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Employment Impacts of Energy Transition in Indonesia

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Abstract

Indonesia has pledged an ambitious target for decarbonizing its energy sectors. This study aims to examine the potential impact of transitioning the power and automotive sectors on employment. Utilizing energy modeling results for three different decarbonization scenarios, this study quantitatively projects the direct, indirect, and induced impacts of transitioning the power sector on employment for the period of 2020-2050. The analysis of the automotive sectors was taken using qualitative method to gather insight into the potential net job creation resulting from transitioning to Electric Vehicle (EV) from Internal Combustion Engine Vehicle (ICEV). The findings suggest that decarbonizing the electricity sector to meet the Paris Agreement target would create 5.86 million direct jobs-year, 2.67 million higher than the business-as-usual scenario. The job creation primarily comes from solar photovoltaics (PV) projects, despite potential job losses from retiring coal plants. Most of these direct jobs are associated with the construction and installation phases of power plants. Overall, the energy transition could result in net job creation (direct, indirect, and induced impacts) ranging from 7.07 million to 12.17 million jobs-years by 2050. In contrast to the positive employment impact Contrasting to the results in the power sector, this study identified two main risks associated with the transition from ICEV to EV manufacturing: lower demand for workers for ICEV components manufacturing and maintenance and higher demand for workers capable of handling more automation-based manufacturing technology, potentially leading to net job losses. This evidence suggests that policymakers should enhance human capital through training and certification, as well as fostering collaboration among stakeholders to address labor market changes during the energy transition and fully capture its benefits.

JEL Classification: E24; J21; Q43

Keywords
net-zero emissions — energy transition — power sector — automotive sector — employment — Indonesia

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1. Introduction

Countries worldwide have made significant efforts to transition to cleaner energy to reduce greenhouse gas (GHG) emissions and align with the Paris Agreement. These decarbonization efforts have primarily focused on increasing the share of renewable energy (RE) sources in electricity generation and reducing the use of fossil fuel energy sources (Ravillard, 2021). While the energy transition is expected to benefit the environment through reduced emissions and create new opportunities within the energy sector, it may also have adverse socio-economic impacts, particularly on the workforce.

The shift toward RE is likely to reduce activities in fossil fuel energy sectors and their supply chains, leading to a reconfiguration of the job market with both winners and losers. Several global studies highlight the potential for job creation in the RE sector. According to research by the International Renewable Energy Agency (IRENA), achieving targeted global RE investments could lead to a 2.5 percent increase in GDP and a 0.2 percent rise in global employment by 2050 compared to the business-as-usual (BAU) scenario. Similarly, the International Labour Organization (ILO) in its 2018 report, ”Greening with Jobs,” estimated that GHG reduction measures in the energy sector, aligned with the Paris Agreement’s long-term goals, could generate approximately 24 million jobs. The International Energy Agency (IEA) projected in 2021 that clean energy technologies would create 14 million new jobs. Another study by Ram et al. (2020) found that the RE sector could grow 20 million jobs. However, despite these opportunities for job creation, significant job losses are anticipated in the fossil fuel sectors as the shift to renewable energy progresses (Carley & Konisky, 2020; Global Energy Monitor, 2023).

Despite growing issues on a global scale, there have been limited studies to estimate the needs at the country level. For instance, Grafakos et al. (2020a) compared the impact of energy transition towards employment creation in Mexico and Rwanda. For Mexico, Grafakos et al. (2020a) estimated the effect of achieving energy transition in the power sector outlined in Mexico’s Nationally Determined Contribution (NDC). The power sector in Mexico was estimated to create 370 thousand more direct job-years, 170 thousand more indirect, and 110 thousand more induced jobs than the BAU between 2020 and 2030. Meanwhile, in Rwanda, Grafakos et al. (2020a) estimated the transition in the power sector impact through three scenarios, which are NDC unconditional, High Ambition, and Sustainable Energy for All, where the first two scenarios represent the low and high ambition plans. The NDC scenario was estimated to generate 14 thousand direct job-years, while the High Ambition scenario will generate around 31 thousand direct jobs-years.

Studies estimating the impact of energy transition on employment in Indonesia have highlighted optimistic findings (Montt et al., 2018; OECD, 2024). Indonesia is expected to experience the second largest economy-wide net job creation from the energy transition until 2030 where

1.12 million jobs are created, only trailing behind China. Energy transition is also projected to create jobs for women and youth as rapidly growing sectors are those with better inclusiveness. On the other hand, job losses are relatively small compared to the stature of the number of jobs created.

In the power sector, Grafakos et al. (2020b) estimated that the energy transition in Indonesia will create 2.1 million direct new jobs under the Power Supply Business Plan of the State Electricity Company (RUPTL PLN) 2019-2028 and 3.7 million direct new jobs under the National Electricity Planning (RUKN) 2019-2038 by 2030. In terms of technology, job gains from RE power plants are expected to be more significant than from fossil fuel technologies, with large hydro generating 3.8 times more jobs per electricity output, small hydro 3.2 times more, geothermal 2.8 times more, and solar photovoltaics (PV) 2.5 times more. However, this study did not account for the net employment impact, as it only considered additional job creation from new power plants without considering the potential job loss from the decline of fossil fuel power plants.

All of the current country scale estimation only focuses on the short-term energy transition target, which may not bring significant changes to the sectors. In the long term, countries must significantly decarbonize their power sector to align with their Net Zero Emission (NZE) target. For instance, Indonesia's current power sector is heavily dependent on fossil fuel power plants, with coal-fired power plants (CFPPs) having the largest share of 67.2 percent, leaving only 14.1 percent for RE in 2022 (MEMR, 2023). Meanwhile, Indonesia's NZE targets to generate 85 percent of electricity from renewable sources by 2060 (MEMR, 2022). Hand-in hand, the government also pursues strategies to enhance the adoption of Electric Vehicles (EVs) to reduce Internal Combustion Engine Vehicles (ICEVs) to significantly reduce GHG emissions from the energy sector to the lowest level possible. If Indonesia pursues its long-term energy transition target, there will be a significant shift in the power systems, significantly impacting employment in the power sector.

Using the long-term power sector projection by Reyseliani et al. (2022), this study explores the potential impact of decarbonizing the power sector on employment changes across two scenarios, Current Policy (CP) and Paris Agreement (PA) and one reference scenario, the BAU, without considering the employment changes. The study produces three key outputs: direct, indirect, and induced impacts on job creation and job changes for each scenario, broken down by technologies and project phases. This study estimates the net job changes from the expansion of clean energy power plants and losses from the decline of fossil fuel power plants by comparing the employment from CP and PA with the BAU scenario, which serves as a counterfactual. The results are visualized over the period of 2020-2050, both as a trajectory (5-year time slice) and as cumulative impacts. The estimates focus on electricity generation and do not consider the employment impact of the upstream sectors. Additionally, the study qualitatively examines the impact of the energy transition in the automotive sector (from ICEV to EV), highlighting the potential job gain or loss and skill required in transitioning the automotive sector.

2. Current Landscape

2.1 Electricity Sector Transition Pathways in Indonesia

RE's contribution to the electricity mix remains a minority in Indonesia (MEMR, 2023). In 2012, renewable energy contributed 12.2 percent of Indonesia's electricity generation. It saw modest growth in 10 years, where it increased to 14.1 percent in 2022. Of that figure, hydropower was the largest contributor, with a share of 8.3 percent. Geothermal energy followed with a share of 1.36 percent. On the other hand, solar PV and wind contributed only a little to the electricity mix. Installed solar PV and wind capacity in 2022 was 283.1 and 154.3 MWs, respectively. In terms of contribution to the electricity mix, solar PV and wind had a share of 0.34 and 0.18 percent, respectively.

More than 80 percent of Indonesia's electricity is generated from coal, gas, and diesel power plants. Coal has been the country's primary source of electricity and has continued to enlarge its contribution on Indonesia's electricity mix. In 2012, CFPPs accounted for 43.7 percent of the electricity generation mix where it alone rose to 67.2 percent in 2022. During this period, Indonesia installed additional CFPPs with a combined capacity of 26.83 GW. The additional capacity of diesel-fired power plants (DFPPs) amounted to 6.83 GW, more than double the additional RE capacity within the period. Despite the de-dieselization program rolled out by the PLN in 2021, DFPPs still had a larger capacity than hydropower—RE's largest contributor—in 2022.

RE's contribution in the last decade has been sluggish and overshadowed by additional fossil fuel power capacity, but it is planned to play a central role in the upcoming decades. Several documents that are the core of Indonesia's energy and electricity sector planning are the National Energy Policy (KEN) and the National Energy Planning (RUEN) enacted by the Indonesian central government, and the RUKN and RUPTL decreed by the MEMR.

KEN serves as the country's long-term strategic vision and plans for Indonesia's energy policies. However, the last KEN was published in 2014 and has not considered global emission reduction commitments. In 2017, the derivative document to the 2014 KEN, RUEN, set out the country's detailed energy planning and included Indonesia's then-current landscape of electricity generation. In the RUEN, Indonesia planned to have installed 45.2 GW of RE capacity in 2025, or around 23 percent of the energy mix, and 31 percent by 2050. Contributions of fossil energy are also intended to be lower in the long run to reach 25 percent from coal, 24 percent from gas, and 20 percent from oil by 2050. Nonetheless, due to slow take-up growth, the central government was set to revise its 2025 RE target from 23 percent to a range between 17 to 19 percent (Junida, 2024).

