



## NUCLEAR-BASED NEW ENERGY DEVELOPMENT AS THE ANSWER TO ENVIRONMENTAL SUSTAINABILITY

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### Abstrak

This research aims to analyze the potential of nuclear energy as a sustainable and viable solution for meeting energy demands. Currently, petroleum and coal are the most heavily relied upon energy sources, yet their high consumption is unsustainable given the limited availability of fossil fuels, particularly petroleum. As a result, there is an urgent need for the government to explore alternative energy sources that can mitigate the economic impacts of fossil fuel dependence and ensure reliable electricity supply for communities. This study employs a normative legal research methodology, primarily through literature reviews. The compiled data will be analyzed using qualitative descriptive methods. A key focus of this research is the advantages of nuclear energy as a sustainable alternative, particularly through the use of thorium fuel in conjunction with Molten Salt Reactors (MSR). To facilitate the successful implementation of nuclear energy, systematic and comprehensive regulations are essential, along with restorative measures to address any potential operational issues. This research concludes the need for further investigation into the legal and practical frameworks that can support the transition to nuclear energy as a cornerstone of future energy policy.

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### I. INTRODUCTION

It is no secret that Indonesia is an equatorial emerald rich in natural resources, the Ministry of Energy and Mineral Resources (ESDM) stated that in 2020 Indonesia ranked 6th in the world in terms of natural resources. Regulations regarding natural resources in Indonesia have been regulated in Law No. 4 of 2009 concerning Mineral and Coal Mining. Some of the natural resources that play a major role are petroleum and coal. Based on data from the Ministry of Energy and Mineral Resources Minerba One Data Indonesia (MODI), coal production as of 10 December 2020 reached 524.2 million tons and is targeted to reach 550 million tons of coal in 2021 (Meilanova, 2020). Meanwhile, in June 2020, oil production alone was recorded at 720 thousand bopd (Atmaja, 2020).

*Salus Populi Suprema Lex*, which means that the state must act optimally in realizing the welfare of the people, is the concept of a welfare state put forward by Prof. Dr. Salus Populi. This is

clearly stated in Article 33 paragraph (3) of the 1945 Constitution of the Republic of Indonesia.<sup>1</sup> To achieve this, which is one of the aspects that must be fulfilled by the state as a form of granting rights to its people is to overcome the potential electricity crisis. In the increase of the industrial revolution every year, the average use of electricity increases by 6.7% per year. Based on data obtained from the Central Bureau of Statistics (BPK), electricity consumption per capita (MWH/capita) in 2020 to 2021 increased by 0.01 MWH/capita and from 2021 to 2022 increased by 0.10 MWH/capita (Draft RUPTL PLN 2018-2027, 2018). The figures that continue to increase every year show that the need for electricity is not proportional to the availability of fossil fuels, especially petroleum, which is estimated to be used only for the next 42 years. The occurrence of this electricity crisis can be clearly seen in early 2022 where there was a coal supply crisis to PLN, causing Indonesia to stop coal exports on January 1, 2022 to January 31, 2024. Coal supply at 20 power plants with a capacity of 10,850 Mega Watts (MW) was threatened and as many as 10 million PLN customers were threatened with darkness. In this case, PLN needs 20 million tons of coal to be able to make coal availability in power plants in a stable condition with at least 20 days of operation in January 2022 (Mae, 2024).

Currently, 90% of the energy used every day comes from coal, gas and oil. With this condition, Indonesia will be in the midst of an energy crisis that will have a significant impact on government and daily life, especially in terms of economic, social, and technological progress. Therefore, the use of petroleum and coal occupies the highest position as the most popular energy source in the fulfillment of national energy sources in meeting the needs of the community, one of which is as a fuel for power plants. A closer look at the development of the economic crisis shows that the supply of energy and the increasing demand for energy use are not balanced. On the other hand, the government is required to optimize the development, as well as realize new energy as a power plant in accordance with the right economic assumptions and also reduce the economic impact of fossil fuels in meeting the electricity needs of the community as well as other alternatives by considering the ecoregion principle. This is also done to meet the Paris Agreement which refers to the green economy, as well as climate neutrality to realize Indonesia as one of the countries with zero carbon emissions.

