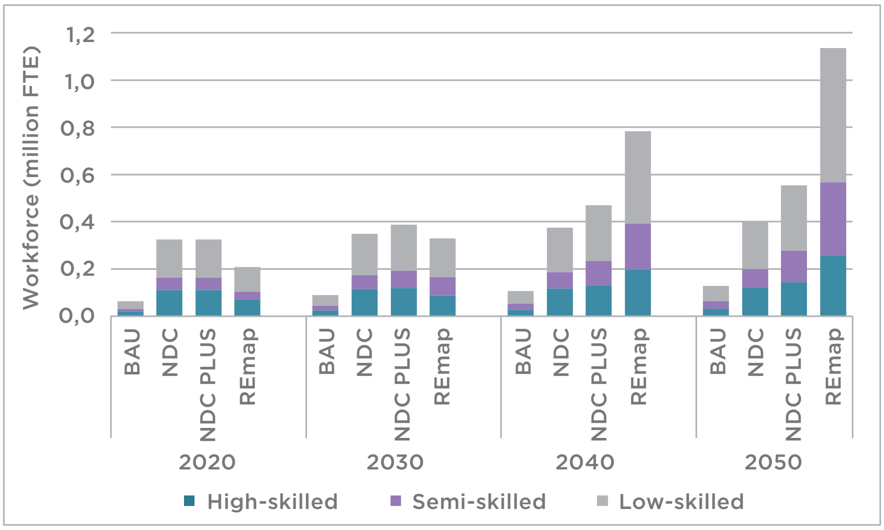

Figure 15: Skillset required in solar sector across scenarios, 2020–2050

Source: own

As shown in Figure 16, the NDC PLUS scenario involves 222 GW of wind power installations, which account for 22,000 skilled, 95,000 semi-skilled and 1,800 low-skilled workers in 2050. The NDC PLUS scenario involves a larger employable semi-skilled workforce as compared to the NDC scenario, due to an 88 GW capacity difference between the scenarios for 2050. According to the REmap scenario, India would require more than 256,000 skilled experts and approximately 879,000 semi- and low-skilled wind technicians.

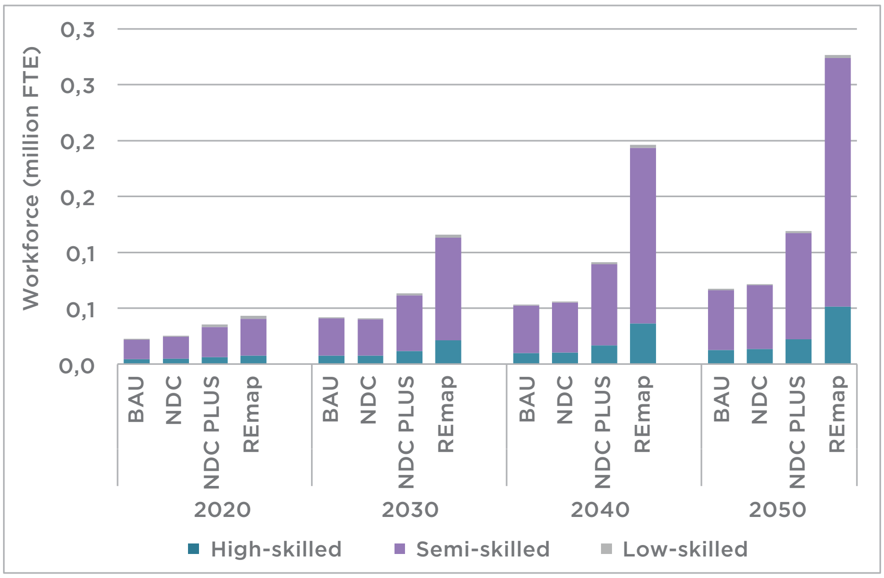

Figure 16: Skillset required in wind sector across scenarios

Source: author

[12] For solar plants, 1.6 per cent of the total workforce is involved in the business development phase, 2.6 per cent in design and pre-commissioning, 72.3 per cent in construction and pre-commissioning, and 23.6 per cent in the operations and maintenance phase.

4. Creating an enabling environment to boost employment with renewables

Impulses for furthering the debate

This COBENEFITS study has quantified the net employment effects of four different scenarios for the Indian power sector involving differing shares of renewable energy sources. It has shown that the renewable energy sector provides huge employment potential, with up to 3.7 million employees in 2050. At the same time, total employment in the renewable energy sector will far exceed current employment in the fossil fuel sector. The analysis also shows that the transition within the employment-intensive Indian coal sector needs to be managed. Skilling and re-skilling of the new workforce in the Indian electricity sector will be most crucial.

What can government agencies and political decision makers do to create a suitable enabling environment to maximise employment benefits in the Indian power sector?

How can other stakeholders unlock the social and economic co-benefits of building a low-carbon, renewable energy system while facilitating a just energy transition?

Building on the study results and the surrounding discussions with political partners and knowledge partners during the COBENEFITS Round Tables, we propose to direct the debate in the following five areas where policy and regulations could be put in place or enforced in order to maximise employment benefits within the shift to a less carbon-intensive power sector.

- Make skilling and female employment a mandatory part of public renewable energy projects.
- Improve data availability concerning employment in the renewable energy sector.
- Foster distributed generation of renewable energy sources.
- Manage the energy transition in the coal sector and coal-producing regions.
- Include job opportunities for (community-owned) renewable energy projects within the Mahatma Gandhi National Rural Employment Guarantee Act (MGNREGA).

Make skilling and female employment a mandatory part of public renewable energy projects

Renewable energy project developers in India operate on very tight profit margins. Many project developers try to save money by focusing on the installation of renewable energies, while reducing the budget for skilling and maintenance and the integration of female workforce. Consequently, there is a risk that qualified maintenance might be neglected; and female employees are underrepresented in the sector.

