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Tripling Renewables and Doubling the Pace of Efficiency Improvement by 2030 in Indonesia

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Suggested Citation
Agus P. Sari, Putri A. Agustina, Jiehong Lou, Dwiputra Ramdani (November 2024). "Growing Strong, Growing Green, Growing Renewables: Tripling Renewables and Doubling the Pace of Efficiency Improvement by 2030 in Indonesia." Landscape Indonesia, Jakarta; Indonesia. Center for Global Sustainability, University of Maryland, College Park, USA.

Acknowledgements
This study was funded by grants from Sequoia Climate Foundation and Center for Global Sustainability, University of Maryland, USA. We appreciate experts from CGS, UMD, among others Nate Hultman and Thomas Hilde for their input We also appreciate of the speakers in the consultative workshop, which are Egi Suarga (Worl Resource Institute Indonesia), Alin Halimatussadiah (IndonesianClimate Modeling & Policy Hub (ICLIMB)), Putra Adhiguna (Energy ShiftInstitute), Paul Butarbutar (Just Energy Transition PartnershipSecretariat), Medrilzam (Ministry of National DevelopmentAgency/Bappenas), Raden Raditya Yudha Wiranegara (Institute forEssential Services Reform) and Ardhi Wardhana (Centre for Strategicand International Studies) for their beneficial input. And for theIndonesian Climate Modeling and Policy Hub (ICLIMB) and WorldResource Institute Indonesia for co-organizing the consultativeworkshop to gain inputs from experts.

November 2024

Executive Summary

As climate change accelerates and global greenhouse gas emissions continue to rise, Indonesia faces significant challenges in transitioning to a sustainable energy system. At COP28 in Dubai, 133 nations pledged to triple renewable energy capacity and double energy efficiency by 2030. However, Indonesia did not commit to this pledge.

Indonesia's energy system remains heavily carbon-intensive, with renewable energy sources vastly underutilized, and only 1.9% of the country's immense renewable energy potential has been tapped. While the 2021-2030 RUPTL outlines increased ambitions for renewables, it simultaneously includes plans for significant coal expansion, resulting in an energy mix that could lead to higher overall emissions. Indonesia is struggling to align its energy transition ambitions with short-term renewable energy commitments. Even with plans for renewable energy expansion, these efforts are overshadowed by the equally large expansion of coal-fired power plants, which undermines progress toward decarbonization.

This report evaluates Indonesia's capacity to address these challenges and meet ambitious energy transition goals while considering its unique economic, energy, and social contexts. It employs a system dynamics model originally developed by the Ministry of National Development Planning under its Low-Carbon Development Initiative (LCDI) to analyze potential pathways and policy implications.

Key Findings:

- In the Business as Usual (BAU) scenario, increased production demands will require greater energy input to fuel economic growth, with fossil fuels continuing to dominate the energy mix while renewables remain underdeveloped.
- Under BAU, the 8% economic growth rate scenario is projected to create up to 10 million additional jobs between 2028 and 2029. However, this growth comes with higher energy demand, increased final energy consumption—led by the industrial sector—and significantly higher emissions.
- The BAU scenario predicts a tripling of renewable energy capacity, from 11 GW to 36 GW by 2030. However, fossil fuel capacity, particularly coal, is expected to grow even faster, doubling from 58 GW to 116 GW, overshadowing renewable energy progress.
- The Just Energy Transition (JET) scenario demonstrates a more ambitious path, achieving a 30% reduction in emissions compared to the baseline, with emissions potentially dropping to near zero by 2060.
- In the JET scenario, solar energy becomes the dominant source of electricity by 2060, unlike the BAU scenario, where coal remains the primary source. Doubling the rate of energy efficiency improvements also reduces electricity demand by half.

- Transitioning from fossil fuels to renewables brings substantial economic and social benefits, including increased investment opportunities, job creation, poverty reduction, and improved quality of life through reduced air pollution.
- For Indonesia, tripling renewable energy capacity by 2030 is already part of the baseline scenario. The real challenge lies in limiting the expansion of coal-fired power plants, which threatens to undermine decarbonization efforts.
- A gradual rollout of JET policies starting in 2025 could cover up to 40% of renewable energy investments by reallocating fossil fuel subsidies and implementing an effective carbon market. A workforce strategy integrating green skills into education and engaging the private sector is key to driving employment in renewable energy sectors like manufacturing, installation, and maintenance.

1 Introduction and Context

1.1 The Imperatives of Tripling Renewables and Doubling Efficiency

The 2015 Paris Agreement sets an objective to keep global heating well below 2°C while pursuing efforts to keep it not to exceed 1.5°C.[1] As global emissions continue to rise, there is a deep-seated concern that the world may miss these objectives or at least meeting them through a significant overshoot. But impacts have already been felt around the world in developed and developing countries alike. As such, ambitions to reduce emissions need to not only be renewed but raised.

In Dubai in 2023, 133 countries around the world made an ambitious pledge to triple renewable energy capacity, or at least 11,000 GW, and double the pace of efficiency improvement from two to four percent by 2030. This pledge was made at the 28th Conference of the Parties (COP28) of the United Nations Framework Convention on Climate Change (UNFCCC) in Dubai, United Arab Emirates, in November 2023. By now, 133 countries have signed up to the pledge. This is a global pledge made earlier by the G20 in September 2023.[2] This pledge was formulated based on the analysis made by the International Energy Agency (IEA) and the International Renewable Energy Agency (IRENA) to keep the windows of achieving the objective of the Paris Agreement open.[3] Moreover, prior to COP28, at the G20 Summit in India,

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[1] UNFCCC (United Nations Framework Convention on Climate Change), 2015. Paris Agreement; UNFCCC, 2023. Global Renewables and Energy Efficiency Pledge. https://www.cop28.com/en/global-renewables-and-energy-efficiency-pledge, accessed on July 31, 2024.

[2] Patel, S., 2023. "G20 agrees to pursue tripling renewables capacity but stop short of major goals", *Reuters* (September 11, 2023).

[3] Cozzi, L., P. Frankl, Wanner, B., Bahar, H., and Spencer, T., 2023. "Tripling renewable power capacity by 2030 is vital to keep the 1.5°C goal within reach" International Energy Agency (IEA) (July 21, 2023), https://www.iea.org/commentaries/tripling-renewable-power-capacity-by-2030-is-vital-to-keep-the-150c-goal-within-reach, accessed on July 31, 2024; IRENA (International Renewable Energy Agency), 2023; "G20 Leaders Endorse IRENA Recommendations for Global Renewable Energy Adoption" (September 11, 2023),

leaders of the G20 countries issed a declaration to "pursue and encourage efforts to triple renewable energy capacity globally through existing targets and policies, as well as demonstrate similar ambition with respect to other zero and low-emission technologies, including abatement and removal technologies, in line with national circumstances by 2030".[4]

The world is already heating very rapidly at an unprecedented rate. July 22, 2023, was already noted as the hottest day on record, beating the second hottest day only the day before. Figure 1.1 below shows the runaway heating of the world until July 22, 2024.[5]

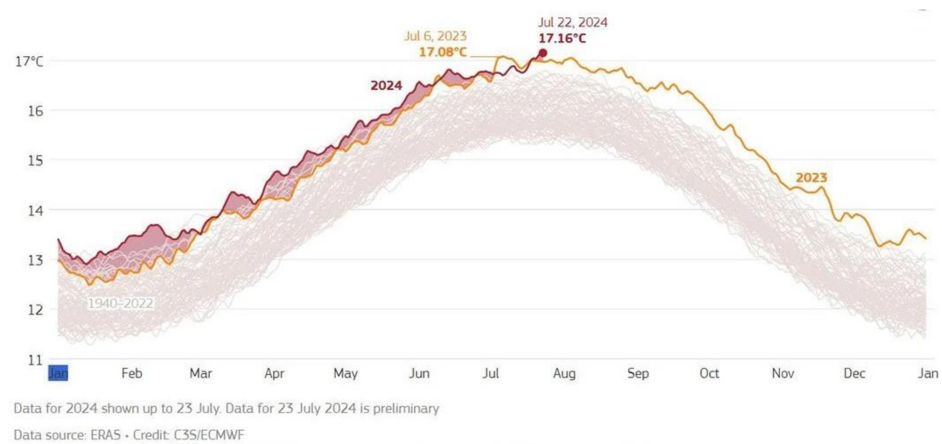

Figure 1.1: July 22, 2024, was the hottest day on record, beating the second hottest day on record on the day before on July 21, 2024. Source | Copernicus Climate Change Service (July 25, 2024).

The runaway global heating is induced by the ever-increasing emissions of greenhouse gases, notably from burning of fossil fuels. The Intergovernmental Panel on Climate Change (IPCC), in its Sixth Assessment, already reported that "human activities, principally through emissions of greenhouse gases, have unequivocally caused global warming".[6] To increase the likelihood of limiting global heating not to exceed 1.5°C as stated in the Paris Agreement, emissions need to peak before 2025, halved by 2030, and achieved net zero by mid-century (about early 2050s) followed by negative

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https://www.irena.org/News/pressreleases/2023/Sep/G20-Leaders-Endorse-IRENA-Recommendations-for-Global-Renewable-Energy-Adoption.

[4] Ministry of Foreign Affairs of the Republic of India, 2023. G20 New Delhi Leaders' Declaration (New Delhi, India, September 9-10, 2023). Ministry of Foreign Affairs of the Republic of Indonesia, New Delhi.

[5] "New record daily global average temperature reached in July 2024", Copernicus Climate Change Service (July 25, 2024).

[6] IPCC (Intergovernmental Panel on Climate Change), IPCC, 2023. Summary for Policy Makers, in Lee, H., and J. Romero (eds.), *Climate Change 2023: Synthesis Report. Contribution of Working Groups I, II, and III to the Sixth Assessment Report of the Intergovernmental Panel on Climate Change*. Intergovernmental Panel on Climate Change, Geneva.

emissions.[7] However, up until today, emissions continue to increase. In 2023, yearly global emissions from burning of fossil fuels have reached an all-time high of almost 54 billion (giga) tons of carbon dioxide-equivalent (GtCO2e).[8] China leads global emissions in 2023 at almost 14 GtCO2e (about 26 percent of global emissions) followed by the US at almost 6 GtCO23 (about 11 percent).

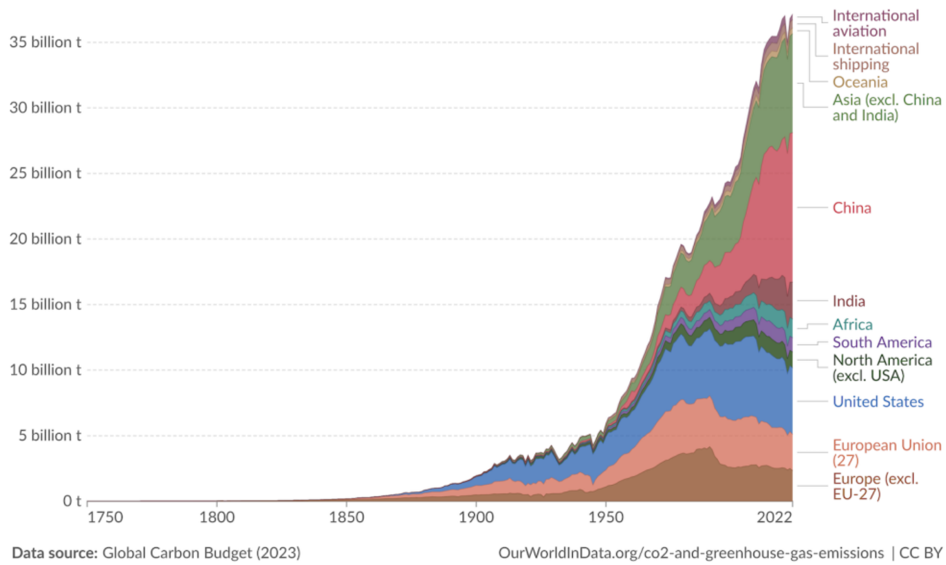

Figure 1.2: Global emissions of greenhouse gases continue to increase especially in the energy sector. By 2022, total emissions from burning fossil fuels globally reached 37 GtCO2e. Source | World in Data.

