Greening energy supply in the light of SDGs and Covid-19

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Abstract. The Paris Agreement calls for universal action to tackle climate change. Accordingly, countries have laid out their climate mitigation pledges and strategies on their Nationally Determined Contributions (NDCs). Most of the submitted NDCs include climate actions in the energy sector as a part of a national strategies in achieving their Paris climate targets. This paper assesses the alignment of the Indonesian power sector's pathway with its Paris Agreement targets. Furthermore, we analyze the role of climate change mitigation in the power sector to Indonesia's SDGs targets. We also identify how Covid-19 might affect the power sector development and subsequently the sector's contribution to NDC. We review the literature and energy sector's publications and apply the SDG interaction framework developed by Nilsson et.al. (2016) for our analysis. Our results indicate how the power sector's pathway contributes to both NDC and SDGs targets.

1. Introduction

Climate change and related environmental issues are the top five global risks in terms of likelihood and impact (World Economic Forum, 2019), making efforts to mitigate climate change even more crucial. In the context of developing countries, climate change mitigation goal interplays with another vital goal, namely providing universal electricity access. These two aspirations align with the United Nations Sustainable Development Goals (SDGs), among others SDG 7 aimed to ensure access to affordable, reliable, sustainable, and modern energy for all.

This paper focuses on Indonesia, an archipelagic country with a 98% current electrification rate. It means around 6 million people still have lack access to electricity (World Bank, 2020). This country's electricity consumption per capita is 870 kilowatt-hours (kWh) in 2016, which is much lower from 3,110 kWh of the world's average per capita consumption in the same year (IEA, 2018). Indonesia is aiming for universal electricity access by 2024 and 2,500 kWh electricity consumption per capita by 2025. Accordingly, these targets imply that electricity demand in Indonesia will continue to grow in the next decade.

At the same time, Indonesia ratified the Paris Agreement in 2016. According to its Nationally Determined Contribution (NDC), Indonesia commits to reducing its greenhouse gas emission by 29% in 2030, compared to the business as usual (BAU) scenario. The energy sector is expected to contribute 314 million tons or 11% of the national emission reduction target (Government of The Republic of Indonesia, 2016). Furthermore, Indonesia's SDGs roadmap identifies targets and strategies to ensure universal access to electricity and to reduce CO_2 emissions intensity under the economic and environmental pillars, respectively (KLHK, 2019).

This paper analyses the alignment of Indonesia's power sector's pathway with its targets to the Paris Agreement. Furthermore, we assess the contribution of climate change mitigation in the power sector to Indonesia's SDGs targets. We also identify how Covid-19 might affect the power sector development and the achievement of NDC and SDGs targets.

2. Methods

We review governmental and company's publications to evaluate the alignment of the power sector development plan with NDC. We apply the SDG interaction framework developed by Nilsson et al., (2016) to analyze the contribution of climate change mitigation in the power sector to Indonesia's SDGs targets. Meanwhile, the identification of the impacts of Covid-19 on the power sector development was based on reviews of the energy sector's publications.

The SDG interaction framework enables evaluations on how goals and interventions of the power sector affect other sectors positively or negatively. A seven-point scale of SDG interactions developed by Nilsson et al., (2016) is used, as presented in Table 1.

Table 1. Goal score used for assessing the interactions between one sustainable development goal with another (Nilsson et al., 2016)

Interaction name	Score	Explanation
Indivisible	+3	Inextricably linked to the achievement of another
Reinforcing	+2	Aids the achievement of another goal
Enabling	+1	Creates conditions that further another goal
Consistent	0	No significant positive or negative interactions
Constraining	-1	Limits options on another goal
Counteracting	-2	Clashes with another goal
Canceling	-3	Makes it impossible to reach another goal

3. The power sector, NDC, and SDGs roadmaps

3.1. Power sector development pathway

We identify the future development of the Indonesian power sector based on the most recent electricity supply business plan (RUPTL) 2019-2028 (PLN, 2019). The RUPTL prepared by PLN and legitimated through the Ministry of Energy and Mineral Resources' Decree No. 39 K/20/MEM/2019. PLN is a state-owned electricity company, which monopolizes the retail electricity sales and is the sole purchaser of electricity produced by independent power producers (IPPs). PLN solely owns and operates the transmission and distribution (T&D) networks, while the power generation assets are divided between PLN, its subsidiaries, and IPPs.

