

Policy Formulation towards Net Zeroemission 2060 and Criteria for Development of Nuclear Power Plants in Indonesia using the Score card Deployment Method

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Abstract:- In the direction of Net Zero Emission (NZE) 2060, the Indonesian government needs the best policy formulation regarding the priority of selecting energy sources to be used. In addition, appropriate criteria are needed so that the planned energy sources can be utilized optimally and are able to reduce CO₂ emissions. In the direction of NZE 2060, there are a number of interests and priority actions related to the energy sector that will be carried out by the Indonesian government. Internationally, NRE and nuclear power plants (NPP) will be important keys in achieving the NZE target. This study aims to look at the priorities of the government's interest in the NZE and the priority actions that need to be taken if involving NPP in achieving the NZE target. This study will examine the formulation of government policies towards NZE and priority actions when involving NPP towards NZE. The research method used is quasi-qualitative using the Scorecard Deployment (QSD) technique. The results of the QSD analysis show that in formulating a strategy towards NZE 2060, the Indonesian government tries to classify the right types of EBT so that the emission reduction target can be achieved. The government also plans to include the construction of NPP in the long-term plan to replace the discontinued coal power plants. The most important thing to start the construction of NPP, is the national commitment to declare 'go nuclear'. Without this commitment, the NPP development plan will be difficult to realize.

Keywords:- Emissions, Policy, NRE, Nuclear, NPP.

I. INTRODUCTION

In Government Regulation No. 14/2015 concerning the 2015-2035 National Industrial Development Master Plan or RIPIN, it is stated that the nuclear power plant (PLTN) industry will be developed in 2020-2024 and 2025-2035. In the 2020-2035 period, the government plans to establish a rare earth metal processing plant as a raw material product for nuclear power plants (PLTN). The government will also facilitate the construction of nuclear fuel plants from uranium or other elements. In addition, the government plans to develop efficient nuclear power plants with high safety technology. However, the national plan contained in the RIPIN regarding nuclear does not seem to have been implemented until now. In fact, towards a global net zero

emission (NZE) 2050, the word nuclear has not been officially included as an alternative energy source that will be used to reduce emissions in Indonesia. It can be seen from the Nationally Determined Contribution (NDC) scenario in 2030 and the Long-Term Strategy on Low Carbon and Climate Resilience 2050 (LTS-LCCR 2050) uploaded by the Indonesian government on the United Nations Framework Convention on Climate Change (UNFCCC) website that does not involve nuclear power plants (PLTN). as one of the preferred energy sources.

In NDC 2030, the government targets to reduce national emissions in the business as usual (BaU) scheme by 29 percent with their own efforts and 41 percent with foreign assistance, which will focus more on new and renewable energy sources (EBT). In this EBT development plan, it will be adjusted to the Electricity Supply Business Plan (RUPTL) from PT PLN. The development of EBT will be more driven towards energy sources with minimal emissions such as PLTS, PLTB, and PLTP (KLHK RI, 2021). Furthermore, in order to reach NZE 2050, the Indonesian government has also planned a Long-Term Strategy on Low Carbon and Climate Resilience 2050 (LTS-LCCR 2050) in various fields such as energy, waste, IPPU, agriculture; and forestry. Specifically in the energy sector, the government is targeting the primary energy mix from the NRE sector to increase to 43 percent by 2050. In addition, it also applies the use of technology that has a significant impact on reducing GHG emissions such as carbon capture and storage (CSS) and bio energy with carbon capture and storage (BECCS). Approximately 75 percent of the PLTU is estimated to have been equipped with CCS to produce low GHG emissions. The development of PLTS and PLTB will be even bigger. With the increasingly massive NRE generation, the development of a smart micro grid network will be increasingly needed. Especially in "remote areas" (KLHK RI, 2021)

In the NDC 2030 and LTS 2050 scenarios, there are no words related to the use of energy from nuclear (NPP). At least until now. The government does not seem convinced to develop nuclear power plants domestically. The government seems to prioritize other NRE sources outside of nuclear. It could be that this is aligned with Government Regulation No. 79/2014 on National Energy Policy (KEN) and Presidential Regulation No. 22/2017 concerning the General National

Energy Plan (RUEN). In the NDC 2030 and LTS 2050 scenarios, there are no words related to the use of energy from nuclear (NPP). At least until now. The government does not seem convinced to develop nuclear power plants domestically. The government seems to prioritize other NRE sources other than nuclear (Arifianto, 2021).

