GGGI COUNTRY REPORT

Employment assessment of renewable energy: Indonesian power sector pathways

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EXECUTIVE SUMMARY

The development and gradual enhancement of countries' Nationally Determined Contributions (NDCs) have gained considerable attention since the 2016 Paris Agreement, ratified by 189 countries to date. Raising the level of ambition in the NDCs can lay the foundation for limiting the global temperature rise to well below 2°C or even further to 1.5°C to mitigate climate change. Climate mitigation action could generate benefits locally, in addition to the global benefits of the GHG emissions reductions and therefore, could be the catalyst for setting more ambitious NDC targets. Reducing GHG emissions by enhancing renewable energy (RE) generation could also contribute to job creation and become a driving force of countries' economic growth. According to the International Energy Agency (IEA), the power sector contributes to 42% of global energy-related CO_2 emissions. Simultaneously, RE electricity generation is becoming cheaper compared to coal and natural gas[1]. In this context, it is becoming essential to explore and estimate the RE employment opportunities of different decarbonization pathways and RE targets under the NDCs.

While the potential for job creation in RE has been assessed at the global level, there is an increasing demand for RE employment studies at the national level. This study aims to assess the employment creation potential of RE technologies based on future power sector scenarios for three GGGI Member countries: Mexico, Indonesia, and Rwanda. This report presents the results for Indonesia only. Goals of this study include estimating the jobs that can be created by selected RE technologies compared to selected fossil fuel-based technologies, providing estimates of the required investments for achieving NDC RE targets, and identifying and assessing the occupations and skills required by the RE sector for each stage of the value chain.

The study applied a scenario analysis to investigate the employment implications of RE technologies under different power sector scenarios up to 2030. Two scenarios each for Indonesia were investigated for assessing the employment effects of selected RE technologies. For Indonesia, the scenarios were not compared with each other as they were developed based on different policy documents. The study utilized a RE value chain analysis for assessing the direct jobs that can be potentially created, and Input-Output (I-O) modeling for assessing indirect and induced jobs and value-added created in the overall economy. The study also analyzed the occupations and skills required at each stage of the RE value chain.

For Indonesia, the analysis included two power sector scenarios, namely the Power Supply Business Plan of the State Electricity Company (PLN) and the General Plan of National Electricity (RUKN). The RUKN scenario is more ambitious in terms of installed RE capacity, reaching 43 GW by 2030, compared to 28.5GW under the PLN scenario. Under the RUKN scenario the selected RE technologies such as hydro, geothermal and solar PV, could create about 3.7 million direct jobs, whereas about 2.1 million direct jobs could be created under the PLN scenario. Every direct job created in the RE sector will create one additional job in the overall economy under both scenarios. Reaching the RUKN scenario RE target by 2030 would require significant investments in RE of about USD 49 billion, while it could generate around USD 24 billion in value-added to the Indonesian economy. According to the skills assessment for solar PV in Indonesia, more than 120 thousand jobs will be in demand in project development (PD) by 2030. Furthermore, 64% of the PD employment will be created for management professionals, while technicians, engineers, and project non-professionals will be in higher demand in the other stages of the solar PV value chain.

1International Renewable Energy Agency, *Renewable Power Generation Costs in 2018*, May 2019, https://www.irena.org/publications/2019/May/Renewable-power-generation-costs-in-2018.

Overall, Indonesia will benefit from investments in RE compared to investments in fossil fuel-based technologies, as RE has greater potential in terms of employment and economic value-added in the wider economy beyond the RE sectors. Since the transition to RE involves high skilled occupations and human resources, policymakers should consider how to equip their labor force to undertake these tasks when developing policy measures such as education and vocational training programs.

Considering the benefits of enhancing RE job creation, establishing emission reduction targets for the electricity sector with RE targets which enable both decarbonization and job creation will be an effective way to facilitate a positive spillover effect. By setting more ambitious goals in their NDCs, countries could create a significant number of quality jobs and economic value-added as co-benefits to reducing GHG emissions, while simultaneously making progress toward multiple Sustainable Development Goals (SDGs).

In order to harness the employment benefits of RE, low and middle-income countries need to create an enabling policy environment. Countries in need of financial support can explore smart financing mechanisms. Extending helping hands from multilateral organizations and international development agencies can reinforce a friendly financing environment for those countries.

Lastly, future RE employment assessment studies should further investigate geographical and gender aspects. Identifying where RE jobs are likely to be located, assessing and mapping the potential occupations and skills gaps, and collecting good quality and detail disaggregated data will provide insights to design more appropriate policy programs.

TABLE OF CONTENTS

LIST OF FIGURES AND TABLES

In Annexes

LIST OF ABBREVIATIONS

BAU	Business-as-Usual
CAPEX	Capital expenditures
C&I	Construction and installation
DG	Distributed Generation
EM&D	Equipment manufacturing and distribution
FTE	Full-time equivalent
GHG	Greenhouse gas
GW	Gigawatt
GWh	Gigawatt hour
IEA	International Energy Agency
ILO	International Labor Organization
I-O table	Input-Output table
I-O modeling	Input-Output modeling
IRENA	International Renewable Energy Agency
LCR	Local content requirement
MW	Megawatt
MWh	Megawatt hour
NDCs	Nationally Determined Contributions
NRE	New and renewable energy
OPEX	Operational expenditures
O&M	Operations and maintenance
PD	Project development
PLN	Power Supply Business Plan of the State Electricity Company (Indonesia)
PV	Photovoltaic
RE	Renewable energy
RUKN	General Plan of National Electricity (Indonesia)
SDGs	Sustainable Development Goals
SE4All	Sustainable Energy for All
TW	Terawatt
TWh	Terawatt hour
UNIDO	United Nations Industrial Development Organization
USD	United States Dollar
USDk	Thousand United States Dollars

1. INTRODUCTION

1.1. BACKGROUND

Under the Paris Agreement, governments have developed their Nationally Determined Contributions (NDCs). NDCs are voluntary commitments by countries on GHG emissions reductions based on their priorities, capacity, and historical responsibilities, and are essential elements of the Paris Agreement. Under the Agreement, countries are expected increase the ambition of their NDCs every five years. The sum of countries' NDC pledges lay the foundation for reducing GHG emissions and limiting global temperature rises to 1.5°C relative to pre-industrial levels[2], as backed by science. When formulating or revising their NDCs, countries should consider the additional benefits that can be generated by taking more ambitious action. Assessing the co-benefits of mitigation actions highlights the importance of setting more ambitious NDCs not only for limiting global warming but also for delivering multiple socio-economic benefits. Job creation is one of the most compelling climate mitigation co-benefits that resonates with policymakers at both the national and local levels. Recent evidence shows that climate mitigation action has significant job creation potential and therefore is becoming increasingly relevant and important for policymakers[3].

The power sector is one of the main carbon-emitting sectors, with fossil fuels representing the highest share in the electricity mix in many countries. According to the IEA, the power sector contributes to 42% of global energy-related CO_2 emissions[4]. On the other hand, renewable energy (RE) penetration in the electricity system has been increasing globally in recent years as its investment costs have been plummeting[5]. Electricity from RE is, in many cases, cheaper compared to coal and even compared to natural gas. However, in most countries, RE is still far from reaching its vast potential. The share of renewables represents only 26% of total electricity generation in 2018.

Several global studies highlight the opportunities for job creation provided by RE[6]. The International Renewable Energy Agency (IRENA)'s research shows that if the targeted global RE investments in the energy sector were met,[7] "by 2050, the energy transformation would provide a 2.5% improvement in GDP and a 0.2% increase in global employment, compared to business as usual". The International Labour Organization (ILO)'s flagship 2018 report, *Greening with Jobs*, estimates that GHG reduction measures in the energy sector to meet the long-term goal of the Paris Agreement, will create around 24 million jobs[8]. Although the potential for job creation in RE has been assessed at the global level, there is a growing need to investigate the employment effects at the national level. Despite the importance of RE employment co-benefits, few national-level assessments of employment effects of RE capacity targets under the NDCs exist, particularly in low and middle-income countries (see *Annex 7*). It is increasingly relevant to study the employment effects of the energy transition at the national level as more and more countries commit to carbon neutrality by 2050 and explore pathways to power sector decarbonization.

[2] IPCC, *Global Warming of 1.5°C*, 2018, https://www.ipcc.ch/site/assets/uploads/2018/10/SR15_SPM_version_stand_alone_LR.pdf.
[3] New Climate Economy, *Unlocking the Inclusive Growth Story of the 21st Century*, 2018, https://newclimateeconomy.report/2018/.
[4] International Energy Agency, *Tracking Power*, May 2019, https://www.iea.org/reports/tracking-power-2019.
5 International Renewable Energy Agency, *Renewable Power Generation Costs in 2018*, 2019.
[6] Jay Rutovitz, Elsa Dominish, and Jenni Downes, *Calculating global energy sector jobs: 2015 methodology*, (Prepared for Greenpeace International by the Institute for Sustainable Futures, University of Technology Sydney, 2015), https://opus.lib.uts.edu.au/bitstream/10453/43718/1/Rutovitzetal2015Calculatingglobalenergysectorjobsmethodology.pdf.
[7] International Renewable Energy Agency, *Global Energy Transformation: A Roadmap to 2050 (2019 Edition)*, 2019, https://www.irena.org/-/media/Files/IRENA/Agency/Publication/2019/Apr/IRENA_Global_Energy_Transformation_2019.pdf.
[8] International Labour Organization, *World Employment Social Outlook 2018: Greening with Jobs*, 2018.

Furthermore, policymakers can gain valuable insights from comparing the employment creation potential of RE with fossil fuel-based technologies. Lastly, the transition to RE can also lead to losses in certain sectors in certain regions, which need to be understood to be addressed and managed in a socially just manner.

International organizations and research institutes have recently started to respond to the need for assessing the potential for RE employment creation at the national level. Two international projects funded by the International Climate Initiative (IKI), *Co-benefits*, and *Ambition to action*, assess the employment impacts of power sector decarbonization on selected low and middle-income countries. GGGI completed a green jobs employment study in Fiji in 2019[9]. GGGI also provides support to its Member and partner countries in enhancing their NDCs. GGGI has also assessed the RE conditional targets and required investments in the NDCs of GGGI countries, identifying investment needs and the potential for raising the level of ambition on RE[10]. In this study, GGGI aims to bridge the knowledge gap on national level RE employment studies, and to support GGGI countries to identify employment co-benefits of the RE targets set in their NDCs and national energy plans. To avoid duplication and maximize potential synergies with other RE employment assessment initiatives, GGGI formed an international experts group (IEG) consisting of experts from international organizations such as IRENA, ILO, UNIDO, research-based institutes such as the New Climate Institute, Energy Research Centre of the Netherlands (ECN), Institute of Advanced Sustainability Studies (IASS), Erasmus School of Economics (ESE), and evidence-based policy organizations such as Power for All. The IEG provided technical guidance and advice throughout this study. Lastly, the study benefited from feedback from the Sustainable Energy and Jobs Platform, initiated by IRENA in January 2020, where GGGI is a core member.

The study is also particularly pertinent to the discussion and debate on post-COVID19 economic recovery measures. As countries' economies enter into recession and unemployment levels increase rapidly, the study results shed some light on the employment potential of RE. Evidence on employment potential provides policymakers with an excellent opportunity to harness the environmental benefits of RE technologies while at the same time boosting the economy.

1.2. STUDY OBJECTIVES

The study assesses the potential for employment generation of new installed capacity of RE in the power sector in the selected GGGI country. The analysis highlights the important role that assessments of employment effects can play during the revision of the country's NDCs. Quantifying the employment effects of investments in RE could provide significant support to countries that are developing their RE strategies and power sector decarbonization plans. Ultimately, the study provides evidence-based policy support to national governments for assessing the employment effects of RE targets in the power sector during the revision of their NDCs while simultaneously addressing the achievement of Sustainable Development Goals (SDGs) 7 (affordable and clean energy), 8 (decent work and economic growth) and 13 (climate action).

The study has the following objectives:

- to identify and assess **RE technologies' potential to generate employment** under different future power sector pathways;

[9] GGGI, *Fiji Green Jobs Assessment: A Preliminary Study of Green Employment in Fiji*, July 2019, https://gggi.org/report/fiji-green-jobs-assessment-a-preliminary-study-of-green-employment-in-fiji/.
[10] Dereje Azemraw Senshaw and Jeong Won Kim, "Meeting conditional targets in nationally determined contributions of developing countries: Renewable energy targets and required investment of GGGI member and partner countries," *Energy Policy* 116, (May 2018): 433–443, https://doi.org/10.1016/j.enpol.2018.02.017.

- to support and strengthen **evidence-based policy frameworks** of the country's NDC revision and implementation concerning power sector RE targets from an employment perspective;

- to support the country to incorporate the assessment of the employment generation potential in the development of **RE strategies and NDCs**; and

- to identify and **assess the occupations and skills** required by the RE sector to support and advance the energy transition.

The study results are intended to inform and support different stakeholders and policymakers in Indonesia. The country's NDC related agencies, climate change-related and energy departments, planning, environmental and energy ministries, labor organizations, energy companies and developers, and vocational training institutes and universities could benefit from understanding the study outcomes.

The geographical scope of the study covers Indonesia. In Indonesia, fossil fuels currently dominate the electricity mix, however, the government has put forward plans to reduce their share considerably by 2030. There are various future development pathways for the electricity supply systems that would lock the economy of Indonesia into or out of different carbon emission levels for the next decades. Policymakers can gain valuable insights by studying the employment implications of these pathways. Indonesia has yet to align its NDC and climate policy with its energy plans.

The study applies a scenario analysis approach to investigate the employment effects of RE technologies under different power sector scenarios. The power sector scenarios are based on national energy policies and plans of the countries assessed. In Indonesia, the scenarios were not compared with each other as they were developed based on different policy documents.

The study also provides estimates on the number of jobs that can be created by selected RE technologies per unit of electricity generation (TWh) and unit of investment (USD) compared to selected fossil fuel-based technologies. The integrated methodology that combines power sector scenario analysis with RE value chain analysis to assess the direct jobs in the RE sector, and I-O modeling to assess indirect and induced jobs and value-added[11] created in the overall economy. Lastly, the study assesses the occupations and skills required to tap the employment opportunities of the energy transition at the different stages of RE value chains. It is recognized that assessing the quality of jobs that can be created in RE is an important issue, however, this is not in the scope of this study.