Critics of nuclear power often claim that these energy sources will be successfully exploited in the relatively near future. Regardless of whether or not these sources can actually help in the short term, they are likely to be needed in the long term. Technical capabilities, capital costs per kilowatt of capacity generated or saved, fuel or resource costs, environmental impacts, and barriers to widespread deployment of the technology must be considered when assessing the potential availability of these energy sources. In this research, the author will elaborate further on the advantages of utilizing nuclear

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<sup>1</sup> Indonesia, Undang-Undang Dasar Negara Republik Indonesia Tahun 1945, Ps.33 ayat (3): "Bumi dan air dan kekayaan alam yang terkandung di dalamnya dikuasai oleh negara dan dipergunakan untuk sebesar-besarnya kemakmuran rakyat."

energy as an answer to the sustainability of the energy law by encouraging the use of nuclear energy materials in power generation and its sustainability to the environment. In realizing this, a systematic and adequate regulation is needed for direct practice, which regulates the classification of what restoration steps can be taken in the event of damage, so that the existence of these regulations can convince the wider community regarding the use of nuclear energy in the construction of Nuclear Power Plants (PLTN).

## II. RESEARCH METHOD

The research method used in writing this article is a normative legal research method based on written positive legal principles. The data obtained from the normative legal research method is secondary data which will be obtained from the results of the analysis by examining the issues raised in the writing. Various data will later be collected and further studied using a case approach, laws and regulations and conducting literature studies on applicable positive legal regulations.

After the data is obtained and collected, then the writing in this research will be carried out using the type of descriptive research nature. This nature is applied by explaining in detail about an object of research, compiling related data into a single unit, problem conditions and forming hypotheses as the culmination of writing to factually confirm the contents of the problems raised systematically (Azwar, 1998). Secondary data used in this writing is obtained by collecting materials and elements that have been obtained through official documents, books, reports, research results, news, and other library materials that have been obtained (Soekanto, 1986). The data that has been compiled and obtained in such a way will later be processed with a qualitative descriptive analysis method. This method is carried out in order to analyze, describe and summarize the entire condition of all data that has been collected to be described into a single sentence, so that conclusions can be drawn to answer the main research (Azwar, 1998).

## III. RESULTS AND DISCUSSION

Environment issues can essentially be local, regional, or global depending on the elements that affect the environment. On the other hand, environmental issues such as global warming, ozone layer depletion, and regional pollution are examples of environmental issues that cross national boundaries and are referred to as "the environment knows no boundaries" (Sunkin, et. al., 2002). Therefore, it can be said that environmental issues are complex, and as a result, states have a general responsibility to adopt an interdisciplinary approach in ensuring operations within their territories which, as a result, are incorporated into international environmental law.

Based on data obtained from the Carbon Dioxide Information Analysis Center, Indonesia is in 15th position as an emitter with total emissions of 397 million tons of CO<sub>2</sub> in the aspect of carbon dioxide emissions from the energy sector (Sampara, et. al., 2020). Not only due to its limited supply and non-renewable nature, coal pollution is also one of the main problems of utilizing coal-fired power plants because it can cause environmental problems such as polluting materials in the form of carbon dioxide, sulfur dioxide, and oxides of nitrogen (Hasan, 2014). Waste generated by coal in the form of fly ash and bottom ash (FABA) is also part of the category of Hazardous and Toxic Materials (B3), so this is not only feared to have an unhealthy impact on the environment, but also on public health with the birth of respiratory diseases caused by the SO<sub>2</sub> content in fly ash which has the potential to reduce function and cause irritation to the lungs which can be fatal (Rahma, 2021).

In view of these conditions and as part of the global commitment to address climate change, Indonesia has ratified the Paris Agreement and committed to reducing greenhouse gas emissions. One way to achieve this target is by developing and implementing New Renewable Energy (EBT). The government seeks to integrate the principles of green economy and climate neutrality in the development of EBT, which includes sustainable environmental management, emission reduction, and wise utilization of natural resources. However, the development of EBT in Indonesia is considered to be slow. The Ministry of Energy and Natural Resources (ESDM) noted that in first semester of 2020, the development of EBT only touched 10.77% of the 13.4% target for that year. Indonesia itself has promised and targeted 25% by 2025 and 29% by 2030 in the development of EBT (Kementerian Energi dan Sumber Daya Mineral, 2020). In response to these conditions, one alternative energy source that can be used and is environmentally friendly is the construction of nuclear power plants. Unfortunately, for the rest of this century, coal and nuclear power will be the main rivals for baseload energy generation. Potential alternatives that can compete or can avoid the major problems arising from nuclear power must be considered when evaluating the need for nuclear power. The idea of utilizing nuclear energy is still debated by some as it is considered dangerous. This is due to the bias of human heuristic thinking in accepting information with incomplete data.