The two government policies state that the use of nuclear energy will be considered after the utilization of new energy sources and renewable energy has been maximized. Nuclear energy is utilized with consideration of the security of national energy supplies on a large scale; reduce carbon emissions; and continue to prioritize the potential of NRE according to its economic value; and considered as a last resort with strict attention to safety factors. So, it implies that nuclear power plants may not be realized in Indonesia if other sources of EBT generation can continue to be optimized for development (Arifianto, 2021).

The condition of Indonesia which tends to avoid nuclear is quite different from the condition of a number of other countries which tend to optimize nuclear development in the future. In the “Net Zero by 2050 A Roadmap for the Global Energy Sector” report, it is estimated that the installed capacity of nuclear power plants in the world will continue to increase. By 2020, the world's nuclear power capacity will reach 415 GW. By 2030, it is estimated that the capacity will increase by about 24 percent to around 515 GW. By 2050, it will increase by about 1.5 times to 812 GW (IEA, 2021). The nuclear generating capacity in 2030 and 2050 only controls about 2-3 percent of the electricity generation in the world. This quantity is relatively very small globally. Nevertheless, nuclear has the highest reliability of energy supply in the world. With this relatively small share of capacity, it turns out that all nuclear power plants are capable of producing energy supplies of up to 8-10 percent of the world's electricity needs. That is, nuclear is capable of producing a large energy output (factor capacity) even with a small capacity.

In addition, based on data from the IAEA (International Atomic Energy Agency), CO₂ emissions produced by nuclear power plants only range from 9-21 grams of CO₂/kWh. This is in stark contrast to generators that use fossil energy such as coal, oil or diesel, and natural gas which produce GHG per kWh of electricity of 974 gr CO₂; 962 mg SO₂; and 700 mg NO_x. The difference in emission output causes nuclear power plants around the world to be able to reduce CO₂ by at least 2 gigatons a year (National Energy Council, 2011). CO₂ emissions produced by nuclear power plants are the smallest equivalent to emissions issued by nuclear power plants. Regions that are starting to feel the impact of reducing emissions from nuclear power plants are mostly developed countries that have used nuclear power plants several decades ago (Arifianto, 2021)

Based on data from the IAEA in 2020 there are at least 30 countries that already have nuclear power plants. From these details, it can be further categorized into two groups, namely developed countries or high-income developed countries and emerging market countries whose income

groups are from low to middle level. There are 18 developed countries owning nuclear power plants and 12 emerging market countries. Based on CO₂ emission data from the World Bank in 2010-2018, the majority of developed countries owning nuclear power plants by 88 percent have entered the CO₂ emission reduction phase. Only two countries are still increasing the number of emissions. These countries are Canada and South Korea. Some of these developed countries are currently trying to increase the generation capacity of nuclear power plants to be even greater to strengthen the energy transition towards NRE.

The success of nuclear power plants in reducing CO₂ emissions is one of the strong driving factors for a number of other countries to participate in developing nuclear power plants. In fact, some emerging market countries whose socio-economic conditions are below those of developed countries are also participating in developing nuclear power plants. For now, there are at least 12 emerging market countries that already operate nuclear power plants. In addition, there are three other emerging market countries that are currently in the stage of constructing nuclear power plants. The countries are Belarus, Turkey and Bangladesh (IAEA, 2020). The phenomenon of the development of nuclear power plants is something that is interesting to be investigated further. Moreover, a number of emerging market countries have socio-economic conditions below Indonesia. Indonesia is likely to be able to develop nuclear power plants like other countries that have previously operated nuclear power plants. Moreover, Indonesia already has a number of important variables in the development of the nuclear power plant.