The RUPTL covers a ten-year plan, presenting the power sector development for the period of 2019-2028. It also stipulates climate change mitigation strategies, which include increasing the share of renewable energy, fuel switching from oil to gas and from coal to biomass, and employing more efficient coal technologies. The RUPTL expects a 16.7 GW increase in renewable capacity until the year 2028 (Fig. 1). Accordingly, the renewable energy share increases to 23% in 2025, as targeted by the Indonesian Government.

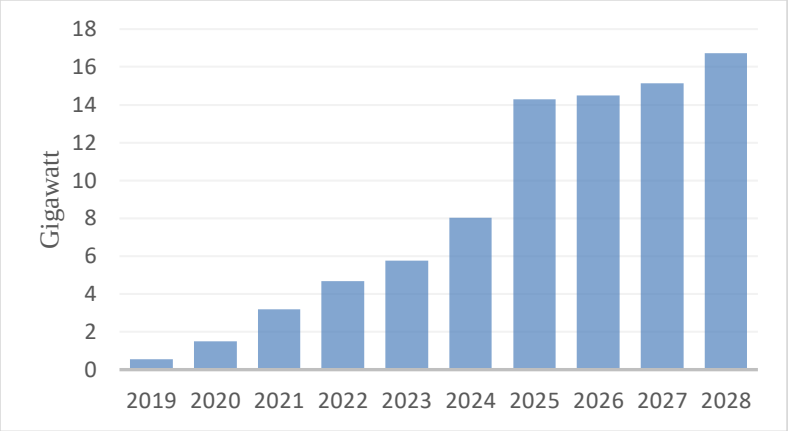

Figure 1. Additional renewable capacity from 2019 to 2028 (PLN, 2019)

Under the business as usual scenario, which is the scenario without considering the 23% of renewable energy target, the CO_2 emissions reach 488 million ton in 2028. Meanwhile, the expansion of renewables in the RUPTL 23% renewables scenario leads to lower CO_2 emissions i.e. 351 million tons in the same year. Thus, the RUPTL indicates a reduction of 137 million tons of CO_2 emissions (see Figure 2) and a decline in emission intensity from 0,82 ton CO_2/MWh in 2019 to 0.70 tons CO_2/MWh in 2028 (Figure 3) (PLN, 2020).

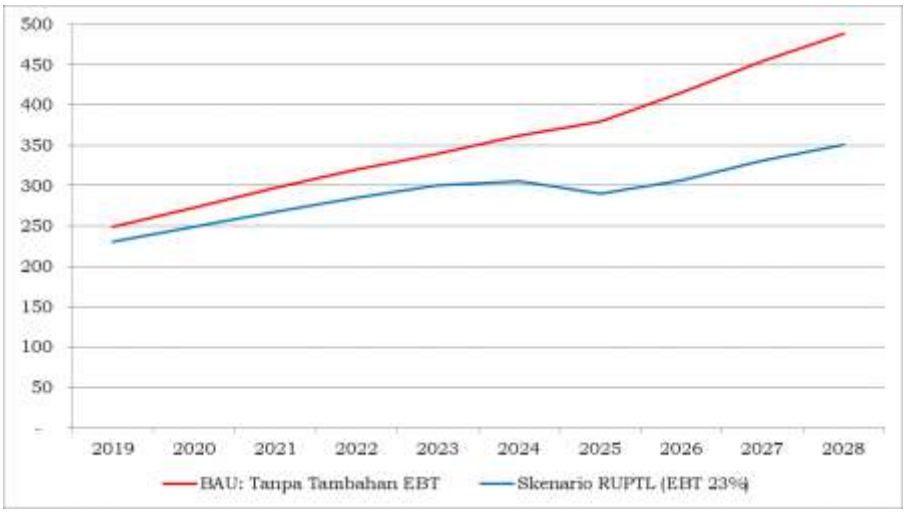

Figure 2. Projected CO_2 emissions under BAU and RUPTL scenarios, in million ton (PLN, 2020)