The report is structured as follows: Chapter 2 describes the overall methodological approach, the data collection and data analysis methods, along with information on the input variables. Chapters 3 outlines the cases and reporting the results for Indonesia. This chapter has a structure that consists of five sections. The first section briefly describes the current situation of the electricity supply system and relevant policies, the second section presents the different power sector scenarios, the third section focuses on the results of the jobs assessment, the fourth section presents the results of the occupations and skills assessment, and the last section draws policy recommendations. Chapter 4 presents the conclusions of the study.

11 Value-added is the contribution of an industry to the national GDP of the country.

2. METHODOLOGY AND CONCEPTUAL FRAMEWORK

2.1. METHODOLOGY

After conducting a comprehensive literature review, detailed in *Annex 7*, the project team developed the research methodology. The study utilized different data collection methods, stakeholder engagement processes, and conducted scenario analysis in the selected countries, looking at different power sector scenarios up to 2030. The overall employment modeling methodology combined two methods: (i) value chain analysis of the different RE technologies for direct jobs assessment, and (ii) I-O modeling for assessment of indirect and induced jobs and added value creation. The study also analyzed the occupations and skills required for each stage of the RE value chain. In this study, the employment assessments resulted in the estimation of the number of job-years at full-time equivalent (FTE) that could be generated by the new capacity of RE technologies during the modeling horizon 2020 - 2030. The terms "jobs" and "job-years" are hereafter used interchangeably and refer to job-years.

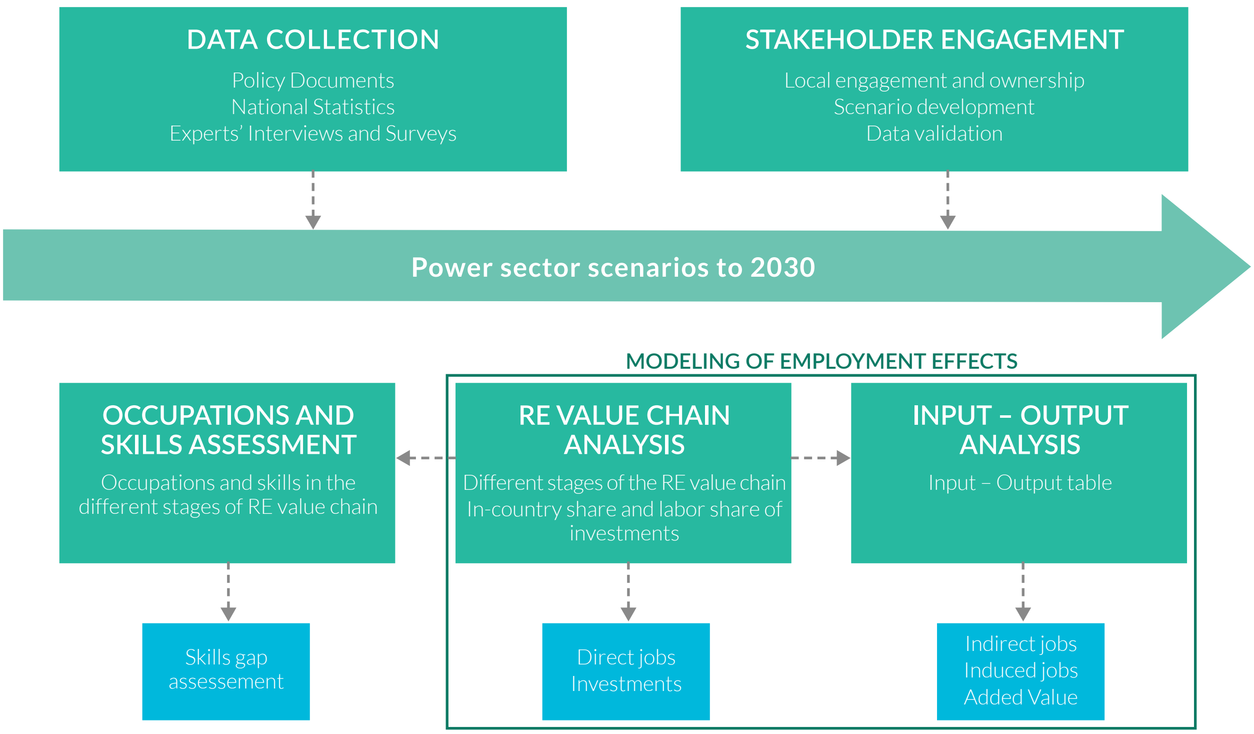

Figure 2.1. Methodology

Further detail on the activities and methods incorporated in the methodological approach follows:

Data collection

Indonesia's NDCs and national energy policies and plans were reviewed, focusing on the RE targets and shares in the electricity mix by 2030. An extensive desk review to collect data and information on the country's NDCs and national electricity plans focused on electricity supply scenarios while looking at RE capacity targets during the NDC time horizon of 2020 to 2030.

Selected RE technologies were assessed. RE project developers' surveys and experts' interviews were conducted to collect data on value chains and cost structure in Indonesia for the selected RE technologies.

Data on capital expenditures (CAPEX) and operational expenditures (OPEX) were collected from national energy sources. CAPEX, OPEX and Levelized Cost of Energy (LCOE)[12] information for each technology in each country are summarized in *Annex 4*. Data on the share of CAPEX and OPEX invested in the country (in-country or domestic share of investment[13]) were collected from interviews and secondary sources in Indonesia.

Technology-related data such as load and learning factors were collected from national energy sources. Learning factors indicate how fast the costs of RE technologies decline through the modeling horizon due to learning and improvements in RE deployment. Learning factors for all technologies were collected from secondary national energy sources.

Average annual salaries by economic sector were collected from national statistics. National I-O tables were obtained from the OECD statistics database[14].

Stakeholder Engagement

The research team engaged with national stakeholders through workshops, interviews, and surveys to validate and discuss different electricity supply and power sector scenarios and their assumptions formed an essential part of the study. During these consultations, stakeholders such as government officials and experts from related ministries and departments and RE associations were able to validate technology and cost data that were collected.

Power sector Scenario Development and Analysis

In close collaboration with government officials from relevant ministries, future power sector pathways were selected and analyzed under different assumptions. Assumptions included different RE capacity targets according to the country's NDCs and national energy policies and plans. In Indonsiea, the study analyzed existing scenarios developed by the energy planning departments which have been published in policy and planning documents. Two power sector scenarios were analyzed with different levels of capacity by 2030, as they were developed by different agencies and published in different policy documents based on different assumptions.

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[12] Levelized Cost of Energy (LCOE) is the present value of the price of electricity production over the lifetime of a plant, including construction, operation and maintenance, and fuel costs.

[13] "In-country share" or "domestic share" of investment is the percentage of the investment that is spent in the country.

[14] OECD, *Input-Output Tables 2018 edition*, updated December 2018, https://stats.oecd.org/Index.aspx?DataSetCode=IOTSI4_2018.

Modeling of employment effects

The employment effects of the different power sector pathways were modeled and assessed by combining a bottom-up technology value chain analysis and a top-down macroeconomic analysis based on I-O modeling. The combination of the RE value chain analysis with I-O modeling resulted in the estimation of **direct, indirect and induced jobs** that can be created by investing in a new capacity of RE sectors.

Analysis of the different stages of the RE Value Chain

The study analyzed the different stages of the RE value chain according to the ILO classification[15], Equipment Manufacturing and Distribution (EM&D), Project Development (PD), Construction & Installation (C&I), Operation & Maintenance (O&M), Cross-cutting/Enabling Activities and Others. Investment costs (CAPEX and OPEX) of each technology were broken down into technology cost components such as, in the case of solar PV, module, inverter, racking, installation, etc. *Annex 8* provides an example of the solar PV components considered in the study. The direct job-years were calculated by following a stepwise approach, as illustrated in figure 2.2 and *Annex 8*.

- **Step 1: Identify each component's share of the CAPEX and OPEX that has been invested in the country (in-country or domestic share, %).** Investment on imports or imported components produced in other countries are not accounted for as they generate employment in the component's country of production.

- **Step 2: Match each RE technology component with an economic sector from the Input-Output (I-O) table**. The objective of this step is to identify the economic sector that corresponds to the different RE technology components. The I-O tables do not specify RE-related sectors and industries. Therefore, to estimate the employment impacts in the RE industries we constructed them by associating each RE technology component with the corresponding economic sector from the I-O table. For instance, the solar PV components correspond to industries from the I-O table, such as "electrical equipment", "fabricated metal products", "construction", "other business sector services", "real-estate activities", etc. By associating all RE technology components with corresponding I-O table sectors we can estimate the jobs that can be created by increased spending in RE technologies. An example of how solar PV components are matched with economic sectors from the I-O table is provided in *Annex 8*.

- **Step 3: Identify the part of the investment for each RE technology component that is spent on labor (labor share, %).** This step identifies the level of investment for each component that is spent in the labor market. In Indonesia, data on labor share were collected mainly from primary sources. In the case of solar PV, labor share estimates for each technology component associated with an economic sector were derived from the I-O table.

- **Step 4: Estimate the direct job-years per MW installed by dividing the domestic investment on labor per economic sector by the average annual salary in the sector.** The best way to approximate the salaries related to the RE technology value chain is by looking at the average salary in the associated economic sectors. As the average salary in the economic sector might not reflect the exact salary of the workers at the different stages of the RE technologies value chain, a sensitivity analysis to investigate the impact of 10 % changes in the average salary of the economic sectors to the employment was conducted.

[15] International Labour Organization, *Skills and Occupational Needs in Renewable Energy*, November 2011, https://www.ilo.org/skills/pubs/WCMS_166823/lang--en/index.htm.

- **Step 5: Estimate the direct job-years for new capacity installed for the period of 2020-2030.** In order to estimate the direct job-years for new capacity installed through the modeling horizon, results were scaled linearly, extrapolating into the future and multiplying by the MW of new installed capacity under each power sector scenario.

Figure 2.2 provides a diagrammatic representation of the steps in the methodology.

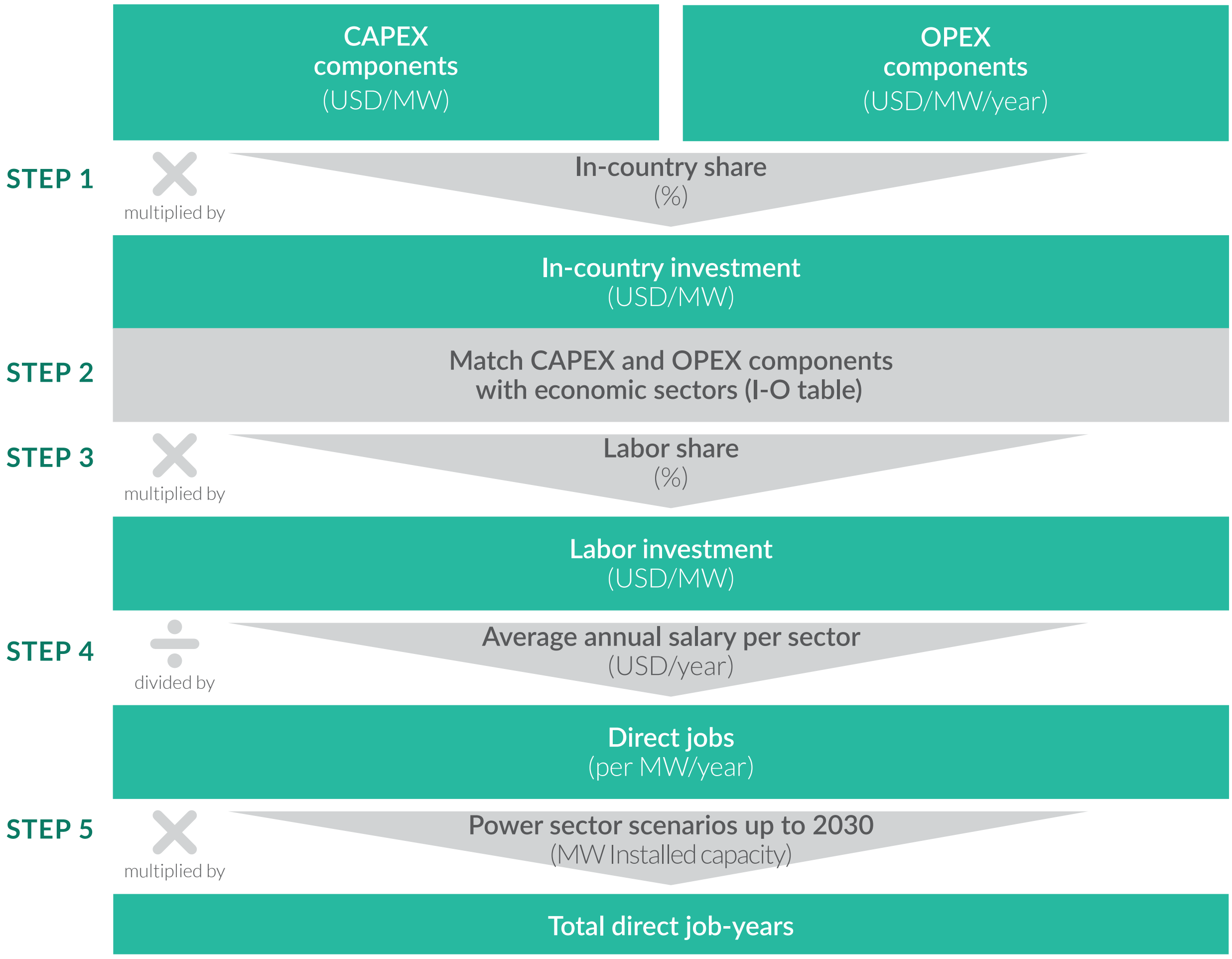

Figure 2.2. Steps to estimate direct job-years

Estimating indirect and induced employment effects
The study also utilized an I-O modeling approach to estimate the indirect and induced jobs and added value that could be created in the overall economy by the required investments in RE.