Nuclear power plants have emerged as a controversial yet potentially attractive solution, offering the promise of high-capacity, baseload electricity generation with minimal greenhouse gas emissions during operation. However, the implications and impacts of the use of nuclear power plants on Indonesia's environment are multifaceted, necessitating a critical examination of the potential benefits and risks inherent in this technology. According to data from the National Nuclear Energy Agency (BATAN) and promoters in Indonesia, nuclear power plants are believed to provide electrical energy that can overcome the potential energy crisis in Indonesia. The claim that PLTN will provide electrical energy that will be able to overcome the potential energy crisis in Indonesia and is the best choice is consistently conveyed in various socializations and exhibitions attended by BATAN and PLTN supporters in Indonesia. As reported from the World Coal Institute, Indonesia's coal reserves

only account for about 3% of the world's coal reserves in Indonesia. In comparison, Indonesia's measured coal reserves are 21.13 billion tons, according to the latest statistics from Indonesian Energy Statistics, of the 263 million tons of coal produced in 2009, 250 million tons were sold to other countries, which means that about 87% of Indonesia's coal production was shipped to other countries. Based on previous data, domestic demand is only about 13%, Indonesia ranks sixth in the world in terms of coal production (Suryana, 2011).

Regulations regarding nuclear power have been regulated in the Law of Government Regulation No. 10/2007 on Nuclear, Government Regulation No. 54/2012 on Safety and Security of Nuclear Installations, Government Regulation No. 29/2008 on Licensing Utilization of Sources of Ionizing Radiation and Nuclear Materials, and Government Regulation No. 79/2014 on National Energy Policy. But in reality, the existence of these various regulations has not been able to answer concerns and bad perceptions of nuclear. This is because various nuclear reactor accidents such as the Fukushima incident in 2011 and the Chernobyl explosion in Ukraine in 1986 still haunt many parties to realize the use of nuclear energy in Indonesia. Then the problem of Indonesia's geographical location on the ring of fire that stretches from Sumatra Island to Java, Sumatra, and Papua is feared to trigger a disaster. This has become a debate in finalizing the use of nuclear energy sources in the Renewable New Energy Bill (RUU EBT) and the use of nuclear as an energy source is used as the last option. Nuclear reactions occur in nuclear power plants inside the reactor core, where fuel rods containing enriched uranium are arranged. This reaction generates very high heat, which is transferred to a coolant, usually water or gas, that circulates through the reactor. The heated coolant then flows through a heat exchanger, transferring its heat energy to a secondary water loop, producing steam. The steam drives a turbine, which spins an alternator to generate electrical power. The electricity generated is then piped into the power grid for distribution to consumers.

Nuclear energy regulations have been made over the past 24 years, although to date no significant steps have been initiated by the government. This is due to several factors, including safety, security, economics, human resources, and the use of fuel in its operation. In looking at the aspect of fuel use, this is one of the important things that must be considered due to the effects that will result from the processed fuel on society and the waste it produces. In this problem, the use of thorium as a fuel for nuclear power plants in Indonesia can be a solution. Thorium or also dubbed as green nuclear is a content that exists in the earth's layers in the form of minerals and rocks. Interestingly, the use of 1 ton of thorium, which is only equivalent to the size of a basketball, can produce 1,000 MW of electrical power that can be used for one year.

