The International Journal of Business Management and Technology, Volume 6 Issue 1 January-February 2022
ISSN: 2581-3889

Research Article Open Access

Nuclear Power Plants Technology to Realize Net Zero Emission 2060

Irza Utami[1], Maydi Aula Riski[2], Dhimas Rudy Hartanto[3]
[1]*Energy Security, The Republic of Indonesia Defense University,*
[2]*Library and Information Science, Sunan Kalijaga Islamic State University,*
[3]*Maritime Security, The Republic of Indonesia Defense University,*

Abstract: *Research on the ability of Nuclear Power Plants (NPP) in realizing Net Zero Emission 2060 has been conducted. Indonesia commits to achieving Net Zero Emission (NZE) by 2060. This target is part of the implementation of Indonesia's commitment to the Paris Agreement. Indonesia must make an energy transition to achieve Net Zero Emissions. This research uses qualitative methods, namely collecting and analyzing secondary (exploratory) data. The research designs used in this study are phenomenology and case studies. The results showed that the nuclear power plant was able to bring Indonesia to NZE 2060. Nuclear power plants produce lower emissions than fossil fuel power plants. The contribution of nuclear power plants by 36.8% can reduce CO2 gas emissions by 55%. The contribution of nuclear power plants by 48.8% can reduce CO2 gas emissions by 73%. Then in terms of meeting Indonesia's energy needs, nuclear power plants can to provide national electricity needs up to 1,000 to 1,400 Mega Watts per unit..*

Keywords: Net Zero Emission, Nuclear Power Plants, Renewable energy

I. INTRODUCTION

In 2012, the UN Secretary-General launched the Sustainable Development Goals (SDGs) (kemlu.go.id, 2019). Localise SDGs Indonesia (2018) said that this is a global action plan agreed by world leaders, including Indonesia, to end poverty, reduce inequality and protect the environment. One of the targets is the efficient, sustainable, environmentally friendly, and renewable use of energy. This target will be achieved if the rest of the world reduces the dependence of energy needs from fossil fuels.

2060 is a year of proof of achievement for the Indonesian nation, especially in the development of environmentally friendly and sustainable energy. Indonesia commits to achieving Net Zero Emission (NZE) by 2060. This target is part of the implementation of Indonesia's commitment to the Paris Agreement. Government Regulation number 79 of 2014 on national energy policy for example mentions that the target of achieving new renewable energy in Indonesia in 2050 is 31%.

Various efforts are made by the government so that the RENEWABLE ENERGY mix target is achieved. Among them is the Regulation of the Minister of Energy and Mineral Resources No. 12 of 2017 on the Utilization of Renewable Energy Sources for the Provision of Electricity. The regulation states that PT PLN (Persero) must buy electricity from power plants that utilize renewable energy sources. In addition, kemlu.go.id (2019) mentioned that the Government has reduced various regulations, regulations, and licensing (about 180). The goal is to increase investment in the energy sector. The regulations in question are regulations that previously hindered investment in new and renewable energy. The Indonesian government also provides various incentives for investment in the sector. Thus, Indonesia is expected to meet energy mix targets as well as reduce greenhouse gas emissions.

Government Regulation number 79 of 2014 states that Indonesia's renewable energy mix target in 2025 is 23%. This target is equivalent to a renewable energy generation capacity of 45 GW. The Press Release of the Ministry of Energy and Mineral Resources of Indonesia on February 7, 2020, mentioned that the power generation capacity of Renewable Energy is currently around 10.3 GW or about 14.8%. This means that an additional 34.7 GW is needed until 2025 or an average of 4.5-5 GW per year since 2017. Thus the addition of 0.47 GW per year or 10% of the average additional capacity per year according to the RUEN target, even an average of 5% throughout 2015-2018 shows that the government's achievements are not actually on the right track.