I-O modeling is a macroeconomic analysis method that utilizes I-O tables describing the interdependencies between the different sectors/industries in an economy. This method is widely applied to estimate the impacts of positive or negative economic shocks, for example from changes in aggregate demand, by analyzing the ripple effects of sectoral investments in the overall economy.

The mathematical equations utilized to estimate direct, indirect and induced job-years during the modeling horizon are provided in *Annex 2*. Modeling was performed using the Economic Impact Model for Electricity Supply (EIM-ES)[16] developed by the New Climate Institute.

[16] New Climate Institute, Economic Impact Model for Electricity Supply v1.0, November 2018, https://newclimate.org/2018/11/30/eim-es-economic-impact-model-for-electricity-supply/.

Overall, the modeling approach estimates the total direct, indirect and induced employment measured in FTE job-years, employment per USD invested, per GWh generated, and employment impact disaggregated per stage of the RE value chain. Furthermore, the approach assesses the direct domestic investment, the portion of the energy technology investment that is spent in the country and the value-added created in the overall economy by the indirect and induced effects of the domestic investment. Figure 2.3 represents the employment effects captured in the study.

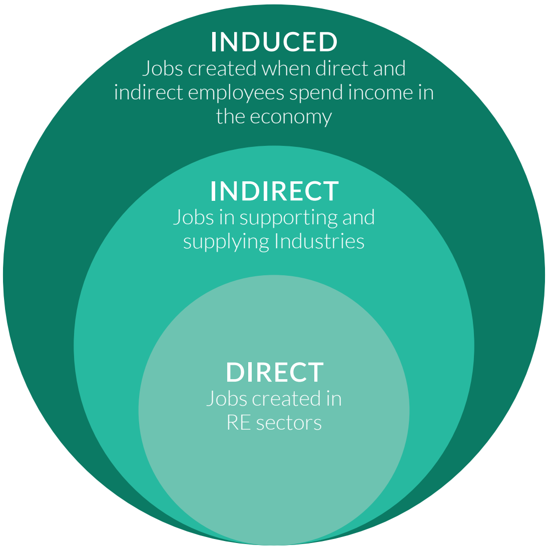

Figure 2.3. Diagrammatic representation of employment effects captured in the study

Occupations and skills assessment

The study estimates the number of jobs by type of human resource as defined by IRENA[17] and by skill level as defined by the ILO[18], disaggregated by RE value chain stages (EM&D, PD, C&I, O&M, Cross-cutting/Enabling Activities and Others) per technology. The RE-specific occupations that are hard to fill due to a lack of available experienced and qualified professionals are also identified. These occupations were identified based on the literature review and interviews conducted with experts in the target country.

The study calculates the proportion (%) of identified human resources or occupations at each stage of development for solar PV and wind technologies by using the human resource factors estimated by IRENA[19]. Each stage requires occupations categorized broadly as *engineers*, *technicians*, *management professionals*, and *non-professionals*. The ILO[20] and IRENA[21] provide examples of occupations for each category (see also annex 6). For example, "engineers" include software and manufacturing engineers. The broad category "technicians" includes technicians that could be chemical laboratory technicians or electrical technicians and factory and construction workers. Representative examples of "management professionals" that require high skill levels include logistics specialists, procurement professionals, financial analysts, environment and safety experts and land development advisors. Equipment transporters, truck drivers and logistics operators that require relatively low skill levels are considered "non-professional" occupations in the RE sector. "Non-professional" jobs are the occupations that do not require specialized professional knowledge or skills. The study estimates the demand for human resources or occupations, measured in jobs. For example, if construction and installation account for 1,000 jobs over 10 years, and 30% of

[17] International Renewable Energy Agency, *Renewable energy benefits: Leveraging local capacity for onshore wind*, June 2017, https://www.irena.org/publications/2017/Jun/Renewable-Energy-Benefits-Leveraging-Local-Capacity-for-Onshore-Wind.

[18] International Labour Organization, *Skills and Occupational Needs in Renewable Energy*, 2011.

[19] International Renewable Energy Agency, Renewable energy benefits: Leveraging local capacity for onshore wind, 2017; International Renewable Energy Agency, Renewable energy benefits: Leveraging local capacity for solar PV, 2017, https://www.irena.org/publications/2017/Jun/Renewable-Energy-Benefits-Leveraging-Local-Capacity-for-Solar-PV.

[20] International Labour Organization, *Skills and Occupational Needs in Renewable Energy*, 2011.

[21] International Renewable Energy Agency, Renewable energy benefits: Leveraging local capacity for onshore wind, 2017; International Renewable Energy Agency, Renewable energy benefits: Leveraging local capacity for solar PV, https://www.irena.org/publications/2017/Jun/Renewable-Energy-Benefits-Leveraging-Local-Capacity-for-Solar-PV.

the time that is allocated to solar PV construction and installation is for engineers, it is estimated that roughly 300 engineers will be needed over the same period.

The study utilizes the ILO[22] and IRENA[23] (see also *Annex 6*) skill level of occupations coding for solar PV and onshore wind technologies to identify the skill level per occupation:

- H = High skilled – Professional/ managerial
- M = Medium skilled – Technician/skill craft/ supervisory
- L = Low skilled – semi-skilled and unskilled

[22] International Labour Organization, *Skills and Occupational Needs in Renewable Energy*, 2011.
[23] International Renewable Energy Agency, *Renewable energy benefits: Leveraging local capacity for onshore wind*, 2017; International Renewable Energy Agency, *Renewable energy benefits: Leveraging local capacity for solar PV*, 2017.

2.2. ASSUMPTIONS, LIMITATIONS AND UNCERTAIN VARIABLES

Every model is an abstraction of reality. It simplifies the complex interrelations of multiple agents into fewer manageable variables that can be more easily manipulated and analyzed. The overall modeling approach makes the following assumptions:

- Cost estimates for different electricity supply technologies (per MW / GWh) are scaled linearly;

- Economic sectors in the model are aggregated into 34 sectors. Aggregation applies to I-O tables, sector allocations for component parts, and the labor share of investments and salaries;

- I-O tables represent an overall picture of the economy at one point in time (the most recent year that the I-O table was constructed). Therefore, the analysis is static, i.e. it does not incorporate dynamics of the economy and labor markets that may affect employment generation in RE technologies in the future;

- The modeling horizon is aligned with the NDC timeframe of 2020 to 2030. This means the study estimated the jobs that can be created from new power capacity installed within this timeframe, although some jobs related to the operation and maintenance of different energy technologies will be generated beyond the 2020 -2030 time horizon. This is particularly relevant for energy technologies with high fuel operation and maintenance costs that require a continuous supply of fuel (for example, biomass and fossil fuels) and will continue to generate jobs for operation and maintenance. In that sense, the modeling horizon selection is favorable towards energy technologies that create jobs mainly during the construction and installation stages (for example, wind and solar);

- Any increase in labor supply required to meet the higher labor demand is readily available at current wage rates. The calculated employment effects therefore represent an upper bound of the actual employment increase that might be realized. The magnitude of overestimation depends on the specific context of a country's overall economy, labor force, unemployment rate, energy sector, and the project being considered. The lower the unemployment rate is for qualified workers, or the less mobile the needed workers are among sectors or geographical locations, the greater the degree of over-estimation. However, when economies experience high unemployment rates, as is the case during the recession brought on by the COVID-19 crisis, a higher labor supply is available, maximizing the employment opportunities of RE investments presented in the study. The study also disregards macroeconomic variables such as the labor retirement rate and the labor migration rate;

- Estimates do not consider other drivers of the future labor markets, such as digitalization, radical technological change, and automation. Technological change may be particularly important in relatively immature RE industries which, as technology develops, may lower the electricity production costs by improving material or energy performance or by reducing labor requirements. A certain level of technology improvement has been considered in the form of technology learning factors, as described in section 2.1.

As explained in the previous page, some of the input variables such as in-country share and labor share of investments, annual salaries, future investment costs, and fuel costs are uncertain. Therefore, the employment results should be treated with caution and considered as best possible estimates that provide an idea of the order of magnitude of the jobs that can be created under different power sector development pathways under certain assumptions. To partially address the issue of uncertainty, a sensitivity analysis of the three main input variables, in-country share, labor share, and salaries, was conducted for all scenarios. The results of the sensitivity analysis are presented in *Annex 5*. The main outcomes of the sensitivity analysis indicate that a 10% change in these three key variables would lead to changes of between 8% to 11% to the direct employment outcomes. This suggests that the model is quite robust to changes of the input variables.

3. INDONESIAN POWER SECTOR PATHWAYS

KEY FINDINGS:

- Under the RUKN scenario, the new RE capacity added by 2030 will generate around 7.2 million total job-years. This represents 3.7 million direct, 1.72 million indirect and 1.74 million induced job-years that will be generated by 2030. The new RE capacity added under the PLN scenario will generate around 3.9 million total job-years. This represents 2.1 million direct, 0.88 million indirect and 0.89 million induced job-years that will be generated by 2030.

- Reaching the RE target under the RUKN scenario by 2030 requires significant direct domestic investments in large and small hydro, geothermal and solar PV of about USD 49 billion. The PLN scenario requires a direct domestic investment of around USD 26 billion on new RE capacity and operations to reach its RE target.

- The direct domestic investments in RE under the RUKN scenario will contribute around USD 24 billion in value-added to the Indonesian economy. The direct domestic investments in RE under the PLN scenario will contribute around USD 10 billion in value-added by 2030.

- Under the RUKN scenario the RE technologies assessed will generate direct employment, mostly in Construction & Installation and Project Development. More than half, around 53%, of the direct job-years created in the RE sectors analyzed will be in Construction & Installation. The other 47% of the direct job-years will be created in Project Development (25%), Equipment Manufacturing & Distribution (20%), and O&M (3 %).

The low carbon development study for Indonesia[24] analyzed various low carbon measures in priority economic sectors under different development scenarios. Although the study looked at different co-benefits of low carbon development in the energy sector, sectoral employment impacts were not addressed. The low carbon development study assessed job creation in the different development pathways at an aggregate level for the whole economy. This study has benefited from the "Ambition to Action" project that was implemented in Indonesia and investigated the employment effects of three solar PV deployment scenarios[25], as stated in the introduction. No other studies have assessed the employment effects of different scenarios of power sector development in Indonesia and therefore, this study aims to bridge this gap.

The Indonesia case study assesses the employment effects of small hydro (<10MW), large hydro (>10MW), geothermal, and utility-scale solar PV under two scenarios. The fossil fuel energy technology assessed is coal.

[24] BAPPENAS, *Low Carbon Development: A Paradigm Shift Towards a Green Economy in Indonesia*, 2019, https://www.un-page.org/files/public/indonesia_lowcarbon_development_full_report.pdf.

[25] International Climate Initiative Ambition to Action Project, *Three Indonesian Solar Powered Futures*, December 2019, http://ambitiontoaction.net/wp-content/uploads/2020/01/A2A-2019-Three-Indonesian-solar-powered-futures.pdf.

3.1. CURRENT SITUATION

According to the State Electricity Company (PLN) statistics for 2018[26], the total Installed capacity in Indonesia was 57.8 GW in 2018, an increase of about 5.2% compared to the previous year. It is made up of 41.7 GW of installed capacity by PLN, 2.5 GW of rented capacity and 13.6 GW of purchased capacity from private companies. Figure 4.1 shows the installed capacity classified by technologies.

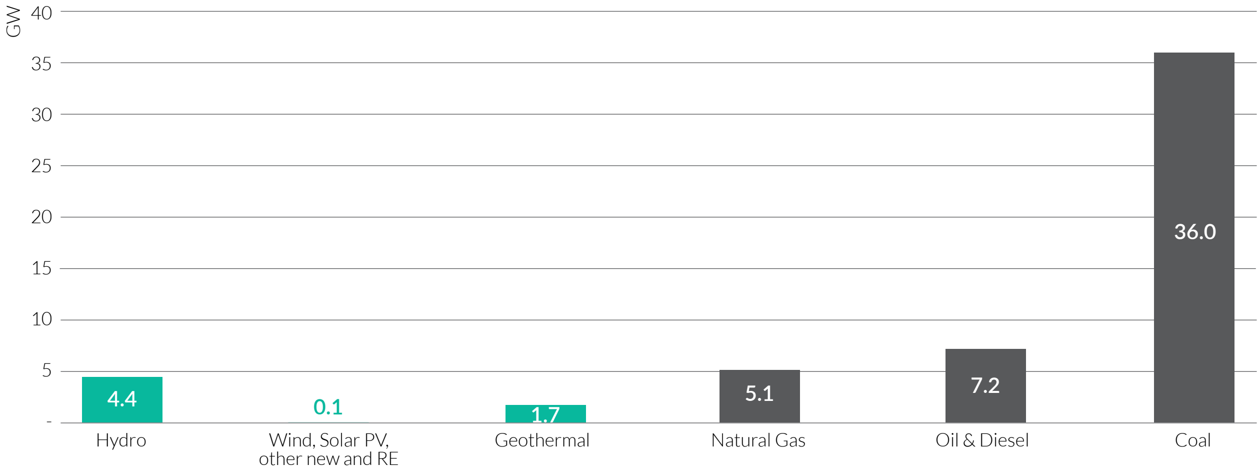

Figure 3.1. Breakdown of Indonesia's Installed capacity (GW) in 2018

Most of the installed capacity in Indonesia in 2018 consisted of conventional energy, composed of natural gas, oil & diesel, and coal, at 88.5% of the total. Large hydro had the highest share of RE technologies in the Indonesian energy mix at 7.7% of the total. Wind, solar PV (11MW), and other new and RE together reach only 0.1GW of installed capacity which is about 0.3% of the total. Figure 3.2 provides information on the share of the composition of installed capacity in Indonesia in 2018.

