

# Thorium Energy for Net Zero Emission: The Opportunities, Challenges, and Legal Issues

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## ABSTRACT

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The issue of Indonesia's reliance on fossil fuels as a primary energy source is a matter of significant concern, particularly in light of the nation's substantial energy demands. The necessity for novel energy sources that can serve as reserves for the country is therefore paramount. The recent discovery of the element thorium, a constituent of nuclear radioactive energy sources, has elevated it to a position of prominence in the realm of sustainable energy sources. To date, no nation has successfully implemented the use of thorium energy; however, numerous studies have been conducted to encourage its development. The present scientific article was prepared using a doctrinal research approach, based on a comprehensive review of the extant literature. The subsequent analysis and organisation of the data collected results in the formulation of structural ideas, which are then explicated through a descriptive-analytical framework. The results of the discussion on this topic concentrate on the evaluation of the potential of thorium as an energy source and the necessity of thorium regulation in Indonesian positive law. The development of thorium in the future is identified as a sustainable aspect that can contribute to the achievement of Indonesia Net Zero Emission.

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## 1. INTRODUCTION

The Constitution stipulates that the realisation of the country's welfare is to be achieved through the management of natural resources contained within the Indonesian earth. This is reflected in Article 33 paragraph (3) of the 1945 Constitution of the Republic of Indonesia (UUD 1945), which emphasises the state's right to control and manage Indonesia's natural resources, including energy management. The law stipulates the utilisation and generation of energy in order to enhance economic activities and national resilience. The

classification of energy is predicated on its availability, which results in the delineation of two distinct categories: namely, non-renewable and renewable energy. Non-renewable energy is defined as energy that will deplete in the future, whereas renewable energy is defined as energy that is abundant and can be used in a sustainable way [1]. In order to ensure the long-term availability of energy, a transition to sustainable management is imperative.

Ensuring the availability of the sustainable energy for future generations is crucial given the high energy consumption in Indonesia. According to the data from the

Ministry of Energy and Mineral Resources (ESDM), Indonesia's energy consumption in 2023 is equivalent to 1.2 billion barrels of oil (BOE). This figure represents a 60% jump from the previous year. The ministry also released the sectors with the largest energy users, namely the industrial sector at 556 million (46%), transportation at 448 million BOE (37%), and households at 150 million BOE (12%), as well as 54 million BOE (4%) consumed by the commercial sector and others. The fulfillment of existing needs is still dependent on fossil energy with the following percentage of use.

The diagram shows that Indonesia still has a dependency in terms of national energy consumption on fossil energy sources. The data also brings bad news for the country's energy security as **Sukusen Soemarionda** stated that fossil energy consumption will become energy dependent until 2030 [2]. This dependence hampers the transition process towards new energy, so it

is certain that the government's target to realize the new and renewable energy mix by 2025 cannot be maximized [3].

In terms of juridical norms, the failure to achieve a mix of new and renewable energy contradicts Law No. 16/2016 on the Ratification of the Paris Agreement to the United Nations Framework Convention on Climate Change (Paris Agreement on the United Nations Framework Convention on Climate Change) which regulates Indonesia's commitment to reducing carbon emissions. A report by the *Think Tank Energy Institute* titled *Statistical Review of World Energy 2024* states that Indonesia produces at least 701.4 million tons of Greenhouse Gas Emissions (GHG) from the energy sector, making it the sixth largest country in terms of carbon emissions from the energy sector behind several other developed countries with the following statistics.