Despite apparent progress, transitioning away from fossil fuels to renewables has not been at the pace required to reach the 1.5°C target. Given that the energy sector contributes massive amounts of emissions to the global greenhouse gases accumulations in the atmosphere, , it is important to ensure that world energy systems transition rapidly and massively from fossil fuels to renewables. Keeping heating below 1.5°C requires reducing emissions by 37 GtCO2e from 2022 levels to keep it on track towards net zero by 2050. Current trajectory sees a gap of 16 GtCO2e in 2050. Energy-related emissions gap will reach 34 GtCO2e in 2050. Meanwhile, renewables need to be deployed more expansively than today. While 83 percent of new capacity installed in 2022 — about 300 Gigawatts (GW) — was renewables, more is needed. Annual deployment needs to achieve more than three-fold, at 1,000 GW.[9]

1.2 Indonesia: Coping with the Climate Crisis

Amid the challenge of the pandemic, Indonesia came at the other end relatively strong. Through Government Regulation No. 23/2020 on the

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[7] *ibid*.
[8] World in Data. https://ourworldindata.org/co2-and-greenhouse-gas-emissions.
[9] IRENA (International Renewable Energy Agency), 2023. *World Energy Transition Outlook 2023*. International Renewable Energy Agency, Abu Dhabi.

National Economic Recovery, the Government of Indonesia allocated more than Rp1,200 trillion (more than $85 billion in U.S. dollars), which is more than half of the government's yearly budget, to address the economic hardship during the pandemic. This includes health support, social safety net, some priority programs, support for micro, small, and medium-scale enterprises, and incentives for businesses.[10] In 2021, despite the pandemic, the economy grew at 3.7 percent and was expected to get back up to 5.2 percent in 2022.[11]

Indonesia has very recently carried out a successful, peaceful, and democratic transfer of government from President Joko "Jokowi" Widodo (2019-2024) to President Prabowo Subianto (2024-2029). The new government increased its economic growth ambition to eight percent, up from the usual five percent in the past ten years of its predecessor, or 6 – 7 percent in most recent development plan assumptions. Among the key prerequisites to achieving such a high economic growth ambition are eradication of poverty and creating more jobs. The high growth is especially necessary to achieve Indonesia's long-term objectives to avoid the middle-income trap and to shoot the economy into a high-income one by 2045 when the country commemorates its 100th independence anniversary.[12] A green economy is now key to achieving that ambition, according to the Asta Cita, or Eight Aspirations in the vision and mission of the new government.

Indonesia is committed to reducing emissions by about 32 percent with own resources and 43 percent with international cooperation by 2030. Its Enhanced Nationally Determined Contribution (NDC), as submitted to the UNFCCC on September 23, 2022, sees that emissions would increase from 1.3 GtCO2e to about 2.9 GtCO2e without any mitigation policy (the "business as usual", BAU, scenario) by 2030. With climate mitigation policies and actions, emissions will be reduced to 1.9 GtCO2e with own resources (the CM1 scenario) and 1.6 GtCO2e with international cooperation (the CM2 scenario) by 2030.[13] Indonesia is currently developing its Second NDC extending its commitments to 2035, calculating emissions against those in 2019 as the base

[10] MOF (Ministry of Finance of the Republic of Indonesia), 2022. "Menkeu: Kebijakan PEN 2022 Responsif dan Fleksibel" (August 28, 2021).

[11] World Bank, 2021. *Indonesia Economic Prospects: A Green Horizon: Toward a High Growth and Low Carbon Economy*, Indonesia Economic Prospects (December 2021). The World Bank, Jakarta; World Bank, 2022. *Trade for Growth and Economic Transformation*, Indonesia Economic Prospects (December 2022). The World Bank, Jakarta.

[12] "Prabowo sets ambitious 8 percent growth target for Indonesia", *Antara* (July 19, 2024).

[13] RI (Republic of Indonesia), 2022. *Enhanced Nationally Determined Contribution: Republic of Indonesia* (September 23, 2022). Ministry of Environment and Forestry, Jakarta. As this paper is being written, the process to develop the Second Nationally Determined Contribution (NDC) remains ongoing. The Second NDC is due to be reported to the UNFCCC in February 2025.

year instead of against a theoretical business-as-usual, and adding marine sector and additional gases.[14]

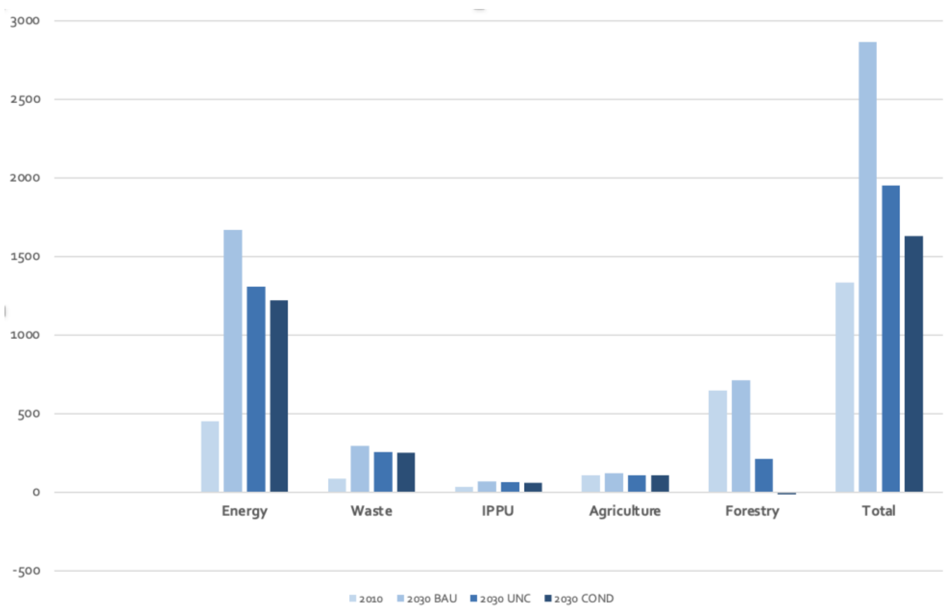

Figure 1.3: Enhanced Nationally Determined Contribution of Indonesia shows that total emissions will be dominated by the energy sector. Source: RI, 2021.

Indonesia is also committed to achieving net zero emissions by 2060 or earlier. While there is no policy depicting this commitment, it has already been stated in the Enhanced NDC that was submitted to the UNFCCC in 2021.[15] The Indonesia Long-Term Strategy for Low Carbon and Climate Resilience, also submitted to the UNFCCC, shows the different scenarios to achieve net zero, including one that is consistent with achieving the objective of the Paris Agreement.[16]

Energy is a strategic sector that will dominate future emissions in Indonesia. Figure 1.3 above shows that, from 0.45 GtCO2e (second only to 0.65 GtCO2e in the forestry and other land uses, FOLU, sector) in 2010, the energy sector will clip the FOLU sector to dominate emissions at 1.6 GtCO2e, about 58 percent of total emissions in 2030. Emissions from the energy sector will need to be reduced to 1.3 GtCO2e (67 percent of total emissions) with own resources and 1.2 GtCO2e (75 percent) with international cooperation, by 2030.[17] FOLU sector, being the sector with the highest emissions at 0.6 GtCO2e in 2010, appears to have been under control with the 2030 net sink FOLU target, turning the sector into carbon sink starting with -0.015 GtCO2e in

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[14] MOEF (The Ministry of Environment and Forestry of the Republic of Indonesia), 2024. "Siapkan Second NDC, Indonesia Perkuat Komitmen Atasi Dampak Perubahan Iklim" (April 22, 2024).
[15] RI, 2022, *op cit*.
[16] RI, 2021. *Indonesia: Long-Term Strategy for Low Carbon and Climate Resilience 2050*. Ministry of Environment and Forestry, Jakarta.
[17] *ibid*.

the NDC, even enhanced to -0.14 GtCO2e in 2030.[18] In the past decade, however, deforestation in Indonesia has indeed been significantly reduced by almost 90 percent, leading to a massive reduction of emissions from deforestation. This marked performance in the FOLU sector leaves the energy sector to catch up with even more massive transition to low-carbon sources, especially renewables.[19]

But emissions appear to continue increasing in the near future. In 2022, Indonesia emitted about 2.1 GtCO2e from about 1.6 GtCO2e in 2000.[20] Emissions are expected to continue increasing until 2030 and beyond. As Figure 1.4 below depicts, emissions in 2020 dropped from that in 2019 due to the pandemic, but steadily increased again to 2022.

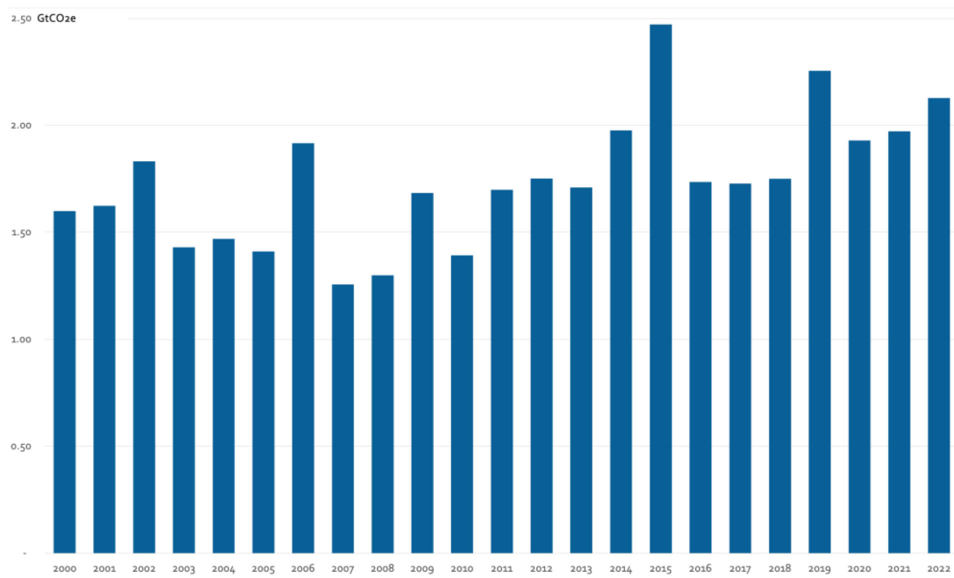

Figure 1.4: Indonesian carbon dioxide-equivalent greenhouse gas emissions, 2000-2022. Source: International Energy Agency (IEA) Database.

Indonesia is struggling with its energy transition ambitions and is abandoning its short-term renewable commitment. Through the Presidential Regulation No. 79/2014 on the National Energy Policy, which was further regulated through the Presidential Regulation No. 22/2017 on the National General Energy Plan (Rencana Umum Energi Nasional, RUEN), Indonesia was committed to increasing the share of renewables in its energy mix to 23 percent in 2025 and 31 percent in 2050. Unfortunately, with only 13 percent contribution to the total energy mix in 2024, it is difficult to see the

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[18] MOEF (Ministry of Environment and Forestry of the Republic of Indonesia), 2022. Operational Plan: Indonesia's FOLU Net Sink 2030, Decree of the Minister of Environment and Forestry No. 168/2022 (February 24, 2022). Ministry of Environment and Forestry of the Republic of Indonesia, Jakarta.
[19] WRI (World Resources Institute), Global Forest Watch. https://www.globalforestwatch.org/dashboards/country/IDN/?map=eyJjYW5Cb3VuZCI6dHJ1ZX0%3D, accessed on August 1, 2024.
[20] IEA (International Energy Agency) Database.

share of renewables being increased almost two-fold to 23 percent by 2025 in only one year. The government has already watered down the national ambition to increase renewable share to about 17-19 percent by 2025.[21]

1.3 Evaluating the implications of the possibility of tripling renewables and doubling the pace of efficiency improvement using system dynamic model

With 133 countries making significant collective pledges on energy, Indonesia faces a crucial question: Can Indonesia triple its renewable capacity and double the pace of its efficiency improvement to align with these ambitious goals? What would be the implications for Indonesia if it took on this challenge? Achieving these targets would of course demonstrate Indonesia's commitment to a sustainable future, but meanwhile it would also necessitate transformative shifts across its energy, economic and social landscapes. Therefore, such an ambitious agenda brings both opportunities and challenges. On one hand, advancing renewable energy could attract substantial foreign investment, create green jobs, and reduce dependency on fossil fuels, supporting Indonesia's long-term economic growth. On the other hand, the transition may require substantial financial resources, policy reform, grid reform, and social adaptation, particularly in coal-dependent regions.

This paper evaluates the options, possibilities, and implications for Indonesia to join the global pledge to triple the capacity of renewables and double the efficiency announced at COP28 in Dubai, United Arab Emirates, in 2023. Increasing Indonesia's energy transition ambitions will lead to additional demand for investments, which will increase economic growth in the electricity sector by an additional 0.4 percent. The actual impact on the economy may be even higher, however, due to indirect and induced multiplier effects on other economy sectors, which are not within the scope of this paper.