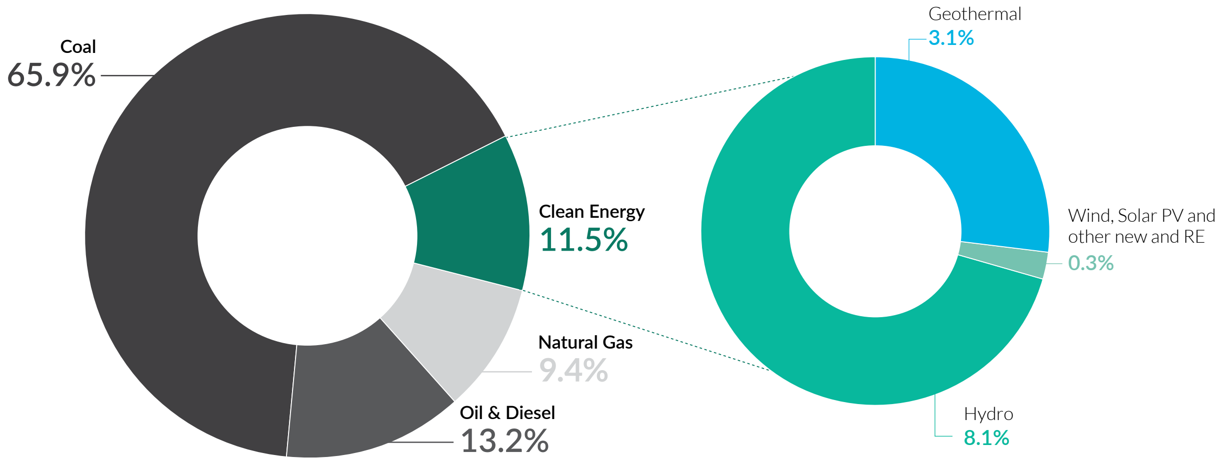

Figure 3.2. Breakdown of Indonesia's Installed capacity (%) in 2018

26 PLN, *Statistics PLN 2018*, 2018.

The Government Regulation No. 79/2014, on National Energy Policy sets out the ambition to transform the energy mix, setting targets for 2025 and 2050:

- New and renewable energy (NRE) should be at least 23% in 2025 and 31% in 2050;
- Oil should not exceed 25% in 2025 and 20% in 2050;
- Coal should not exceed 30% in 2025 and 25% in 2050; and
- Gas should be at least 22% in 2025 and 24% in 2050.

According to Indonesia's NDC, the country pledges unconditionally to reduce its GHG emissions by 29% by 2030 compared to the business as usual scenario and sets a conditional emissions reduction target of 41%[27]. The Indonesian NDC does not include any specific emission reduction targets for the power sector or RE capacity targets for the power sector. The study assesses different power sector pathways based on national electricity planning documents. Table 3.1 provides background information on the Indonesia case study.

Table 3.1. Summary of Indonesia's background information

Total Current installed capacity (2018)	57.8 GW
Total Current RE installed capacity (2018)	6.8 GW
RE Technologies analyzed	• Hydro (small and large) • Solar PV • Geothermal
Fossil fuel-based technologies analyzed	• Coal
NDC power sector related target	NO reference to power sector targets

Electricity Planning in Indonesia

Aiming to achieve a 100% electrification ratio for the benefit of its people[28], Indonesia reached 98.14% in 2017[29]. The government and PLN released a plan to guide investment and funding in the context of increasing electricity demand nationwide. Two policy documents, the National Energy Plan (RUEN) and the General Plan of National Electricity (RUKN), have been published by the Indonesian government. PLN leads the execution of the electrification program with contributions from the national government and regional governments[30].

PLN provides more than 70% of the installed capacity in Indonesia. In 2018, PLN released the Electricity Supply Business Plan (RUPTL[31]), a 10-year electricity development plan for operating areas. Thus, there are two governmental plans for electricity in Indonesia, the PLN-RUPTL and the RUKN (described above). The PLN-RUPTL has been developed by the state-owned electricity utility company, while the Indonesian government developed the RUKN[32]. The RUKN planning horizon is up to 2038, while the PLN-RUPTL provides plans up to 2028. The RUKN considers both supply and demand sides by including energy efficiency measures, while the PLN-RUPTL focuses only on supply. The study assesses the employment effects of both the PLN-RUPTL and RUKN plans.

[27] UNFCCC, *First Nationally Determined Contribution Republic of Indonesia*, 2016. https://www4.unfccc.int/sites/ndcstaging/PublishedDocuments/Indonesia%20First/First%20NDC%20Indonesia_submitted%20to%20UNFCCC%20Set_November%20%202016.pdf.
[28] Asian Development Bank, *Achieving Universal Electricity Access In Indonesia*, 2016, https://www.adb.org/sites/default/files/publication/182314/achieving-electricity-access-ino.pdf.
[29] World Bank World Development Indicators (ID:EG.ELC.ACCS.ZS; Accessed 2019), https://data.worldbank.org/indicator/EG.ELC.ACCS.ZS?locations=ID.
[30] Korea Energy Economics Institute, *World Energy Market Insight*, 2016, 16(34).
[31] PLN, Statistics PLN 2018.
[32] Ministry of Energy and Mineral Resources, *Power Supply Business Plan PT State Electricity Company (Rencana usaha Penyediaan Tenaga Listrik PT Perusahaan Listrik Negara)*, 2018.

3.2. POWER SECTOR SCENARIOS

The study analyzes two scenarios for the Indonesian electricity sector, the PLN-RUPTL, hereafter referred to as the PLN, and the RUKN. The PLN is based on the business plan released by the state-owned electricity company PLN (RUPTL-PLN, 2019-2028), while the RUKN is based on the National Electricity Plan 2019-2038, Rencana Umum Ketenagalistrikan Nasional (RUKN). Table 3.2 compares the capacity targeted in the PLN and the RUKN scenarios.

Table 3.2. Scenario comparison of installed capacity by 2030 for Indonesia

Scenario	Total installed capacity (GW, 2030)	Renewable Energy		Fossil fuel-based Energy	
		Installed capacity (GW, 2030)	Share (%)	Installed capacity (GW, 2030)	Share (%)
PLN	123	28.5	23%	94.5	77%
RUKN	166	43	26%	123	74%

3.2.1. PLN SCENARIO

The PLN scenario represents the current capacity based on historical information from PLN's Power Supply Business Plan report[33] and its projected future capacity. For the period 2019-2028, the PLN scenario includes all reported additions disaggregated by technology. For the period 2029-2030, a 5-year compound annual growth rate (CAGR) was used to extrapolate the scenario for each technology.

According to PLN scenario projections, by 2030 Indonesia will reach a total installed capacity of 123 GW, of which 28.5 GW (23.2%) will come from RE while 94.39 GW (76.8%) is projected to come from conventional energy.

The PLN scenario uses constant load factors based on actual operations as indicated in PLN 2018 statistics.

3.2.2. RUKN SCENARIO

Capacity additions from 2019 to 2030 are based on the RUKN[34] projections. This scenario projects renewable capacity to be 26% of the total and conventional energy capacity to be 74% of the total by 2030. According to the RUKN, there will be retirements for conventional energy facilities such as natural gas, oil and diesel, and coal by 2030 but not for RE. The existing conventional energy capacity was around 48 GW in 2017 but according to the RUKN scenario will be decreased to about 38 GW in 2030 due to the retirements. However, new capacity additions both in RE and conventional energy will continue to increase every year during the forecasting period.

Large hydro is projected to have the highest newly installed capacity of approximately 16 GW, followed by solar PV with 9 GW newly installed capacity by 2030. Oil and diesel are the only technologies with an expected net decrease in capacity from about 7.2 GW in 2017 to about 5.4 GW in 2030.

[33] Ministry of Energy and Mineral Resources, *Power Supply Business Plan PT State Electricity Company*, 2018.
[34] Kementarian Energi Dan Sumber Daya Mineral Jakarta, *Rencana Umum Ketenagalistrikan Nasional*, 2019.

The total installed capacity in 2030 is projected to be more than three times larger than it was in 2017. Total RE installed capacity in 2030 is projected to be seven times larger than it was in 2017, while total conventional installed capacity in 2030 is about 2.5 times larger than it was in 2017. The total RE capacity share is 11.5% (6.26 GW) in 2017 which increases up to around 26% (43.26 GW) in 2030. The total conventional energy share is around 88.5% (48.3 GW) in 2017 which decreases up to around 74% (122.83 GW) in 2030.

The RUKN scenario uses the same constant load factors as the PLN scenario, which are based on actual operations as indicated in the PLN's 2018 statistics.

Figure 3.3 shows the installed capacity over time in both the PLN and RUKN scenarios.

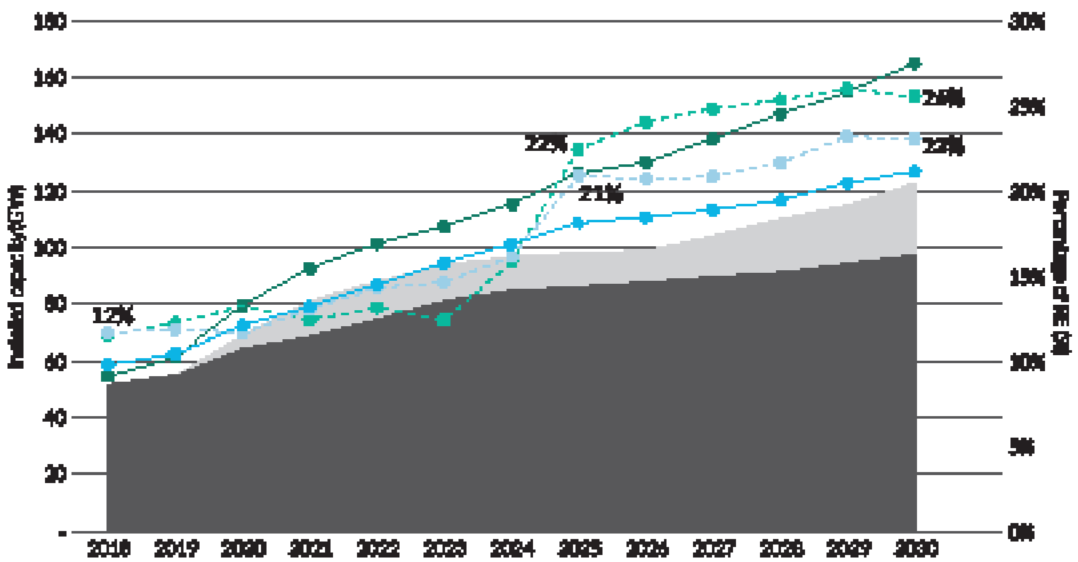

Figure 3.3. Installed capacity (GW) and share of RE per scenario modeled for Indonesia

Figure 3.4 shows the breakdown of installed capacity in 2030 for both the PLN and RUKN scenarios.

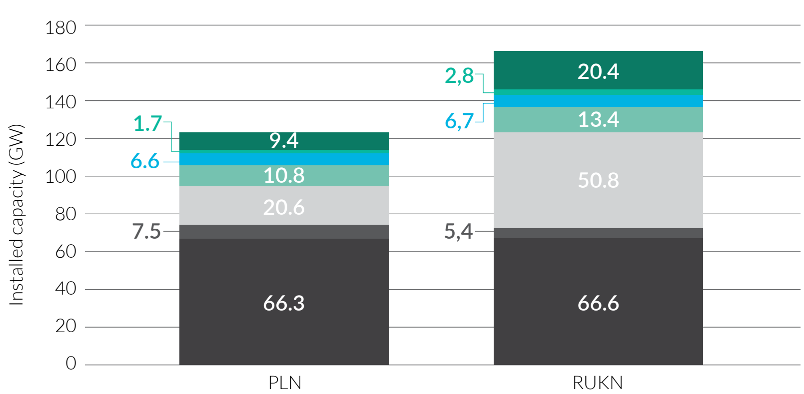

Figure 3.4. Installed capacity (GW) by 2030 per scenario modeled for Indonesia

3.3. JOBS ASSESSMENT

3.3.1. VARIABLES AND DATA COLLECTION

Surveys and interviews with large and small hydro and geothermal project developers and experts, including the Indonesian Hydropower Association and the Indonesian Geothermal Energy Association, were conducted to collect technology cost data, along with in-country share of investment data and labor share data. The Danish Energy Agency (DEN)[35] provided secondary data for technology cost data for solar and coal. Local content requirement (LCR) figures for solar PV according to the Ministerial Decree or Order No. 54/M-IND/PER/3/2012 and No. 05/M-IND/PER/2/2017 were used to estimate the in-country share of investment for solar PV. The LCR for solar PV is 42% for goods and 100% for services. Salary data were collected from national statistics and the Indonesian I-O table of 2018 was derived from the updated OECD database. Learning factors for all energy technologies assessed were also obtained from the 2017 DEN technology data. Fuel costs for coal were assumed to meet the price cap at USD 70 per ton of coal as set by the government through the MEMR Decree No. 1395/K/30/MEM/2018, issued in March 2018.

3.3.2. EMPLOYMENT EFFECTS OF RE TECHNOLOGIES

Under the PLN scenario, large hydro creates the most total job-years at around 1.7 million, followed by geothermal that creates 1.4 million, whereas solar and small hydro can create 0.5 and 0.4 million jobs, respectively. Large hydro is also the highest jobs creator of all RE technologies assessed under the RUKN scenario, generating around 4.6 million total jobs[36], followed by geothermal with 1 million jobs, small hydro with 0.9 million jobs, and solar PV with 0.7 million jobs. The job-years numbers are broken down by technology in figure 3.5.