This element is a more environmentally friendly alternative fuel compared to the use of Uranium which requires 200 tons to generate electricity for one year. Thorium is certainly a fuel that can be considered as an alternative energy because of its weak radioactive level, and the volume of waste produced is also much less. The success of the Molten Salt Reactor as a nuclear reactor in

processing thorium-fueled 4th generation thorium can be used as evidence of public concern for nuclear use. However, it should be noted that regulations are needed in the fulfillment of legal certainty from the government as a legislative body in fulfilling the principle of legality (*wetmatigheid van bestuur*) based on *freies ermessen* as a government effort to ensure the safety of human life, the survival of living things and ecosystems as stipulated in Article 3 letters (b) and (c) of Law of the Republic of Indonesia Number 32 of 2009 concerning Environmental Protection and Management.<sup>2</sup> Looking at these aspects, if its use is immediately realized, thorium has a great opportunity to become an alternative energy source that can save the earth as a whole, because in the process of its use there is no burning of carbon elements that can cause CO<sub>2</sub>, SO<sub>x</sub>, NO<sub>x</sub>, VHC emissions which can produce greenhouse effect gases. Thorium reserves in Indonesia, especially in Bangka Belitung, reach 70,000 tons, or 4 times more and evenly distributed than uranium reserves. Based on BATAN data, there are 140,411 tons of thorium reserves in Indonesia, which if calculated, these reserves can be available and used for tens of thousands of years (Wiratmini, 2019). In addition, not only Bangka Belitung is rich in thorium sources, but also in several other areas such as Sumatra, Kalimantan, and Sulawesi so that the development and utilization of nuclear-based thorium fuel can have great potential if developed.

In its implementation, the nuclear reactor is the most important part in producing hot steam from nuclear reactions which will then drive a generator to produce electricity. Because of its sensitive position and prone to leaks that can trigger an explosion, it is important to use a nuclear reactor with high safety quality (Aziz, et. al., 2021). Thorium itself is an element that cannot perform fission reactions (nuclear fission), in contrast to Uranium which can basically perform these reactions. However, with the limited amount of Uranium reserves available, the fission breeding process is carried out on Thorium to be conserved into U-233 in order to generate electricity. In carrying out the conservation process, various experiments have been carried out on other reactors, but in the end the MSR became a reactor that was successfully operated using thorium and U-233 fuel through the fission breeding process with the use of molten salt fuel (Adiwardojo, et. al., 2005). The combination of environmentally friendly thorium with the high-temperature salt content inside the MSR eliminates the possibility of dangerous radioactive material release. Not only that, with its smaller form than other types of nuclear reactors, it is also cheaper. Therefore, MSR reactors are much safer, efficient, economical and have a reliable safety system, which can prevent the possibility of accidents due to the release of radioactive materials that are very dangerous to humans and the environment.

The development of infrastructure that supports the thorium supply chain, from mineral discovery and processing to reactor fuel delivery, is one of the critical stages. In addition, as Indonesia is located in the earthquake-prone Ring of Fire region, the reactor design must utilize a thorough risk

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<sup>2</sup> Indonesia, Undang-Undang Republik Indonesia Nomor 32 Tahun 2009 tentang Perlindungan dan Pengelolaan Lingkungan Hidup, Ps.3 ayat (b) dan (c): "Menjamin keselamatan, kesehatan, dan kehidupan manusia; menjamin kelangsungan kehidupan makhluk hidup dan kelestarian ekosistem."

assessment-based methodology to ensure resilience to natural disasters. In accordance with IAEA guidelines, this requires improved safety standards and technological adaptation. However, to increase public acceptance, effective implementation also requires increased education and involvement of local communities in the decision-making process. Research and development should be a top priority for the government, in collaboration with the business sector and academia, to maximize the effectiveness of RMPs and maintain environmental sustainability. Systematic regulations also need to integrate radioactive waste risk mitigation measures and environmental restoration mechanisms as part of the national energy policy. If these steps are taken consistently, Indonesia can not only utilize thorium as a future energy solution, but also become a global pioneer in clean energy technology.