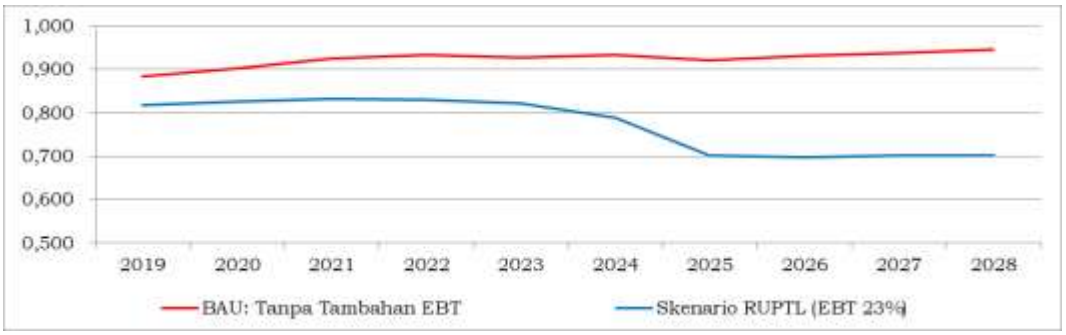

Figure 3. Projected emission intensity under BAU and RUPTL scenarios, in ton CO_2/MWh (PLN, 2020)

3.2. NDC roadmap

The energy sector is the second-largest contributor to the national greenhouse gas emission after the forestry sector (Boer et al., 2018). Therefore, the sector plays a critical role in climate change mitigation efforts. Accordingly, Indonesia's NDC lays out strategies to reduce emissions in the energy sector. The energy sector's emissions inventory comprises activities that involve the use of energy generated from the burning of fossil fuels, including transportation, power, industry, commercial, and household subsectors.

The emission reduction target is calculated based on the BAU scenario, which assumes the continuation of the historical energy development path, without any policy intervention for reducing CO_2 emissions. On the other hand, the mitigation scenario considers intervention activities from 2010 to 2030, which results in lower emissions compared to the BAU scenario.

For the power sector, the country's NDC roadmap sets out three main strategies: i) utilization of renewable energy for electricity generation (97.3 million ton CO_2e reduction), ii) the use of clean coal technology (39.3 million ton CO_2e reduction), and (iii) the use of natural gas for electricity production (34.7 million ton CO_2e reduction). These strategies cover 53% of the energy sector emission reduction target (KLHK, 2019).

The NDC roadmap stipulates the plan to add renewable capacity from geothermal, hydro, solar, biofuel, biomass, and wind, as depicted in Table 2. Meanwhile, the roadmap for clean coal technology involves the use of supercritical, ultra-supercritical, and Integrated Gasification Combined Cycle (IGCC) technologies for a total of 11,751 MW of coal power plants by 2030.

Table 2. Roadmap of renewable additional capacity, calculated from KLHK (2019)

Year	**2020**	**2021**	**2022**	**2023**	**2024**	**2025**
Additional capacity (MW)	3,680	3,763	3,309	3,262	4,359	7,788

3.3. SDGs targets and indicators

The Indonesian SDGs include the 17 goals, 169 targets, and 319 national SDGs indicators (Reagan, 2019). Climate change mitigation actions in the power sector directly link with SDG 7: Affordable and Clean Energy and SDG 13: Climate Action. With respect to SDG 7, Indonesia has set six indicators, two of which are related to the power sector (Bappenas, 2017a). Meanwhile, there are five indicators of SDG 13, three of which involve the contribution of the power sector (Bappenas, 2017b). Table 3 depicts SDGs indicators that relate to power sector development.

Table 3. Power sector-related SDGs indicators

SDG7	**SDG13**
• Electric power consumption per capita • Renewable energy mix	• Biennial update report document • Greenhouse gas emission reduction reporting document • The intensity of the greenhouse gas emissions

Indonesia's SDGs roadmap stipulates the target of 3,201 kWh per capita electricity consumption in 2030, prioritizing the acceleration of electricity infrastructure development in regions with a lack of access to electricity. Furthermore, the roadmap outlines the target of 26.1% of the renewable energy share in 2030, highlighting the importance of developing renewable energy-based small electricity systems in regions that are not connected to the electricity grid. Concerning SDGs 13, a reduction of emission intensity from 367,78 ton CO_2e/billion rupiah in the BAU scenario to 261,06 ton CO_2e/billion rupiah in the intervention scenario in 2030 is targeted (Bappenas, 2019). The target involves strategies to expand energy efficiency implementation and renewable energy capacity.

4. Results and discussions

4.1. Alignment of the power sector development plan with NDC

The Indonesian NDC (Government of The Republic of Indonesia, 2016) uses RUPTL 2016-2025 (PLN, 2016) as a reference for projecting the mitigation scenario, suggesting that the NDC target was generated using a bottom-up approach. By comparing the projection of additional renewable capacity between the NDC roadmap (KLHK, 2019) and the updated RUPTL (PLN, 2019), we observe several discrepancies.