According to the BATAN (BRIN) report, Indonesia has domestic potential for nuclear raw materials in the form of Uranium and Thorium. It is estimated that the potential for Uranium in Indonesia is around 82 thousand tons and Thorium around 143 thousand tons. The resources of these two types of energy minerals are spread over three regions in Indonesia, namely on the islands of Kalimantan, Bangka Belitung, and Sulawesi. Indonesia also has experience in managing three research reactors. The Triga 2000 reactor in Bandung, the Kartini reactor in Yogyakarta, and the GA reactor. Siwabessy in Serpong. The oldest is the Triga reactor, which was inaugurated in 1965. In terms of human resources, Indonesia already has skilled experts in the nuclear field under the institution of BATAN (BRIN) and the Nuclear Energy Supervisory Agency (BAPETEN). Since the 1980s, the government has also conducted several studies to a number of locations where nuclear power plants will be developed. Such as in Muria, Banten, Bangka Belitung, West Kalimantan, and East Kalimantan. A number of these descriptions show that Indonesia actually already has the capability and readiness to build nuclear reactors. However, the implementation of the nuclear power plant project requires courage and firmness from the government (Arifianto, 2021)

Therefore, the researcher wants to know to what extent the current government wants to prioritize towards the global NZE 2050 or the Indonesian NZE 2060. The researcher also wants to know what criteria the Indonesian government

needs to take if nuclear power plants (PLTN) will be involved in leading to NZE 2060. A number of variables supporting the development of nuclear power plants are already available in Indonesia. Only the government's priorities need to be investigated more deeply to ensure the utilization of energy sources that will be used to reduce CO2 emissions in the future.

II. RESEACH METHODS

This study uses descriptive and quasi-qualitative analysis methods. Descriptive analysis is used to process primary or secondary data simply to be presented in written form, data, or tables. The qualitative descriptive design format has many similarities with the quantitative descriptive design. Therefore, qualitative descriptive can also be called quasi-qualitative or quasi-qualitative. That is, this design is not really qualitative because its shape is still influenced by the quantitative tradition, especially in placing theory on the data it obtains (Bungin, 2010). Quasi-qualitative analysis in this study uses interview techniques which are then processed using the Quality Scorecard Deployment (QSD) method. This technique seeks to produce the best options from a number of government policy plans in reducing carbon emissions. The researcher will conduct interviews with several sources related to nuclear and energy policy as well as confirm with a number of actors, observers, and academics in the nuclear field. The resource persons planned for this research are the Ministry of Energy and Mineral Resources, DEN, Bapeten, Nuclear Energy Research Organization (ORTN-BRIN), nuclear energy organization (HIMNI), nuclear energy observers, and academics who are experts in the nuclear field.

This QSD technique is a commodification of the Quality Function Deployment (QFD) research technique. This QFD technique was originally developed in Japan in the 1960s for the purpose of industrial development. This QFD technique was first developed by Prof. Shigeru Mizuno and Yoji Akao to develop a quality assurance method for a product according to customer satisfaction before the product is produced. In addition, it is also to develop quality control methods to fix problems that arise during or after production takes place (Fatimah, 2019). Fatimah (2019) explained that the QFD describes a number of parameters or variables that some consumers want "What". Furthermore, it is translated in the form of a "how" or "how" process to realize other functions in order to support and play a role in supporting the realization of the variables desired by the consumers concerned. In the QFD a matrix diagram is formed that describes the five variables. Consists of customer requirements (whats); technical specifications (hows); relation matrix between "whats" and "hows"; customer importance rating; and target goals. These goals describe what variables are needed for the development of a product to be accepted by the market and be able to satisfy customers.