The RUKN further details the planning provisions from both the KEN 2014-2050 and RUEN 2017 - 2050, particularly regarding electricity planning. RUKN 2019-2038 aligned its target to the RUEN where RE supplies at least 23 percent of electricity in 2025. Further, it established another target in 2038 where RE's contribution to the electricity mix should be at a minimum of 28 percent. As for its plan on fos-

Table 1. Indonesia Electricity Planning Documents

No	Energy Planning Document	Period of the latest document	Issuing Institution	Regulatory Form
1	National Energy Policy (KEN)	2014-2050	Central Government	Government Regulation
2	National Energy Planning (RUEN)	2017-2050	Central Government	Presidential Regulation
3	National Electricity Planning (RUKN)	2019-2038 (in effect) / 2023-2060 (draft published)	Ministry of Energy and Mineral Resources	Minister Decree
4	National Electricity Supply Business Plan (RUPTL)	2021-2030	State Electricity Company (PLN)	Minister Decree

Source: Authors' compilation, 2024

sil energy, the document prescribed that diesel for electricity generation is only allowed for emergency purposes and CFPPs must utilize Clean Coal Technology (CCT). Nuclear power is also in accordance with the KEN document.

The MEMR has recently published a draft of the RUKN 2023-2038, where it laid more detailed and more ambitious plans for renewable energy. It also formally revises the target in the KEN, where RE is expected to contribute 22 percent of the electricity mix in 2025. RE capacity is estimated to be at 722 GW in 2060, where solar PV power dominates with a share of 64 percent. The nuclear power plant is targeted to start its commercial operations in 2032 with a capacity of 0.4 GW.

In the short run, Indonesia plans its electricity generation through the RUPTL, developed and published by the state-owned electricity company PLN. In the latest RUPTL, PLN, as the country's sole on-grid electricity seller, planned to add 40.6 GW of electricity generation capacity from 2021 to 2030. Of that amount, 20.9 GW or around 51.6 percent of the additional capacity will be from RE by 2030. This is a significant increase from the previous RUPTL 2019-2028, where RE only had a share of 29.6 percent of the additional capacity by 2028. Hydropower will continue to lead as the renewable source with the most additional capacity, followed by solar PV and geothermal. On the other hand, the proportion of fossil fuel in the electricity mix will also be reduced. PLN planned to shift its base-load power plants to renewables only after 2025 and retire several subcritical CFPPs in 2030. The RUPTL also mentioned the de-dieselization program, where one of the scenarios was to replace DFPPs with solar PV.

As a complement to the planning documents, Presidential Regulation No. 112/2022 was enacted as a regulatory foundation for accelerating RE development in Indonesia. The core of the regulation lies in the establishment of RE power purchasing price, where the price for electricity sold by renewable energy IPPs to the PLN is capped at a level deemed supportive. The regulation also factored in the type of technology and location factors in determining the premium price received by the IPPs. Other important points mentioned in this regulation include the prohibition of the development of new CFPPs not planned in the latest RUPTL, mechanisms of early retirement of CFPPs, and fiscal and nonfiscal support for RE development.

There are three main issues with Indonesia's energy planning documents. First, there appears to be inconsistencies between the government planning documents, particularly in the installed energy capacity targets and the use of coal as a last resort in several regions in Indonesia (Widyaningsih, 2018). The targets in the documents are supposed to refer to their parent documents. In this case, targets and plans in RUKN and RUPTL do not adhere to the objectives and strategies stipulated in the KEN and RUEN. Targets of total and renewable energy capacities do not align between the documents. The targets in the RUPTL do not match Indonesia's latest commitment to the NDCs. Second, Indonesia's progress in implementing the plans remains lagging. As elaborated earlier, the government has continued to revise its renewable energy targets since its actual take-up has been far lower. Ruslan (2021) also argued that the targeted renewable energy contribution in the 2025 energy mix would not be achieved. This implies that the impact of the energy transition on the workforce might be lower than past estimates such as the one yielded by Grafakos et al. (2020b). Third, different targets and scenarios lead to a range of estimates which will later confuse its policy implications. As there is a wide range of estimated quantified impacts of employment, strategies will need to anticipate numerous possible outcomes.

2.2 Potential Impact of Energy Transition on Jobs

Energy transition has fuelled a global acceleration in the creation of clean energy employment, whereas fossil fuel employment growth has been slowing down and even declining. The IEA (2023) noted that more people work in the energy sector today than it was in 2019, and it was almost exclusively attributed to the rise in clean energy jobs. Clean energy sectors added 4.7 million jobs in the energy sector, where it cumulatively stood at 35 million in 2023. In the same period, fossil fuel employment's growth had been much slower, and it was still 1.3 million below prepandemic employment levels at 32 million. IRENA (2023) also noted that jobs in solar PV were the dominant force in this rise of clean energy jobs, comprising a third of the global renewable energy workforce in 2022. Using the multiregional input-output model (MRIO), Montt et al. (2018) estimated that there will be 18 million jobs created in 44 major economies worldwide due to the shift driven by energy transition until 2030.

Montt et al. (2018) also made the earliest accounts of estimates on the energy transition's positive impact on Indonesia's employment landscape. The estimates exhibit how the energy transition should induce significant job creation in Indonesia with low between-sector excess job reallocation, where it is among the largest beneficiaries of the transition in the world. According to the study, adhering to the 2-degree scenario (2DS) scenario until 2030 creates 2.1 million more jobs for Indonesia compared to the BAU. Indonesia is also expected to experience the second-largest job creation of the 44 countries, only behind China, and the third-largest in terms of the percentage change in net employment, behind Bulgaria and Taiwan. On the other hand, the study also found that Indonesia's estimated excess job reallocation rate is among the lowest. Where Indonesia's net employment change is estimated to be almost 0.9 percent, its between-sector excess job reallocation rate is lower than 0.1 percent of projected employment in 2030.

A study by OECD (2024) builds upon the findings from Montt et al. (2018) to detail the implications of energy transition on employment in Indonesia. Where Montt et al. (2018) did not further detail the exact figure of how many jobs would be impacted during its observed period, the study adapted the findings from Montt et al. (2018) by calibrating the results using the Indonesian Labour Force Survey Data (Sakernas). It is estimated that there will be around 31 thousand jobs lost until 2030. In contrast, 1.12 million jobs created in the same period will be attributed to energy transition. The OECD (2024) also delivers more nuanced insight regarding the employment creation in different electricity-generating subsectors. Electricity from solar PV is estimated to be the largest driver of job creation among electricity-producing sub-sectors, followed by electricity from biomass and waste and geothermal.

The OECD (2024) study also details how energy transition would impact related sectors and groups in society. The study constructed profiles of sectors where job creation gains are most reaped and where job losses are most incurred. Job gains are estimated to be spread across several sectors, ranging from electricity and gas to manufacturing. In contrast, job losses will be mostly experienced by fossil fuel-related activities, such as mining. Energy transition is also expected to create employment for women and youth as the positively impacted sectors have a relatively large share of women and youth in their workforce. These gaining sectors potentially generate more jobs with formal contracts and employee status.

Job losses from energy transition also bear their own issue. Indonesia is one of the largest coal-producing countries in the world, employing around 160,000 workers in the industry. In reference to IEA (2023), Indonesia's growth in fossil fuel employment, particularly in the coal sector, was among the several countries to experience above-global average growth since the pandemic. The Global Energy Monitor (2023) highlighted that Indonesia would experience one of the most significant layoffs in the coal mining sector. On the other hand, the OECD (2024) pointed out that workers in fossil fuel extraction and processing, on average, attained higher educational levels; thus, phasing them out would be a challenge as they need to be reallocated to a sector that matches the skills they can offer.

While other studies relied their estimates on economy-wide data and labor survey calibrations, Grafakos et al. (2020b) referred to Indonesia's energy planning documents, the RUKN 2019-2038 and the RUPTL 2019-2028, in calculating potential job creation in the power sector and providing more attention to the skills needed for fostering energy transition. The difference between the two documents is driven by different RE power plant targets, with 123 GW for RUPTL PLN and 146 GW for RUKN by 2030. The study also includes calculations on job creation, economic impacts, employment effects across value chains, and a specific occupation and skill assessment on the solar PV value chain.

According to the study, under the RUKN 2019-2038 scenario, the additional 43 GW RE capacity installed until 2030 shall generate around 7.2 million job-years. This additional capacity comprises 3.7 million direct job-years, 1.72 million indirect job-years, and 1.74 million induced job-years. In addition to the RUKN scenario, the study projected that under the RUPTL 2019-2028 scenario, an additional 28.5 GW shall create around 3.9 million job-years by 2030. This estimate represents 2.1 million direct, 0.88 million indirect, and 0.89 induced job-years. The gain on employment from RE will be much more significant than that from fossil fuel technologies, with large hydro generating 3.8 times more job-years per electricity output, small hydro generating 3.2 times more, geothermal by 2.8 times, and solar by 2.5 times.

The study also estimated the direct jobs potentially generated across the value chains under the RUKN scenario. Around 53 percent of the jobs created by RE will be in the construction and installation phase. Of the remaining 47 percent, 25 percent of jobs in RE will be generated from project development, 20 percent from equipment manufacturing and distribution, and 3 percent from operation and maintenance. Further, solar PV is estimated to create more than 325 thousand job-years under the RUKN scenario, where different parts of the value chain will generate jobs with distinct requirements. The project development stage of solar PVs will intensively require engineers and management professionals. In contrast, the construction, installation, and operation and maintenance stages will require less skilled laborers. However, the construction and installation stage will generate the largest number of jobs.

Having said that, there are several notes regarding Grafakos et al. (2020b)'s estimates. First, the estimates are grounded not on the latest electricity planning documents, the RUPTL 2021-2030 and the draft of the new RUKN 2023-2060 which place more ambitious RE targets. Second, this study was limited to estimating employment creation in several RE technologies and did not account for the magnitude of job changes, i.e., incorporating job losses in the power sector. Nonetheless, the analysis is narrowed to certain renewable energy technologies. Other renewable technologies estimated to contribute to Indonesia's energy mix, such as wind and tidal, are not incorporated into the calculations.