Firstly, the additional capacity of renewable energy during 2020-2025 in the NDC roadmap is 293 MW higher than that in the RUPTL 2019-2028. Secondly, the NDC roadmap already considers IGCC as an option for cleaner coal power plants. At the same time, the RUPTL has not yet adopted the technology but considers it as an option when it is commercially available. The discrepancies can be caused by the dynamics of the RUPTL. It is updated annually, while Indonesia's NDC has not updated since the first submission in 2016.

Concerning the projection of CO_2 emissions reduction, the NDC roadmap expects a 168 million ton CO_2e emissions reduction in 2030 compared to BAU. Meanwhile, the updated RUPTL projects 137 million tons of CO_2 emissions reduction in 2028 compared to BAU. The two projections could not compare as they do not refer to the same baseline and end years of the projection periods.

An alignment of NDC and RUPTL strategies is essential since the power sector is expected to contribute more than half of the energy sector target and 20% of the national target. Despite the limited 10-year plan coverage of RUPTL, it is worth projecting CO_2 emissions reduction using the same period as the NDC target, i.e., 2010-2030. Thus, the RUPTL could keep track of the progress on achieving the power sector's NDC target. Moreover, methodological alignment is also suggested for calculating the CO_2 emission of the power sector.

4.2. Interactions between the power sector goals with other SDGs

Besides contributing to SDG7 and SDG13, the low-carbon power sector development also affects other SDGs. Our assessment using Nilsson et.al. scale (Nilsson et al., 2016) and findings from (McCollum et al., 2018) reveals possible contributions of the power sector to other SDGs. We focus on the positive and negative interactions with other SDGs indicators that are highlighted in the SDGs roadmap (Bappenas, 2019), as depicted in Table 4.

Table 4. Interactions between the power sector-related SDGs with other SDGs

SDGs indicators	National Targets	Interactions	Score
 1.2.1 Percentage of people living below the national poverty line	The poverty rate in 2030 with intervention in the range of 4-4.5%	The expansion of electricity access and improvement of electricity service reinforces at least two strategies of SDG 1: - Improving high-quality social protection and basic services - Utilizing appropriate technology for increasing the value-added of the community's productive business.	+2
 2.1.2 Prevalence of population who experienced food insecurity at moderate or severe levels based on Food Insecurity Experiences Scale (FIES) 2.2.1 Prevalence of stunting in children under five	- FIES decrease to 3.3 in 2030 with the intervention scenario - Prevalence of stunting decreased to 10% in 2030 with the intervention scenario	The use of large-scale bioenergy for electricity generation might create competition for land use and other inputs of large-scale food production, such as water and fertilizer.	-1

Table 4. Continued

SDGs indicators	National Targets	Interactions	Score
 3.1.1 Maternal mortality per 100,000 live birth 3.2.2 Infant mortality per 1,000 live birth 3.3.2 Tuberculosis (TB) incidence per 100,000 population	- Maternal mortality rate decline to 131 mortality per 100,000 live birth - Infant mortality rate decline to 12 mortality per 1,000 live birth - A decrease in TB incidence to 65 per 100,000 population with intervention scenario	Lack of access to quality health-care may increase maternal and infant mortality and TB incidence. Electricity supply is critical for a fully functioning health care facility as it enables medicine and vaccine storage, utilization of electrical medical equipment, operation of air conditioner, and keeping electronic medical records.	+1
 4.1.1 Proportion of children and adolescent who achieve minimum proficiency in (i) reading and (ii) mathematics 4.2.2 Gross enrollment rate at preprimary, higher secondary, and tertiary levels	- The proportion of students who achieve minimum proficiency in reading and mathematics in 2030 with intervention scenario: i) for 4th grader, 67.2% (reading) and 35.5% (mathematics), ii) for 9th grader 50% (reading) and 38% (mathematics) - The gross enrollment rate in higher secondary education in 2030 with the intervention scenario reaches 90,55% and 60.84% for higher secondary and tertiary educations, respectively	Strategies to achieve the 4.1.1 and 4.2.2 targets include improving the access and quality of early childhood education services. Electricity supply is necessary to enable the improvement of such services. For example, electricity allows proper lighting and make it possible to use of information, communication, and technology in educational activities.	+1
 5.3.1 Proportion of women aged 20-24 years old who were married or in a union before 18 years old	Child marriage in 2030 with intervention projection drops to 6.94%	Access to electricity helps to enhance communication, information, education, and counseling on family planning and reproductive health.	+1
 6.1.1 Percentage of households having access to an improved drinking water service	100% in 2030 with intervention projection	Accelerating the infrastructure development for a safe drinking water system for society is a strategy mentioned in the SDGs roadmap. Such infrastructures include water treatment plants, which require electricity to function.	+1
 8.1.1 Growth rate of real GDP per capita 8.5.2 Unemployment Rate	- 5.4% real GDP per capita growth rate in 2030 with the intervention scenario - 3.8% unemployment rate in 2030 with intervention projection	Electricity is one of the input factors of the economic process. It enables productive activities and income generation. Furthermore, the development of electricity infrastructure involves local workers, thus contribute to increasing employment rates.	+2