This paper utilizes a system dynamic model originally used by the Ministry of National Development Planning under its Low-Carbon Development Initiative (LCDI). Some adjustments are made to simplify the model, to allow for different assumptions, and minor modifications to allow for additional relationships among the variables and parameters in the model. The model uses the National Electricity Supply Business Plan (RUPTL) 2021-2030 as the business-as-usual (BAU) scenario to represent renewable energy development trajectories, alongside policy scenarios, the JET scenarios, from the Comprehensive Investment and Policy Plan (CIPP) under Indonesia's Just Energy Transition Partnership (JETP). While the BAU scenario already forecasts a tripling of renewable electricity capacity, the question remains: from Indonesia's perspective, will tripling renewables be sufficient to align our climate actions with a 1.5ºC trajectory?

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[21] Karyza, D., 2024. "Indonesia to abandon 23% renewable energy target by 2025", *The Jakarta Post* (January 16, 2024).

2 The Road to Net Zero in the Electricity Sector in Indonesia

2.1 Greening the Energy Sector

Indonesia is a success story of economic development. Indonesia has graduated to upper-middle income country in 2023. In 2019, Indonesia already graduated, but the pandemic brought it back to lower-middle income country in 2020. In 2022, immediately after the pandemic, Indonesia's economic growth already recovered at 5.31 percent.[22] In 20 years, per capita income has increased by more than 6.5 times due to maintained economic growth 5-6 percent in the past 20 years (2005-2025). Poverty rate decreased to less than 10 percent today while contribution of eastern Indonesia increased to 21.5 percent.[23]

Indonesia begins with a challenging situation with an energy system that is heavily carbon intensive. Due to the rapid economic growth, energy demand is increasing. With an increasing role of coal-fired power plants (CFPP), it is increasingly carbon intensive. In 2021, about two thirds of electricity in Indonesia was generated by CFPP while renewables contributed only about 19 percent, as Figure 2.1 below shows.[24]

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[22] Belinda, Y., 2023. "Indonesia returns to upper-middle income status", *The Jakarta Post* (July 5, 2023).
[23] RI (Republic of Indonesia), 2024. *Rencana Pembangunan Jangka Panjang Nasional 2025-2045*, Law No. 59/2024. Ministry of National Development Planning of the Republic of Indonesia, Jakarta.
[24] Enerdata, 2024. *Country Energy Report: Indonesia*. Enerdata, Jakarta.

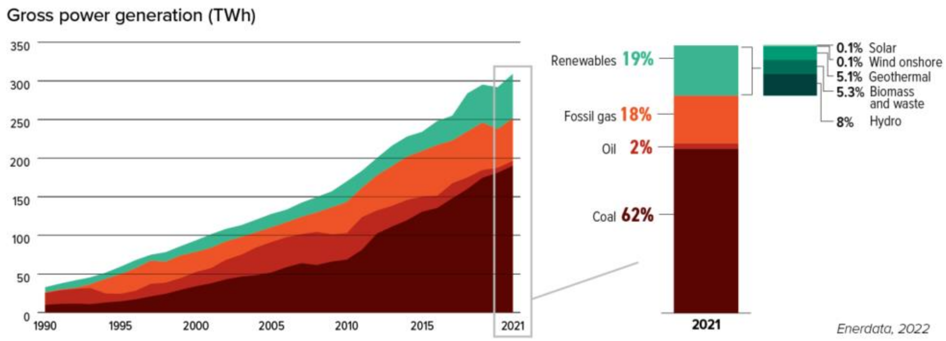

Figure 2.1: Energy mix in the electricity system in Indonesia is increasingly more carbon-intensive due to the growth of coal-fired power plants.

Indonesia has devised what has been coined as a "green" electricity expansion plan. In Indonesia, electricity business nationwide is carried out monopolistically by Perusahaan Listrik Negara (PLN, the state-owned electricity company). Periodically, PLN devised its business plan, called the Business Plan for Electricity Generation (Rencana Usaha Pembangkitan Tenaga Listrik, RUPTL). The latest (2021-2030) RUPTL as formalized by the Decree of the Minister of Energy and Mineral Resources No. 188/2021 on the Business Plan for Electricity Generation has been coined as the "Green RUPTL" for its ambition to develop renewables. The RUPTLwas devised in the aftermath of a global pandemic that led to uncertain demand. In this document, electricity demand growth is expected to be 4.9 percent per year, lower than the previous RUPTL (2019-2028) that had been expected to be 6.4 percent.[25]

The proliferation of the use of electric vehicles is a positive trend but increases demand for electricity. From less than 800 units sold in 2020, the sales of EV are expected to grow to almost 40,000 in 2024, a 50-times growth. It will increase electricity demand to almost 150 GWh in 2024 from EV alone. As such, in addition to more substantial adoption of electric vehicles, renewables need to increasingly dominate the energy system needs to be increasingly.

Coal needs to peak in 2030 and reach zero by 2060. The 2021-2030 RUPTL is expected to increase the installed capacity of renewables in the electricity sector by 20.9 GW cumulative until 2030. Meanwhile, the draft RUPTL (2024-2033) sets an even higher target, planning for 31.6 GW of renewable capacity additions between 2024 to 2033. With this trend, emissions from the electricity sector will increase from 264 MtCO2e in 2020 to 349 MtCO2e in 2030. The 2021-2030 RUPTL recognizes that emissions need to peak by 2030 and decrease to net zero by 2060 following the government's commitment.

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[25] PLN (State-Owned Electricity Company), 2021. *Rencana Usaha Pembangkitan Tenaga Listrik 2021-2030*, Keputusan Menteri Energi dan Sumberdaya Mineral No. 188/2021.

The RUPTL has stated that PLN will prioritize the development of renewables to reduce emissions and to achieve Indonesia's NDC. Following the minimum target of 23 percent renewables by 2025, PLN projects an increase in renewable capacity.

Indonesia houses a substantial number of renewables. However, renewable sources have been underutilized. In 2015, from the apparent potential of more than 400 billion (giga) watt (GW), Indonesia only utilized 8.2 GW, or only about 1.9 percent.

	Potential (MW)	Installed Capacity (MW)	Utilization rate (percent)
Geothermal	29,544	1,438.5	4.9
Hydro power	75,091	4,826	6.4
Mini and micro hydro power	19,385	197.4	1.0
Bioenergy	32,654	1,671.0	5.1
Solar (4.8 kWh/m2/day)	207,896	78.5	0.04
Wind	60,647	3.1	0.01
Ocean	17,989	0.3	0.002
Total	**443,208**	**8,215.5**	**1.9**

Table 2.1: Utilization of renewables in Indonesia remains very low. Source: RUPTL 2021-2030.

In the RUPTL 2021-2030 ("Green RUPTL"), electricity sales are projected to grow at 5.2 percent between 2024 and 2025. To follow this projected demand, about 40.6 GW new capacity would be added by 2030 to increase installed capacity from 63.3 GW to about 99.2 GW in 2030.[26]

	RUPTL		
	2019-2028	**2021-2030**	
	2030	**2025**	**2030**
Annual growth of electricity sales (percent)	6.4	5.2	6.4
Capacity addition (GW)	56.0	26.9	40.6
Energy mix			
• Renewables	23	23	24.8
• Gas	22	15.6	15.4
• Coal	54.6	61.0	59.4
• Oil	0.4	0.4	0.4

Table 2.2. Summary of the electricity expansion plan in the RUPTL 2021-2030 shows that renewables will contribute 24.8 percent, about 28.9 GW, of total installed capacity in 2030, an increase from 7.95 GW in 2020. This plan has already shown a tripling of renewable capacity between 2020 and 2030. Source: PLN, 2021.

[26] *ibid*.

	2020	2030	Addition
Coal			
• Installed capacity	31,952	44,726	13,819
• Share	50	45	34
Gas			
• Installed capacity	23,438	25,613	5,833
• Share	37	26	14
Hydro Power			
• Installed capacity	5,178	15,565	10,391
• Share	8	15	20
Geothermal			
• Installed capacity	2,443	5,798	3,355
• Share	4	6	8
Solar			
• Installed capacity	—	4,680	4,680
• Share	—	5	12
Other renewables			
• Installed capacity	329	1,817	1,487
• Share	1	2	4
Other renewables for base-load			
• Installed capacity		1,010	1,010
• Share		1	2

Table 2.3: expansion of power plants in Indonesia according to the 2021-2030 RUPTL that increases the share of renewables rapidly from 12 percent in 2020 to 46 percent in 2030. Source: PLN, 2021.

While the ambition for renewables is higher in the 2021-2030 RUPTL, the expansion of coal is also higher, resulting in increased overall emission from the energy mix.. The total capacity of renewables will have increased from about 8 GW in 2020 to about 20.9 GW in 2030. This means that the tripling of renewable capacity will have been achieved when the expansion plan is duly implemented through an additional installation of 26 GW of renewables, or about 40 percent of the new capacity in the 10 years period. Unfortunately, the massive expansion plan will be followed by a similarly massive expansion **in** coal-fired power plants. From 31.8 GW in 2020, coal-fired power plants will expand to about 44.7 GW in 2030 through additional installed capacity of 13.8 GW. As a result, the share of renewables increases only from 23 percent in 2025 to 24.8 percent in 2030. Coal, on the other hand, will increase its share from 50 percent in 2020 to 59.4 percent in 2030. In the 2030 energy mix, the 2021-2030 RUPTL will increase the contribution from renewables to 24.8 percent, higher than 23 percent in 2019-2030 RUPTL. But that of coal is also increasing substantially. From 54.6 percent in 2025 according to the 2019-2028 RUPTL, contribution of coal is expected to increase higher to about 59.4 according to the 2021-2030 RUPTL.[27]

[27] *ibid*.

2.2 Just Energy Transition in Indonesia

At the G20 Summit in Bali, Indonesia, in 2021, A number of friendly countries commit to a Just Energy Transition Partnership (JETP) with Indonesia. The partnership is committed to mobilize more than $20 billion financing to facilitate energy transition in Indonesia. This is the second JETP in the world following the $8.5 billion with South Africa but is the largest climate financing commitment ever carried out with only one country.[28]

Some concerns have been aired about JETP. Weak involvement of and coordination with stakeholders, independent but empowered secretariat, integration of ETM into JETP, and credible reference for energy transition that is "just" have been cited as some points that may need to be carefully reviewed.

The financing structure of JETP is also of concern. Out of the more than $20 billion financing pledges, most of the financing, even that from public sources, is commercial. Grant financing is much less than $400 million (2 percent). The non-grant, publicly sourced financing from the International Partners Group (IPG), the public sector partners, may be provided as soft loan, but still commercial. Meanwhile, the privately sourced financing from the Glasgow Financial Alliance for Net Zero (GFANZ) may be fully commercial. For which, investment climate of the recipient country such as Indonesia will determine their appetites. Out of the issues raised surrounding the financing, early retirement of CFPP is not attractive to investors. In addition to the financing gap from negative net-present value (NPV), the green financing taxonomy still excludes financing coal facility.[29]

[28] JETP Indonesia (Just Energy Transition Partnership Indonesia), 2023. *Comprehensive Investment and Policy Plan 2023*. Just Energy Transition Partnership Indonesia, Jakarta.
[29] Tenggara Strategics and CSIS, 2023. *Naskah Kebijakan: Risiko dan Tantangan Just Energy Transition Partnership (JETP) Indonesia*. Tenggara Strategics and Center for Strategic and International Studies, Jakarta.

3 Scenario Analysis of the Energy System Expansion using System Dynamic Model

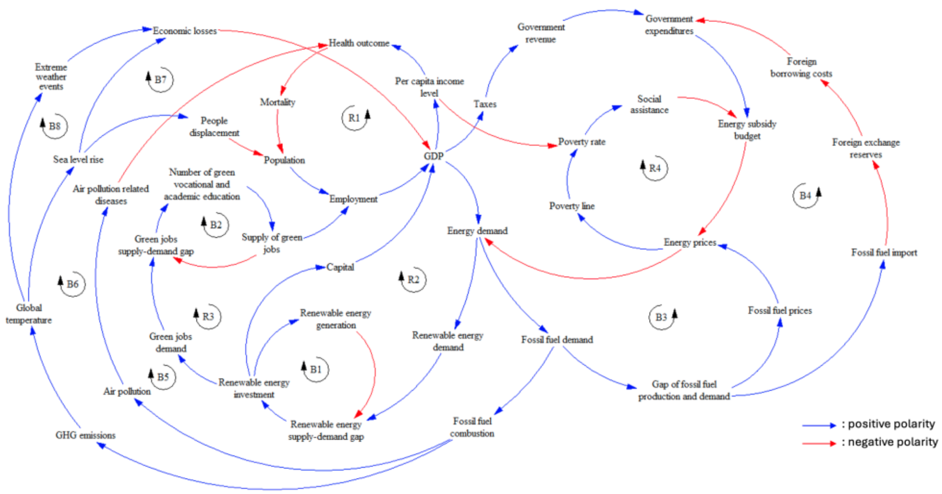


Figure 3.1: Causal loop diagram of the system dynamic model utilized in this analysis, originally utilized by the Low-Carbon Development Initiative (LCDI) under the Ministry of National Development Planning (Bappenas) of the Republic of Indonesia.