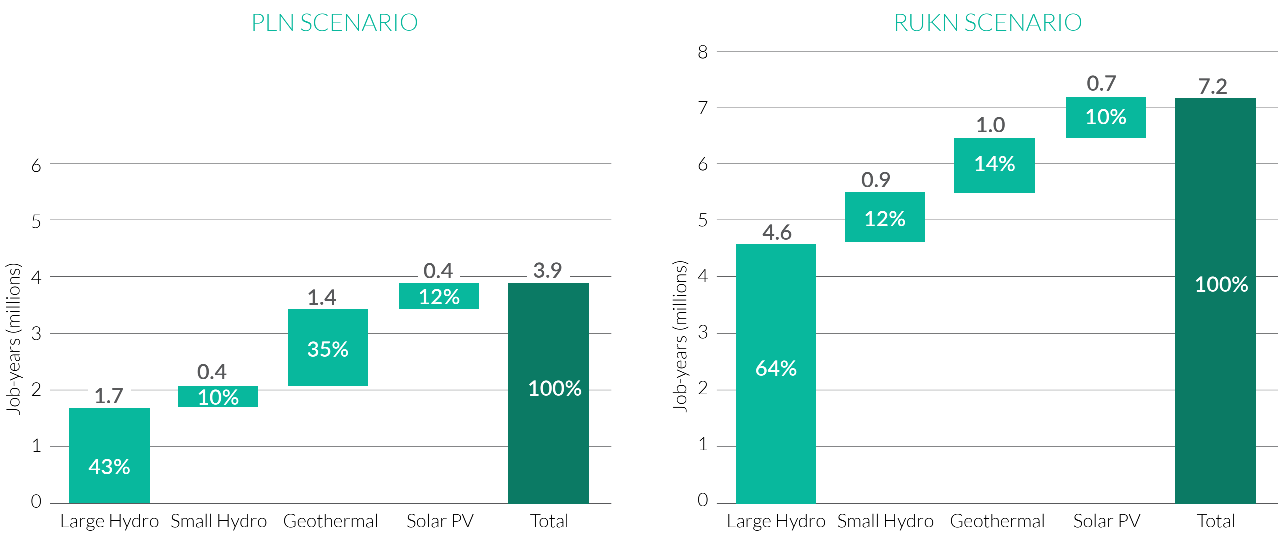

Figure 3.5. Employment effects (in million job-years) per RE technology per scenario for Indonesia

Source: GGGI Analysis

[35] Danish Energy Agency, *Technology Data for the Indonesian Power Sector: Catalogue for Generation and Storage of Electricity*, 2017, http://www.ea-energianalyse.dk/reports/1724_technology_data_indonesian_power_ector_dec2017.pdf.

[36] Total jobs include direct, indirect, and induced jobs.

Annex 9 illustrates the temporal distribution of direct job-years for each analyzed RE technology through the modeling horizon. Under both scenarios, the highest share of jobs will be created in the first years until 2024. Under the RUKN scenario, large and small hydro will provide most of the jobs during the first years of the modeling horizon, whereas after 2026 a gradual increase of geothermal capacity will provide a high share of the direct jobs.

3.3.3. EMPLOYMENT EFFECTS OF RE TECHNOLOGIES FOR EACH POWER SECTOR SCENARIO

Under the RUKN scenario, all hydro (large and small), geothermal and solar energy together could generate about 3.72 million direct jobs. Under the PLN scenario, the RE technologies assessed could generate around 2.12 million direct jobs. Under the RUKN scenario a further 1.72 million indirect and 1.74 million induced jobs can be created, whereas under the PLN scenario, 0.88 million indirect and 0.89 million induced jobs can be created. This means that under both the PLN and RUKN scenario, for every direct job created, 0.5 additional indirect jobs and 0.5 additional induced jobs can be created in the overall economy.

In both scenarios, around 95% of potential direct jobs would be in sectors where CAPEX is spent, such as equipment manufacturing and distribution (EM&D), PD and C&I. Sectors where OPEX is spent, such as O&M and the replacing of equipment, will generate far fewer direct jobs at around 5% of the total. Figure 3.6 shows the job creation effects of CAPEX and OPEX.

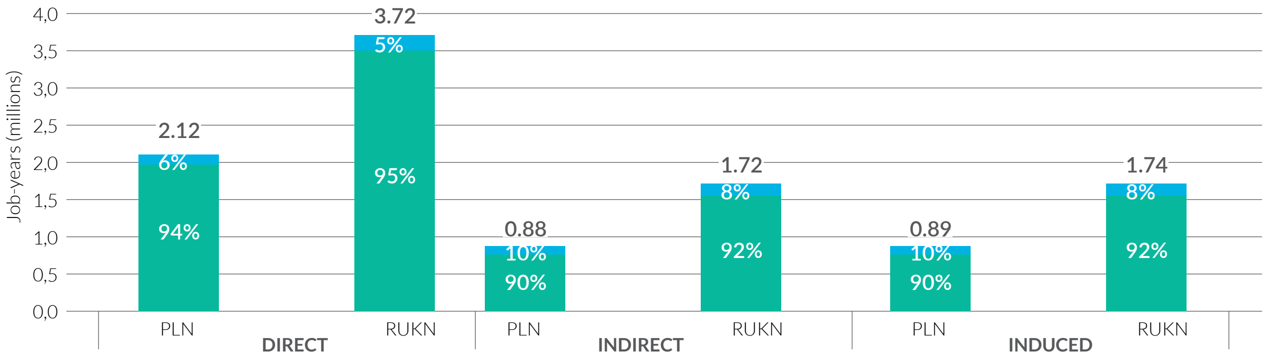

Figure 3.6. Direct, indirect and induced job creation per type of expenditure for each scenario* for Indonesia

*All numbers in the figure are rounded to the second digit.

Source: GGGI Analysis

3.3.4. EMPLOYMENT EFFECTS COMPARISON BETWEEN RE AND FOSSIL FUEL TECHNOLOGIES

Under the RUKN scenario, all RE technologies analyzed provide a higher return of job-years per GWh of electricity generated by new capacity compared to coal. Large hydro generates 3.8 times more job-years per electricity output than coal, followed by small hydro at 3.2 times more than coal, and geothermal and solar, both generating 2.8 and 2.5 times more jobs per GWh respectively compared to coal.

Per USD million invested in new capacity under the RUKN scenario, small hydro has the potential to create the most jobs at 165 job-years, whereas geothermal, large hydro and solar create approximately 126, 63, and 55 job-years per USD million respectively. Coal generates the least number of jobs per USD million invested, at 31 job-years, when compared to the selected RE technologies.

Figure 3.7. shows the job creation per unit of capacity added in terms of capacity and USD investment.

Figure 3.7. Direct job creation per unit of electricity generation (GWh) from new capacity and per unit of investment (USD million) under the RUKN scenario in Indonesia

Source: GGGI Analysis

The study results show that RE technologies can create more jobs per unit of electricity generated and unit of investment than coal. One of the main reasons for this is that, as the interviews with the hydro and geothermal associations revealed, large hydro, small hydro, and geothermal have higher in-country share of labor compared to coal. For large hydro for instance, almost all, around 94% of the investment in project development (in other business sector services) and civil works (in construction) is spent in Indonesia. In addition, small hydro and geothermal have a considerably higher labor intensity (higher labor share) compared to coal[37], particularly on construction and installation and project development stages of the value chain. *Annex 3* presents the in-country share per technology per stage of the value chain.

3.3.5. ECONOMIC IMPACTS OF EACH SCENARIO

Reaching the RUKN RE target would require significant direct investments of around USD 49 billion, which could generate around USD 24 billion direct value-added to the Indonesian economy. Under the PLN scenario around USD 26 billion of direct investments would be required, which could generate around USD 10 billion value-added to the Indonesian economy. Figures 3.9 and 3.10 highlight the difference in domestic investment value-added to the Indonesian economy in the two scenarios.

When including the indirect and induced economic effects, the total domestic investments that will be required will be around USD 110 billion and USD 57 billion for RUKN and PLN respectively, and could create total value-added of USD 53 billion and USD 23 billion, respectively, in the Indonesian economy.

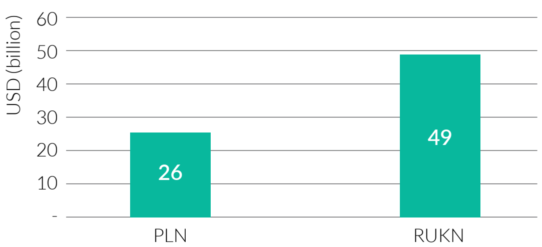

Figure 3.9. Direct domestic investment per scenario from RE for Indonesia

Source: GGGI Analysis

Figure 3.10. Direct domestic value-added per scenario from RE for Indonesia

Source: GGGI Analysis

3.3.6. EMPLOYMENT EFFECTS ACROSS RE VALUE CHAINS

The study quantified the number of direct jobs required at each RE stage of the value chain for the RUKN scenario. Figure 4.11 shows the breakdown of job creation by technology for each stage of the value chain under the RUKN scenario.

More than half, around 53%, of the direct job-years created in the RE sectors analyzed will be in C&I. The other 47% of the direct job-years will be created in PD[38] (25%), EM&D (20%), and O&M (3 %). Large hydro and small hydro together generate more than 1.4 million job-years in the C&I sector. As explained also in 3.3.4 both the in-country share and labor share of investments in hydro are very high in construction and installation stage of the value chain. Solar PV generates more jobs in PD (almost 40%) than in C&I. More than 50% of job-years generated from geothermal are in C&I.

[37]As explained in the introduction, the employment effects are estimated for the modeling horizon 2020-2030. Additional jobs that might be generated during operation and maintenance of the energy systems assessed beyond 2030 were not considered.
[38] Financing and permitting related activities were considered to fall in the PD stage of the value chain.

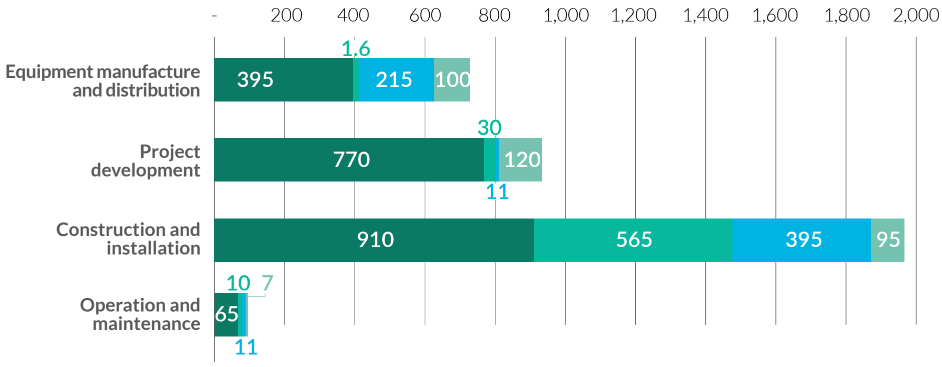

Figure 3.11. Direct job creation for the 2020-2030 period under the RUKN Scenario per technology per value chain stage for Indonesia

3.4. OCCUPATIONS AND SKILLS ASSESSMENT

Under the RUKN scenario, solar PV generates more than 325 thousand direct jobs. The study estimates the type of occupations and skills in demand in each stage of the solar PV value chain (see *Annex 6*). The study estimates a high demand for highly skilled occupations such as engineers and management professionals accounting for more than 170 thousand jobs (52%). The technical and non-professional workforce accounts for more than 155 thousand jobs, almost half of the direct jobs (48%). These occupations are identified as technical and construction workers that require a medium to low skill set.

Figure 3.12 shows the distribution of jobs along the value chain.

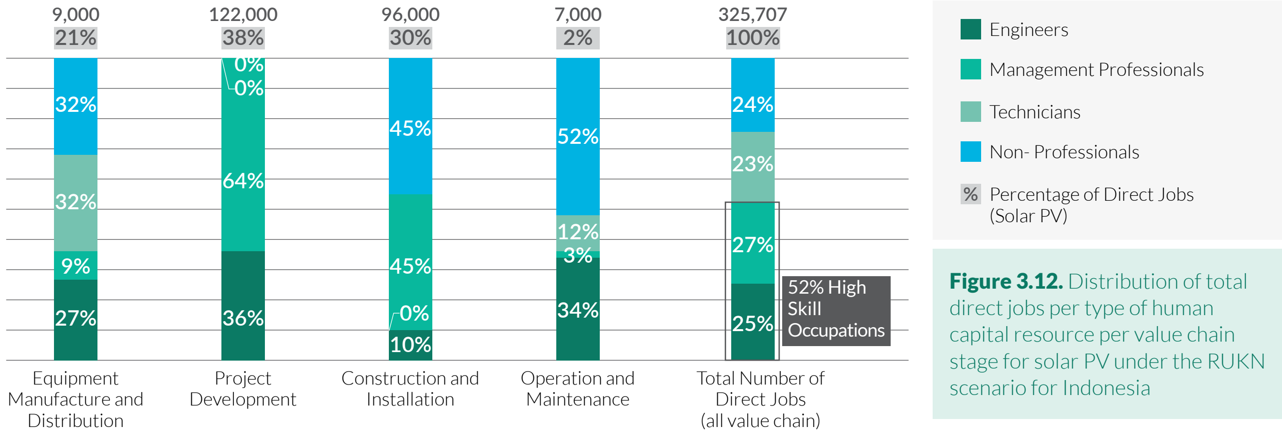

Figure 3.12. Distribution of total direct jobs per type of human capital resource per value chain stage for solar PV under the RUKN scenario for Indonesia

Source: GGGI Analysis

The Indonesian equipment manufacturing sector is estimated to require more than 100 thousand direct jobs, of which 64% will be created for medium and low skilled occupations for factory workers[39] and technicians. Additionally, more than 36 thousand highly skilled jobs are required, including more than 10 thousand (9%) management professionals and around 26 thousand engineers.

More than 120 thousand jobs are created in the PD phase, with several professional occupations from different fields in demand. Around 36% of these jobs will be from several engineering fields such as electrical, civil and

[39] Factory workers refer to human resources required to manufacture the main components of solar PV plant; International Renewable Energy Agency, *Renewable energy benefits: Leveraging local capacity for solar PV*, 2017.

mechanical, the equivalent of 44 thousand jobs. Around 78 thousand (64%) people working in management related jobs including jobs in the financial sector, administrative staff, logistics and environment and safety experts will also be in demand. All jobs in PD require high skilled labor.

The C&I stage of the value chain requires more than 96 thousand jobs, where around 43.5 thousand (45%) are estimated to be low skilled jobs, identified as non-professional workers, and around 43.5 thousand jobs (45%) are estimated to be medium to low skilled jobs, identified as technicians. It is estimated that the remaining 1600 jobs (10%) are engineers.

O&M generates 7 thousand jobs, with a high number of jobs in low skilled occupations for more than 3.5 thousand non-professional staff. It is estimated that around 2.4 thousand high skilled engineers will be required. There are also more than 800 jobs for low and medium skilled technicians.