Mitigating these environmental risks requires a multi-pronged approach. First and foremost, the adoption of advanced reactor technologies with enhanced safety features and inherent resilience to natural disasters such as earthquakes and tsunamis is essential. A robust regulatory framework and strict safety protocols must be established to govern the entire life cycle of nuclear power plants, from construction and operation to decommissioning and waste disposal. Investing in research and development of safe and secure long-term storage solutions for radioactive waste is critical. Transparency and public trust are also critical. Open communication with the public regarding safety measures, potential risks and waste management plans can promote acceptance and reduce public concerns. Basically, the purpose of law is not only to fulfill the principles of legal certainty and justice, but also to provide benefits to society by seeing its effect on human welfare, as stated by Jeremy Bentham by stating that, "The purpose of law is the greatest happiness for the greatest number" (Besar, 2016). According to Jeremy Bentham, every human being is in two states, namely dissatisfaction (pain) and pleasure. Humans, by nature, seek pleasure and avoid unhappiness to gain happiness. When viewed from a moral aspect, morality is an action that must be determined by weighing its usefulness in seeking human happiness, which ultimately becomes the basic foundation in the principle of utilitarianism (Rahmatulla, 2021). A different opinion is conveyed by Jhon Stuart Mill, according to him the types of pleasure have quite a lot of scope and are not only based on the body, but with the spirit as well, this is because utilitarianism must seek the greatest happiness for many people and not just certain individuals. The similarity of views held by Jhon Stuart Mill includes this (Rahmatullah, 2021):

1. What is morally good in this case is what can produce the greatest possible happiness or prosperity for the greatest number of people;
2. Both are interested in developing a rational way of moral guidance and consider that the goal of morality is for the good of mankind by looking at the element of utility; and
3. Neither makes any claim to moral authority, where morals are seen as based on experiences that can be happy or unhappy.

From both, it can be seen that the principle of utilitarianism is to place all problems and conditions of community governance as human affairs in pursuit of welfare as the main goal. For the constitution and

law in Indonesia, utilitarianism has a considerable influence both directly and indirectly by making collective happiness the ultimate goal of law.

Looking at its relevance to the theory of utilitarianism, in this case nuclear energy is considered to provide a more stable and sustainable electricity supply for the next few years, replacing the maximum and extensive use of coal for the community. On the other hand, in its benefits to the environment and contributing to climate change mitigation efforts, nuclear power plants are an energy source that is low in carbon emissions, so that it can reduce dependence on fossil fuels. These benefits will certainly not only have an impact on the environment, but also on the security of energy supply and economic stability, which is in accordance with the principle of utilitarianism which prioritizes collective welfare (Pusat Studi Lingkungan Hidup Universitas Gadjah Mada, 2021). Continued dependence on fossil resources is feared to have an impact on the environment due to global warming climate change. This is because each year, the use of fossil fuels has injected 23 billion tons of carbon dioxide into the atmosphere (Khairunnisa, 2017). Therefore, the exclusion of coal waste from the B3 category is also feared to be the starting point for the relaxation of rules that will not only have an impact on the environment, but also on health with the birth of various respiratory diseases. Dust produced from coal mining activities can later cause black spots on the lungs which if accumulated can cause pneumoconiosis, and even more fatal if you suffer from incurable silicosis due to excessive inhalation of quartz and silica crystals.

In this case, it is a solution where coal is replaced with the use of nuclear-based thorium combined with MSR reactors to reduce these impacts. Meanwhile, in an effort to realize the utilization of nuclear energy and the construction of nuclear power plants, Indonesia already has adequate resources. However, the utilization of renewable energy only becomes a mere discourse if there is no establishment of a regulation that relies on aspects of International Law in the utilization of nuclear systematically and adequately. Based on the Charter of the United Nations (UN) regulates nuclear utilization in Article 13 paragraph 1-part b as a peaceful purpose which contains "advancing international cooperation in the fields of social economy, culture, education, health and assisting the implementation of human rights and basic freedoms for all human beings without distinction of race, sex, language or religion."<sup>3</sup> This is still a role model for the Indonesian government in formulating the right strategy to realize the use of nuclear as a future energy source. However, it is unfortunate that Article 11 paragraph (3) of Government Regulation No. 79/2014 on National Energy Policy confirms

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<sup>3</sup> Perserikatan Bangsa-Bangsa, Piagam Perserikatan Bangsa-Bangsa, Ps.13 butir 1 bagian B: "Memajukan kerjasama internasional di bidang ekonomi, sosial, kebudayaan, pendidikan, kesehatan dan membantu pelaksanaan hak-hak asasi manusia dan kebebasan-kebebasan dasar bagi semua manusia tanpa membedakan ras, jenis kelamin, bahasa, atau agama."