III. RESULT AND DISCUSSION

From the results of interviews with resource persons, a number of headers or variables were produced. For the left header, Left Quality Scorecard (LQS) which comes from interview screening from the Ministry of Energy and Mineral Resources, DEN, and Bapeten, there are 8 variables that become government priorities towards NZE 2060. Furthermore, for the top header, Top Quality Scorecard (TQS) which derived from the screening of interview variables from ORTN-BRIN, HIMNI, academics, and expert observers resulted in 7 variables that became the criteria for the development of nuclear power plants towards NZE Indonesia 2060.

Indikator /Variabel /Header	Riset PLTN	Teknologi PLTN Mutakhir	Komitmen Nasional	Sosialisasi PLTN	Sinergi BRIN	Kompensasi Masyarakat	Kerjasama Internasional	Bobot Kepentingan	Prioritas Kepentingan
	Optimalisasi EBT	■	■	●	▲	■	▲		
Regulasi EBT (investasi)	■	■	●	▲	▲	▲			
Terminasi PLTU- Pembangunan PLTN	▲	■	●	▲	▲	▲	▲		
Penguatan Teknologi	■	●	■	▲	■	▲	▲		
Kebijakan Politik	■	■	●	■	■	■	■		
Sinergi Antarlembaga	▲	▲	▲	▲	●	▲	■		
Komunikasi/ sosialisasi	▲	■	▲	●	■	▲	▲		
Diversifikasi Energi	▲	▲	▲	▲	●	▲	▲		
Bobot Tindakan									
Prioritas Tindakan									

Sumber: Hasil olah data, 2022
Table 1: Qsd Operation

Indikator /Variabel /Header	Riset PLTN	Teknologi PLTN Mutakhir	Komitmen Nasional	Sosialisasi PLTN	Sinergi BRIN	Kompensasi Masyarakat	Kerjasama Internasional	Bobot Kepentingan	Prioritas Kepentingan
	Optimalisasi EBT	3	3	9	1	3	1		
Regulasi EBT (investasi)	3	3	9	1	1	1	3	21	3
Terminasi PLTU- Pembangunan PLTN	1	3	9	1	1	1	1	17	
Penguatan Teknologi	3	9	3	1	3	1	1	21	3
Kebijakan Politik	3	3	9	3	3	3	3	27	1
Sinergi Antarlembaga	1	1	1	1	9	1	3	17	
Komunikasi/ sosialisasi	1	3	1	9	3	1	1	19	
Diversifikasi Energi	1	1	1	1	9	1	1	15	
Bobot Tindakan	16	26	42	18	32	10	16		
Prioritas Tindakan		3	1		2				

Sumber: Hasil Olah Data, 2022
Table 2: Qsd Assesmen

The QSD assessment data is then abstracted to select the one with the highest value weight. The results are as follows.

Indikator/Variabel/Header	Bobot/Nilai	Prioritas
Kebijakan politik	27	1
Optimalisasi EBT	23	2
Regulasi EBT (investasi)	21	3
Penguatan teknologi	21	3

TABLE 3: Priority Interest in Towards NZE 2060 in Indonesia

Sumber: Hasil Olah Data, 2022

In the direction of net zero emission 2060, there are a number of priority interests pursued by the Indonesian government. Sequentially consisting of political policies, optimization of EBT, regulation of EBT (investment), and strengthening of technology. Further explanation will be elaborated below:

A. Political Policy

Political policy is an important key towards NZE 2060. Politics related to this policy are not only politics at the national level, but also politics at the global level. With Indonesia's participation in the "Paris Agreement" in "COP 21", Indonesia is committed with the world's citizens to jointly reduce CO2 emissions. According to the discussion of Law No. 16/2016 concerning Ratification of the Paris Agreement to The United Nations Framework Convention on Climate Change. This law is an important legal umbrella for Indonesia in the context of implementing a number of government policies related to efforts to reduce GHG emissions. In addition to ratifying Law no. 16/2016, the government also seeks to implement the implementation of the global commitment in the form of an NDC to reduce GHG emissions by 29 percent with its own efforts by 2030.