4. CONCLUDING REMARKS AND RECOMMENDATIONS

4.1. ENHANCING RE JOB CREATION

The study results suggest that by investing in RE, jobs will be created in different stages of the value chain, not only in the RE sectors but also through ripple effects in the overall economy. According to the results, for every direct job created in the RE sectors, up to 0.5 for Indonesia additional indirect jobs could be created in other sectors of the economy that supply goods and services in the RE sectors. Up to 0.5 for Indonesia additional induced jobs could be created in other sectors of the economy. Induced jobs result from employees in the RE sector and supply chain spending their income on buying goods and services, thus triggering more production and creation of more jobs. **Investing in RE sectors creates spillover effects in terms of employment and economic value-added in the wider economy beyond the RE sectors**. Indonesia should aim to increase the local content share at all stages of the value chain, particularly in the equipment manufacture and distribution stages, where the spillover effects found in the study are higher.

Investments in RE generate more jobs per GWh generated and USD invested compared to fossil fuel-based technologies. Fossil fuel-based technologies selected for analysis Indonesia is coal. The fact that geothermal, large hydro, and small hydro have higher in-country share and higher labor share compared to coal can explain the higher employment generation per GWh generated and USD invested. Solar PV also proves to potentially generate more jobs than coal, given that solar PV developers meet the LCR set by the Indonesian government. **The results demonstrates that investing in RE is more beneficial for the country in terms of socio-economic benefits than investing in fossil fuel-based technologies**. Job creation is, however, just one criterion to be considered by policymakers in addition to cost minimization.

Enhancing further the local content requirement (LCR) policies for RE technologies while combined with other labor and industrial policies could increase the in-country share of RE investments and boost local employment. This study was conducted under the assumption that the LCR for solar PV that was set by regulations such as the Ministerial Decree or Order No. 54/M-IND/PER/3/2012 and No. 05/M-IND/PER/2/2017 was met by the project developers. However, additional research is needed to investigate the extent to which project developers meet the LCRs in practice for goods and services in solar energy. Further research should also examine how the LCRs for RE in Indonesia could potentially lead to the creation of new industries and create even greater employment opportunities. However, meeting the LCR in some cases may lead to higher RE investment costs and consequently to less RE deployment and fewer jobs. Therefore, an LCR for different Res should be carefully designed, including long term planning and a combination of industrial and labor policies to create an enabling policy environment, while simultaneously preparing the local labor force with the necessary skills and competences to participate in the energy transition.

The results show that investments in solar technology to meet Indonesia's solar PV target specified in their National Electricity Plan will require 52% of high skilled occupations and human resources. **This increasing demand for high skilled labor in the RE sectors must be carefully addressed through collaboration between higher education and vocation training institutions, the private sector and national governments**. The design of vocational and on-the job training programs for difficult to fill RE occupations is particularly important. Multilateral organizations can also provide support and could bring in international experience for enhanced learning and sharing best practices, in partnership with government.

O&M generates fewer jobs than the other stages of the RE value chain, according to the results of the studies. However, the country should aim to **create more jobs and economic value-added in O&M stages by adopting an integrated approach to energy services provision, promoting services such as information sharing and energy efficiency improvements**. The creation of Energy Service Companies[40] (ESCOs) could provide a promising opportunity to provide integrated energy services to customers while enhancing employment creation and value-added. Another option to enhance the creation of jobs and value of certain RE systems during the stage of decommissioning could be end-of life management. End-of-life management should follow principles of the circular economy, particularly for wind[41] and solar PV[42].

Matching the potential for RE deployment with the local provision of human resources and occupations will be necessary to ensure alignment between supply and demand of the specialized labor force in the various RE value chain stages. Vertical alignment, between national and state level, and horizontal alignment, between labor and energy ministries, should both be strengthened, together with policy alignment and coordination. This will ensure that the labor force needed at specific RE project locations is available and equipped with the relevant skills. Enhanced coordination between RE Associations and national and state government energy agencies is needed to support the development of vocational programs in the areas targeted for RE development.

4.2. STRENGTHENING RE TARGETS IN NDCS AND NATIONAL ENERGY PLANS

Indonesia will benefit by establishing RE and GHG emission reduction targets for the power sector under its revised NDC. The current Indonesian NDC does not include any power sector RE targets or GHG emissions reduction targets for the power sector. Indonesia's economy is growing fast and the electricity system is currently dominated by fossil fuel-based technologies, particularly coal. Therefore, Indonesia should consider the alignment of energy and climate policies and the introduction of power sector RE targets in combination with higher emission reduction targets in the next NDC revision by the end of 2020. According to the "climate action tracker" the Indonesia's current NDC is highly insufficient in the context of the Paris Agreement goal. Establishing higher emission reduction targets will set Indonesia's electricity system on a decarbonization pathway, where RE technologies could play a vital role. Incorporating RE targets and emission reduction targets could reinforce the process of decarbonization of the Indonesian power sector, while simultaneously tapping into the co-benefits of RE that could be generated, including employment benefits. Exploring the most cost-effective technologies to reduce carbon emissions can be supported by an assessment of the employment and economic benefits of these technologies, providing the necessary evidence for well-informed decision-making. This study provides clear evidence of the significant employment opportunities that could arise from significant investments in RE compared to coal. Indonesia should incorporate this evidence in the revision of its NDC.

[40] International Institute for Sustainable Development, *Energy Services Companies (ESCOs) in Developing Countries*, May 2010, https://www.iisd.org/sites/default/files/publications/bali_2_copenhagen_escos.pdf.

[41] Niklas Andersen et al., "Wind Turbines' End-of-Life: Quantification and Characterisation of Future Waste Materials on a National Level," *Energies 9*, (December 2016):999, https://doi.org/10.3390/en9120999.

[42] International Renewable Energy Agency, *End-of-life Management Solar Photovoltaic Panels*, June 2016, https://www.irena.org/documentdownloads/publications/irena_ieapvps_end-of-life_solar_pv_panels_2016.pdf.

Based on the analysis, it is evident that there is a great opportunity for Indonesia to **increase their RE targets in the electricity sector** under their NDCs and National Energy Plans. By utilizing higher shares of RE sources, low and middle-income countries can contribute to global carbon emission reductions, while simultaneously generating considerable socio-economic benefits such as a high number of good-quality jobs and economic value-added. Establishing emission reduction targets for the electricity sector will pave the road towards countries' electricity systems decarbonization, where RE technologies will play a vital role. Combining RE targets and carbon emission reduction targets could reinforce the process of decarbonization of countries' power sectors and boost job creation.

Indonesia could benefit from incorporating this evidence on the socio-economic benefits in the revision of their NDCs. The current process of NDC revision to be completed by the end of 2020 provides an opportunity for Indonesia to include RE targets and carbon emission reduction targets for its electricity sector. By setting higher RE targets in their NDCs, countries, including Indonesia, can contribute to the achievement of multiple SDGs such as SDG 7 (affordable and clean energy), SDG 8 (decent work and economic growth), and SDG 13 (climate action).

Indonesia can benefit from setting RE targets in other high-emitting sectors, such as transport, cooling and heating, buildings and industry sectors. Integrating sectoral RE objectives into governments' long-term energy strategies will increase the certainty required to strengthen future investment forecasts. Including an assessment of potential job creation related to each of the sectoral RE targets can also be a persuasive way to strengthen the rationale for prospective RE deployment. The creation of employment opportunities is an important co-benefit of NDC implementation. Therefore, Indonesia's NDC revision could include estimates of the short, medium- and long-term job creation potential of mitigation actions.

Furthermore, Indonesia could benefit from setting **RE targets in other emitting sectors**, for example, transport, cooling and heating, buildings, and industrial sectors. Integrating RE objectives per sector in the governments' long-term energy strategies creates certainty that enhances future investment forecasts.

4.3. MAINSTREAMING EMPLOYMENT STUDIES IN NDCS, NATIONAL ENERGY PLANS, AND OFFICIAL DEVELOPMENT AID

Additionally, including an assessment of potential job creation related to each of the sectoral RE targets can be persuasive in strengthening the narrative for prospective RE deployment. The creation of employment opportunities is an important co-benefit of NDC implementation. **Job creation potential should, therefore, be included and highlighted as Indonesia revises its NDCs for 2020**. An assessment of the short- and long-term employment opportunities of climate action, including RE, could be mainstreamed in the NDC enhancement processes and the development of Long-Term Low Emissions Development Strategies (LT-LEDS). RE technologies and climate actions under the NDCs and LT-LEDS could be assessed and rated against their job creation potential to supplement the assessment of their abatement potential and associated costs. This is particularly relevant during the post-Covid19 crisis period where Indonesia seeks to identify sectors and actions to include in its economic stimulus packages.

Additionally, **updated versions of RE deployment roadmaps and RE strategies could include a section on assessment of the potential for RE job creation**, providing valuable insights to policymakers and other key sector stakeholders. Medium to long term energy strategies and plans like the RUPTL (in Indonesia) is essential electricity plans for setting high RE targets for the future. These plans can establish a level playing field and a long – term certainty for RE developers and investors.

RE projects supported by official development assistance could incorporate **project requirements related to employment generation potential**. The ability to measure the employment effects of RE projects accurately will improve the efficiency and effectiveness of the design of projects and programs. Furthermore, this will provide the opportunity to transparently compare RE technologies, projects, and programs. An employment generation potential assessment should be incorporated at the early stage of design of a project or program. This will maximize the synergies among improved quality of life, the creation of decent jobs and sustainable development.

4.4. BOOSTING RE DEPLOYMENT THROUGH AN ENABLING POLICY ENVIRONMENT, FINANCING, AND GREEN STIMULI

The study provides estimates of the investment requirements for achieving RE targets set under Indonesia's National Electricity Plans. **The Indonesian government should work towards creating a stable and enabling policy environment, including fiscal and financial incentives, to attract investor and RE project developers**. According to IISD (2018)[43], RE project developers identify the lack of stable regulatory and policy framework as one of the main challenges for developing RE project. As a result of frequent changes in the regulations, project development costs could be increased while some projects might become unfeasible to be developed. Therefore, providing clear policy signals of long-term support for RE by setting medium and long term RE targets in NDCs and National Energy Plans could provide project developers and investors with more certainty.

In 2017, Indonesia abandoned through new regulations the feed-in tariff scheme to support REs and introduced a new pricing scheme where PLN should pay up to only 85% of the average regional generation costs, effectively capping RE purchase prices. This is certainly a very unfavorable policy for RE, with projects paid less for than average prices. Furthermore, an IISD study[44] found that in 2015, the Indonesian government provided around USD 664 million in subsidies and fiscal supports to the coal industry creating an even less favorable policy and pricing framework for RE. In order to achieve the RE targets set under the RUKN and harness the employment benefits among other additional co-benefits of RE, the Indonesian government needs to revisit these policies.

Despite steadily decreasing costs of electricity generation from RE and increasing returns in most middle-income countries, governments and project developers still do not have direct access to the initial capital required. Financing costs are still high in Indonesia, with commercial cost of capital at levels even higher than 10%[45]. High capital costs lead to higher Power Purchase Agreement prices to ensure financial viability. To improve this imbalance, multilateral organizations and international development agencies could act as intermediaries and enabling agents by supporting

[43] International Institute for Sustainable Development, *Missing the 23 Per Cent Target: Roadblocks to the development of renewable energy in Indonesia*, 2018. https://www.iisd.org/sites/default/files/publications/roadblocks-indonesia-renewable-energy.pdf.
[44] International Institute for Sustainable Development, *Financial Supports for Coal and Renewables in Indonesia*, 2017. https://www.iisd.org/sites/default/files/publications/financial-supports-coal-renewables-indonesia.pdf.
[45] International Renewable Energy Agency, *Renewable Energy Prospects: Indonesia, a REmap analysis*, Abu Dhabi, 2017. www.irena.org/remap.

governments to develop smart and blended financing options while supporting them to develop bankable projects, e.g. by conducting pre-feasibility studies and to improve access to international climate financing. RE projects that meet certain eligibility criteria could qualify for receiving funding from international climate financing schemes and climate funds (for example, the Green Climate Fund). Furthermore, multilateral organizations and international development agencies can support countries to access climate finance by providing support for the establishment of national institutional structures (for example, a fund-specific national designated authority or national implementing entity)..

4.5. IMPROVING THE QUALITY AND AVAILABILITY OF THE HUMAN CAPITAL, OCCUPATIONS, AND SKILLS

This study estimates the employment effects of different future power sector pathways at the national level, providing information on the jobs that could be created at different stages of RE value chains. However, **identifying and assessing the locations of these potential RE jobs could provide important insights to support the development of training and vocational programs** in provinces and regions where specific occupations and skills in RE will be in high demand. Therefore, additional research on RE deployment potential and the required skills and occupations at the provincial or regional level is necessary. This type of evidence could enhance policy coherence between energy, labor, and education and training policies, and policy alignment at the national, sub-national, and local levels.

Further assessment is needed to review **RE skills development programs and policies and evaluate their alignment with RE and industrial policies** in Indonesia. Such an assessment could identify opportunities for and barriers to coordination on skills development to boost the deployment of RE and job creation. In close collaboration and with the support of multilateral agencies, the government can leverage international experiences and best practices for learning and building institutional capacity from successful RE vocational programs and partnerships. Besides the RE skills development, **training and vocational programs that can be developed and tailored towards RE related occupations, and technical universities' curricula** could be enriched with RE related specialized subjects and courses. According to the results of the study, achieving the RUKN target for solar PV would require around 52% of high skill occupations such as engineers and management professionals. Such courses would enable students to acquire the necessary skills, capacities, and knowledge that will allow them to enter into occupations in demand in the RE sectors.

4.6. OPPORTUNITIES FOR IMPROVED METRICS, ENHANCED REPORTING AND FUTURE RESEARCH

It is important to identify and address opportunities and limitations of assessing the employment impacts of RE plans, targets, and projects. **Policymakers would welcome the definition and standardization of suitable indicators, taxonomies, and methodologies** to better understand and measure the direct, indirect, and induced employment effects of RE projects and plans. The Sustainable Energy and Jobs Platform (SEJP)[46] aims to advance the development of methodologies and metrics for RE employment assessment to support research and evidence-based policymaking and advocacy in the field of RE. This study and methodology developed aims to contribute to these efforts, particularly in supporting national governments to analyze the employment effects of the RE targets under their NDCs and national energy plans.