The visible optimistic results in studies examining the impact of energy transition on jobs, especially in Indonesia, must come with an important caveat. The quality of human capital is a critical factor that must be considered when estimating the implications of energy transition on employment. Vona et al. (2015) and Consoli et al. (2015) argued that green jobs differ from their non-green counterparts in that green jobs demand higher levels of analytical and technical skills. Related characteristics of workers in green jobs include higher formal education, work experience, and experience in on-the-job training. Compared to non-green jobs, green jobs demand intensively higher cognitive and interpersonal skills. These factors are not accounted

The Indonesian Roadmap of NZE in the Energy Sector

The MEMR with assistance from the IEA), launched the Indonesian Roadmap of NZE in the Energy Sector in 2022. Despite having no legal basis, the roadmap complements Indonesia's energy and electricity planning in achieving NZE. The document devises the main strategies Indonesia needs to deploy, namely 1) massive RE development; 2) gradual phase-out of CFPPs; 3) low-emission technology deployment; 4) electric vehicle conversion; 5) energy efficiency technology utilization for industrial, transportation, and construction sector; and 6) utilization of nuclear, hydrogen, and ammonia. Until 2030, power sector development will remain in accordance with the RUPTL PLN. The roadmap plans for Indonesia to develop clean energy for electricity only after 2030. The acceleration of RE development will be led by solar, wind, hydropower, and geothermal that will account for 482 GW of electricity supply by 2060. The first nuclear power plant will start operating in 2039. On the other hand, the CFPPs will be completely phased out in the 2050s. This implies that there will be massive demand for workers in the RE sector, while labor demand from fossil power plants will decrease gradually as they are slowly phased out.

for when calculating energy transition impacts using a top-down approach, such as the method used by Grafakos et al. (2020b).

This issue was captured by the OECD (2024) study, which identified the different characteristics of different jobs across impacted sectors. It argued that some of the main gaining sectors, especially electricity and gas, will require more workers with intermediate levels of skills and knowledge. 51 percent of the potential jobs created require an intermediate education level or higher, whereas Indonesian workers with such attained education level only amounted to 39 percent in 2016—the base year used by the study to make it comparable to Montt et al. (2018). Reallocating adversely impacted workers to proliferating sectors would also need to consider their skill and knowledge level. The study observed that even if the workers formerly working in negatively impacted sectors such as CFPPs and coal mining are reallocating to the growing critical mineral and metal mining; the latter sector is characterized by workers with higher education and lower levels of informality.

An empirical study by Curtis et al. (2023) supports the notion that human capital factors impede carbon-intensive sector workers' transition into green sectors. The study examined the movement of workers transitioning from carbon-intensive to green sectors in the US. The transition from fossil fuel to green sectors was found to be accelerating ten-fold over the period of 2005-2021. Nonetheless, the absolute scale of the transition was relatively small. Less than 1 percent of workers who left jobs in brown sectors moved into green jobs. On the other hand, around 22 percent of workers who left a brown job moved into other brown jobs. It was also found that workers with a high school diploma or less who left carbon-intensive jobs were likelier to remain employed in carbon-intensive sectors. Even though such findings were observed in a developed country, such implications also need to be considered in developing countries such as Indonesia. The quality of Indonesia's human capital shall become one of the determining factors in the effort to capture the benefit of the energy transition.

Indonesia faces a huge task of ensuring its workers are ready to fulfil the demands of green jobs, but avenues of opportunities remain open. Despite the skill requirement issue promoted by Vona et al. (2015) and Consoli et al. (2015), Bowen et al. (2018) argued that the majority of green jobs bear similar tasks to non-green ones and thus enable affordable and manageable up-skilling and re-skilling. Many skills in both types of jobs are rudimentary and generally applicable in different sectors, such as welding and regular desk work. Given their similarities and marginal differences, on-the-job training would suffice in preparing workers for green jobs. This means workers would only need additional hours of training and supervision instead of an academic qualification. Hence, although most Indonesian workers do not have a high school diploma or higher, on-the-job training should be able to help the Indonesian workforce qualify for green jobs.

3. Methods

The general objective of this study is to examine the potential employment impact of decarbonizing the power and automotive sectors. To estimate the impact of the energy transition on the power sector, this study uses a quantitative approach to estimate three different impacts: direct, indirect, and induced impact of transition in the power sector. The direct impact was estimated by utilizing the employment factor to convert the power sector decarbonization pathways of Reyseliani et al. (2022) to employment change estimates. The indirect and induced impacts were estimated using the Input-Output (I-O) model. To analyze the impact of energy transition on the automotive sector, this study utilizes qualitative data gathered from a literature review, in-depth and focus group discussions (FGD).

3.1 Quantitative Approach

This study utilizes quantitative methods to project the impact of the transition in the power sector on job creation in Indonesia for the period of 2020-2050. The estimation of potential job creation is driven by (1) the new job opportunities from developing clean energy power plants and (2) the job losses from the phasedown of fossil fuel energy power plants.

To estimate the impacts, this study employs three main data: (1) electricity generation planning from Reysiliani et al. (2022) that represents Indonesia's electricity system decarbonization pathways 2020–2050; (2) employment coefficient factors from Rutovitz (2015) and regional adjustment factor from Ram et al. (2020); (3) Local content requirement (LCR) per type of technology from the Ministry of Industry (MoI), Republic of Indonesia (2023); and (4) I-O 2016 table from Statistics Indonesia/Badan Pusat Statistik (2016). Table 2 summarises the dataset used in this study.

Table 2. Data Sources

No	Data	Definition	Source
1	Electricity Generation Planning	The technology mix of energy used in the power sector. This variable is represented by the installed capacity of electricity generation in megawatts (MW).	Reysiliani et al. (2022)
2	Employment factor	The number of jobs per MW of installed capacity by technology and by project stage. This variable is represented by job-years and jobs. The coefficients are calibrated using regional adjustment factor.	Rutovitz (2015) and Ram et al. (2020)
3	LCR rate	Percentage of required local content by type of technology.	Ministry of Industry (2023)
4	I-O 2016 Table	This study utilizes the coefficients derived from the I-O table to capture the linkages of the electricity sector to other sectors in the economy and the potential impact of job changes in the electricity sector on overall job changes in the economy.	Statistics Indonesia (2021)

Source: Authors' Compilation, 2024

3.1.1 Power Sector Decarbonization Pathways

The generation planning in this study was taken from Reysiliani et al. (2022) that use the TIMES[1] model to examine Indonesia's transition in the electricity system for the period of 2020–2050. Three energy transition pathways are examined: the BAU, CP, and PA. The main difference between each pathway lies in the RE and other clean energy penetration and CO2 carbon budget. The BAU scenario depicts a projection of Indonesia's future electricity generation without the influence of specific energy or climate-related policies and targets. The CP scenarios represent the projection of Indonesia's electricity generation pathway according to Indonesia's KEN, RUEN, RUKN, and RUPTL targets. The PA scenario represents the electricity generation pathway to achieve the Paris Agreement target. The emission level of the PA scenario is capped to fulfil the carbon budget for Indonesia, according to Robiou du Pont et al. (2017) and van Soest et al. (2021). Table 3 depicts the difference between each electricity transition pathway.

The distinct difference between each pathway is the main energy source for electricity generation. In both BAU and CP scenarios, CFPP is still the largest. The BAU system will be 77 percent dominated by CFPPs, and CP with only 67 percent in 2050. However, the PA scenario shows different results, in which the number of solar PV PP will become the largest electricity power plant, leaving only 10 percent of CFPPs in 2050. Figure 1 below shows the electricity generation planning for each scenario.

Direct, indirect, and induced impacts are estimated for each electricity generation pathway, reflecting job creation for BAU, CP, and PA scenarios. In addition, the net job creation will be measured as the difference of job creation from decarbonization scenarios (CP and PA) relative to the BAU scenario.

3.1.2 Estimation of Direct Impact using Employment Factor

The direct impact of energy transition on jobs is calculated using the method Ratovitz (2015) used. The calculation of jobs created considers two things: type of technology and project stage. The employment factor or labor multiplier is assigned for each technology and each project phase per MW installed. The technology includes fossil fuels power plants (coal, gas, and diesel including Carbon Capture and Storage/CCS), renewable energy power plants (solar, wind, hydro, biomass, biomass, bioenergy with carbon capture and storage/BECCS), energy storage (pump hydro storage/PHS, and lithium-ion battery), and nuclear. The project stages are broken down into four: manufacturing, construction and installation, operation and maintenance, and decommissioning. Each stage has its specific employment factor based on the type of technology per MW installed. Then, the employment factor is multiplied by the estimated capacity installed for each technology based on the electricity pathways from 2020 until 2050.

The employment factors need to be adjusted with the regional employment multiplier and the requirements for local component requirements rate (*Tingkat Komponen dalam Negeri*/TKDN). The regional employment multiplier for Indonesia is adopted from Rutovitz (2015), taking a number of 1.4 that represents the coefficient for the non-OECD Asia country group. The regional employment multiplier stems from the difference in labour productivity across regions used in the estimation of jobs created during energy transition from 2015 to 2050 by Ram (2020) and Rutovitz (2015). The regional employment multiplier is used to adjust the employment factor for all technology types and stages. The second adjustment is the rate of local content requirement for each technology, which refers to Ministry of Industry Regulation No. 54/2012. The local content requirement rates are used to multiply further the employment factor for all technology types but are only applied in the manufacturing stage. The detailed rate of local content requirements for each technology is shown in Table 4.

Thus, the formula for calculating job creation following Rutovitz (2015) is as stated in equation 1.