The 2030 NDC will also be followed by a long-term strategy (LTS) until 2060 to achieve NZE. The government will make every effort to involve all stakeholders so that the target of achieving NZE can be achieved in the future. Political policies that are the result of decisions from policy makers from the government level to politics will be an important guide in formulating steps towards NZE 2060.

B. NRE Optimization

EBT will continue to be optimized for its utilization in Indonesia. Slowly but surely NRE will become a priority energy source to be excelled in national energy supply. The Ministry of Energy and Mineral Resources already has three major targets that must be met. In terms of time, there are short, medium and long-term targets. For the short term, it has been stated in the national energy policy (KEN) where the mix of EBT in primary energy in 2025 must reach 23 percent. In the medium term, Indonesia has committed to "COP "21 in Paris, to reduce CO2 emissions in 2030 by 29 percent with their own efforts and 41 percent with assistance from outside or international (foreign) parties. Long-term targets, in COP 26, Indonesia conveys will achieve net zero

emission by 2060. This long-term target can be achieved more quickly if it gets support from the international community.

In the short term, the government will try to encourage EBT from PLTS to accelerate rapidly. This is because the potential of PLTS in Indonesia is very large and the installation process is fast. According to the Ministry of Environment and Forestry, (2020) in terms of price, PLTS is now relatively competitive or quite cheap. So, the energy mix target of 23 percent in 2025 is optimistic that it can be met. In the medium term towards NDC 2030, the government has prepared a "green RUPTL" scenario in the 2021-2030 range which will be dominated by power plants sourced from NRE. NRE will become an important backbone for energy supply in Indonesia. In the long term, the government will gradually increase the energy mix from NRE and it will continue to grow. The peak is in 2060, energy sources in Indonesia are targeted to be 100 percent of NRE. Energy sources from solar, water, and bioenergy will be Indonesia's mainstay in the future.

C. EBT Regulation (Investment) and Technology Strengthening

To encourage the entry of investment from IPP, the Ministry of Energy and Mineral Resources as well as a number of related ministries drafted the "Rperpres on EBT". In the Rperpres there are 3 schemes for purchasing electricity, namely, first, feed in tariff. This scheme is applied to EBT plants with a capacity of up to 5 MW. It is hoped that this scheme can be carried out by the regional government or BUMD as well as the local private sector. Second, with the purchase mechanism of the highest benchmark price. This scheme is applied to the development of EBT above 5 MW. Intended for all parties are welcome to participate and participate in developing NRE in Indonesia. Third, based on the agreed price for certain types of EBT. For example, marine energy plants, waste power plants, biofuel power plants. Therefore, the plan to ratify the Presidential Regulation on EBT is a good step to attract investors in the NRE sector. According to PLN, (2021) with the legal umbrella, PT PLN can buy electricity from the IPP with a number of mechanisms. Pricefeed-in tariffs; the highest benchmark price; and/or deal price with or without taking into account factors location. If this is realized, the opportunity to attract the presence of NRE investors will be even greater because the scheme promises profits.

In the direction of net zero emission (NZE) or carbon neutral in 2060, the use of the latest technology is a necessity. Various obstacles faced today will be overcome gradually with the use of reliable technology. Intermittent constraints from NRE generation will be overcome with a smartgrid system that is connected to base load generation. Energy from hydrogen will be utilized more massively with the invention of technology that can store and convert that energy into a power source. Energy storage technology in batteries will be increasingly developed for both transportation and daily needs. Reliable technology that prioritizes high safety will be used for the development of nuclear power plant reactors. In addition, the government

will also develop technology that can generate energy from ocean currents. People in the future will be more familiar with tools or technologies that promote environmental sustainability.