In this paper, the author proposes nuclear as an energy source to meet the target that has been set, namely utilizing nuclear as a power plant. Nuclear power plants are the answer to Indonesia's energy needs that are more

environmentally friendly. Indonesia has a potential thorium content estimated at 210,000 - 270,000 tons (Hidayat, 2018). The National Nuclear Technology Agency (Batan) mentioned that one of the areas that could potentially be built by nuclear power plants in east Kalimantan (Batan.go.id, 2016). His study found that East Kalimantan has 3 potential locations built by nuclear power plants. Syeilendra Pramuditya (2008), a biophysical nuclear physicist from the Bandung Institute of Technology Indonesia mentioned in his writing that the comparison between nuclear power plants and plants is as follows:

a. Theoretically, nuclear fission reactions produce 10 million times more energy than chemical combustion reactions.
b. A uranium fuel pellet measuring 1 cm3 would produce energy equivalent to burning 800 kg of coal, or 500 m3 of gas, or 600 liters of oil.
c. 1 Kg of Uranium produces 50,000 kWh of electrical energy. Burning 1 kg of coal produces 1.6 kWh of energy. Burning oil and gas produces 3-5 kWh.
d. Capacity factor (percentage of electricity that power is generated by power plants relative to the potential of electricity that can be generated) gas power plants by 15 - 38%, oil 29.8%, coal 72.6%, and nuclear 89.3%
e. The average electricity production cost as of 2005 was 8.09 US cents/kWh for oil, 7.51 CENTS USD/kWh for gas, 2.21 US cents/kWh for coal, and 1.72 CENTS USD/kWh for nuclear.
f. The price of nuclear fuel is much more stable than fossil fuels.
g. In the right handling, nuclear power plants are the most environmentally friendly compared to other energy sources. Nuclear power plants hardly produce any pollutants or particulates into the soil, water, and air. By 2005, nuclear reactors in the United States had prevented the emissions of 3.32 million tons of SO2, 1.05 million tons of NOx, and 681.9 million metric tons of CO2 into the air. If America uses fossil fuels to produce its electricity, the harmful gases above will be transmitted into the earth's atmosphere.

II. METHOD

This research will use qualitative methods, namely collecting and analyzing secondary (exploratory) data. The research designs used in this study are phenomenology and case studies. Researchers use qualitative data collection techniques as basic guidelines. Researchers also conduct descriptive analyses of secondary data such as journal references, reports, and more.

III. RESULT AND DISCUSSION

3.1 Indonesia's nuclear power plants and energy policies

The discussion about the development of nuclear energy in Indonesia is one of the problems that never end. The extent of the area with a non-light geographical field, and 100% electrification challenges, as well as renewable energy targets, make the development of nuclear energy in Indonesia an absolute must-do. Nevertheless, the pros and cons always color the discussion about this development. The pro-nuclear side feels this needs to be done immediately to support national energy security. Meanwhile, the counter-parties are behind Government Regulation 79/2014 on national energy policy which states that nuclear is the last option. Thus Indonesia does not need to develop nuclear energy because there are still many other RENEWABLE ENERGY sources such as solar, wind, water, etc.

Pratically, no regulation prohibits nuclear power plants. The nuclear power plant is the mandate of Law 2006 number 17 on the National Long-Term Development Plan 2005 - 2025. Hopefully, by 2024 the nuclear power plant will be operational. The last option referred to in Government Regulation number 79 does not mean that nuclear energy is only developed when there is no other energy that can be utilized in Indonesia. The last option that is intended in Government Regulation number 79 is that nuclear energy needs to be developed immediately if all studies have been carried out and there is an urgent need. Thus, the nuclear power plant can be built immediately if Indonesia meets urgent needs. Related to the current conditions, Indonesia should have built a nuclear power plant. Here are some of the factors that cause Indonesia to develop nuclear power plants:

a. National electricity needs in 2015-2024 will increase to 5,900 MWe per year (2015-2024 AGM). PT PLN and Independent Power Producer (IPP) are only able to meet about 4,200 MWe per year. Meanwhile, the nuclear power plant can provide national electricity needs up to 1,000 to 1,400 Mega Watts per unit.
b. Fulfillment of mixed targets. Based on Government Regulation No. 79 of 2014 on National Energy Policy (KEN), the projected electricity needs until 2025 are 115 GWe. This means that an additional generating capacity of 69 GWe is needed within 11 years or 6.2 GWe per year. The Utilization of solar, geothermal, wind, hydro, and other power will not reach 95 GWe by 2025. This means that another energy is needed that can help meet this target, namely nuclear energy.

c. Indonesia's commitment to reducing CO2 emissions. In 2016, Indonesia ratified the 2015 Paris Agreement into a legal document on the administration of the country. The ratification was passed through Law number 16 of 2016 concerning the ratification of the Paris Agreement to the United Nations Framework Convention on Climate Change Majority. At the moment, Indonesia's power plants are still fossil-fueled. The utilization of renewable energy that has been done has not been able to replace the amount of energy produced from fossil plants. This is different if the nuclear power plant is already in operation. The energy generated by nuclear power plants is very large and can replace fossil plants. Or at least it can meet the renewable energy mix target.