The results of this calculation are regarded as the direct impact of jobs from the transition in power generation. This means that the estimation includes job loss from fossil fuels reduction and job gains from low-carbon technology development. The direct impact is used as the input or stimulus for calculating the indirect and induced impacts.

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[1] This system model is built in the TIMES model. The Integrated MARKAL–EFOM System (TIMES) is a model generator developed by the IEA's Energy Technology System Analysis Program. The TIMES model results are energy system configuration/generation planning, energy flows, and balances, environmental impact (GHG), and cost related to the energy infrastructure. This study will only focus on using electricity generation planning.

Table 3. Difference Between Energy Transition Pathway Scenarios

Scenarios	Description	RE Share	Emission Level in 2050
BAU	Represent Indonesia's least cost electricity system planning without climate policies implemented	2025: 24% 2050: 24%	2050: 900 million tons of CO2-eq
CP	Implementation of the KEN, RUEN, RUKN, and RUPTL target	2025: 23%, 2050: 31%	804 million tons of CO2-eq
PA	Electricity pathway to achieve the Paris Agreement target, which is to maintain the earth's temperature rise well below 2°C	2050: 50%	0 million tons of CO2-eq

Source: Reysiliani et al. (2024)

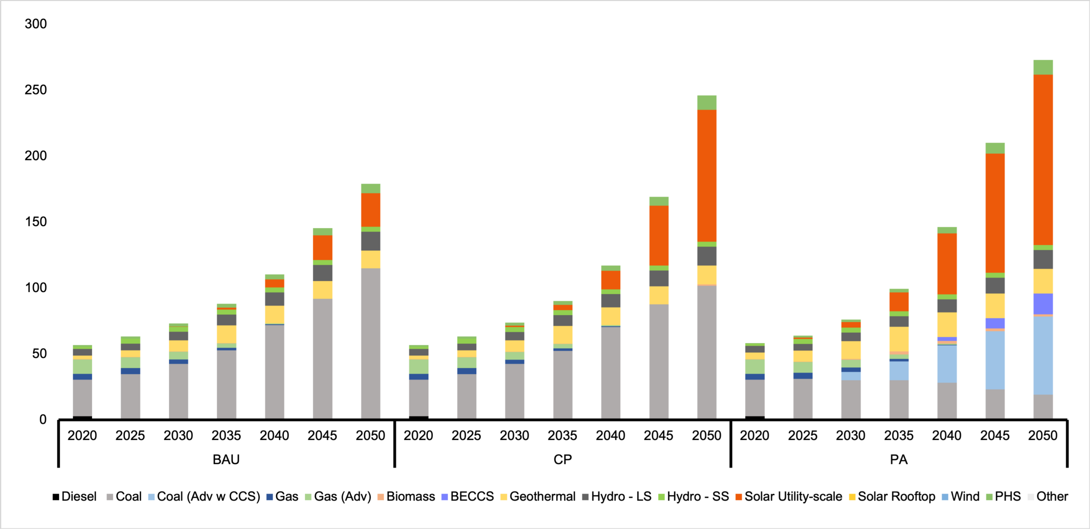

Figure 1. Electricity Generation Planning by Technology Type 2020-2050 (in GW)
Source: Reyseliani et al. (2022)

$$\begin{aligned} \textit{Jobs creation}_{i,t} = {} & \textit{regional employment multiplier} \times \big(\text{capacity installed}_{i,t} \times \textit{manufacturing employment factor} \times \textit{region job multiplier} \\ & \times \textit{local content requirement rate}\big) \\ & + (\text{capacity installed per period} \times \textit{construction and installation employment factor} \times \textit{region job multiplier}) \\ & + (\text{cumulative capacity installed} \times \textit{operations and maintenance employment factor} \times \textit{region job multiplier}) \\ & + (\text{decommission capacity per period} \times \textit{region job multiplier}) \end{aligned} \tag{1}$$

where,

- **Job creation$_{i,t}$**: Job created by technology i in period t in number of job-years.
- **Regional employment multiplier**: Multiplier to adjust regional factor = 1.4.
- **Capacity installed$_{i,t}$**: Additional capacity of electricity generation for technology i in period t in MW.
- **LCR rate$_i$**: Local content requirement rate for technology i in percentage.
- **Cumulative capacity installed$_i$**: Total capacity of electricity generation for technology i in MW.
- **Decommission capacity$_{i,t}$**: Electricity capacity decommissioned by technology i in period t in MW.
- **Manufacturing employment factor$_i$**: Multiplier coefficient in the manufacturing stage for electricity generated by technology i in period t.
- **Construction and installation employment factor$_i$**: Multiplier coefficient in the construction and installation stage for electricity generated by technology i in period t.
- **Operation and maintenance employment factor$_i$**: Multiplier coefficient in the operation and maintenance stage for electricity generated by technology i in period t.
- **Decommission employment factor$_i$**: Multiplier coefficient in the decommissioning stage for electricity generated by technology i in period t.

The I-O model is a quantitative economic modelling technique that captures the flow of goods and services across sectors and economic agents and represents the interdependencies between different sectors of a national economy and is utilized to assess the impact of a change in a particular sector or industry on the whole economy.

The I-O model is derived from the I-O table, a statistical matrix that presents detailed information about the transactions of goods and services within an economy. Intuitively, the I-O model enables insights into the general equilibrium of the entire economy. With this feature, the I-O model can be utilized to assess the impact of transition in the electricity sector on job creation because it is equipped with the interaction aspect of economic sectors, and it allows for

Table 4. Employment Coefficient Factor of Electricity Generation Development

Technologies	Manufacturing[2] [Job-yrs/MW]	Construction & Installation[3] [job-yrs/MW]	Operations & Maintenance[4] [Jobs/MW]	Decommissioning[5] [Job-yrs/MW]
Diesel	0.93	1.30	0.21	0.44
Coal	5.40	11.20	0.14	1.65
Coal (w CCS)	5.40	11.20	0.14	1.65
Coal (Adv)	5.40	11.20	0.14	1.65
Coal (Adv w CCS)	5.4	11.20	0.14	1.65
Gas	1.86	2.60	0.28	0.21
Gas (Adv)	1.86	2.60	0.28	0.21
Gas (Adv w CCS)	1.86	2.60	0.28	0.21
Biomass	2.90	14.00	1.50	0.32
BECCS	2.90	14.00	1.50	0.32
Geothermal	3.90	6.80	0.40	0.21
Hydro-Large Scale	8.75	18.50	0.50	2.22
Hydro - Small Scale	8.75	18.50	0.50	2.22
Nuclear	1.30	11.80	0.60	0.95
Solar Utility-scale	6.70	13.00	0.70	0.80
Solar Rooftop	6.70	26.00	1.40	1.21
Wind	15.60	8.00	0.20	0.72
PHS	7.00	14.80	0.40	4.44
Li-ion Battery	16.90	10.80	0.40	1.21

Note: Adv= Advance Technology, CCS = Carbon Capture and Storage, & Adv with CCS = Advance Technology using Carbon Capture and Storage

[2] Based on Ram et al. (2020), Manufacturing jobs in the power generation sector are defined by the number of full-time positions needed to produce equipment and components for a power plant, typically quantified as job-years over the plant's construction period. These jobs are often temporary, lasting only as long as it takes to manufacture the unit of power generation capacity.

[3] Based on Ram el al. (2020), Construction and installation jobs refer to all employment related to building and setting up power generation facilities, typically undertaken by the local workforce. These jobs, expressed as job-years, are concentrated in the early phase of a power plant's life cycle and span the duration of its construction and installation. The total number of full-time jobs required is annualized over the construction period and calculated per megawatt (MW) of installed capacity.

[4] Based on Ram et al. (2020), Operation and Maintenance (O&M) jobs include all employment necessary for the ongoing operation and upkeep of a power plant throughout its operational life. These long-term roles are essential for the plant's entire lifespan, often spanning decades, and are quantified as jobs per power generation capacity. As plants are decommissioned and new ones built, O&M jobs persist, adapting with technological advancements and operational efficiencies that may affect job numbers over time. This dynamic is captured by a learning factor that accounts for increases in productivity and corresponding decreases in O&M job requirements.

[5] Based on Ram et al. (2020), Decommissioning Jobs – consists of all jobs associated with the decommissioning of installed power plants at the end of their operational lifetimes, especially if plants are repowered or if certain elements are recycled or

Sources: Compiled from Ram et al. (2020) and Rutovitz (2015)

Table 5. Local Content Requirement (LCR) for Technology Type

Technology	LCR Rate
Diesel	40.81%
Coal	40.81%
Coal (w CCS)	40.81%
Coal (Adv)	40.81%
Coal (Adv w CCS)	40.81%
Gas	40.81%
Gas (Adv)	40.81%
Gas (Adv w CCS)	40.81%
Biomass	40%
BECCS	40%
Geothermal	35%
Hydro-LS	70%
Hydro-SS	70%
Nuclear	40.81%
Solar Utility-scale	40%
Solar Rooftop	40%
Wind	40%
PHS	40.81%
Li-ion Battery	40.81%

Source: Ministry of Industry, Republic of Indonesia (2023)

a detailed examination of how changes in the electricity sector influence labour markets across various industries. The I-O database used in this study is the 2016 Indonesia I-O table with 185 economic sectors.

The indirect impact represents the ripple effects that arise throughout the supply chain as a response to the direct impact of job creation by the change in electricity capacity. When jobs in the electricity sector increase, it creates additional demand for jobs in other sectors that support the activity of the electricity sector. These interactions between sectors, as traced through the I-O table, highlight the interconnected nature of the economy.