that the Indonesian government limits the utilization of nuclear energy.<sup>4</sup> In addition, this article also states that nuclear utilization is set as the last option. Although the government has raised many articles regarding nuclear afterwards in Law No. 11/2020 on Nuclear and established rules regarding investment in the nuclear field, there are still many other things that have not been adequately regulated such as implementation in the field, supply chain management systems, control of non-conforming products, and communication with consumers (Cusmanri, 2020). Given that the situation of conventional energy supply in the future is increasingly unbalanced with demand, the nuclear option in long-term national energy system planning is one of the solutions that is expected to reduce pressure on energy supply problems, especially electricity in Indonesia. Some things that are still a hindrance in the nuclear power plant program in Indonesia are still issues in the community that cause concerns and doubts in heading towards the nuclear era in Indonesia. Some important issues that often arise among the public are problems related to:

1. Nuclear power plant safety
2. Nuclear waste handling
3. Impact of radiation on the environment.

Currently, it is considered that there is no appropriate legal basis for the utilization of nuclear power plants (especially for thorium fuel) in Indonesia in the context of the required field implementation. For the utilization of nuclear power plants (especially for thorium fuel) in Indonesia in the context of implementation in the field. Specific regulatory specifications such as the use of reactors and fuel and processes in the field become one of the important rules to ensure that nuclear utilization is carried out competently to maintain the welfare and safety of the wider community acting as consumers. According to the author, education regarding the utilization of thorium-based nuclear power plants is the right way to eliminate public fear of nuclear. Law Number 8 Year 1999 on Consumer Protection regulates several consumer rights, one of which is the right to correct, clear, and honest information regarding the condition and guarantee of goods and/or services. In addition, clear and transparent AMDAL and licensing are also important factors in the construction of nuclear power plants. The active involvement of local governments because they are considered to better understand the situation of conditions in the area that is the target of development can also be used as a way in the procedure for making these regulations.

The legal framework in Indonesia related to energy, including nuclear energy, starts from the 1945 Constitution which emphasizes that natural resources, including energy resources, are controlled by the

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<sup>4</sup> Indonesia, Peraturan Pemerintah Nomor 79 Tahun 2004 tentang Kebijakan Energi Nasional Ps. 11 ayat (3): "Ketentuan sebagaimana dimaksud pada ayat (2) dikecualikan bagi Energi Nuklir yang dimanfaatkan untuk keamanan pasokan Energi nasional dengan skala besar, mengurangi emisi karbon dan tetap mengutamakan potensi Energi Baru dan Energi Terbarukan sesuai dengan nilai keekonomiannya, serta mempertimbangkannya sebagai pilihan terakhir dengan memperhatikan faktor keselamatan secara ketat."

state and used for the greatest prosperity of the people. Law No. 30/2007 on Energy states that nuclear energy is one of the energy sources that can be developed to support national energy security. Regulations regarding nuclear energy have been regulated in Government Regulation No. 10/2007 on Nuclear Energy, Government Regulation No. 54/2012 on Safety and Security of Nuclear Installations, Government Regulation No. 29/2008 on Licensing for Utilization of Sources of Ionizing Radiation and Nuclear Materials, and Government Regulation No. 79/2014 on National Energy Policy. Law No. 10/1997 on Nuclear is the main foundation for the development of nuclear energy in Indonesia. This law regulates various aspects related to nuclear, including research, development, utilization, supervision, and control. Under this law, BATAN is established and responsible for research and development of nuclear technology, and the Nuclear Energy Regulatory Agency (BAPETEN), which is responsible for safety and security oversight. As a member of the international community, Indonesia is subject to a number of international nuclear energy regulations and agreements, especially the Nuclear Non-Proliferation Treaty (NPT) and the IAEA as an international agency or organization that takes care of nuclear issues has issued several regulations that must be obeyed by member countries. The regulation is known as the Safety Standards Series, which in it regulates in detail the safety standards or Specific Safety Requirement, abbreviated as SSR, which among others are related to Nuclear Power Plants, one of these regulations is IAEA SSR-2/1 of 2016 concerning Safety of Nuclear Power Plants (Harianto, 2023). This regulation regulates radiation safety and protection which states that the dose from radiation exposure in the installation or exposure due to planned radioactive releases from the installation is kept below the dose limit and kept as low as reasonably achievable. This is to fulfill the safety principles, which are necessary to ensure all operational conditions of the nuclear power plant and for all related activities. It is emphasized that dose limits that are acceptable to humans or the environment should be kept to a minimum. The regulation also mentions the importance of selecting the design and type of reactor to be used. Therefore, the reactors selected and prioritized are those that have been tested to be safe for humans and the environment.