d. Nuclear power plants produce much lower emissions than fossil fuel power plants. Budi and Suparman (2013) found in their research that the emission factors for each coal-fired power plant are as follows: Banten Power Plant 1,033 kg / kWh, Indramayu Power Plant 1,002 kg / kWh, Rembang Power Plant 1,136 kg / kWh, and 0 kg / kWh. The average CO2 emission factor is 1.05 kg/kWh, and that factor is influenced by the thermal efficiency of the plant, the NCV of the fuel used, and the carbon content (%C) in the fuel. Power generation of 1700 MWyr using Banten, Indramayu, and Rembang power plants will produce CO2 of 16 thousand kTon. If the power generation is replaced with 2 units of 1000 MWe nuclear power plant then CO2 emissions will be reduced by 16 thousand kTon.

e. Nuclear power plants also do not produce pollutant particles such as fossil plants. Nuclear energy has the highest energy intensity, very large energy produced from a very small amount of fuel. The most important thing is that nuclear energy is very reliable, not depending on the weather, unlike air power plants or hydropower plants.

3.2 Nuclear Power Plant (NPP) Technology

One of the developments in nuclear technology is nuclear power plants that use liquid thorium fluoride as a heat transfer substance (octadiansah and Sodik, 2012). Thorium has an atomic number of 90. Thorium is solid like crystals and other minerals, silver, and has radioactive properties (Hidayat, 2018). According to BATAN, quoted from Hidayat (2018) Bangka Belitung is an Indonesian territory that has Thorium reserves. Thorium reserves amounted to 121,500 tons. The article also mentions that with thorium as much as it can provide 121 gigawatts of power for 1000 years.

The nuclear power plant technology that uses Thorium as fuel is the Molten Salt Reactor (MSR). Research on the Molten Salt Reactor has been going on for a long time. Extensive research into the Molten Salt Reactor began when the U.S. Aircraft Reactor Experiment supported the U.S. Aircraft Nuclear Propulsion program. ARE, this experimental high-temperature MSR was developed at Oak Ridge National Laboratory (ORNL) (Serp et all, 2014). MSR is a 4th generation nuclear power plant.

Molten Salt Reactor (MSR) is a nuclear technology that uses liquid fuel. The working principle of MSR technology is almost the same as the use of nuclear energy in nuclear power plants, which uses energy (heat) released in the process of fission (cleavage) of atoms to heat water to temperatures above 500oC. The steam generated in the process is used to spin turbines and generate electricity (figure 1).

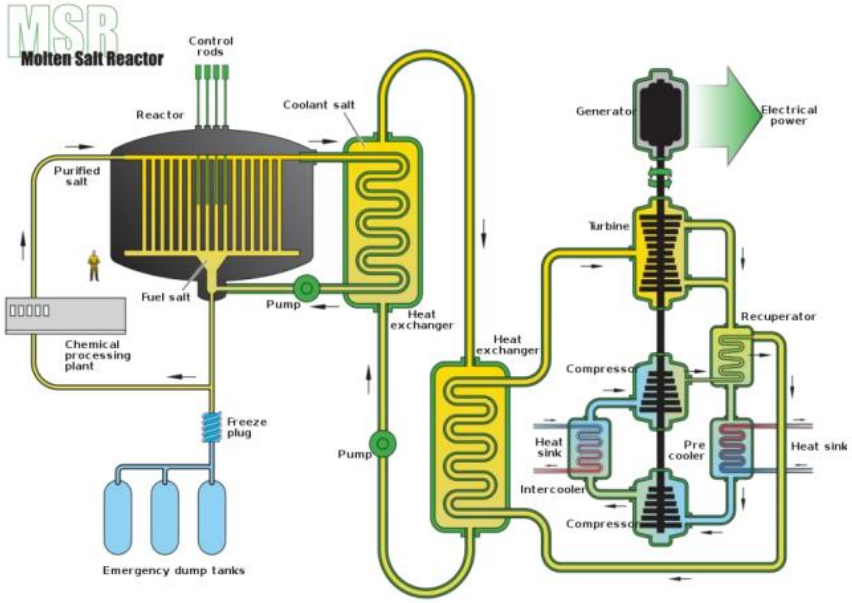

Figure 1. Molten Salt Thorium Nuclear Power Plant Scheme
(Source: Hidayat, 2018)