Indikator/Variabel/ Header	Bobot/ Nilai	Prioritas
Komitmen nasional	42	1
Sinergi BRIN	32	2
Teknologi PLTN mutakhir	26	3

Table 4: Priority Actions in the Development of Nuclear Power Plants in Indonesia

Sumber: Hasil Olah Data, 2022

In the development or construction of nuclear power plants in Indonesia, there are a number of priority actions taken by the Indonesian government or stakeholders related to nuclear power plants. Sequentially consisting of national commitments, BRIN synergies, and state-of-the-art nuclear power plant technology. Further explanations will be described below:

D. National Commitment

National commitment is very important in its position in deciding the construction of nuclear power plants in Indonesia. This national commitment is a form of official statement from the government that has official political support in declaring “Go” or “Not Go” in the nuclear power plant development plan. With this commitment, there will be a mutual agreement between the government, politics, and a number of stakeholders that Indonesia is serious about building a nuclear power plant. This commitment will create a supply chain in nuclear development. Starting from vendors who will build reactors, financing mechanisms, to supply of raw materials for nuclear power plants. In addition to the IAEA and the vendor's countries of origin, countries around Indonesia will also review the safety system of the reactor that is planned to be built. So, it will further strengthen the supervision of the safety and security factors of the nuclear power plant reactors that will be developed.

E. BRIN Synergy

The merger of a number of state research institutions within the National Research and Innovation Agency (BRIN) is a benefit for the development of nuclear power plants. The Nuclear Energy Research Organization (ORTN), previously known as BATAN, is now not working alone. ORTN has a great opportunity to collaborate with other research organizations within the BRIN institution in order to strengthen the IAEA assessment in passing the plan for the development of nuclear power plants in Indonesia. ORTN-BRIN can provide cutting-edge research support related to the development of the right nuclear power plant to be built in Indonesia. ORTN-BRIN can also develop research related to materials or mining of uranium raw materials that are more up-to-date. In addition, ORTN-BRIN can provide education and socialization related to nuclear power plants to all stakeholders so that nuclear power plants can be accepted. So, nuclear power plants can be accepted and minimal

rejection from the community or certain other parties. With more and more stakeholders involved positively outside the ORTN-BRIN, the road to the realization of nuclear power plant development will be wide open.

F. Advanced Nuclear Power Plant Technology

Issues related to the security and safety of nuclear power plants are crucial issues that often hinder the development of nuclear power plants in a country. Therefore, to mitigate these hazards, the choice of using the latest technology nuclear power plants is a necessity. The use of the fourth-generation nuclear power plant reactor which has an inherent safety system is a wise choice in order to maximize the safety and security factor. In addition, by using generation IV nuclear power plants that are modular in nature, the reactor construction time can be shortened. In terms of costs, it can also be reduced because the processing time is shorter. The development of technologically advanced nuclear power plants is very promising in Indonesia. With a compact modular design, the investment costs from the initial research to the decommissioning of the nuclear power plant result in a competitive electricity selling price. In addition, this modular reactor can be developed by several vendors with a small generating capacity of less than 300 MW, so it is relatively suitable to be developed in archipelagic areas such as Indonesia.

IV. CONCLUSIONS AND SUGGESTION

The conclusion from the QSD method is that a number of priority formulations of interests towards NZE or carbon neutral 2060 are obtained. In addition, the formulation of priority actions that need to be taken in the construction of nuclear power plants to support NZE 2060 is obtained.

- The priority of interests towards NZE or carbon neutral 2060 consists of political interests or policies, optimization of EBT, regulation of EBT (investment), and strengthening of technology.
- The priority of action in the development of nuclear power plants in support of NZE 2060 consists of national commitments, BRIN synergy, and the selection of the latest nuclear power plant technology.