A system dynamic model is utilized to analyze the implications of pledging to triple renewable capacity and double the pace of energy efficiency in Indonesia. The systems dynamic model is based on a simplified version of the model utilized by the Government of Indonesia developed by the Ministry of National Development Planning under the Low-Carbon Development Initiative (LCDI).[30] The even more simplified structure of the model, the causal loop diagram (CLD) is depicted as below.

[30] Bappenas (Ministry of National Development Planning of the Republic of Indonesia), 2019. *Low Carbon Development: A Paradigm Shift Towards a Green Economy in Indonesia*. Ministry of National Development Planning of the Republic of Indonesia, Jakarta; Bappenas, 2021. *Green Recovery: Roadmap Indonesia 2021-2024: Building Back Better Low Carbon Development Post-COVID19*. Ministry of National Development Planning, Jakarta; Bappenas, 2021. A Green Economy for a Net-Zero Future: How Indonesia can build back better after COVID-19 with the Low Carbon Development Initiative (LCDI); Landscape Indonesia, 2022. *The Green Reset:*

The CLD highlights both reinforcing and balancing loops that govern the interaction between various sectors and variables, as illustrated in the following key loops:

1. **Loop R1 – Economic and Health Reinforcement Loop**: **A reinforcing loop that begins with economic growth, illustrating how prosperity can lead to improved health outcomes and further social and economic benefits**. This loop shows that, **a**s GDP increases, so does per capita income level, raising the standard of living and enabling greater access to healthcare services. Improved healthcare and living conditions lead to better health outcomes, reducing mortality rates and contributing to population growth. A larger, healthier population expands the labor force, which in turn supports higher employment levels. Increased employment feeds back into GDP growth, creating a self-reinforcing cycle where economic prosperity enhances health and well-being, which then further drives economic growth. This loop highlights how economic growth can act as a catalyst for sustained social and health improvements.
2. **Loop R2 – Renewable Energy Investment and Demand Growth Economic growth: A reinforcing loop that illustrates how economic growth drives renewable energy demand and investment, which further stimulates economic growth.** As GDP increases, energy demand rises, including demand for renewables. This demand creates a supply-demand gap in renewable energy, encouraging additional investments in renewable energy infrastructure. Increased capital directed toward renewable energy reduces this gap, and, according to the Cobb-Douglas production function, greater capital translates into higher overall economic production. Greater renewable energy capacity enhances the productivity of the energy sector, supporting GDP growth and driving further economic development. The expanded production capacity not only meets the growing demand for energy but also strengthens the foundation for sustainable growth.
3. **Loop R3 – Green Jobs Demand and Economic Growth Reinforcement: This reinforcing loop illustrates how increased demand for renewable energy expansion creates more green jobs and supports economic growth.** As investments in renewable energy grow, demand for green jobs rises, creating employment opportunities in the renewable energy sector. The increased availability of green jobs leads to a more skilled and environmentally focused workforce, which not only supports further renewable energy generation but also contributes to overall economic growth by supplying labor force into the labor market.

Enhancing Ambition for Emission Reduction from the Energy Sector in Post-Pandemic Indonesia (December 2021). Landscape Indonesia and Ministry of National Development Planning, Jakarta.

4. **Loop B2 – Green Jobs Education and Supply Balance: This balancing loop addresses the gap between the supply and demand for green jobs by focusing on education and training**. As the demand for green jobs grows, there is often a supply-demand gap, indicating a shortage of qualified workers. To bridge this gap, investments are made in green vocational and academic education, which increases the supply of qualified individuals for green jobs. As the supply of green jobs meets the demand, the pressure to further expand green job training diminishes, creating a balance.

The simulation interval is set to 2010-2060 and the initial values of key social, economic, and energy variables are the same as those utilized in the LCDI model.

Key variables	Initial Value	Unit	Reference
Social			
Total population	238.5	million	BPS, 2013, Proyeksi Penduduk Indonesia 2010-2035
Total fertility rate	2.49	children per woman	BPS, 2013, Proyeksi Penduduk Indonesia 2010-2035
Infant mortality rate	20.5	death per 1,000 births	BPS, 2013, Proyeksi Penduduk Indonesia 2010-2035
Labor force participation rate	67.8	percent	BPS, 2010, Labor Force Participation Rate February 2010
Initial unemployment rate	7.41	Percent	BPS, 2010, Unemployment Rate February 2010
Share of employment per economic sector [Agriculture, Industry, Services, Others]	[38.4, 12.8, 42.3, 6.5]	Percent	BPS, 2010, Labor force per sector 2010
Economic			
Gross Domestic Product (GDP)	6,472	Rp billion, constant 2010	BPS, 2010, GDP per sector (processed)
Economic growth target	6	percent	Bappenas, 2024, RPJPN 2025-2045
Economic growth target	8	percent	Assumptions, according to the new government target
Capital exponent per economic sector [Agriculture, Industry, Services, Others]	[0.2; 0.65; 0.5; 0.4]	unitless	Assumed.
Total factor productivity growth	0.5-2	percent	Assumed.
Inflation rate target	3	percent	Assumed.

Energy[31]			
Household fuel shares [Electricity, Oil, Gas]	[41.67, 58.17, 0.16]	percent	MEMR, 2010, Handbook of Energy and Economy Statistics 2009 data
Industrial fuel shares [Electricity, Oil, Gas, Coal, Biomass]	[10.88, 23.07, 34.23, 31.82, 0]	percent	MEMR, 2010, Handbook of Energy and Economy Statistics 2009 data
Commercial fuel shares [Electricity, Oil, Gas]	[72.51, 24.9, 2.59]	percent	MEMR, 2010, Handbook of Energy and Economy Statistics 2009 data
Number of motor vehicles by type [passenger cars, motorcycles, buses, trucks]	[7.91, 52.8, 0.15, 4.5]	million units	BPS, 2012, Statistical Yearbook of Indonesia 2012, 2009 data
Power plant lifetime	25-60	years	MEMR, 2024, Technology Data for the Indonesian Power Sector
Capacity factor power plant	21-90	percent	MEMR, 2024, Technology Data for the Indonesian Power Sector
Availability factor power plant	90-99	percent	MEMR, 2024, Technology Data for the Indonesian Power Sector
Capital expenditure per power plant technology	0.91 – 9.00	USD 2022 million per MW	MEMR, 2024, Technology Data for the Indonesian Power Sector
Fixed operational expenditure per power plant technology	7,500 – 277,818	USD 2022 per MW per year	MEMR, 2024, Technology Data for the Indonesian Power Sector
Variable operational expenditure per power plant technology	0 – 27.5	USD 2022 per MWh	MEMR, 2024, Technology Data for the Indonesian Power Sector
Desired reserve margin	30	percent	Assumed.
GHG emissions factor [Coal, Oil, Gas]	[106,476; 73,900; 57,640]	kg CO_2e per TJ	MEMR, 2019, Guidelines for GHG emissions and reporting in power generation sector
CO2 price	0 (2020) – 160 (2050)	$ / tCO2e	IEA, 2024, World Energy Outlook 2024
Oil price	82 (2023) – 75 (2050)	$ / BOE	IEA, 2024, World Energy Outlook 2024

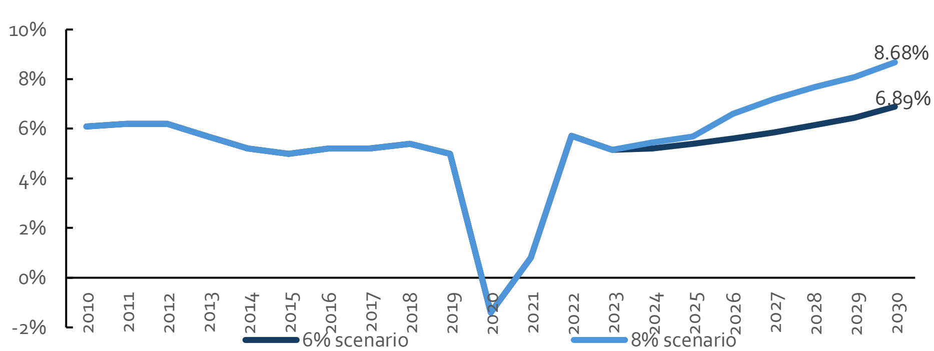
Table 3.1: Key input and assumptions on social, economic, and energy variables in the model and their references.

3.1 Baseline

[31] All of the fuel shares mentioned here exclude traditional biomass.

The baseline scenario for Indonesia's energy system expansion adopts a business-as-usual (BAU) approach, reflecting historical trends from 2010 to 2023. This baseline offers a control perspective against which alternative policy and technology scenarios can be compared. Here, the baseline presumes no major policy shifts or aggressive interventions aimed at accelerating renewable energy deployment or energy efficiency beyond current levels. The economic growth assumptions for the baseline are derived from two distinct targets, as follows. The two economic growth rates play different but similarly critical roles in estimating future energy demand and emissions under the BAU scenario. Each growth assumption illustrates a different trajectory for Indonesia's energy intensity and carbon footprint, eventually influencing projections on power generation needs, capacity, and environmental impact.

1. **A 6 percent economic growth rate per year aligns with Indonesia's RPJPN for 2025-2045, representing an ambitious target to escape the middle-income trap before 2045.** This growth assumption reflects historical averages with some structural changes, anticipating higher growth and emphasizing gradual changes in energy demand. The current LCDI model of Bappenas follows this assumption. The baseline scenario for a 6 percent growth rate assumption leads to a 6.89 percent growth rate by 2030.
2. **An 8 percent economic growth rate per year projects a more aggressive economic expansion based on the current government target for 2025-2029**. This scenario envisions increased investment, industrial productivity, and favorable macroeconomic conditions driving greater demand for energy and associated infrastructure. A new LCDI model is currently being developed to reflect the new ambition. Indonesia's 2025-2045 National Long-Term National Development Plan (Rencana Pembangunan Jangka Panjang Nasional, RPJPN) already includes this new ambition.[32] The baseline scenario for an 8 percent growth rate assumption leads to a 8.68 percent growth rate by 2030.[33] Figure 3.2below shows the economic growth assumptions over time to 2030.



[32] RI, 2024. *Rencana Pembangunan Jangka Panjang Nasional 2025-2045*, Law No. 59/2024. Ministry of National Development Planning of the Republic of Indonesia, Jakarta.

[33]

Figure 3.2: Two economic growth assumptions in the baseline scenarios. The 6 percent scenario shows that GDP growth will reach 6.89 percent whereas the 8 percent scenario it will reach 8.68 percent, respectively.

The baseline assumptions for electricity supply reflect the generation capacity mix outlined in the RUPTL 2021-2030. As mentioned previously, while this latest plan is coined as the "Green RUPTL", the addition of fossil-based power plants is roughly equal with the addition of renewable power plants, therefore this scenario can still be considered as a business-as-usual approach. This scenario remains inconsistent with what Indonesia needs to have to contribute to a 1.5ºC emissions trajectory. In both the 6 percent and 8 percent growth scenarios, until 2050, all installed power plant capacity projections will follow the JETP scenario. From 2051 onward, power plant capacity will be driven by electricity demand from all four energy demand sectors.

A more ambitious renewable energy development scenario is adopted by following the JETP scenario. The JETP scenario follows the assumptions made in the Comprehensive Investment and Policy Plan.[34]

Historical data has shown limited improvements in energy efficiency in all energy demand sectors. Industrial energy intensity, the energy needed (gigajoules, GJ) to produce an economic output in the energy sector (Rp billion), shows an increasing instead of decreasing trend. The historical trend data from 2010-2023 is set as the baseline. The alternative scenario sets the pace of efficiency improvement twice as rapidly as in the baseline scenario by 2030.