In addition to IAEA SSR-2/1, regulations regarding the operation of nuclear power plants are also regulated in IAEA Safety Series Standards No NS-R-2 in 1996 which consists of regulations regarding nuclear power plant safety. In the General section, it is stated that this Safety Requirements Publication sets out the requirements that must be met to ensure the safe operation of nuclear power plants. This standard was later updated in 2011 to "IAEA Safety Series Standards No SSR-2/2: Commissioning and Operation". If in 1996 this standard regulates the operation of nuclear power plants; then, in 2016 this standard was updated and equipped with the commissioning or shutdown of nuclear reactors. In this safety series, it regulates several principles that must be applied in the operation of nuclear power plants, namely:

1. The primary responsibility falls on the institutions/companies and people who conduct and operate nuclear power plants that generate radiation.

2. Safety leadership and management must be continuous and the designated institution must also demonstrate its leadership.
3. The principle of protection optimization, protection must be carried out optimally to achieve optimal protection.
4. The principle that must be applied is that the radiation that occurs is at the lowest level for humans (Limitation of Risk to Individuals). In this case, the risk to radiation must be monitored so that it does not exceed the predetermined dose limit.
5. The principle of protection of present and future generations, which in this case is also to preserve and protect the environment (Protection of Present and Future Generations). Where humans and the environment are the top priority that must be protected from radiation.
6. The principle of accident prevention in which all efforts must be made to prevent nuclear accidents from occurring.

The safety system concept adopted in nuclear power plants to keep the radioactive substances contained in the reactor from spreading to the environment is the concept of Layered Defense (depth of defense) (Kunarsih, et. al., 2022). This layered defense concept is (Harjanto, 2008):

1. Prevention of the onset of abnormal conditions.

As the first line of defense, prevention of abnormal conditions should be implemented from the design of systems and components. Reactor systems and components must meet administrative and quality assurance procedures. To prevent the occurrence of operation and procedure errors that have a great influence on the safety of the reactor, high-quality and reliable materials must be used, so that fail-safe systems and interlock systems can be realized. In this case, the so-called fail-safe is that if the system is partially damaged, the safety system will work automatically. For example, in a control rod system, if an abnormality occurs, the control rod will move automatically by gravity. While the so-called interlock system is a system that can lock automatically to prevent an action from the operator that can cause abnormal conditions or accidents.

2. Prevention of abnormal conditions developing into accidents.

As the second layer of safety defense, "preventing abnormal conditions from developing into accidents". This means that abnormal conditions must be prevented from developing, such as discovering abnormalities quickly, and if abnormal conditions have occurred, in order to prevent them from developing further, special treatment must be taken, for example, the reactor must be shut down. As an example of a case where for some reason the pressure inside the reactor increases suddenly, the reactor must be shut down. Immediate inspections should also be carried out and control rods automatically inserted into the reactor core, so that the reactor is forced to stop.

3. Prevention of release of radioactive substances into the environment.

The third layer of defense is "prevention of release of radioactive substances into the environment". This means that in the event of a completely unexpected accident, the environment should not be contaminated by radioactive substances and even radioactivity anomalies should not occur in the environment. This is made possible by the presence of emergency cooling systems, reactor barrels that prevent and inhibit the release of cleavable substances into the environment.

In preventing the spread of radioactive substances into the environment at nuclear power plants, there are several barrier systems. Each of these barriers is:

1. Fuel pellets/pills

Special treatment is performed on fuel pellets such that they retain radioactive fission products within the pellets.

2. Fuel cladding

The fuel cladding pipe is designed to contain radioactive substances coming out of the fuel pellets, especially radioactive substances in gaseous form.

3. Cooling water reservoir

Radioactive substances released from the cladding, especially under abnormal operating conditions, will be dissolved in the cooling water. But these substances will still be prevented from escaping from the coolant due to the cooling water storage system in the form of pipes, vessels, and so on.