The induced impact occurs when the income generated from both direct and indirect economic activities leads to

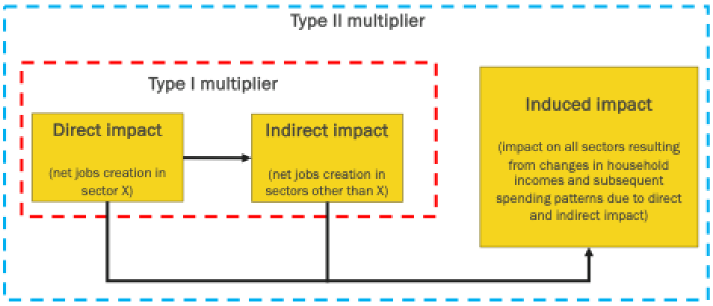

Figure 2. Input-Output Employment Multiplier

Notes: Direct impact – job creation in the electricity sector from additional capacity in the electricity sector.
Indirect impact – job creation in non-electricity sectors from additional capacity in the electricity sector.
Induced impact – job creation in all sectors resulting from changes in household incomes and subsequent spending patterns due to direct and indirect impacts.
Source: Authors' Illustration, 2024

further spending within the economy. Employees in the sectors affected by the direct and indirect impacts spend their earnings on goods and services, stimulating economic activity in other parts of the economy. This process reflects how household consumption contributes to overall economic expansion, reinforcing the broader effects of an initial economic action.

The result of direct impact from section 3.2.2 is used as a stimulus to calculate the indirect and induced impacts. The indirect impact is calculated using the employment multiplier on each economic sector with a Type I employment multiplier and a Type II employment multiplier of the I-O table. The details for each multiplier are as follows:

- Type I employment multiplier measures the direct and indirect impacts of the number of job changes in a specific sector on the economy. In detail, direct impact measures the immediate effects of the number of job changes in a sector, while indirect impact measures the ripple effects due to changes in the number of jobs in other sectors that are backwardly and forwardly linked to the sector in question. For example, if jobs in the electricity sector increase by 100, the I-O model calculation using Type I employment multiplier of 1.2 results in the total job creation of 120. Of these 120 jobs created, 100 are contributed by the direct impact and another 20 are contributed by the indirect impact.
- Type II employment multiplier includes both the direct and indirect impacts (similar to Type I) but also adds the induced impact. Induced impact is the change in the number of jobs in the economy resulting from changes in household incomes and subsequent spending patterns due to the initial change in job creation. Jobs created in the Type I employment multiplier increase the overall labour income in the economy. Consequently, there is an increase in total household consumption that creates additional demand in various sectors, such as food and beverages. This additional demand will further increase job creation in the whole economy. For example, 100 direct jobs calculated with Type II employment multiplier of 2.1 results in the total job creation of 210. Suppose 100 direct jobs created increases labor income in the economy of USD2 million. USD2 million increase in labour income will be spent by labour as household consumption. Additional USD2 million in household consumption will increase demand in various sectors of the economy, such as food and beverages and transportation. As a result, there will be an increase in job creation in the economy. Of these 210 jobs created, 100 are contributed by the direct impact, 20 are contributed by indirect impact, and 90 are contributed by induced impact.

3.2 Qualitative Approach

The qualitative approach is employed to assess the potential impact of transitioning the automotive sector from ICEV to EV. This analysis provides a preliminary examination of the transition's impact, focusing on several critical aspects: (1) the role of the automotive sector in the energy transition; (2) the interconnectedness of EV development with other relevant sectors; (3) the potential impact of transitioning the automotive sectors to the employment; (4) and the skills required for ICEV- and EV-based industries and the transition in the labor market. The analysis primarily draws on data from in-depth interviews and a focused group discussion (FGD). The interviews and FGD were conducted between September and October 2023, involving key stakeholders such as government officials, industry representatives, experts, and labor organizations (Table 4). In addition, a literature review was undertaken to provide further context and justification for the findings from the interviews and FGD.

4. Results

4.1 Projection of Net Job Creation from Decarbonizing Electricity Sector

This study aims to examine whether decarbonization can lead to a net increase in job creation. It estimates the job creation across various electricity transition pathway scenarios (BAU, CP, and PA), each representing a different energy mix and technology use. Furthermore, the study compares job creation under decarbonization scenarios (CP and PA) against the BAU scenario to determine net job creation. A positive result, where creation in CP or PA exceeds that of BAU, would indicate that decarbonization in the electricity sector fosters more jobs compared to a non-decarbonized pathway. Conversely, a negative result would suggest the opposite.

Based on Reyseliani et al. (2022), the share of RE under the BAU, CP, and PA scenarios will reach 24 percent, 31

Table 6. FGD Participants and Interviewees

Activities	Group	Stakeholders
FGD	Government	Coordinating Ministry of Economic Affairs Ministry of Manpower Ministry of Energy and Mineral Resources National Energy Council National Development Agency (Bappenas)
	Enterprises	PT Perusahaan Listrik Negara Gabungan Industri Kendaraan Bermotor Indonesia/Association of Indonesia Automotive Industries (GAIKINDO) Asosiasi Pengusaha Indonesia/ Indonesian Employers Association (APINDO)
	Labor representative	Konfederasi Serikat Buruh Indonesia/Confederation of All Indonesian Trade Unions (KSBI)
	Scholar/Expert	Faculty of Engineering, Universitas Indonesia
In-depth Interview	Government	National Energy Council Ministry of Energy and Mineral Resources
	Enterprises	Automotive Company in Indonesia
	Scholar/Expert	Faculty of Engineering, Universitas Indonesia

Source: Authors' Compilation, 2024

percent, and 50 percent, respectively. Based on our calculations, the BAU scenario will generate a cumulative total of approximately 3.19 million job-years for the period from 2020 to 2050, compared to 4.82 million in the CP scenario and 5.86 million in the PA scenario. While job creation follows a similar trend across the three scenarios, the CP and PA scenarios demonstrate more rapid growth after a certain point. The job creation in the BAU scenario is expected to increase steadily until 2050, whereas job creation in the CP and PA scenarios shows accelerated growth, particularly after 2035 (see Figure 3).

Figure 3 illustrates that more aggressive pathways lead to higher job creation in RE and lower job creation in fossil fuel-based energy. In the BAU scenario, the majority of jobs (53.9 percent) are generated by CFPPs. Similarly, in the CP scenario, CFPP remains the largest contributor to job creation, though at a reduced share of 30.5 percent compared to BAU scenario. In the PA scenario, however, CFPP jobs ranked second, with a 21.3 share. The largest source of job creation in the PA scenario is projected to be utility-scale solar PV, accounting for 53.2 percent of the total. Additionally, utility-scale solar maintains a significant share of job creation in the other two scenarios, contributing 19.1 percent in the BAU scenario and 48.9 percent in the CP scenario.

The estimation results suggest that both the CP and PA scenarios create more jobs compared to the BAU scenario. Across all scenarios, the majority of jobs are generated during the construction and installation stages (Figure 4). On average, the construction and installation stage (shown in red) accounts for 74.5 to 75.8 percent of total jobs in the power sector. In contrast, the decommissioning stage (shown in purple) contributes the least, with job creation ranging from just 0.2 to 0.6 percent across scenarios. Furthermore, manufacturing jobs (shown in blue) represent approximately 15.1 to 16.3 percent of the total, while operation and maintenance (shown in green) contribute between 8.4 to 9.8 percent.

Net job creation is measured as the difference in job creation between the CP and PA scenarios compared to the BAU scenario. In the CP scenario, the net job creation is estimated to be around 1.62 million job-years by 2050 (Figure 5), which is 50.8 percent higher than in the BAU scenario. In the PA scenario, job creation is projected to be approximately 2.66 million job-years, or 83.2 percent more than in the BAU scenario by 2050. The annual net job creation in the CP and PA scenarios are 54.1 and 88.6 thousand job-years higher, respectively, compared to the BAU scenario. However, the PA scenario shows a net job loss of about 15.4 thousand job-years during the 2020-2025 period, primarily due to the large-scale decommissioning of CFPPs. Coal technology (shown in grey) is expected to experience a job loss of 253.1 thousand job-years in the CP scenario and 1.6 million job-years in the PA scenario compared to the BAU scenario during the 2020-2050 period.

In line with the previous estimates, most net job creation in both CP and PA scenarios will occur during the construction and installation stages (Figure 6). On average, additional jobs in construction and installation (shown in red) account for approximately 75.6 percent of total net job increase relative to the BAU scenario. While there is no net job creation in the CP scenario between 2020-2025 due to no difference in installed capacity compared to the BAU scenario, the PA scenario experiences a net job loss during the same period in manufacturing, construction, and installation work.

It is estimated that net job gains in the manufacturing stage (shown in blue) will total around 257 thousand job-years in the CP scenario and 364 thousand job-years in the PA scenario by 2050. Moreover, the net job creation for construction and installation (shown in red) is projected to be 1.25 million and 1.96 million job-years in the CP and PA scenarios, respectively. For the operation and maintenance stage (shown in green), net job gains are estimated at around 111 thousand job-years in the CP scenario and 303 thousand job-years in the PA scenario. On the other hand, while there is a positive net job creation of approximately 25 thousand job-years in the decommissioning stage (shown in purple) for the PA scenario, the CP scenario is expected to experience a minimal net job loss of 47 job-years in comparison to the BAU scenario.