MSR technology is believed to be a very suitable author developed in Indonesia, here are the reasons:

a. Thorium-based nuclear power plants are safer. The Th-232 must be shot with a continuous external slow neutron source (it can be via accelerators/photon beams/plutonium nuclei as developed in India). This shooting was done to turn it into U-233 (fission reaction). Thorium's scheme has no chain reaction. Thus, there are not enough neutrons to continue the fission reaction. When the neutron source is removed, the reactor will die. When the reactor is overheated (as in Fukushima), a small plug under the reactor's curvature vessel will melt and a solution of thorium salts pours down due to heavy force into the underground tank that has been provided. This can happen automatically because it does not require a computer or electric pump that could be paralyzed by a tsunami (Oktadiansyah and Sodik, 2012).
b. Waste generated is little, as almost 100% of the fuel is used (Hidayat, 2018)
c. Waste produced by MSR is in the form of isotopes that cannot be used to make nuclear weapons (Rahardjo, 2016).
d. Rahardjo (2016) mentions that MSR Technology does not require special anchoring to prevent high pressure. This is because the pressure generated inside the reactor is equal to the pressure outside (atmospheric pressure). In addition, this technology has a simple design. This allows MSR technology to be mass-produced.

3.3 Capabilities of nuclear power plants in realizing NZE 2060

The results of the IESR analysis (2021) stated that Indonesia can achieve carbon neutrality before 2060. The strategy is to reduce greenhouse gas emissions from various sectors, namely power generation, transportation, and industry. This all contributed to emissions of 406.8 million tons of CO2 or about 93% of the total Co2 emissions of the energy sector in 2015. Deon Arinaldo, Manager of IESR's Energy Transformation Program, said that Indonesia was able to increase the primary energy mix from renewable energy to 69%. The trick is to increase the capacity of renewable energy generation to at least 24 Giga Watt (GW) by 2025. Then, Indonesia must also build 408-450 GW of renewable energy generation by 2060. Indonesia must stop the construction of new coal plants from 2025, and retire the plant early.

The Institute for Essential Services Reform (IESR) has explained that Indonesia needs electricity generation that is environmentally friendly and produces large energy. The authors believe that the power plant that best fits these criteria is a nuclear reactor. Nuclear power plants can provide a large demand for Indonesia's energy. Thus, the NPP is very feasible to replace coal-fired power plants. This has been done immediately because the source is a contributor to Co2 emissions. Budi (2013) has conducted research related to the study of the contribution of nuclear power plants in reducing CO2 gas emissions using data from studies on optimization of Sumatra power generation system development with nuclear options. His research shows that in variable discount rates of 8% and 10%, nuclear power plants will appear on the Sumatran electricity system with portions of 48.8% and 36.8% respectively. The results of calculating CO2 gas emissions in 2006-2030 at discount rates of 8%, 10% and 12% amounted to 506,208, 1,138,360 and 1,872,238 kilotons, respectively. This shows that the contribution of nuclear power plants by 36.8% can reduce CO2 gas emissions by 55%. The contribution of nuclear power plants by 48.8% can reduce CO2 gas emissions by 73%.

In 2013, Budi and Suparman researched to calculate CO2 emission factors in power plants and nuclear power plants. In his research, he did calculations for Banten Coal Power Plant, Rembang Power Plant, Indramayu Power Plant, and PWR type 1000 MWe power plant. The results of his research found that the emission factors from each plant are as follows:

a. Banten Power Plant 1,033 kg/kWh,
b. Indramayu Power Plant 1,002 kg/kWh,
c. Rembang Power Plant 1,136 kg/kWh,
d. and 0 kg/kWh nuclear power plant.

The average value of the emission factor is 1.05 kg/kWh. Power generation of 1700 MWyr using Banten, Indramayu, and Rembang power plants will produce CO2 of 16 thousand kTon. If this power plant is replaced with 2 units of 1000 MWe capacity nuclear power plant, it can reduce CO2 emissions by 16 thousand kTon.

IV. CONCLUSION

Indonesia could reach carbon neutral before 2060. The strategy is to reduce greenhouse gas emissions from various sectors, namely power generation, transportation, and industry. Indonesia was able to increase the primary energy mix from renewable energy to 69%. The trick is to increase the capacity of renewable energy generation to at least 24 Giga Watt (GW) by 2025. Then, Indonesia must also build 408-450 GW of renewable energy generation by 2060. Indonesia must stop the construction of new coal plants from 2025, and retire the plant early.