It is evident that there are substantial constraints to the availability of good quality data for conducting research in least developed countries. **Good quality data, data availability and accessibility are fundamental conditions for conducting employment assessments in the RE sector in low-income countries.** A forthcoming discussion paper[47] highlights the importance of sex-disaggregated data collection. Precise and sex-disaggregated data enables the identification of gender gaps in the labor force, its socio-economic impact, and the development of vocational training and employment policies. The role of multilateral agencies is vital for providing institutional capacity development to selected departments and ministries, such as the statistics department, ministry of energy, and ministry of finance. Support could include improving data collection protocols and methods and enhancing monitoring and reporting procedures and systems.

The Indonesian government should **support and encourage RE companies to report and regularly and systematically share information on the labor force employed in the RE sector**. Regular reporting on the number of employees per the different stages of the RE value chain can be incorporated in regular annual enterprise surveys. RE associations could play a major role in coordinating the collection of employment data and occupations and skills requirements on different RE sectors and report back to the government to inform the design of energy and labor policies. Project developers' surveys could also be conducted to collect investment and labor share data for RE to fully understand the labor intensity of the different stages of RE value chains and to complement data collection from secondary sources. Another option could be to mainstream RE-related questions in existing business and household surveys to assess the number of employees currently working in different RE sectors.

The study may have underestimated the total employment generation due to some assumptions on specific input variables during the modeling horizon. The model does not consider changes in the in-country share of investments and local labor share throughout the modeling horizon. The model therefore disregards country's capacity to strengthen its supply chain and start manufacturing of specific RE technology components. In Indonesia, it is assumed that solar PV developers comply with the LCR set by government regulation, with the LCR assumed to remain constant through the whole modeling horizon. However, Indonesia could achieve higher LCR for specific components of solar PV systems in the coming decade, with the right blend of energy, industrial and

[46] Sustainable Energy Jobs Platform, http://www.sejplatform.org/.

[47] Ana V. Rojas, Tracking Increase in Women's Employment in the Renewable Energy Sector under NDC Targets (GGGI, forthcoming).

human resource policies,[48] tapping in its human resources, and further maximizing the potential for employment and value-added creation. **More in-depth research on the opportunities and challenges relating to the application of LCR government regulations is needed**.

This study estimates the employment effects of different future power sector pathways at the national level, providing information on the jobs that could be created at different stages of RE value chains. **Identifying where RE jobs are likely to be located could provide insights to support the development of training and vocational programs in provinces, states, and regions where specific occupations and skills in RE will be in high demand**. Therefore, additional follow-up research on RE deployment potential and the required skills and occupations at the provincial /regional level in Indonesia is needed. This type of evidence could enhance policy coherence between energy, labor and education and training policies and policy alignment at the national, sub-national, and local levels.

Gender aspects of RE employment were not explicitly discussed in this report. According to the above-mentioned forthcoming discussion paper, more women participate in the global labor force, the better the socio-economic benefits. Guaranteeing women's participation at levels similar to that of men is estimated to add trillions of USD in investment to the global annual GDP. Better performance and decision-making are made possible by gender diversity in high-level positions. Women are also expected to play a critical role in energy justice and energy democracy. Therefore, **the consideration of the gender aspects of RE employment is crucial to further research on the co-benefits of mitigation and adaptation plans in NDCs**.

Future research is necessary to **explore the employment opportunities created by other sectors and technologies** not assessed in this study. For instance, biomass and wind energy have great technical potential in Indonesia and could play a major role in Indonesia's power sector decarbonization. Assessing the employment benefits of wind and biomass will provide policymakers with valuable insights on designing economic stimulus packages to be aligned with energy planning. Biomass job opportunities could be particularly significant considering the labor-intensive production process of feedstock for biomass. Although this study assessed and compared the job creation potential of selected RE technologies and fossil fuel based technologies in terms of job creation per unit of electricity generation and unit of investment, additional research is needed to address any potential job losses in sectors like the mining industry by including all the technologies of different power sector scenarios.

[48] International Climate Initiative Ambition to Action Project, *Three Indonesian Solar Powered Futures*, 2019.

ANNEXES

ANNEX 1: VARIABLE TABLES

	Input variables	Unit	Output
Technology and cost data	CAPEX: Cost structure per technology component	USDk/MW	Direct employment impacts, Required investment
	OPEX fixed: Cost structure per technology component	USDk/MW/yr	
	OPEX variable: Cost structure per technology component (utilities)	USDk/MWh	
	OPEX variable: Cost structure per technology component (fuel cost)	USDk/MWh	
	In-country share (share of domestic investment)	%	
	Labor share (share of labor expenses)	%	
	Actual and future capacity per technology	MW	
	Electricity Generation per technology	GWh	
	Average annual salary per sector	FTE	
Macroeconomic data	IO table values (in combination with Technology and cost data)	USD	Indirect employment impacts, Induced employment impacts, Added value
Skills demand	IRENA's occupations per stage of RE Value Chain	%	Number of occupations per stage of RE Value Chain, Number of RE hard-to-fill occupations
	ILO's hard-to-fill RE occupations	Type of Occupations	

ANNEX 2: EQUATIONS UTILIZED FOR THE ASSESSMENT OF DIRECT, INDIRECT AND INDUCED JOB-YEARS

1. Direct jobs per MW

The equations below illustrate how the direct jobs per MW have been calculated.

a. CAPEX direct jobs

The number of direct CAPEX jobs "x" for the CAPEX component "c_1" is calculated as follows. We estimate the share of the CAPEX of component c_1 that is spent in the country, denoted by and its share spent on labor denoted by . That results on the overall CAPEX of component c1 spent on labor. By dividing the CAPEX of component 1 (c1) spent on labor by the average annual salary of the economic sector of component 1, denoted by we estimate the number of direct jobs per MW of CAPEX component 1.

$$x_{c1} = \frac{CAPEX_{c1} * \%IC_{c1} * \%L_{c1}}{\bar{S}_{es-c1}}$$

By following the same approach for all CAPEX components, we can estimate the CAPEX direct jobs per MW created per every CAPEX component as illustrated at the following equation:

$$x_{cn} = \frac{CAPEX_{cn} * \%IC_{cn} * \%L_{cn}}{\bar{S}_{es-cn}}$$

Total CAPEX jobs per MW

The total CAPEX jobs per MW then is calculated as the summation of the direct jobs per MW of all CAPEX components as illustrated by the following equation:

$$X_{CAPEX-total} = \sum x_{cn}$$

Total CAPEX direct jobs during the modeling horizon

The total CAPEX job-years are calculated by multiplying the total CAPEX jobs per MW by the number of MW of new installed capacity during the modeling horizon 2020-2030.

b. OPEX direct jobs

Direct OPEX jobs *x* of operation is calculated as follows. We estimate the share of the OPEX of operation that is spent in the country, denoted by $\%IC_o$ and its share spent on labor denoted by $\%L_o$. That results in the overall OPEX of operation spent on labor. By dividing the OPEX of operation (*o*) spent on labor by the average annual salary of the economic sector of OPEX of operation, denoted by we estimate the number of OPEX direct jobs per MW related to the operation of the technology assessed.

$$x_o = \frac{OPEX * \%IC_o * \%L_o}{\bar{S}_{es-o}}$$

By following the same calculations for the maintenance part of the OPEX we can estimate the OPEX direct jobs per MW created by the maintenance of the technology assessed as illustrated at the following equation:

$$x_m = \frac{OPEX * \%IC_m * \%L_m}{S_{es-m}}$$

Total OPEX jobs per MW per year

The total OPEX jobs per MW then is calculated by adding the direct jobs per MW of operation part of OPEX () and the direct jobs per MW of maintenance part of OPEX () as illustrated by the following equation:

$$X_{OPEX-total} = x_o + x_m$$

Total OPEX direct jobs during the modeling horizon

The total OPEX job-years are calculated by multiplying the total OPEX jobs per MW per year with the number of MW of new installed capacity during the modeling horizon 2020-2030.

Total direct jobs per MW per year

Lastly, the Total direct jobs per MW is calculated by adding the CAPEX direct jobs per MW ($X_{CAPEX-total}$) and the OPEX direct jobs per MW ($X_{OPEX-total}$) as it is illustrated by the following equation:

$$X_{total} = X_{CAPEX-total} + X_{OPEX-total}$$

c. Indirect and induced jobs

As described in the methodology, the indirect and induced jobs are calculated by utilizing an Input–Output modeling approach. The standard representation of the Input–Output model in matrix notation can be defined as follows:

$$X = (I - A)^{-1} Y$$

Where **X** is the vector of final production of the economy assessed, whereas **Y** is the vector of final demand of the economy.

"**A**" is an **n × n** matrix of technical coefficients. A technical coefficient a_{ij} is defined as the amount of production of sector *i* that sector *j* requires to produce one unit of output. Through these technical coefficients the direct impacts from an increase in final demand for a particular product on the various economic sectors can be estimated. "**I**" denotes the identity matrix.

The $(I - A)^{-1}$ is the Leontief inverse $n \times n$ matrix that determines the input–output multipliers. The rows and columns of the Leontief inverse matrix indicate the economic sectors and each element a_{ij} of the matrix shows the total required increase in the production of sector ***i*** to meet an increase of one unit in the final demand of sector *j*. The sum of all the elements of the column j of the Leontief inverse matrix gives the output multiplier of the sector *j*. The output multiplier for the sector *j* is the total change in gross output of the entire economy by an initial change in the final demand in sector *j* of USD 1.

There are two types of Leontief inverse matrices. The first matrix, Type I, includes the relationships between the various economic sectors and is used to estimate the **indirect economic effects**. The second matrix, Type II, is expanded by one column to include the effect of households' consumption (expenditure) and by one row to include labor compensation. The Type II Leontief inverse matrix is combined with the Type I Leontief inverse matrix to estimate the induced effects of a project or investment.

The **Type I employment multiplier** is the ratio of the sum of direct and indirect employment effects by direct employment effect. The **Type II employment multiplier** is the ratio of the sum of direct, indirect and induced employment effects by direct employment effect.

ANNEX 3: SHARE OF INVESTMENT LOCALLY SOURCED (IN-COUNTRY SHARE)

Table 1. Indonesia in-country share of investment

Development stages / Technology	EM&D	PD	C&I	O&M	Other	Data source
Large hydro	47%	93%	70%	100%		Interview/survey
Small hydro	18%	74%	100%	100%		Interview/survey
Geothermal	59%	66%		89%		DEN, 2017
Solar PV	42%	100%	0%	42%		DEN, 2017
Coal	38%	77%	0%	75%		DEN, 2017

ANNEX 4: COST STRUCTURE PER TECHNOLOGY

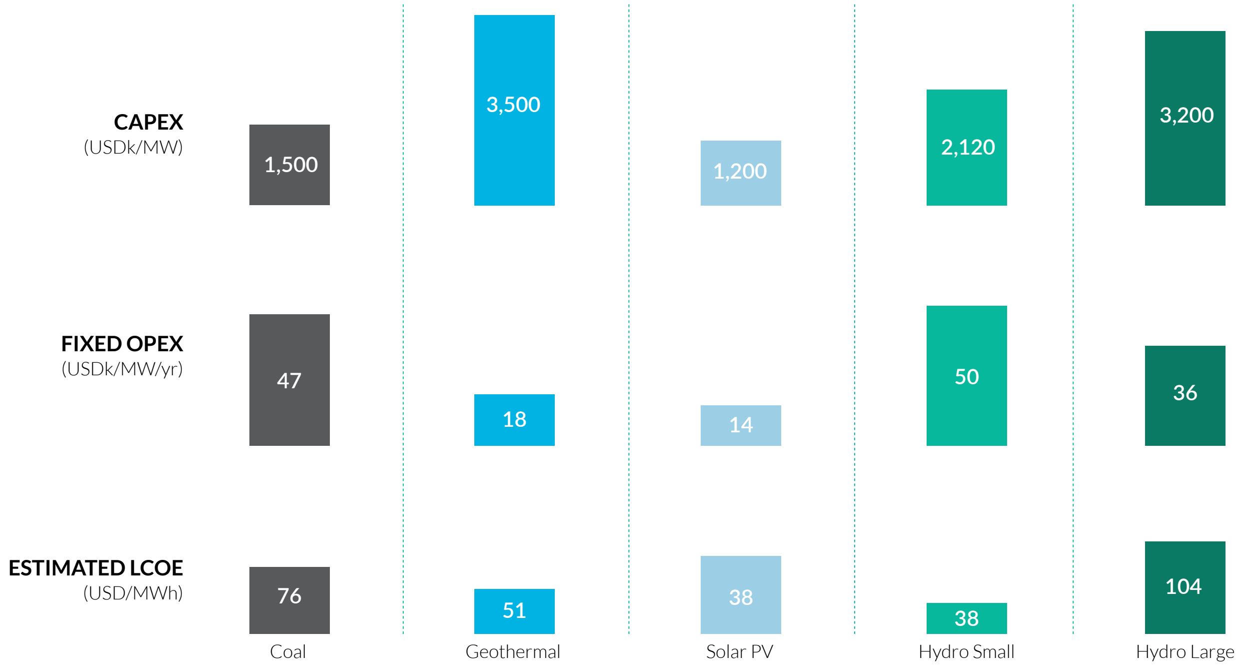

Figure 1. Cost structure per technology for Indonesia

Source: DEN (2017) and interviews

[49] A discount rate of 7.5% was assumed. International Renewable Energy Agency, *Renewable Power Generation Costs in 2018*, 2019.

ANNEX 5: SENSITIVITY ANALYSIS

Sensitivity analysis explores how the change of selected input variables affects the final results. Sensitivity analysis is particularly relevant and useful in cases where input variables are uncertain.

Sensitivity Analysis was conducted to measure the robustness of the results of direct employment on +/-10% changes in the following key input variables:

1. **Average annual salary per economic sector**, measured in USDk/year,
2. **In-Country share or local share**, share of domestic spending,
3. **Labor share**: share of domestic spending allocated to labor.

Indonesia

The Sensitivity Analysis that was conducted for Indonesia indicates that salary has an inverse relationship with the number of direct jobs, while in-country share and labor share both have a positive relationship with direct employment.

Under the RUKN scenario, when salary decreases by 10%, direct jobs increase by 11%. When labor share increases by 10%, direct jobs will also increase by 10%. Finally, an increase of 10% in 'in-country' share, will increase direct jobs by 8%.