The suggestions put forward in this study consist of:

- Every country, including Indonesia, needs to immediately realize the construction of nuclear power plants. The NPP reactor was statistically proven to significantly reduce emissions. The recommended technology to be chosen in the construction of nuclear power plants is the type IV generation which has a high level of safety and security. This IV technology has a relatively faster development time and has a modular concept so that it can be built with a small capacity of < 300 MW. Relative to the territory of Indonesia which is in the form of an archipelago.
- In the direction of NZE 2060 the government should not discriminate against certain energy sources. All energy sources are developed jointly to increase national energy security. The development of nuclear power plants should be carried out together with other energy sources in Indonesia.

- The implementation of the carbon tax starting April 1, 2022 is expected to be realized so that it accelerates the phase down of PLTU and accelerates the policy of PLTN development.
- The government and institutions related to nuclear power continue to carry out socialization and education to the public and all stakeholders so that understanding regarding nuclear energy (PLTN) increases so that the development of nuclear power plants can be accepted by all levels of society.
- The current government's policy priorities or interests are relatively good. The government needs to immediately realize the Presidential Regulation and Bill related to EBT so that investment in the NRE sector is more attractive.
- The priority of action in the realization of nuclear power plant development is currently waiting for the most important commitment from the government, namely the decision to "go nuclear". With this national commitment, the link in the development process and the licensing of nuclear power plants will be maximally established. With a firm government policy, a conducive ecosystem will be created to support the development of nuclear power plants.

Atas Konvensi Kerangka Kerja PBB Mengenai Perubahan Iklim)

- [13.] Peraturan Pemerintah No. 14/2015 Tentang Rencana Induk Pembangunan Industri Nasional (RIPIN)
- [14.] Peraturan Pemerintah No. 79/2014 tentang Kebijakan Energi Nasional (KEN)
- [15.] Peraturan Presiden No. 22/2017 tentang Rencana Umum Energi Nasional (RUEN).

REFERENCES

- [1.] Bungin, Burhan. "Penelitian Kualitatif Komunikasi, Ekonomi, Kebijakan Publik, dan Ilmu Sosial lainnya". Edisi Keempat. Jakarta: Kencana Predana Media Grup, 2010.
- [2.] Fatimah, Rika. "*Quality Scorecard Deployment*". Yogyakarta, 2019.
- [3.] IEA. Net Zero by 2050 A Roadmap for the Global Energy Sector, 2021.
- [4.] IAEA. IAEA Annual Report, 2020.
- [5.] PT PLN. Rencana Usaha Penyediaan Tenaga Listrik (RUPTL) PT PLN (Persero) Tahun 2021-2030, 2021.
- [6.] KLHK RI. Updated Nationally Determined Contribution Republic of Indonesia.
- [7.] KLHK RI. Indonesia Long-Term Strategy for Low Carbon and Climate Resilience 2050, 2021.
- [8.] Arifianto, Budiawan Sidik. Kolaborasi EBT dan Nuklir Menuju Emisi Nol Dunia. Retrieved from <https://www.kompas.id/baca/riset/2021/08/29/kolaborasi-ebt-dan-nuklir-menuju-emisi-nol-dunia/>, 2021.
- [9.] Arifianto, Budiawan Sidik. (2021). *Nuklir Salah Satu Andalan Dunia Menuju Emisi Nol*. Retrieved from <https://www.kompas.id/baca/riset/2021/09/19/nuklir-salah-satu-andalan-dunia-menuju-emisi-nol/>
- [10.] Arifianto, Budiawan Sidik. Transisi Dunia Menuju Energi Bersih. Retrieved from <https://www.kompas.id/baca/riset/2021/09/13/transisi-dunia-menuju-energi-bersih/>, 2021.
- [11.] DEN. *Go Green Dengan Nuklir*. Retrieved from <https://www.den.go.id/index.php/dinamispage/index/108-.html>, 2011.
- [12.] UU No.16/2016 Tentang Pengesahan *Paris Agreement To The United Nations Framework Convention on Climate Change* (Persetujuan Paris