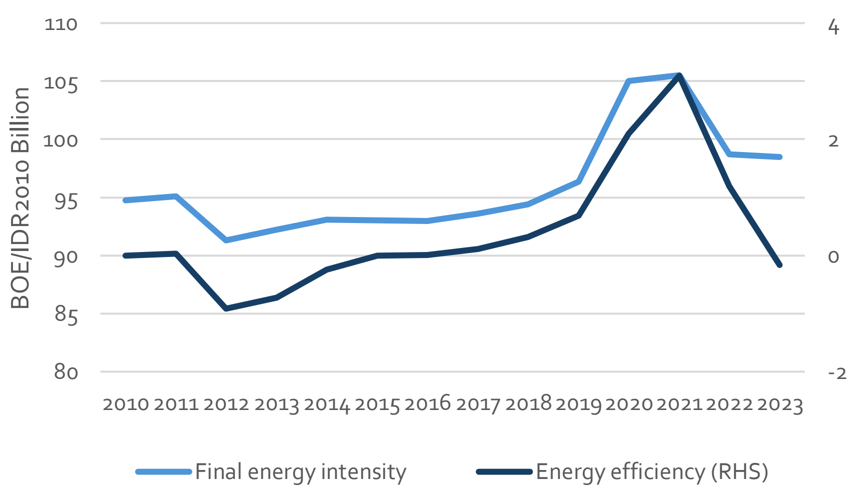


Figure 3.3: Indonesia's economy becomes more energy intensive overtime. The overly energy intensive profile within the 2020-2022 period is due to the economic contraction due to the covid19 pandemic.

[34] JETP, 2021. *Comprehensive Investment and Policy Plan*. JETP Secretariat, Jakarta.

The 8 percent growth rate scenario results in more job creation that can reach an additional 10 million jobs in between 2028-2029. The acceleration of economic growth starts in 2025 and starts to grow and reach its 8 percent growth rate by 2028.

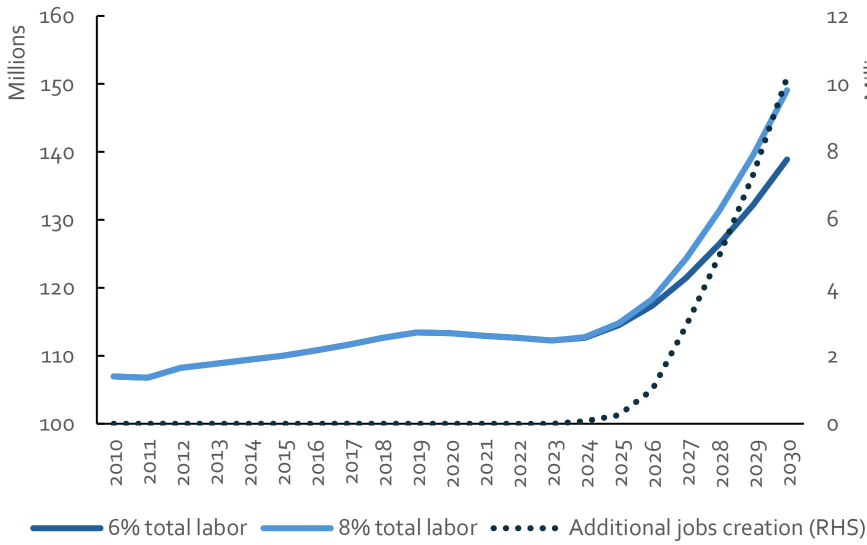


Figure 3.4: Economic growth will create jobs. About 10 million new jobs will be created by the 8 percent economic growth scenario by 2030.

A higher demand for production means that more energy input will be needed to fuel the economy. Figure 3.5 below shows that, in 2030, there will be a 6 percent difference of final energy consumption in all sectors.

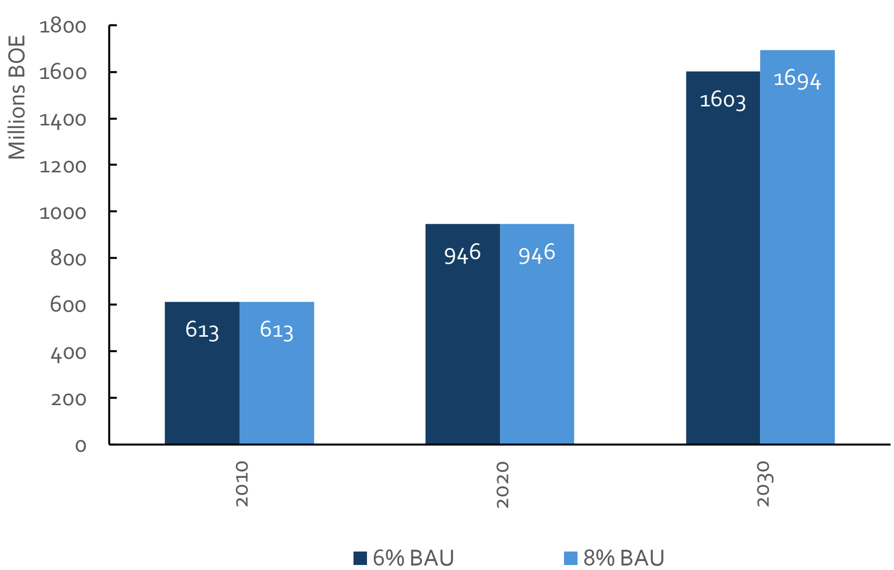


Figure 3.5: Energy demand will increase as the economy grows. By 2030, the 6 percent growth rate scenario will increase energy demand to 1.6 billion barrel of oil equivalent (BOE) whereas the 8 percent growth rate scenario will increase it to 1.7 billion BOE.

In 2030, most energy consumption (about 45 percent) will occur in the industrial sector, followed by transportation (33 percent), households (13 percent), and the commercial sector using the remainder. About 42 percent of energy consumption across all demand sectors uses direct oil combustion, followed by direct coal combustion within the industrial sector. Total electricity demand in all sectors will account for 28 percent of total final energy demand. The remaining 11 percent will be allocated to direct gas combustion.

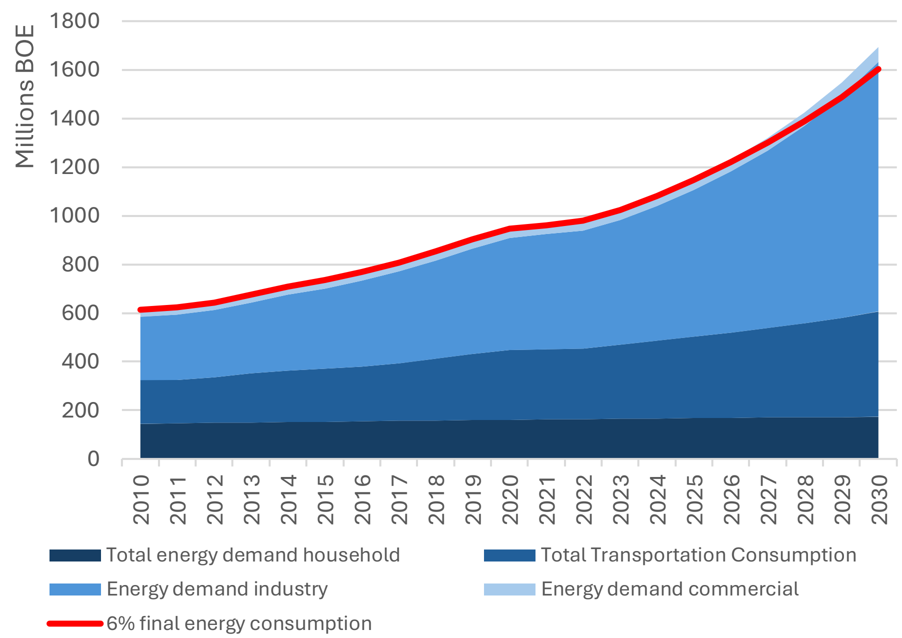


Figure 3.6: The 8 percent economic growth scenario increases final energy consumption, led by the industrial sector. About 42 percent of the energy production uses direct oil combustion.

Following RUPTL 2021-2030, the majority of electricity will still be generated from fossil fuels in 2030. Coal remains the dominant source at 37.5 percent of total electricity generation, followed by gas at 34.6 percent. Renewable energy will continue to grow, reaching 25 percent of total electricity generation, with more than half of this coming from hydropower followed by geothermal. Solar PV will be a key focus for development in 2025-2030, with installed capacity expected to reach 4.7 GW by 2030. However, it will contribute only 1.3 percent of total electricity generation.

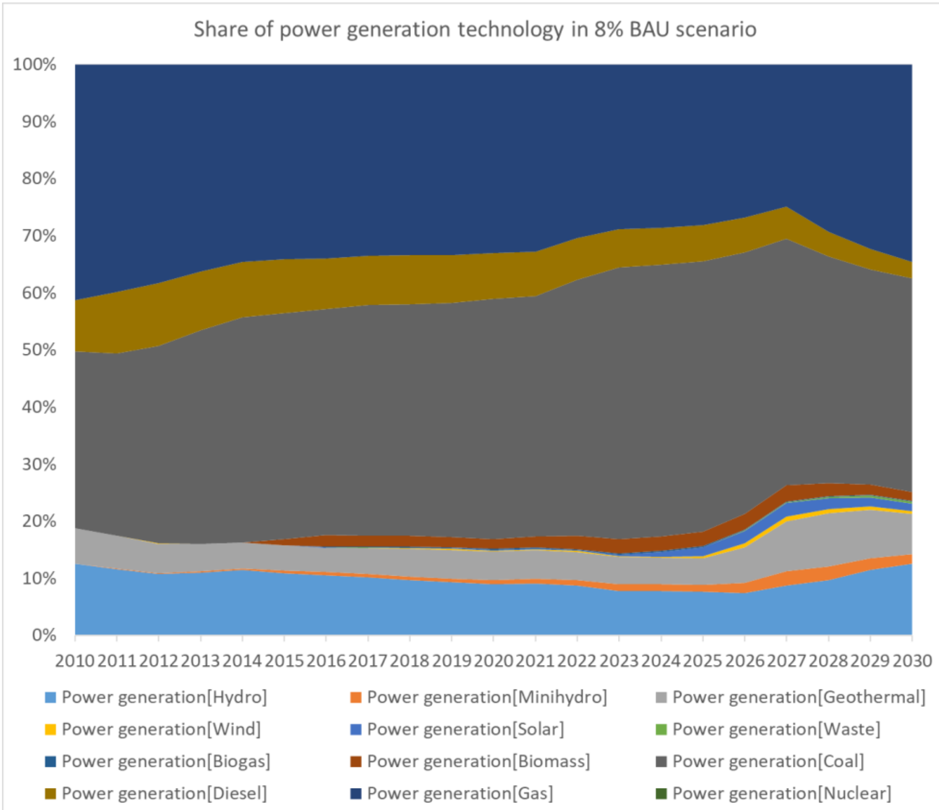


Figure 3.7: Energy mix of electricity over time. Fossil fuels will continue to dominate while renewables remain lagging.

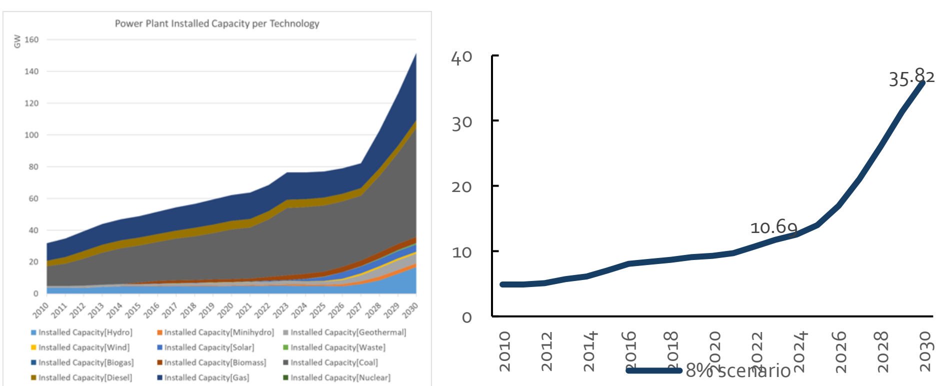


Figure 3.8: Power plant installed capacity by technology. Renewables are expected to increase more than three times between 2022 and 2030, from 11 GW to 36 GW. But fossil fuels, including coal, are growing at an even higher rate, doubling the capacity from 58 GW to 116 GW.

The baseline scenario already shows a tripling capacity of renewables. Figure 3.8 shows that, following economic growth and resulting energy demand growth, installed capacity of electricity system in Indonesia will increase from about 68 GW in 2022 to about 152 GW in 2030. Figure 3.8 shows that installed capacity of coal will increase from 36 GW in 2022 to about 69 GW in 2030. Meanwhile, as depicted in **Error! Reference source not found.**, r enewables will increase from 10.7 GW to 35.8 GW in 2030.

As a result, emissions from the electricity sector are expected to increase considerably due to continued proliferation of CFPP. From 173 MtCO2e in 2020, emissions will increase to about 326 MtCO2e in 2030.