On the contrary, a 10% increase in salary will reduce direct employment by 9%. In the same vein, a decrease of 10% of the labor share results in a 10% decrease in direct jobs.

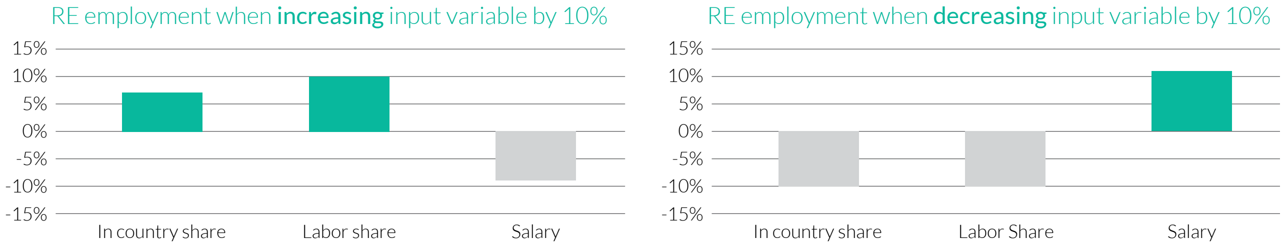

Figure 1. RE employment sensitivity analysis for Indonesia

ANNEX 6: OCCUPATIONS, EDUCATION FIELDS, AND LEVEL OF SKILLS OF EACH STAGE OF THE RE VALUE CHAIN

Table 1. List of occupations of each stage of the value chain stage, education fields, and skills level

			Skills Level		
Value Chain Stage	**Occupation**	**Education Fields**	**High**	**Medium**	**Low**
Equipment manufacture and distribution (EM&D)	Factory Workers and technicians	Technicians		x	x
	Industrial engineers	Engineering	x		
	Administrative personnel	Management	x		
	Marketing and sales personnel	Management	x		
	Logistics experts	Engineering & Logistics and Quality Assurance	x		
	Quality control experts	Engineering & Logistics and Quality Assurance	x		
	Health and safety experts	Health and Safety	x		
	Regulation and Standardization experts	Management	x		
	Chemical Engineers	Engineering	x		
Project development (PD)	Legal Energy regulation, real estate and taxation experts	Law	x		
	Financial Analyst	Finance	x		
	Electrical, Civil, Mechanical, and Energy engineers	Engineering	x		
	Logistic experts	Engineering & Logistics and Quality Assurance	x		
	Environmental experts	Engineering & Natural Sciences	x		
	Health and safety experts	Health and Safety	x		

			Skills Level		
Value Chain Stage	**Occupation**	**Education Fields**	**High**	**Medium**	**Low**
Construction and installation (C&I)	Construction workers and technical personnel	Technicians		x	x
	Civil engineers and foremen	Engineering	x	x	
	Health and safety experts	Health and Safety	x		
	Electrical and mechanical engineers	Engineering	x		
	Environmental Experts	Engineering & Natural Sciences	x		
	Quality-control Experts	Engineering & Logistics and Quality Assurance	x		
Operation and maintenance (O&M)	Construction workers	N/A			x
	Safety experts	Health and Safety	x		
	Industrial, electrical and telecommunication engineers	Engineering	x		
	Operators	Technicians		x	
	Technical Personnel	Technicians		x	
	Administrative and Accountant personnel	Management	x		
	Environmental experts	Engineering & Natural Sciences	x		
	Lawyers, experts in energy regulation	Law	x		
	Management	Management	x		
Others (I.E. Transportation and Storage)	Logistic experts	Engineering & Logistics and Quality Assurance	x		
	Quality Control agents	Engineering & Logistics and Quality Assurance	x		
	Administrative personnel	Management	x		
	Shipping agents	Management	x		
	Loading staff	N/A			x
	Truck drivers	N/A			x

Sources: IRENA (2017)[50], ILO[51] and ANUIES[52]

[50] IRENA. 2017. Renewable energy benefits: Leveraging local capacity for solar PV. Abu Dhabi: International Renewable Energy Agency. Retrieved from https://www.irena.org/-/media/Files/IRENA/Agency/Publication/2017/Jun/IRENA_Leveraging_for_Solar_PV_2017.pdf

[51] International Labour Organization. *Skills and Occupational Needs in Renewable Energy*. November 2011. https://www.ilo.org/skills/pubs/WCMS_166823/lang--en/index.htm.

[52] ANUIES, *Información Estadística de Educación Superior* , accessed November 12, 2019, http://www.anuies.mx/informacion-y-servicios/informacion-estadistica-de-educacion-superior/anuario-estadistico-de-educacion-superior.

ANNEX 7: LITERATURE REVIEW

Table 1. Literature review on renewable energy employment assessment studies

Type of publication	Year	Title	Author	Energy technologies examined	Methodology	Type of employment (direct, indirect,	Scope	Country/ Region
Academic	2017	Promoting renewable energy and energy efficiency in Africa: a framework to evaluate employment generation and cost effectiveness	Cantore et al.	[RE] Renewable energy [CE] Fossil fuels, nuclear [Others] Energy efficiency	Employment factor approach, scenario analysis	Direct and indirect	Regional	Africa
Academic	2016	Employment from renewable energy and energy efficiency in Tunisia - new insights, new results	Lehr et al.	[RE] Biogas, wind, solar water heaters and PV	Ex-post analysis, Input-Output Analysis	Direct and indirect	National	Tunisia
Academic	2016	Employment impact assessment of renewable energy targets for electricity generation by 2020 - An IO LCA appraoch	Henriques et al.	[RE] Biowaste, biomass, biogas, wind, PV, hydropower large and small, geothermal [CE] Coal, natural gas, oil	Input-Output Analysis in combination with Life Cycle Assessment (LCA)	Direct, indirect and induced	National	Portugal
Academic	2013	Employment impacts of CDM projects in China's power sector	Wang et al.	[RE] Wind, hydro, biomass, solar [CE] Gas (fuel switch), nuclear, oil, small and large	Input-Output Analysis	Direct and indirect	National	China
Academic	2013	Green economy and green jobs: Myth or reality? The case of China's power generation sector	Cai et al.	[RE] Wind, hydro, biomass, solar PV [CE] Small and large coal-fired, oil, gas, nuclear	Project-level survey, Input-Output Analysis	Direct and indirect	National	China
Report	2020	Measuring the socio-economics of Transition: Focus on Jobs	IRENA	[RE] Solar, bioenergy, wind, [CE] Fossil Fuels, Nuclear [Others] Energy Efficiency, Energy Grid	E3M3 Macroeconometric model	Direct, indirect and induced	Global/ Regional	Africa, Middle East OPEC, Southern Europe, China
Report	2019	Future skills and job creation through renewable energy in Vietnam	IASS	[RE] Biomass, wind, hydropower, solar [CE] gas, coal	In depth interviews, Input-Out Analysis	Direct, indirect and induced	National	Vietnam

Report	2019	Future skills and job creation through renewable energy in South Africa	IASS	[RE] Hydro, wind, geothermal, biomass, PV, solar thermal [CE] Coal, gas, diesel, nuclear	In depth interviews, General Equilibrium Model approach, Input-Output Analysis	Direct, indirect and induced	National	South Africa
Report	2018	Renewable Energy Job Creation in Thailand	Greenpeace	[RE] Biomass, biogas, solar, wind[CE] Coal	Scenario analysis, Employment factor approach, qualitative assessment	Direct and indirect	National	Thailand
Report	2015	Clean Energy Powers Local Job Growth in India	CEEW team and NRDC team	[RE] Solar PV, wind	Scenario analysis	Direct and indirect	National	India
Report	2009, 2015, 2012	Energy Sector Jobs to 2030: A global Analysis	Rutovitz and Atherton	[RE] Hydropower large and small, wind, biomass, solar PV, geothermal, concentrating solar thermal power, ocean power [CE] Coal, gas, nuclear	Employment factor approach	Direct	Global	Global
Academic (review)	2015	Employment factor for wind and solar energy technologies: A literature review	Cameron et al.	[RE] Wind, solar PV, concentrated solar power	Employment factor approach	Direct	Global	Global
Academic (review)	2012	The challenges of determining the employment effects of renewable energy	Lamber et al.	[RE] Solar PV, solar thermal, wind, biomass[CE] Coal, natural gas	Literature review	Direct	Global	Global

ANNEX 8: BACKGROUND METHODOLOGY RELATED INFORMATION

Table 1. Example and illustration of Methodology steps 1 to 4 for solar PV in Indonesia

		STEP 1		STEP 2	STEP 3		STEP 4	
CAPEX Components	**CAPEX Value** (USDk/ MW)	**In-country share** (%)	**In-country Investment** (USD k/MW)	**Match Economic sectors** (I-O table)	**Labor share** (%)	**Labor Investment** (USD k/MW)	**Average Annual Salary per sector** (USD k/yr)	**CAPEX Direct Jobs** (yr/MW)
PV module	409	42%	172	D27: Electrical equipment	13%	22	3.48	6.4
Inverter	72	42%	30	D27: Electrical equipment	13%	4	3.48	1.1
Racking/ Mounting	111	42%	47	D25: Fabricated metal products	9%	4	3.97	1.1
Installation	149	100%	149	D41T43: Construction	20%	30	2.33	12.8
BOS, grid connection	206	42%	87	D27: Electrical equipment	13%	11	3.48	3.2
Developer cost	145	100%	145	D69T82: Other business sector services	22%	32	3.01	10.6
Land	3	100%	3	D68: Real estate activities	5%	0	3.08	0.0
Fees and contingencies	106	100%	106	D64T66: Financial and insurance activities	20%	21	3.75	5.7
OPEX Components	**OPEX Value** (USDk/ MW)	**In-country share** (%)	**In-country Investment** (USD k/MW)	**Match Economic sectors** (I-O table)	**Labor share** (%)	**Labor In-vestment** (USD k/MW)	**Average Annual Salary per sector** (USD k/yr)	**OPEX Direct Jobs** (yr/MW)
Maintenance	6	100%	6	D27: Electrical equipment	13%	0.8	3.48	0.22
Operation	8	42%	3	D35T39: Electricity, gas, water supply, sewerage	12%	0.4	2.65	0.14

Table 2. Assumptions for Learning factors variable for different energy technologies used in Indonesia

Technologies/ Countries	Indonesia
Large hydro	
Utility-scale solar PV	2.7%
Solar PV DG	
Onshore wind	
Geothermal	0.9%
Combined cycle	
Coal	0.3%
Methane	
Peat	
Source	DEN[53] (2017)

[53] Danish Energy Agency, Technology Data for the Indonesian Power Sector: Catalogue for Generation and Storage of Electricity, 2017.

ANNEX 9: TEMPORAL DISTRIBUTION OF JOBS GENERATION PER TECHNOLOGY THROUGH THE MODELING HORIZON

Indonesia

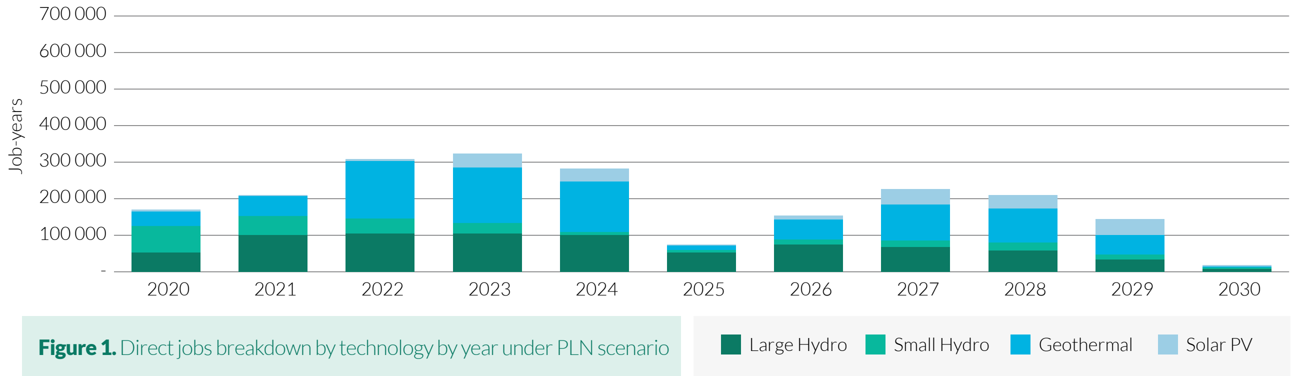

Figure 1. Direct jobs breakdown by technology by year under PLN scenario

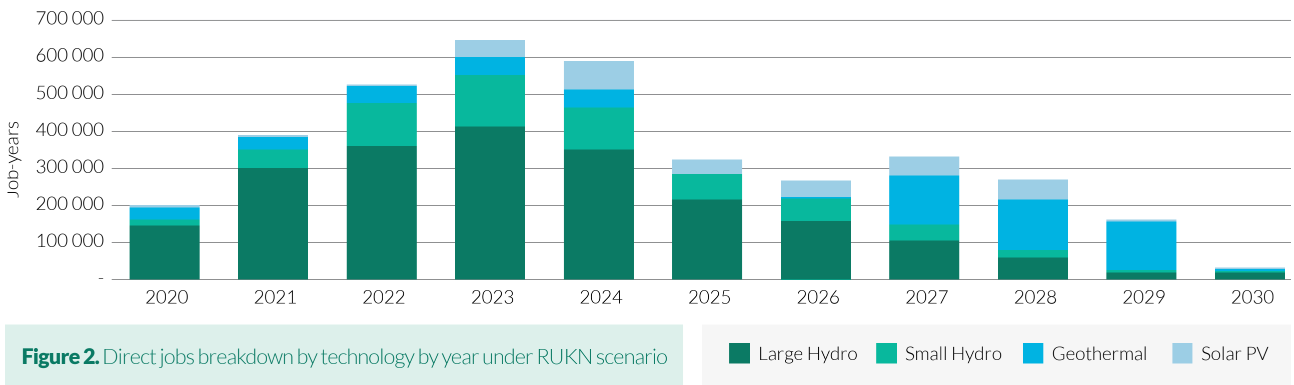

Figure 2. Direct jobs breakdown by technology by year under RUKN scenario

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