4. Reactor containment building

If under some circumstances, radioactive substances can escape the barrier, they remain inside the containment building, which usually has an air pressure that is kept lower than the surrounding air pressure.

5. Exclusive area/zone

Around the nuclear power plant there is an area/zone that is empty and not inhabited by humans. The radius of this exclusion zone has been carefully calculated to be as safe as possible. Thus, if any radioactive substances are released from the reactor building enclosure, they remain in the uninhabited exclusion zone. Therefore, there is no direct impact on the people around the nuclear power plant in the event of a release of radioactive substances from the fourth layer of defense.

It can thus be concluded that in general, reactor safety is of the highest standard.

Nonet-Selznick developed a model or theory of responsive law in response to Neo-Marxist criticism of liberal legalism. As is well known, liberal legalism assumes that law is an independent institution with a set of norms and processes that are objective, impartial and fully autonomous. Legal autonomy is the epitome of liberal legalism. The most visible type of autonomy is the rule of law system.

With its independent nature, the law is thought to be able to control repression while maintaining its own integrity. The case for integrity is understandable when viewed from the perspective of the internal interests of the justice system itself. However, law does not function as an end in itself. Law functions as a tool for mankind. Law is a tool to fulfill human desires. In this context, separating the legal system from the various social institutions that surround it has a detrimental effect on human needs. Law can easily turn into a self-serving institution and no longer serve the public. Law can no longer be relied upon to effect change or achieve true justice. Critics of the law have pointed out the danger indicators of this erosion of power and delay of substantive justice (Nonet, et. al., 2003).

The need for responsive law has been a central concern of modern legal theory, with the aim of making law more responsive to social demands and taking a broader and more intelligent account of the social facts upon which, the law is applied and enforced. Responsiveness can be characterized as meeting the needs and interests of society as experienced and discovered by society, not by the authorities. To deliver them genuinely, additional effort is required. As a result, new routes of engagement are required. Nuclear power plant regulations need to be designed to accommodate the precautionary principle and be based on sound scientific evidence, while considering public concerns regarding the risk of natural disasters, such as earthquakes and tsunamis, given Indonesia's geographical location on the ring of fire. For example, a responsive law can integrate mechanisms for involving local communities in the decision-making process, both at the planning, implementation and operational evaluation stages of nuclear power plants. This is in accordance with the concept of sustainable development that places the community as the main actor in maintaining the balance between energy needs and environmental sustainability.

Therefore, there is a need for pioneers in starting socialization actions to introduce and educate the public. Socialization action to introduce and educate the public, and ensure that thorium-based nuclear power plants can be promoted immediately. With this paper, we can know that the utilization of nuclear resources with thorium fuel does have enormous potential in various aspects in the country and has many advantages. However, this must be followed by the creation of a sense of security for the community, which is a responsibility and obligation that must be fulfilled in fulfilling the concept of a welfare state by the state. The use of nuclear energy in the construction of nuclear power plants is expected to be realized in order to become a reference for advancing the amount of renewable energy development so that not only Indonesia's contribution in the Paris Agreement in 2030 can be fulfilled properly, but also the protection of public security is guaranteed supported by systematic and adequate practical arrangements.

#### IV. CONCLUSION

The development of nuclear power plants in Indonesia basically requires a comprehensive strategic approach to answer national energy challenges while supporting environmental sustainability. Although still faced with various obstacles, such as public perceptions that tend to be skeptical, a regulatory framework that is not yet fully supportive, as well as technical challenges related to infrastructure readiness and human resources, the potential of thorium-based nuclear energy provides great opportunities. The combination of Thorium with MSR technology is able to produce clean energy with less risk to the environment, high efficiency, and minimal waste volume. The main steps that need to be taken include the establishment of integrated regulations governing aspects of safety, waste management, and disaster mitigation, accompanied by community involvement from the early stages of planning. Public education should be prioritized to increase understanding of the benefits of nuclear energy and address safety-related concerns. In addition, investment in research and development of nuclear technology, as well as strengthening the capacity of oversight institutions, will ensure effective and sustainable implementation. With consistent and targeted efforts, the construction of nuclear power plants can be a strategic solution to overcome the energy crisis, improve national resilience, and fulfill global commitments in reducing carbon emissions.

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