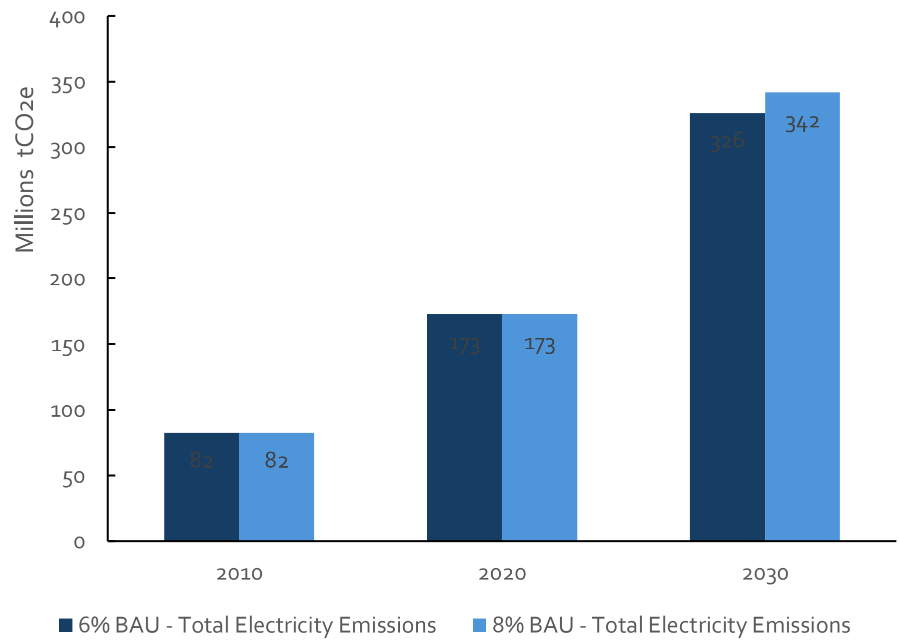


Figure 3.9: Emissions from the electricity sector continue to increase in the baseline scenario, to 326 MtCO2e in the 6 percent growth scenario and to 342 MtCO2e in the 8 percent scenario.

3.2 Alternative Scenarios: The Just Energy Transition (JET) Scenarios

In the alternative policy scenarios, the JET scenarios, we adopted the following assumptions, as used in the Comprehensive Investment and Policy Plan of the Just Energy Transition Plan, as follows:

- Total on-grid power sector emissions peaking by 2030 with an emission target of no more than 250 MT CO2 in 2030.
- A renewable energy generation share of 44 percent by 2030.
- achieving net zero emissions in the power sector by 2050.

The JET scenarios show reductions of emissions from baseline by about 30 percent. The more ambitious scenarios follow assumptions and policy options contained in the Comprehensive Investment and Policy Plan of the JETP.[35] In both the 6 percent and 8 percent economic growth scenarios, electricity emissions could be reduced by about 30 percent, reaching 229-240 $MtCO_2e$ by 2030, with further reductions aiming to achieve zero-emissions electricity by 2060.

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[35] JETP (Just Energy Transition Partnership), 2021. *Just Energy Transition Comprehensive Investment and Policy Plan*. Just Energy Transition Partnership Secretariat, Jakarta.

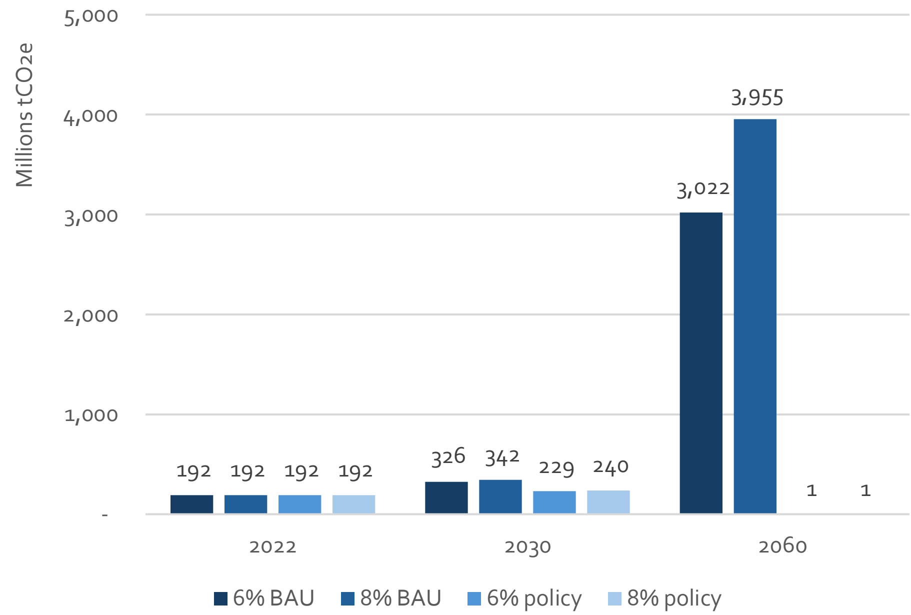

Figure 3.10: Implementing the JET scenario will continuously reduce emissions under both economic scenarios, ultimately reaching near-zero electricity emissions by 2060.

While the Just Energy Transition scenario will already limit emissions at about 30 percent lower than the business as usual scenario in 2030, emissions will continue to decrease to about zero in 2060. Emissions from the electricity sector will reach 229 - 240 MtCO2e in the JET scenario compared with 326 - 342 MtCO2e in the JET scenario in 2030. These emissions will continue to decrease to near zero in the JET scenario compared with 3 - 4 GtCO2e in 2060 under the business-as-usual scenario.

Additionally, all energy demand sectors are assumed to have adopted energy efficiency measures to double the rate of efficiency improvements compared with the baseline. The initiative would make the final energy intensity drop from 99 to 84 BOE per 1 billion of IDR (constant 2010). Consequently, lower final energy intensity will significantly reduce the total electricity demand by 13 and 70 percent in 2030 and 2060, respectively.

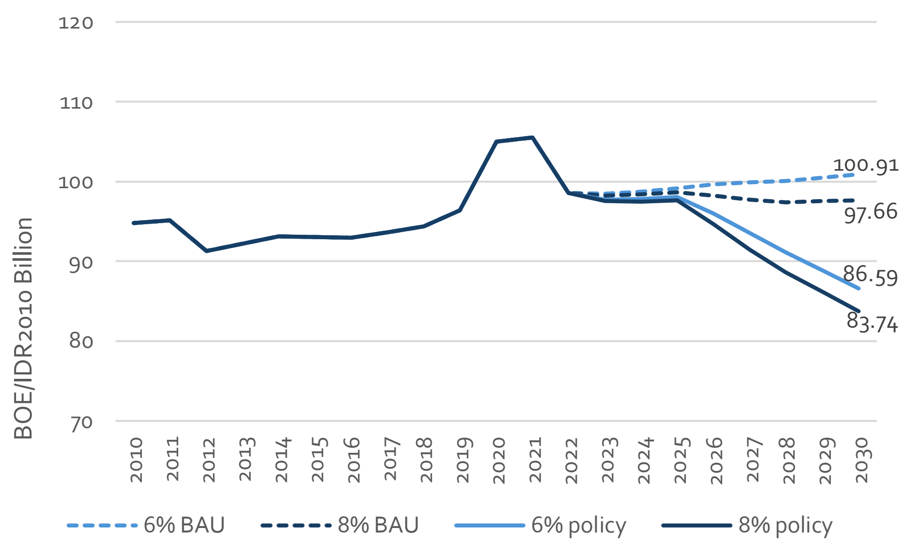

Figure 3.11: Rates of improvement of the energy intensity of the economy in the JET scenarios are assumed to be twice as fast as those in the baseline scenarios.

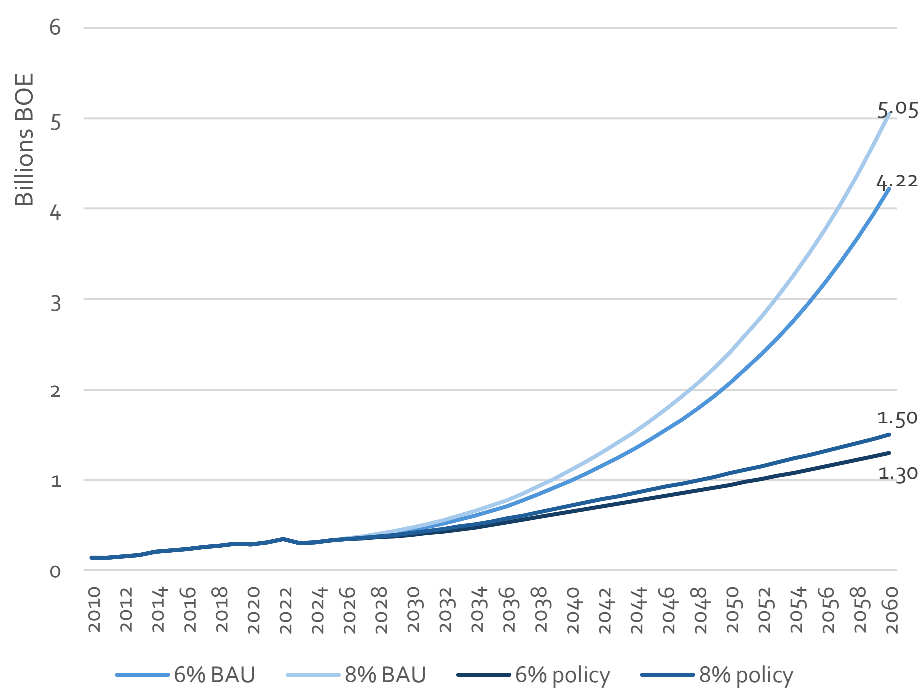

Figure 3.12: Projected total final electricity demand until 2060 under 6 percent and 8 percent growth rates after implementing energy efficiency measures can reduce electricity demand by 2.92–3.05 billion BOE by 2060 in the 6 percent and 8 percent scenarios, respectively.

In the JET scenario, solar will become the primary source of electricity by 2060. Solar is expected to account for 47.3 percent of generations, followed by hydropower at 18.5 percent. Geothermal will provide 8.7 percent while wind and biomass contribute 9.4 and 8.3 percent, respectively. Nuclear energy will also play a role, supplying 7.7 percent of electricity generation. Altogether, by

2060, almost all electricity will be generated from renewable sources. In terms of installed capacity needed to achieve this renewable energy mix, solar is projected to exceed 500 GW. Hydropower will be the second largest source, with a capacity of 78 GW, followed by wind at 73 GW and biomass at 64 GW. To meet our climate targets, maximizing all potential clean energy sources is essential; therefore, nuclear capacity is also expected to exceed 50 GW by 2060.

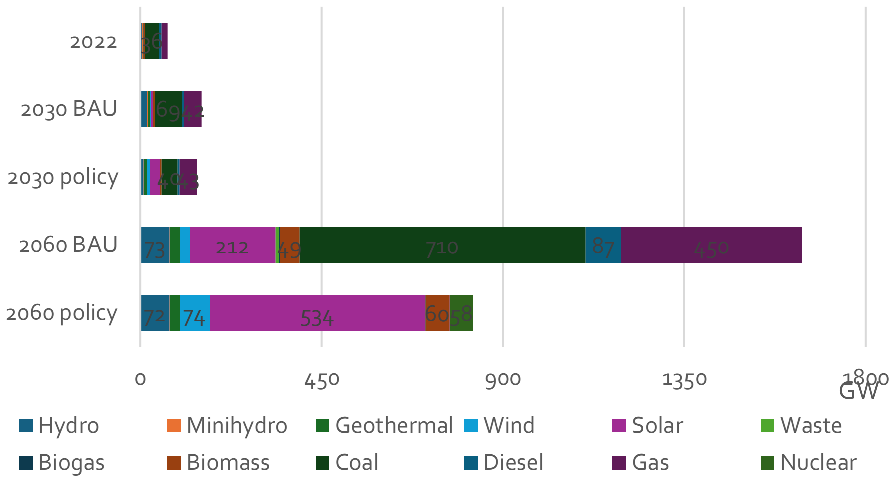

Figure 3.13: Installed capacity of electricity generation in the four scenarios under the assumption of an 8 percent economic growth. In 2060, Indonesia will generate almost all of its electricity with renewables. Doubling the rate of efficiency improvement will also slash electricity demand by half.