Besides estimating the direct impact of job creation,

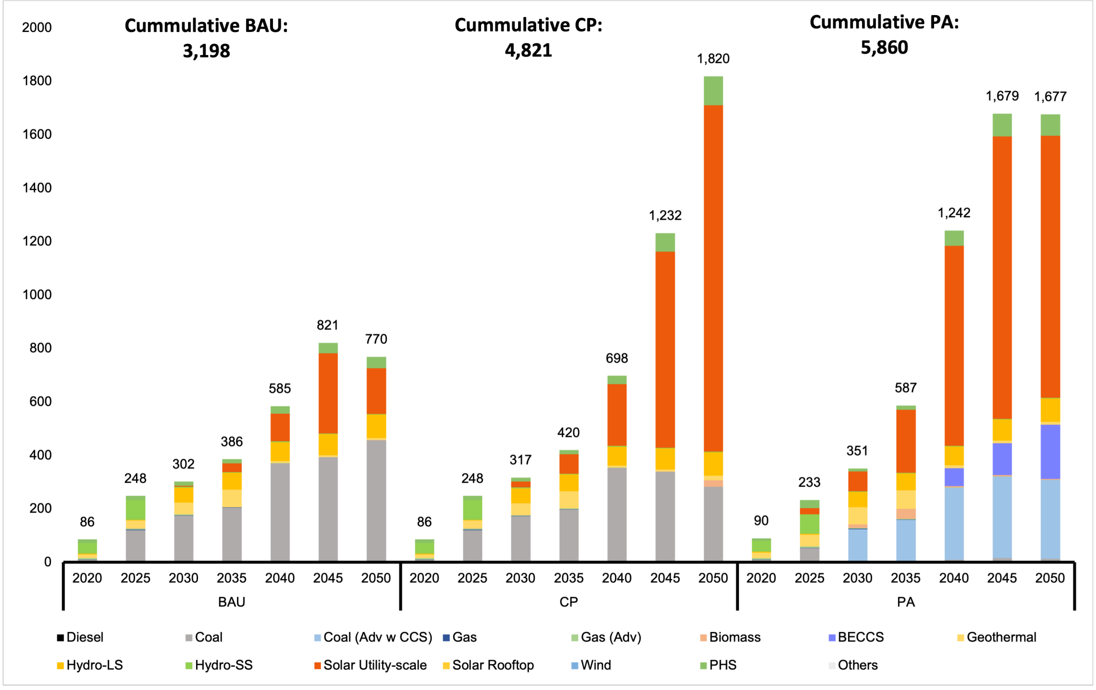

Figure 3. Direct Job Creation by Technology Type (in '000 job-years)

Notes: Technologies that are classified as others include coal (w CCS), Coal (Adv), Gas (Adv w CCS), Nuclear, and Li-ion batteries.

Source: Authors' Compilation, 2024

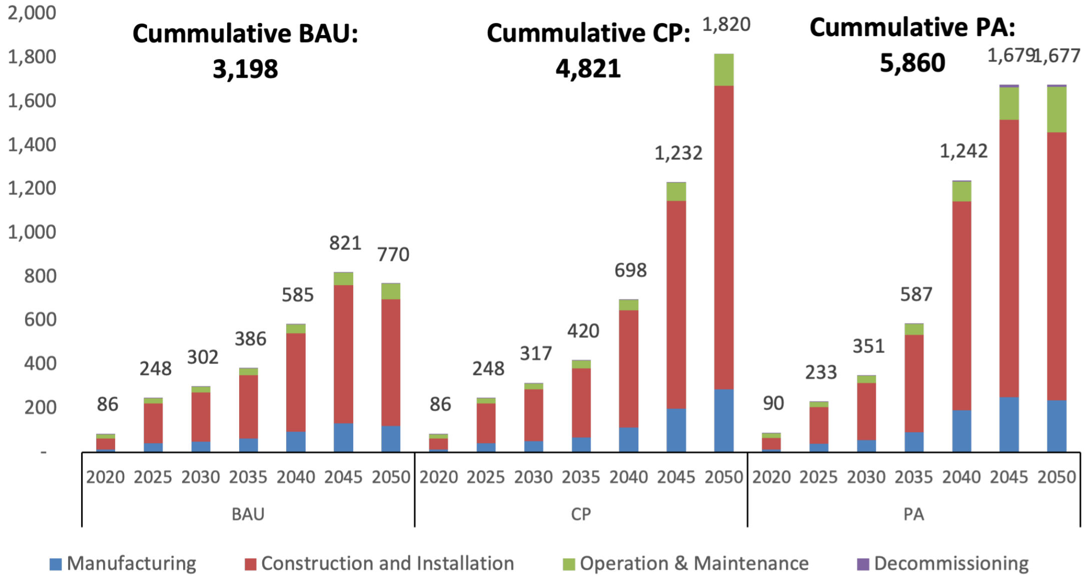

Figure 4. Direct Job Creation by Project Stages (in '000 Job-years)

Source: Authors' Compilation, 2024

the total impact on job creation in an economy is also contributed by the indirect and induced impacts. Increased installed capacity stimulates additional economic activity in other sectors linked to the power sector. Consequently, the indirect impact (additional economic activity in other sectors triggered by the electricity sector transition pathways, shown in red) generates 4.35 million job-years in the BAU scenario, 6.82 million job-years in the CP scenario, and 8.20 million job-years in the PA scenario from 2020 to 2050.

Furthermore, the additional economic activity represented by direct and indirect impacts increases labor income, which in turn boosts household spending. This increased spending leads to further economic activity and job creation, classified as the induced impact (shown in green). The induced impact is estimated to create up to 6.17 million job-years in the BAU scenario, 9.72 million job-years in the CP scenario, and 11.69 million job-years in the PA scenario cumulatively from 2020 to 2050.

As shown in Figure 7, total job creation, accounting for all impacts, is estimated at 14.07 million job-years in the BAU scenario, 22.08 million job-years in the CP scenario, and 26.46 million job-years in the PA scenario (Figure 7). Across all scenarios, the direct impact contributes to around 25 percent of total job creation, while indirect and induced

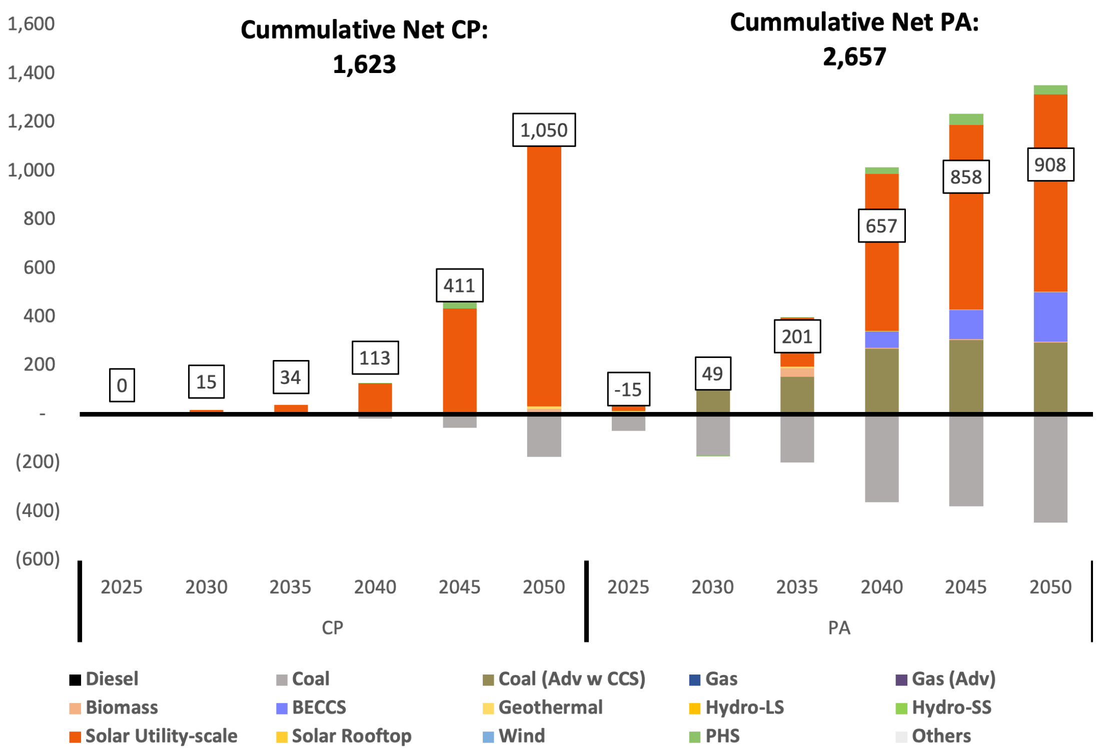

Figure 5. Direct Net Job Creation relative to BAU by Technology (in '000 Job-years)
Notes: Technologies that are classified as others include coal (w CCS), Coal (Adv), Gas (Adv w CCS), Nuclear, and Li-ion battery Net job creation: Difference of job creation in CP and PA scenarios in comparison to BAU scenario.
Source: Authors' Calculation, 2024

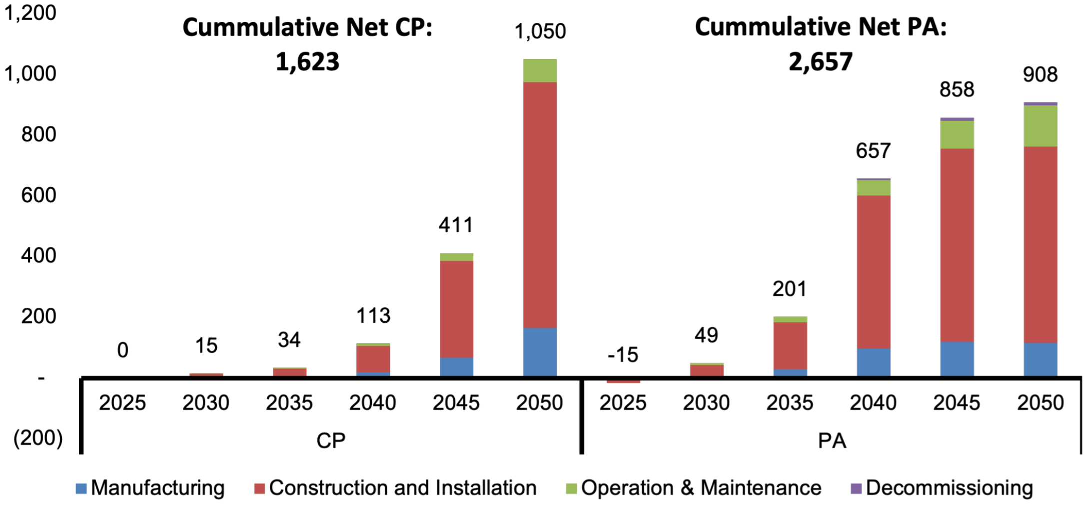

Figure 6. Direct Net Job Creation relative to BAU by Project Stages (in '000 Job-years)
Source: Authors' Calculation, 2024

impacts account for 31 percent and 44 percent, respectively.