Renewable energy projects promoted by the central and state governments could contribute to resolving both these issues, by introducing mandatory project obligations to train local workforces to maintain renewable energy installations, and to establish favourable conditions for women.

The financial sustainability of these measures could be ensured by revising auction regulations, so that a certain percentage of each project budget is assigned to training low- and semi-skilled workers and to supporting female employees.

Improve availability of employment data in the renewable energy sector

There is limited scope of analysing employment numbers and trends in India, since there is a lack of granular data. More granular data on employment would help researchers and policymakers to track total employment in the sector. Policymakers could then design policies in ways that maximise job creation (e.g., best technology mix, increased domestic manufacturing, etc.).

Individual organisations across the sector value chain should also be encouraged to report employment generation, in order to create a transparent data system for future analysis. Making job- and skill-reporting a mandatory part of project reporting for renewable energy projects advertised by central and state governments would provide a way to collect valuable data from renewable energy project developers. Such a policy would require the Ministry of New and Renewable Energy and the Ministry of Power to review and adapt their auction conditions for RE projects.

In order to utilise the resulting data for assessment, evaluation and planning purposes, it is recommended that a regular joint working group should be established between the Ministry of New and Renewable Energy, the Ministry of Skill Development and Entrepreneurship (MSDE) and the Skill Council for Green Jobs. Another option would be to collect employment data as part of the household survey within the Employment and Unemployment survey of the National Sample Survey (NSS). This could be implemented by a joint initiative by the Ministry of Labour and Employment, the Ministry of Statistics and Programme Implementation and the Ministry of New and Renewable Energies.

Foster distributed generation of renewable energy sources

Distributed renewable energy technologies such as small hydro, rooftop-scale solar and biomass create maximum employment for every MW of installed capacity. Rooftop solar employs 24.72 persons, small hydro 13.84 persons and biomass 16.24 persons, respectively, for constructing and running a one-megawatt plant. This suggests huge potential for job growth in distributed RE technologies. Policymakers should prioritise distributed forms of renewable energy technologies in order to accelerate employment creation in the renewable energy sector.

Distributed renewable energy technologies such as biomass, rooftop solar and small hydro have the potential to provide employment in rural areas. Biomass energy facilities have an employment coefficient of 9.28 FTE jobs per year per megawatt during the operations and maintenance phase, and another 34.5 people per ton of biomass are employed in sourcing this feedstock. Biomass also provides additional income to farmers for their crop residues.

Manage the transition in the coal sector and coal-producing regions

As discussed, deeper decarbonisation of the Indian power sector would eventually result in reduced employment in the coal sector. To alleviate the social impacts of the energy transition in the Indian coal regions, specific measures can be taken that have proven successful in other countries around the world. In a first step, India could assess the renewable energy potential in the coal regions; deploying renewables in the (former) coal regions can generate employment and economic activities in those regions. Secondly, policymakers could plan location-specific renewable energy auctions in (former) coal regions. Re-skilling of the existing workforce would ensure their employability in emerging renewable energy technologies. Implementation of re-skilling programmes would be imperative in the medium- to long term.

Include job opportunities for (community-owned) renewable energy projects within the Mahatma Gandhi National Rural Employment Guarantee Act (MGNREGA)

Renewable energy projects have the potential to create new jobs in India's rural areas, which go beyond the agricultural sector. However, incentives have to be provided to ensure that jobs are also offered for unskilled and low-skilled workers from the communities where renewable energy installations will be located.

The integration of employment opportunities for the joint installation, operation and management of (community owned) renewable energy projects into the MGNREGA scheme would give low- and unskilled workers and women the opportunity to connect, through this established employment scheme, to opportunities offered from renewable energies, and to create a sense of ownership for renewable energy in their villages. Furthermore, the combination of renewable energy projects with the scheme would ensure the maintenance of renewable energy installations in the medium and long term and might lead to cost reductions and synergies, e.g., in biomass projects.

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List of abbreviations

CIL	Coal India Limited
CSP	Concentrated solar power
EPC	Engineering, Procurement, Construction
REmap	IRENA REmap scenario
MGNREGA	Mahatma Gandhi National Rural Employment Guarantee Act
MSDE	Ministry of Skill Development and Entrepreneurship
NDC	Nationally Determined Contribution
NDC PLUS	Scenario that takes up strategies for deeper decarbonisation over and above the NDC scenario.
NSS	National Sample Survey
O&M	Operations and maintenance

COBENEFITS

COBENEFITS
Connecting the social and economic opportunities of renewable energies to climate change mitigation strategies

COBENEFITS cooperates with national authorities and knowledge partners in countries across the globe such as Germany, India, South Africa, Vietnam, and Turkey to help them mobilise the co-benefits of early climate action in their countries. The project supports efforts to develop enhanced NDCs with the ambition to deliver on the Paris Agreement and the 2030 Agenda on Sustainable Development (SDGs). COBENEFITS facilitates international mutual learning and capacity building among policymakers, knowledge partners, and multipliers through a range of connected measures: country-specific co-benefits assessments, online and face-to-face trainings, and policy dialogue sessions on enabling political environments and overcoming barriers to seize the co-benefits.

Contact

COBENEFITS focal point India
Arunima Hakhu and Neha Pahuja, The Energy and Resources Institute (TERI)
arunima.hakhu@teri.res.in, neha.pahuja@teri.res.in

COBENEFITS project director
Sebastian Helgenberger, Institute for Advanced Sustainability Studies (IASS)
sebastian.helgenberger@iass-potsdam.de

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