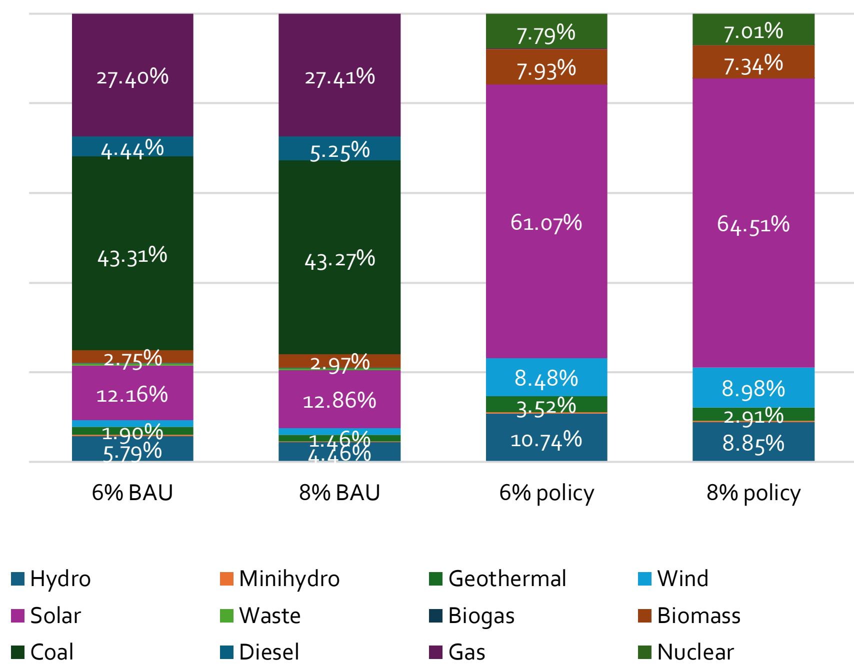

Figure 3.14: By 2060, Indonesia will generate almost 100 percent of its electricity with renewables. Solar will dominate with 61-65 percent in the JET scenario compared with the domination of coal at 43 percent in the business-as-usual scenario.

3.3 Macroceconomic Implications

Transition from fossil fuels to renewables in the electricity system will affect the economy. Such implications are observed through the outcomes of the system dynamic modeling exercise. Specifically, macroeconomic variables of interests are the implications of energy transition on investment, job creations, and poverty alleviation.

Achieving ambitious renewable energy mix will open substantial investment opportunities. Under the JET scenarios, from 2025 to 2030, a cumulative green investment of $65 billion USD is needed to accelerate the development of renewable infrastructure. Extending to 2060, the cumulative investment requirement will grow significantly, reaching $1.08 - $1.22 trillion USD, in 6 and 8 percent economic growth assumptions, respectively. Investing at this scale is essential for meeting climate targets and ensuring a sustainable energy future.

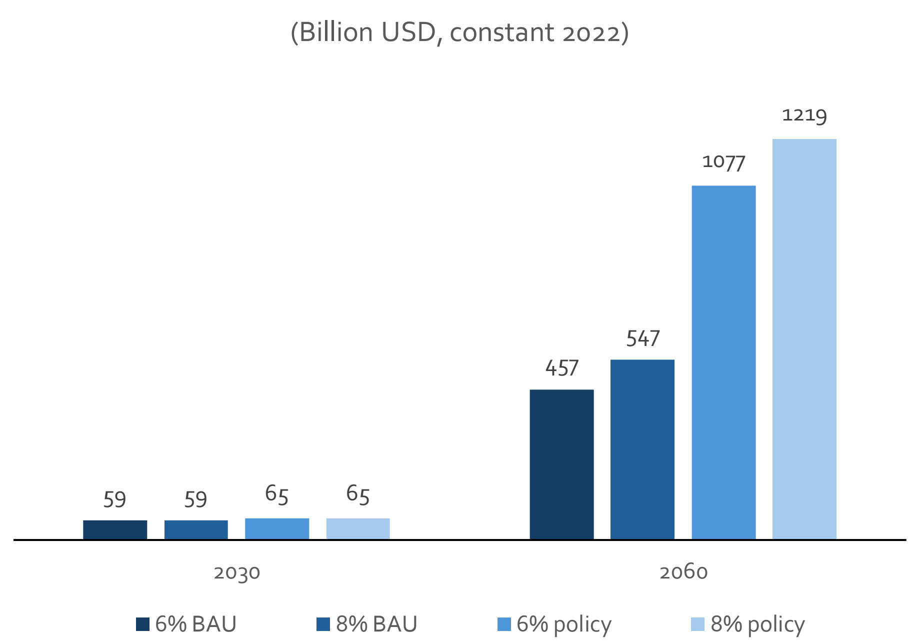

Figure 3.15: Cumulative renewable energy investment from 2025 to 2060 shows that investment requirements will be the highest in JET scenario, at $1 trillion in 2060 at 6 percent economic growth rate and $1.2 trillion at 8 percent economic growth rate assumptions, in 2022 $).

Increased potential investments in green, low-carbon, and renewable electricity generation technology will significantly increase job creation. Not only does the increase in green investment fuel the needed transition to renewable energy but also drives significant job creation in the green sector. Under the JET scenario, an estimated 1.2 million additional green jobs will be created between 2025 and 2030, supporting communities and boosting economic growth. This momentum continues through 2060 with a projected total of 28.1 million new green jobs in the 8 percent growth scenario, averaging nearly 800,000 green jobs per year from 2025 onward. Before 2051, all scenarios will follow the same installed capacity under the JET scenario. From 2051 onward, green job creation in the JET scenarios will diverge due to lower energy demand in the 6 percent growth scenario.

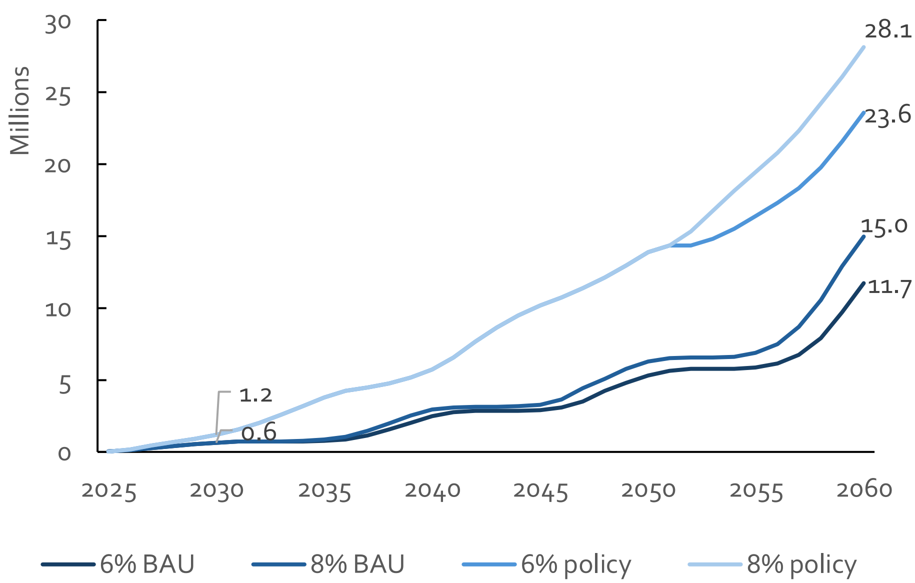

Figure 3.16: More jobs will be created in JET scenarios compared with the business as usual ones, adding 28 million cumulative new green jobs from 2025 until 2060.

Expanding green investments and job opportunities also strengthens Indonesia's economic foundation. With a larger labor force engaged in clean energy industries and increased capital flows into green projects, the economy is set for accelerated growth. By 2030, economic output of the other sectors comprising electricity, water, and gas generation, as well as construction, are projected to be 0.4 percent higher in the JET scenarios than under the business- as-usual scenarios, driven by the expansion of labor and capital stocks dedicated to renewable energy development and operation.

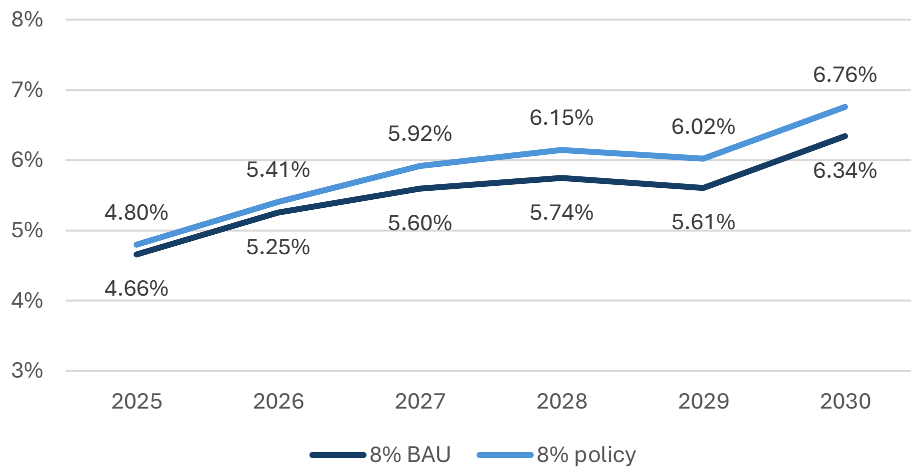

Figure 3.17: Economic growth of sectors other than energy. Driven by the development in the electricity sector following the transition, growth in other sectors will also increase.

Higher economic growth fueled by expansion of renewables that increases green investments and job creation will help reduce poverty. Driven by a more ambitious transition to renewables, JET scenarios could allow an additional 560,000 people escape poverty by 2030 compared to a 6 percent business as usual scenario. When compared with the 8 percent business as usual scenario, the JET scenario can provide a pathway for an additional 40,000 – 70,000 people escaping poverty by 2030 and 2060, respectively. An ambitious transition to renewables has the potential to make a profound social impact.

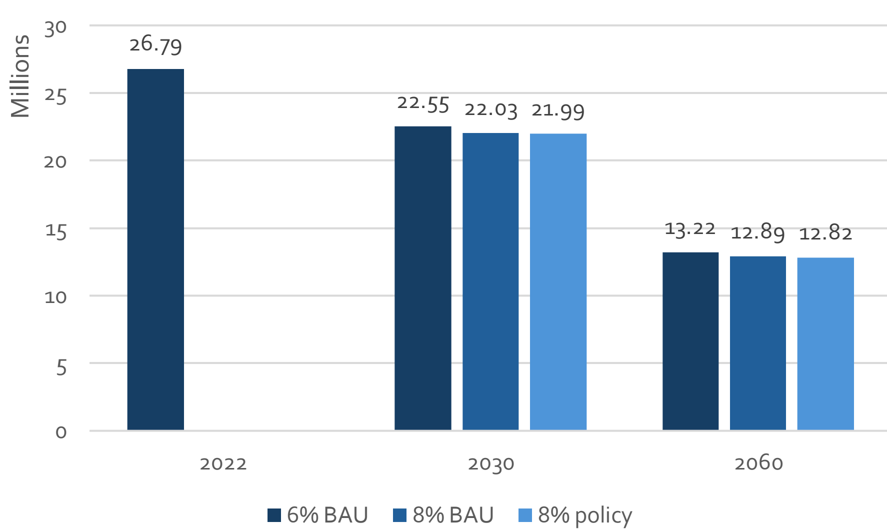

Figure 3.18: The number of people living in poverty will decrease even more due to realized JET scenarios by 2030, and further by 2060. About 4 million people may

cumulatively escape poverty between 2022 and 2030, and 14 million people by 2060 under the JET scenarios.

Renewable energy adoption will also improve quality of life by reducing air pollution. By 2030, sulfur dioxide (SO_2) emissions from power generation may be nearly halved, down from 1,980 to 1,180 tons. This will lower average ambient SO_2 concentrations from 3.1 μg/m³ to 1.9 μg/m³. This reduction will lead to a significantly positive health impact with annual cases of pneumonia attributed to air pollution expected to fall from 2.8 million to 1.7 million cases by 2030. Lower pollution levels will not only ease healthcare burdens but also support healthier and more productive communities.