Furthermore, the net job creation is projected to reach 7.08 million job-years in the CP scenario and 12.17 million job-years in the PA scenario (Figure 8). This net job creation stems from the indirect impact estimated at around 2.26 million job-years in the CP scenario and 3.91 million job-years in the PA scenario. In addition, the induced impact is expected to generate up to 3.19 million job-years in the CP scenario and 5.60 million job-years in the PA scenario.

While the estimates indicate net job gains for most periods, there is an expected net job loss in the PA scenario between 2020 and 2025, amounting to approximately 53.30 thousand job-years compared to the BAU scenario. Overall, the CP scenario is projected to create total job gains 235.94 thousand job-years anually, while the PA scenario is expected to create around 405.63 thousand job-years anulaly until 2050, relative to BAU.

4.2 Automotive Sector

The transportation sector plays a vital role in achieving Indonesia's decarbonization agenda. The transportation sector is the second highest emission source in energy sectors, ac-

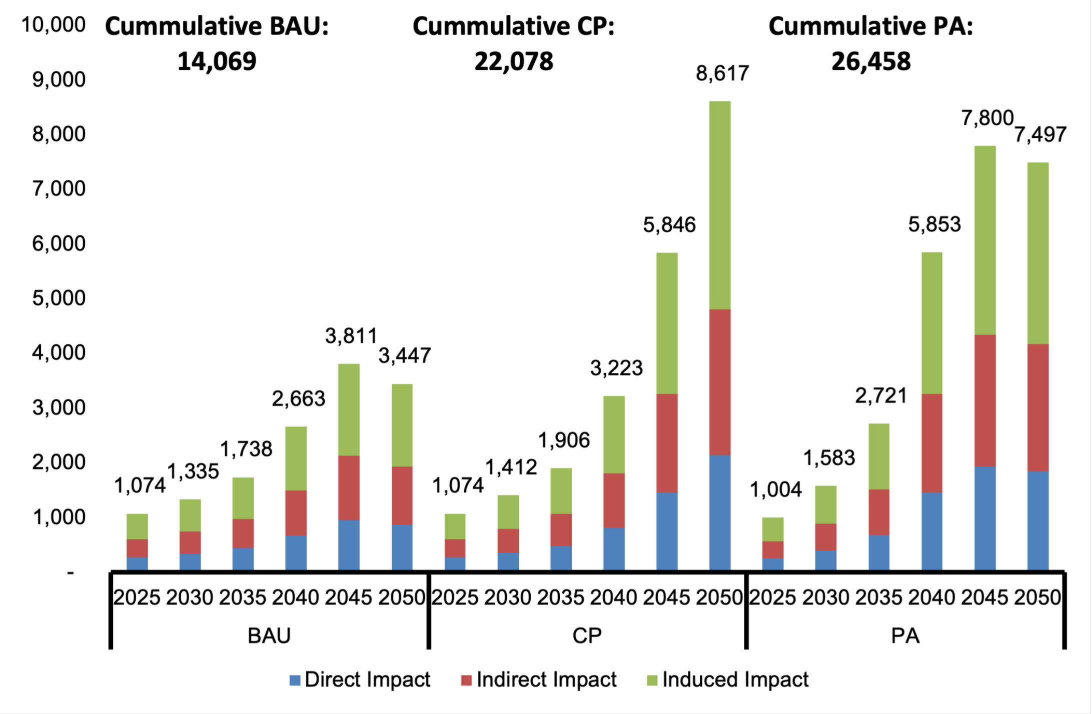

Figure 7. Direct, Indirect and Induced Job Creation (in '000 Job-years)
Source: Authors' Calculation, 2024

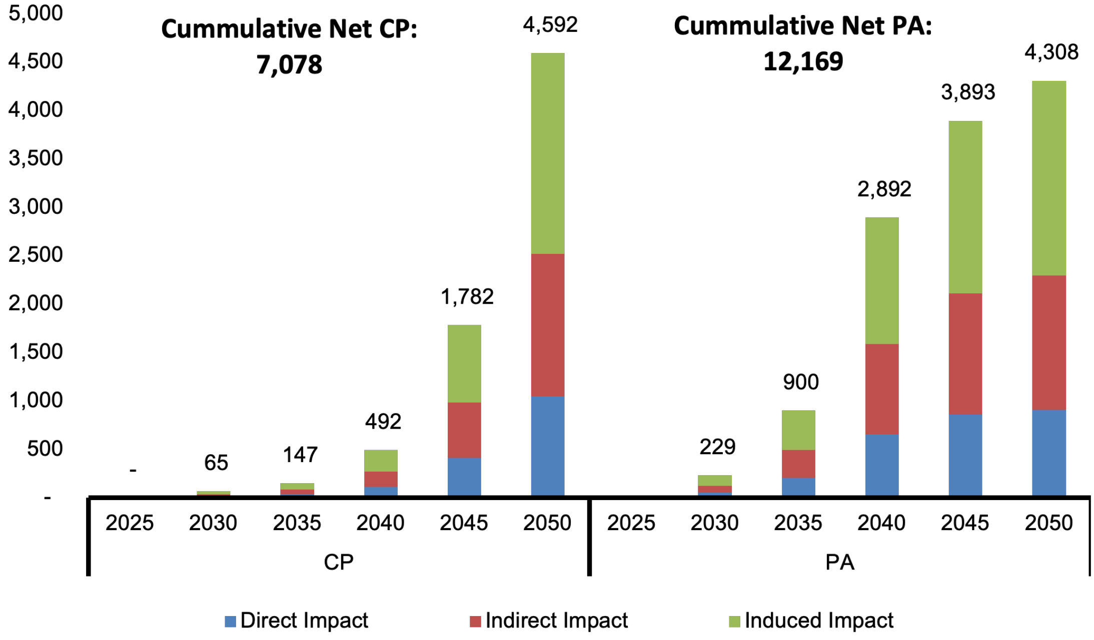

Figure 8. Net Direct, Indirect and Induced Job Creation (in '000 Job-years)
Notes: Net job creation: Difference of job creation in CP and PA scenarios in comparison to BAU scenario.
Source: Authors' Calculation, 2024

counting for 23 percent of the total energy emissions, with road transportation contributing over 90 percent of the share (MoEF, 2021). As the government aims to reduce emissions from transportation sectors, adopting EVs emerges as one of the key strategies to achieve it. In the Enhanced NDC, the government targeted to have 15.2 million units of EVs on the road by 2030. Meanwhile, in the MEMR NZE planning document, there will be no sales of ICE motorcycles starting from 2030, ICE cars from 2036, and ICE trucks and buses from 2040. The sales of EV for road transportation in 2060 are projected at 15.8 million Battery EV motorcycles, 5.46 million Battery EV cars, 2.7 million Hybrid EV cars, 0.5 million Plug-in Hybrid EV cars, 1.1 million Battery EV trucks, 367 thousand fuel cell trucks, and 38 thousand Battery EV buses.

The adoption of EVs has witnessed a notable surge in recent years. In 2022, the presence of electric two-wheelers (E2W) and electric four-wheelers (E4W) on the roads in-

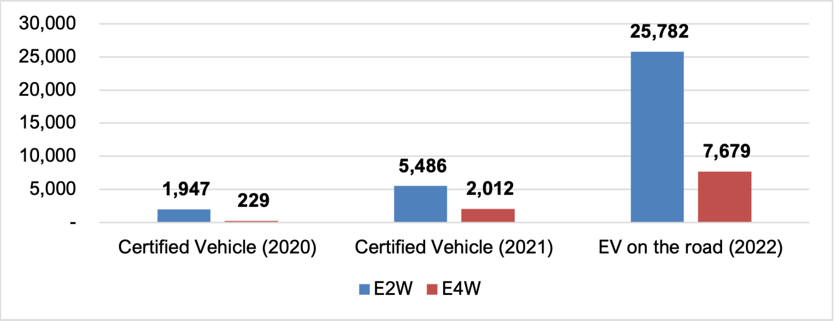

Figure 9. The Adoption of EV in Indonesia

Source: Source: Ministry of Transportation and Ministry of Energy and Mineral Resources in IESR (2023)

creased nearly fivefold and fourfold, respectively, compared to 2021 (IESR, 2023) (see Figure 3.5). Despite this substantial growth in 2022, it is important to note that the rate of EV adoption still falls significantly short of Indonesia's Enhanced NDC and MEMR NZE targets. Meanwhile, at the current production site, four companies specialize in electric buses, three in electric cars, and 35 in electric two- and three-wheeled vehicles in the country. The production capacity is 2,480 units for buses, 14 thousand units for electric cars, and 1.04 million units for electric two- or three-wheeled vehicles per year.