Table 4. Continued

SDGs indicators	National Targets	Interactions	Score
 9.c.1 Proportion of population served by mobile broadband service	100% in 2030 with intervention projection	Access to electricity allows the provision of mobile broadband service while also drives demand for the service	+1
 10.1.1 Gini coefficient	Reduced to 0.363 in 2030 with intervention projection	Expansion of electricity access improves the distribution of economic activities and thus reduces inequality between electrified and unelectrified villages.	+1
 11.1.1. (a) Proportion of households with access to decent and affordable housing	68.06% in 2030 with the intervention scenario	Electricity supply is a basic infrastructure service of a decent residential housing	+1
 15.1.1 (a) Proportion of forest cover to total land area	45.5% proportion of forest coverage to total land area in 2030 with intervention scenario	Renewable energy resources such as geothermal and hydro are often located in the forest area. Therefore, the development of such renewables generally involves the opening of forest land.	-1
 17.8.1 Proportion of individuals using internet	89% in 2030 with intervention projection	Access to electricity enables the provision of internet infrastructure	+1

4.3. Identification of Covid-19 impacts on the power sector

The Covid-19 pandemic brings an unprecedented challenge for the global power sector. According to an IEA report, the Covid-19 pandemic significantly affects the global electricity demand (IEA, 2020). In several countries that applied full lockdowns, the electricity demand fell by 20% or more. The power mix is also affected in which renewables share lifted, while coal, gas, and nuclear power plunged. Furthermore, the report projects a 5% reduction in global electricity demand for the whole year of 2020. Interestingly, renewables are expected to outstrip coal-based power generation owing to their low operating generation cost and preferential access to many power systems. Meanwhile, the global CO_2 emissions are estimated to decline by 8%, or nearly 2.6 Gigatons, reaching the level of a decade ago.

Zooming to Southeast Asia, a similar situation was reported. The Java-Bali power system, which represents 70% of Indonesia's electricity demand, experienced a 10% drop of peak demand at the end of April compared to that in January (Utama et al., 2020). Mirroring the IEA report, a survey conducted by ASEAN Center for Energy, which involved 401 respondents from 25 countries, concludes that fossil fuels are affected the most by the global pandemic (Suryadi & Rika Safrina, 2020). Concerning CO_2 emissions, 58% of the respondents agreed that activities relaxation during the pandemic resulted in lower emissions.

The Government and PLN are currently reviewing the power sector development plan taking into account the global pandemic. Considering the uncertainties related to future demand, economic growth, and other planning inputs, several plausible scenarios shall develope for updating the RUPTL. Although some studies at global and regional levels point to a reduction in economic growth, electricity demand, and CO_2 emissions, it remains unclear to what extent the Covid-19 pandemic will affect Indonesian NDC and SDGs targets.

5. Conclusions

This paper assesses the linkage between Indonesia's power sector development with the country's NDC and SDGs targets, relying on publicly available publications and an SDGs interaction framework. Our analysis reveals that Indonesia has set clear roadmaps on power sector development as well as on NDC and SDGs targets. However, an alignment between the NDC roadmap and RUPTL is still needed following updates and the actual progress on the power sector development. This alignment is even more crucial in the light of the Covid-19 pandemic, which will likely affect the power sector development and in turn affect the achievement of NDC and SDG targets. Concerning the contribution to SDGs, our analysis indicates many positive and a few negative interactions of the power sector-related SDGs with other SDGs, which could be considered as priorities for policymaking.

The Covid-19 pandemic adds uncertainties and risks to future power sector development. This point in time could be an opportunity to develop a green and sustainable plan as a part of the recovery from the health crisis and its intersectoral impacts. Hence, future works could focus on assessing plausible scenarios of future power sector development considering the Covid-19 impacts and green recovery, and subsequently, analyze the contribution of each scenario to the achievement of NDC and SDGs targets.

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