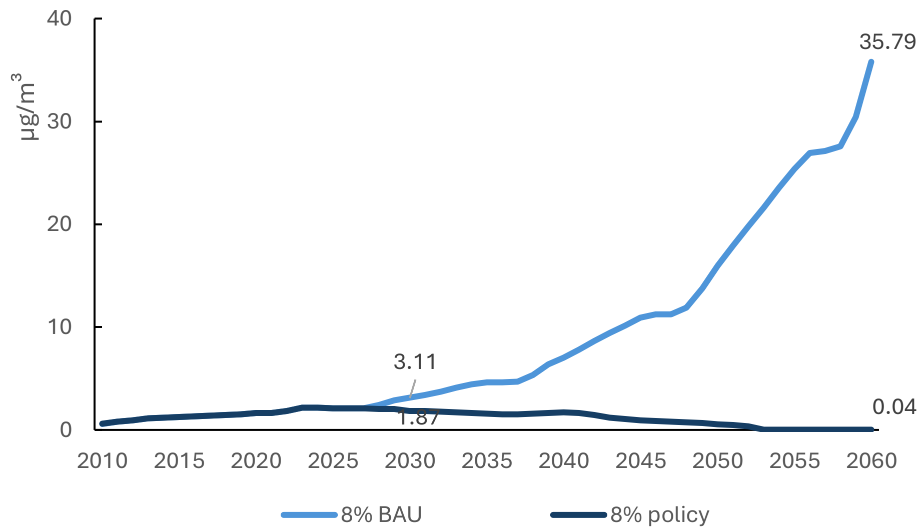

Figure 3.19: Transition from fossil fuels to renewables will bring the concentration of sulfur oxides down, supporting healthier and more productive communities.

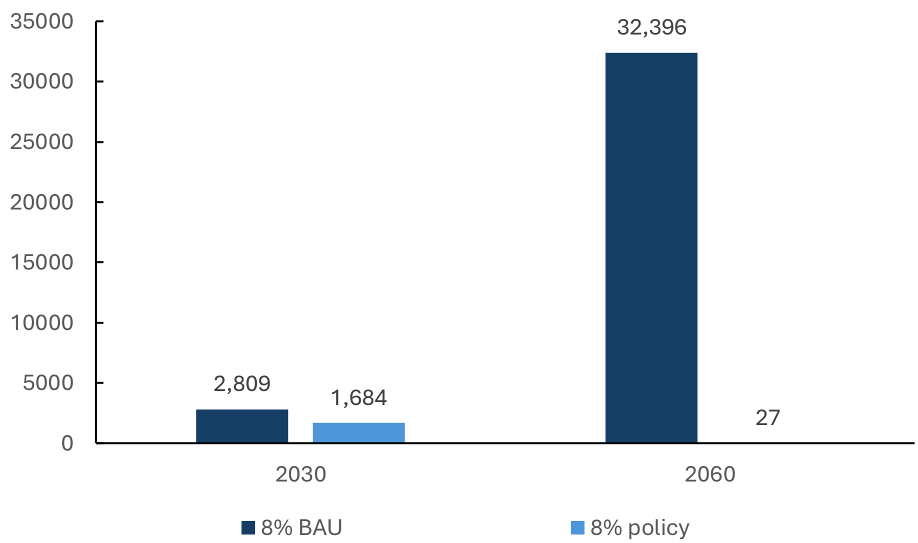

Figure 3.20: The number of pneumonia cases attributable to air pollution will decrease to 1,684 under JET scenario from 2,809 under business-as-usual scenario in 2030, and a

mere 27 cases under JET scenario compared with a whopping 32,396 cases under business-as usual scenario assuming 8 percent economic growth rate.

The modeling outcomes show that transitioning Indonesia's electricity system from fossil fuels to renewable sources produce positive macroeconomic outcomes. Energy transition increases investment opportunities, maintains high economic growth, increases job creations especially in green sectors, reduces poverty, and increases public health. Table 3.2 below summarizes the macroeconomic implications of the transition to renewables as simulated through the system dynamic modeling exercise.

2030	**Baseline 6 percent**	**Baseline 8 percent**	**JET Scenario 6 percent**	**JET Scenario 8 percent**
Economic growth (percent)	6	8	6	8
Coal capacity	68.8 GW	68.8 GW	39.5 GW	39.5 GW
Coal electricity generation	200 TWh	209 TWh	117 TWh	122 TWh
Coal generation percentage	37.5%	37.5%	25%	25%
Renewable capacity	35.8 GW	35.8 GW	53 GW	53 GW
Renewable electricity generation	133 TWh	140 TWh	145 TWh	152 TWh
Renewable generation percentage	25%	25%	31.2%	31.2%
Poverty (percent)	7.72%	7.54%	7.70%	7.52%
(Green) job creation cumulative	632,271	632,271	1,186,971	1,186,971
(Green) Investment cumulative ($2022 billion)	$83.5 billion	$83.5 billion	$91.2 billion	$91.2 billion
Emissions (GtCO2e)	0.33	0.34	0.23	0.24

2060	**Baseline 6 percent**	**Baseline 8 percent**	**JET Scenario 6 percent**	**JET Scenario 8 percent**
Economic growth (percent)	6	8	6	8
Coal capacity	543 GW	704 GW	0 GW	0 GW
Coal electricity generation	1,807 TWh	2,343 TWh	0 TWh	0 TWh
Coal generation percentage	38.8%	39.2%	0%	0%
Renewable capacity	311 GW	391 GW	674 GW	817 GW
Renewable electricity generation	929 TWh	1,087 TWh	1,507 TWh	1,766 TWh
Renewable generation percentage	19.9%	18.2%	91.6%	92.1%
Poverty (percent)	3.82%	3.72%	3.79%	3.70%
(Green) job creation cumulative	11,722,074	14,959,594	23,562,374	28,117,213
(Green) Investment cumulative ($2022 billion)	$482 billion	$572 billion	$1103 billion	$1245 billion
Emissions (GtCO2e)	3.02	3.96	0	0

Table 3.2: Summary of system dynamic modeling outcomes, showing the positive macroeconomic implications of transitioning Indonesia's electricity sector from fossil fuels to renewables.

There are policy implications for the JET scenarios. A gradual rollout of these policies, beginning in 2025, could help cover up to 40 percent of renewable energy investment needs, or approximately $5.25 billion by 2030. Specifically, reallocating fossil fuel subsidies could contribute $0.9 billion USD, while revenue from carbon credit, when carbon market exists and effective, is estimated at $2 billion with the cap-and-tax scheme could add another $2.3 million USD.

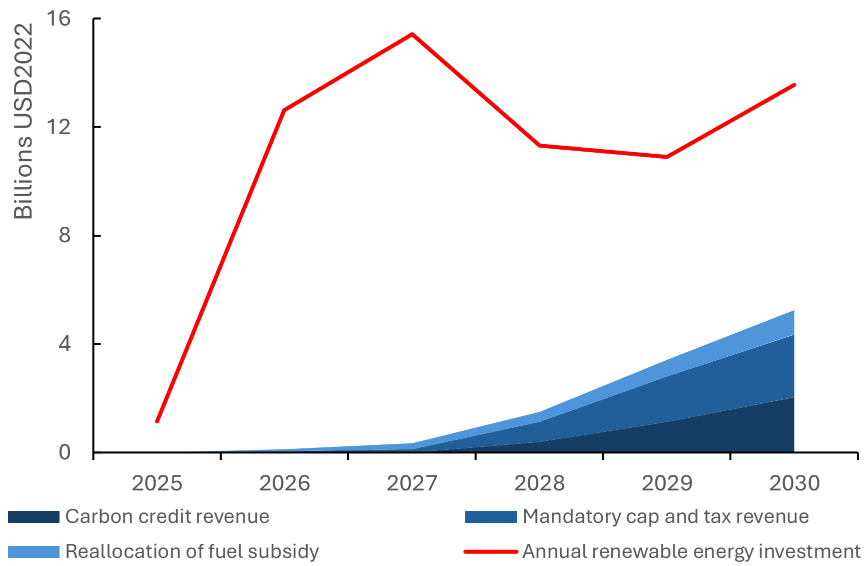

Figure 3.21: Renewable investment needs and financing will grow.

A comprehensive workforce strategy integrating green skills across education and training system is essential to meet Indonesia's green job requirements. There are 1.2 million of green jobs that could be created by 2030 and 28.1 million by 2060. This includes embedding green skills into technical and vocational education, aligning with national qualification frameworks, and expanding green skills training across state-run vocational institutions and industry-based programs. Special attention should be given to women, youth, and communities impacted by the shift, ensuring inclusivity and broader participation in green sectors.

This strategy must also engage the private sector by incentivizing partnerships that foster employment in renewable energy fields such as manufacturing, installation, and maintenance. Social protection measures and active labor market programs (ALMPs) will further support the transition, ensuring displaced workers and other vulnerable groups have access to green job opportunities and training and other opportunities driven by the energy transition. By establishing clear pathways and securing inclusive, skill-aligned opportunities, Indonesia can meet its workforce needs for a sustainable energy transition.

4 Conclusion and Lessons Learned

Climate change is worsening and decarbonizing the world's economy has become a imperative. In Dubai, 133 countries have pledged to triple the capacity of renewables, to 11,000 GW, and to double the pace of efficiency improvement by 2030. Indonesia is not a signatory to this pledge.

For Indonesia, however, tripling the capacity of renewables by 2030 is already a baseline. As such, Indonesia may not need to be concerned about whether it can achieve it. But the growth of coal-fired and other fossil fuel-fired power plants is keeping up due to the rapid demand, resulting in the energy mix in the electricity sector being relatively unchanged.

Doubling the pace of energy efficiency improvement is a different story. Indonesia's economy and its electricity system is increasingly carbon intensive with the proliferation of coal-fired power plants. Efficiency improvement can be pursued on the demand side by reducing energy intensity especially in key sectors such as industry where the growth rate and energy use are the highest, or on the supply side by ensuring that energy production is carried out in the most efficient manner.

The actual challenge for Indonesia is not to triple the capacity of renewables, but to limit the proliferation of coal fired power plants. The challenge in limiting the growth of coal-fired power plants are as follows:

- Not allowing any more new coal-fired power plants to be constructed in Indonesia as soon as possible.
- Retiring existing coal-fired power plants, especially the old ones with subcritical technologies, as soon as possible. This may be easier said than done. Retiring power plants earlier than their otherwise natural productive lifetime imposes foregone incomes that will lead to negative net-present value. Moreover, coal-fired power plants in Indonesia are dominated by young ones with 10-15 years of age. As such, the foregone incomes and consequently the negative NPV will be even larger. Unless there is additional income opportunity that can close the financial gap, early retirement of coal-fired power plants is not an attractive investment proposition.

- Peaking emissions of carbon dioxide and other greenhouse gas emissions at lower levels by 2030 or earlier.

But the macroeconomic implications of transitioning Indonesia's electricity sector from fossil fuels to renewables are potentially positive. Table 3.2 above shows the macroeconomic improvements, which can be summarized as follows.

- **Increased investment opportunities**. Cumulative investment opportunities driven by the transition are larger than business-as-usual. Cumulative investment amounts to $91.2 billion in the JET scenario compared with $83.5 billion in the business as usual scenarios by 2030. This will increase to $1.1 trillion - $1.2 trillion in the JET scenario compared with $482 - $572 billion in the business as usual scenarios.
- **Increased job creation**. New green jobs will be created more by the transition than business as usual. Cumulative new green jobs will be 1.2 million in the transition scenarios compared with 630,000 in the business as usual scenarios by 2030. This will increase to 23.5 – 28 million in the JET scenarios compared with 12 – 15 million in the business as usual scenarios.
- **Reduced poverty**. The number of people living in poverty will decrease due to the macroeconomic effect of the transition. Poverty rate will decrease only slightly to 7.52 – 7.70 percent in the JET scenarios from otherwise 7.54 – 7.72 in the business as usual scenarios. This will get better in 2060 with poverty rate will decrease further to 3.70 – 3.79 percent in the JET scenarios compared with 3.72 – 3.82 percent in the business as usual scenarios.

Transition from fossil fuels to renewables will reduce emissions not only through reduced levels of peak emissions, but may accelerate the peak year. Further successful transition will bring the electricity sector to utilize 100 percent renewables by 2060 and reduce emissions to zero, hence achieving the Indonesia's pledge to reach net zero by 2060 or earlier.

A point to ponder: climate financing may provide the necessary financial boost to close the financial gap — the negative NPV — of early retirement of coal-fired power plants. The main motivation to retire coal-fired power plants earlier than their natural productive age is to avoid future emissions from the power plants. However, financial analyses pertaining to early retirement of coal-fired power plants have not included potential avoided emissions and ways to financially compensate forsuch avoidance. The Monetary Authority of Singapore has published a white paper showing the possible use of carbon market in monetizing the emissions avoidance from early retirement of coal-fired power plants. The white paper shows that a typical 10 years-old 1 GW coal-fired power plant retired five years early has a $70 million negative NPV but avoids 22 million tons of carbon dioxide emissions. The creation of transition credits — carbon credits specifically developed for transitioning from coal to renewables — can compensate for the financial gap with a price as low as a little more than $3 for early retirement. Already, methodologies to calculate avoided emissions have been developed for voluntary and compliance markets for grid-connected coal-fired power plant early retirement and replacement with renewables.

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