The implication of achieving the EV target is that it will impact the whole economy, including employment. Transitions toward EV are still debated in several pieces of literature. According to Winebrake and Green (2009) and Winebrake et al. (2017), potential net job gain from the transition from ICEV to EV will create between 162 and 863 thousand jobs in the US. Meanwhile, Kuhlmann et al.'s (2021) analysis of the European auto industry posits that about 930 thousand existing auto manufacturing and supplier jobs will disappear with the introduction of EVs by 2030, but another 895 thousand new jobs will be added. Additionally, Rajagopal (2021) also shows that there will be a decline in total employment by 19 percent in India.

In Indonesia, Pirmana et al. (2023) found that EV production creates around 538 thousand additional jobs in the economy, with 85 percent of the additional employment coming from the industries with the most significant increase such as sectors such as the sale, maintenance, repair of motor vehicles, and accessories and the wholesale trade. Another potential increase can come from the mining sector as the upstream of EV the sector. Indonesia stands unique as a manufacturing nation possessing the nickel resources required for EV batteries, and the potential to supply EV could potentially increase employment (IESR, 2023). The government supports nickel mining for EV through the Ministry of Energy and Resources Regulation No. 11/2019 concerning the nickel ore export ban with the content below 1.7 percent, which, combined with a ban on exports of high-grade nickel in 2014, brought all exports of nickel ore to a halt by Indonesia. These documents show that Indonesia is ambitious to become Asia's production hub for electric vehicles.

The limitation for Pirmana et al. (2023) is that the study only focuses on producing EVs intended only for export purposes and not to replace conventional domestic vehicles. If it is designed to replace the current domestic vehicle, there will be a significant potential job loss in the automotive sectors. The potential job loss comes from the lower labor needed for manufacturing EVs compared to ICEVs. According to one of the automotive companies in Indonesia, the ratio of labor required to produce EV compared to ICEV is 1:10. Another EV producer in the US also predicted that there would be a 30 percent reduction in labor hours per unit for EV compared to ICEV. The decrease could happen due to the declining number of laborers needed for engine and transmission manufacturing, which exceed the increase in battery and electrical equipment. The transition would also simplify maintenance with fewer components, thereby reducing the number of workers in maintenance services required.

While achieving climate targets, the transition from ICEVs to EVs is inevitable. This shift requires a different set of skills for the workforce, with a greater emphasis on areas like application and software development, which starkly contrasts with the manufacturing-heavy focus in the ICEV sector. Such a transition will likely reduce the number of labor-intensive jobs due to increased automation in EV production. This change opens up greater opportunities for women as the demand for automation and software development increases and physical and heavy labor diminishes in the EV sector. However, the shift from ICEVs to EVs may also result in a net loss of jobs, as the new skill requirements and automation processes alter the traditional employment landscape in the automotive sector.

Despite the opportunities presented, the transition towards EVs is anticipated to decrease the number of workers in the automotive sector. The government needs to take the right policy to be able to benefit from the transition and anticipate the potential losses fully. Developing a policy to facilitate re-training and re-skilling for labor in the automotive sector transitioning from ICE-based production to EV has become critical, along with providing support for displaced workers to help employees transition to new industries, in order to minimize potential economic downturns.

5. Conclusion

5.1 Summary and Policy Recommendations

Indonesia has set ambitious targets for decarbonizing its economy and must focus on the future of employment in this transition. Shifting from a fossil fuel-based economy to one powered by clean energy will open new employment opportunities. This study aims to quantify the impact of the energy transition on employment, particularly in the power and automotive sectors.

The findings of this study suggest that more aggressive electricity transition pathways, namely PA and CP scenarios, create more jobs compared to the BAU scenario. The results also indicate that job creation will primarily occur in low-carbon technology, while fossil fuel technologies will experience job losses due to the phaseout of CFPPs. Across all scenarios, most jobs are generated during the construction and installation stage, accounting for 74.5 to 75.8 percent of the total jobs created in the power sector.

In terms of net job changes, the PA scenario—the most optimistic decarbonization pathway—shows a net job loss during the early period (2020-2025), mainly due to the large-scale decommissioning of CFPPs. However, direct net job creation is substantial. When considering the total net job creation, including indirect and induced impacts, the figures are significantly larger. The indirect impact on of net job creation is estimated 40 to 47 percent greater than the direct impact, while the induced impact could be as much as 96 to 110 percent larger than the direct impact.

As for employment in the automotive sector, the impact of the energy transition appears to be mixed. Transitioning from manufacturing ICEV to EV is projected to create a significant number of jobs. Other findings support that this transition must be welcomed cautiously as manufacturing EVs is considered more capital- than labor-intensive. Higher levels of technology and fewer components mean that manufacturing EVs would demand high-skilled workers and fewer workers for manufacturing and assembly. This repercussion could happen if producers only consider the domestic market, where the scale of production remains constant. Hence, the opportunity to escape potential job losses is to increase the scale of EV production by considering export markets.

Moreover, the quality of human capital eventually needs to match up the short- and long-term energy transition demands. In the short-term, workers, especially those in disadvantaged sectors, will need smoother paths in switching to green jobs. Reskilling and upskilling are relevant in this area as they build upon the basic skills and knowledge already acquired by the workers. In the long term, we need to seek to upgrade those considered to have low skills so that they become high-skilled. Higher education and vocational education can play a pivotal role in developing programs and courses that are tailored to building the foundations and skills needed in renewable energy and green jobs. For all that, investing in improving human capital in light of the energy transition is an urgent issue that needs to be done immediately.

Energy transition poses challenges and opportunities for job creation in Indonesia. Going forward, it is essential to ensure that the welfare impact of job losses can be minimized and, at the same time, job creation opportunities in Indonesia can be optimized. This situation also presents the potential for balancing the gender aspect, particularly in terms of more participation of women in the labor market. To achieve those goals, numerous policy steps should be taken. Those policy recommendations are as follows:

1. **The Indonesian government must identify workers impacted by energy transition and develop mechanisms to support a smooth transition to other employment opportunities.** Job losses are inevitable during the energy transition process, and unemployed individuals might need help getting re-employed. Identifying impacted workers enables the government to further provide an appropriate and accurate social safety net to absorb the short-term impact of job losses. Another important form of support is to develop a mechanism that assists impacted workers in exploring local employment opportunities through job-seeking assistance or other platforms.
2. **Develop strategies to upscale on-the-job training, certification, and knowledge to improve workers' capacity for RE and other green sectors.** Indonesia's enormous planned additional capacity will require a significant number of workers. The shift from fossil fuel-powered energy to RE will demand human capital with higher analytical and technical skills. However, carbon-intensive and green jobs still bear similarities where some of fundamental skills in both types of jobs are similar. These similarities allow workers with carbon-intensive skills to attain supplementary skills for many green jobs through only on-the-job training and certification. In addition, facilitating knowledge transfer from countries with high adoption of RE also allows the Indonesian workforce to absorb specific skill sets and know-how for higher levels of technology. This process can be materialized through foreign direct investment (FDI), work exchange programs, or collaboration between local governments or companies with foreign universities or vocational schools.
3. **Integrate gender equality aspect to ensure the inclusiveness of energy transition process.** To ensure gender equality in the power and automotive sector, the Indonesian government should increase women's participation in STEM education through affirmative scholarships, implement inclusive hiring practices, create supportive work environments, establish a gender quota, offer incentives for inclusive companies, and promote gender mentorship programs.
4. **Encourage collaboration and participation of various stakeholders to address job issues during the energy transition.** Involving stakeholders, such as the university, private sector, civil society, labor union, and research institute, will be useful in identifying multidimensional issues brought by energy transition in the context of jobs. On the other hand, stronger commitment and more action from important government stakeholders in just energy transition, particularly the MoM, Ministry of Social Affairs (MoSA), and Ministry of Education (MoE), will be needed for better coordinated national policies responding to the implications of energy transition on employment.

5.2 Limitations

This study acknowledges several limitations and opportunities for further studies as follows:

1. **This study limited the scope of the quantitative analysis to the impact of the transition in the power generation sectors.** The power sector accounted for more

than 50 percent of energy emissions and is thus one of the most significant sectors to prioritize to achieve Indonesia's climate target. The power sector is also the most "practical" to be decarbonized compared to other sectors. Additionally, the power sector data in Indonesia is available with a sufficient level of granularity to be utilized for analysis. Further studies should cover energy and industry sectors in broader terms to generate a more comprehensive image of the impact of energy transition. The automotive sector as a downstream industry is discussed within this study without detailed elaboration on its relations with the power sector.

2. **The employment factors utilized in this study are adjusted to the non-OECD countries.** Further studies can seek to develop country-specific employment factors, as regional-based employment factors tend to generalize the characteristics of different countries and assume uniformity. Given the variation in technological development, regulations, and geographical features across countries within a region, regional-based parameters may lead to inaccurate estimates.
3. **Limited data prevent a quantitative analysis of the automotive sector and the skillsets required for the energy transition.** The analysis of the impact of this transition on the sector is constrained by the use of qualitative methods, as exercised in this study. The complexity of project value chains requires detailed data on both manufacturers and their suppliers. Additionally, data on the necessary skills for the transition are unavailable, hindering accurate estimates of Indonesian workers' potential absorption into green sectors. Therefore, further efforts should focus on enriching the industrial database, particularly in project value chains and skillsets required for energy transition-related occupations. Green industrialization must be supported by more accurate data to enable better monitoring, review and human capital development.

Analyzing the impact of the energy transition on employment requires several key steps to improve estimates and support future research and policymaking. First, a comprehensive, cross-cutting database on energy transition, industrial development, and employment must be established to support in-depth studies. Second, immediate investment in human capital is crucial to equip workers with the skills needed to adapt to new technologies and production methods. Third, the government must create a strategy to anticipate the employment impacts of the energy transition, ensuring stakeholder buy-in and improved coordination.

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