Indonesia needs electricity plants that are environmentally friendly and produce large energy. The power plant that best fits these criteria is the nuclear power plant. PPN can bring Indonesia to NZE 2060. Nuclear power plants produce much lower emissions than fossil fuel power plants. The contribution of nuclear power plants by 36.8% can reduce CO2 gas emissions by 55%. The contribution of nuclear power plants by 48.8% can reduce CO2 gas emissions by 73%. Then in terms of meeting Indonesia's energy needs, nuclear power plants can provide national electricity needs up to 1,000 to 1,400 Mega Watts per unit.

REFERENCES

[1] Batan.go.id, 2016, Kalimantan Timur Miliki 3 Lokasi Potensial untuk PLTN, http://www.batan.go.id/index.php/id/kedeputian/teknologi-energi-nuklir/kajian-sistem-energi-nuklir/2743-kalimantan-timur-miliki-3-lokasi-potensial-untuk-pltn

[2] Budi, S. F. R., Suparman., 2013, Perhitungan Faktor Emisi Co2 PLTU Batu Bara dan PLTN, *Jurnal Pengembangan Energi Nuklir*, Vol. 15 No. 1.

[3] Hidayat, N. Y., 2018, Pemasukan Opsi Pembangkit Listrik Tenaga Nuklir Thorium (PLTN-Thorium) dalam Kebijakan Energi Nasional (KEN) merupakan Langkah Multihasil untuk menyelesaikan Permaslaahan Perubahan Iklim dan Ketersediaan Energi, *Prosiding Seminar Bumi dan Atmosfer STMKG*, pp. 104-116.

[4] IESR, 2021, Deep decarbonization of Indonesia's energy system A pathway to zero emissions by 2060, IESR, Agora Energiewende, LUT University.

[5] Kemlu.go.id, 2019, Sustainable Energy dan Upaya Ketahanan Energi Nasionalhttps://kemlu.go.id/portal/id/read/171/halaman_list_lainnya/sustainable-energy-dan-upaya-ketahanan-energi-nasional

[6] KESDM, 2020, Siaran Pers Nomor: 062.Pers/04/SJI/2020 pada 7 Februari 2020: Kapasitas Pembangkit Naik Jadi 69,6 GW, EBT Sumbang 10,3 GW, https://ebtke.esdm.go.id/post/2020/02/10/2473/kapasitas.pembangkit.naik.jadi.696.gw.ebt.sumbang.103.gw.

[7] LocaliseSDGs, Sustainable Development Goals, https://localisesdgs-indonesia.org/17-sdgs

[8] Oktadiansyah., Sodik, A., 2012, PLTN Berefisiensi Tinggi dengan Kombinasi Teknologi Reaktor Thorium Fluorida dan Siklus Brayton Tertutup, *Prosiding Seminar Nasional Pengembangan Energi Nuklir V*, Pusat Pengembangan Energi Nuklir, Badan Tenaga Nuklir Nasional (BATAN).

[9] Rahardjo, I., 2016. Proyeksi Bauran Energi di Sektor Ketenaganukliran. Tangerang Selatan : Pusat Teknologi Konversi dan Konservasi Energi, BPPT.

[10] SERP, J., et al., 2014. The molten salt reactor (MSR) in generation IV: Overview and perspectives. Progress in Nuclear Energy xxx (2014) 1–12.

[11] Syeilandra Pramuditya, 2008, mengapa harus nuklir?, KK Fisika Nuklir dan Biofisika Institut Teknologi Bandung, https://syeilendrapramuditya.wordpress.com/2008/06/.

[12] Peraturan Pemerintah Nomor 79 Tahun 2014 tentang kebijakan energi nasional

[13] Peraturan Menteri Energi dan Sumber Daya Mineral Republik Indonesia Nomor 12 Tahun 2017 tentang Pemanfaatan Sumber Energi Terbarukan untuk Penyediaan Tenaga Listrik.

[14] Undang-undang (UU) No. 17 Tahun 2007 Rencana Pembangunan Jangka Panjang Nasional Tahun 2005 – 2025.

[15] RUPTL 2015-2024: Rencana Usaha Penyediaan Tenaga Listrik PT PLN (Persero)

[16] UU Nomor 16 Tahun 2016 tentang pengesahan Paris Agreement to the United Nations Framework Convention on Climate Change Mayoritas