Total National Energy Consumption by Energy Source (Darmawan, 2024)

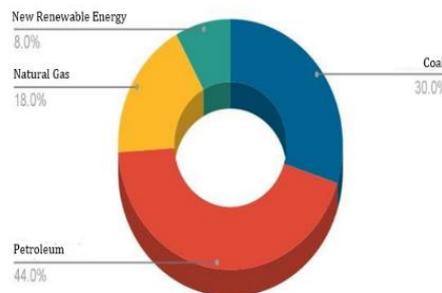


Figure 1. GHG emitting countries of the world (Kompas, 2024)

Table 1. Carbon Dioxide Equivalent Emissions by Country

State	Amount of Emissions
China	11,218.4 million tons of carbon dioxide equivalent
United States	4,639.7 million tons of carbon dioxide equivalent
India	2,595.6 million tons of carbon dioxide equivalent
Russia	1,614.7 million tons of carbon dioxide equivalent
Japan	1,012.8 million tons of carbon dioxide equivalent
Indonesia	704.4 million tons of carbon dioxide equivalent

In order to respond to these negative impacts, a number of strategic steps must be taken, which can be used as guidelines to encourage the energy transition process. At the 2022 G20 Summit, the matter of transitioning away from fossil-based energy

sources that are not environmentally sustainable in favour of clean energy sources was identified as a global priority [4]. One such transition is facilitated by the exploration of novel and renewable energy sources. The exploration of novel and

renewable energy sources has the potential to facilitate the transition towards a clean energy future. This exploration will generate opportunities for the discovery of new energies that are both cleaner and more sustainable.

One alternative that can be used as a new energy source is derived from radioactive mining materials, namely thorium. As one of the alternative nuclear fuels, it has been demonstrated to react readily with oxygen, hydrogen, halogen, and sulfur, thus rendering it a suitable candidate for utilisation as a fuel in nuclear power plants (NPPs). From the standpoint of its abundance in nature, thorium is found to be significantly more plentiful than uranium, with a supply that is over three times greater than the global uranium supply. The global abundance of thorium reserves has been demonstrated by the recent discovery of substantial new reserves in China, which have the potential to contribute to the country's energy supply. Thorium exhibits numerous advantages as an energy source when compared with uranium. For instance, it does not require enrichment, its waste management is comparatively brief, and it is safer than uranium. In accordance with this standpoint, the Head of the Nuclear Power Research Organization, **Rohadi Awaludin**, disclosed that nuclear power plants have the potential to be developed as stable energy producers, emit minimal greenhouse gases, and can operate with a limited quantity of fuel [5].

The efficiency of thorium is very high. Based on the data released by the Conseil European por la Recherche Nucleaire (CERN), it is estimated that the efficiency level of thorium is 1 ton of thorium is equivalent to producing as much energy as 200 tons of uranium which is equivalent to even 3.5 million tons of coal [6]. This clearly shows that thorium is a nuclear energy fuel that can last a very long time considering the ratio of energy produced by thorium is far comparable to the energy produced by uranium. Departing from this efficiency, several countries are interested in conducting further research on the development of

thorium as a sustainable energy source. For example, China in 2023 has approved the construction of the Thorium Molten Salt Reactor (TMSR) and will operate it in 2029 [7]. The reactor is predicted to produce 10 megawatts of electricity which will promise energy independence for China. Meanwhile, India is also developing research on thorium due to the signing of the non- proliferation treaty (restrictions on nuclear weapons) which implies restrictions on uranium so that the country is exploring thorium resources to replace uranium [8].

Departing from the problems related to the need to fulfill the country's energy needs, thorium-based nuclear potential, and the need to achieve *Net Zero Emission*, this scientific article is entitled "**Thorium Energy for Net Zero Emission 2060: Opportunities, Challenges, and Legal Issues.**"

## 2. LITERATURE REVIEW

For comparison and as a basis for this article, the author has adapted several writings relevant to the topic at hand. The following studies provide a scientific overview of the potential, challenges, and regulations surrounding the development of thorium as a sustainable energy source.

### *2.1 An Overview of Thorium as A Prospective Natural Resource for Future Energy*

The article titled "An Overview of Thorium as A Prospective Natural Resource for Future Energy" written by [9] contains a discussion of the potential of thorium as a clean energy source with the ability to produce energy more efficiently and safely than energy produced by uranium. However, concerns remain regarding the cost and operational scalability of thorium, which are still beyond the scope of estimates. Nevertheless, the development of thorium cannot be underestimated due to its positive projections as a provider of clean energy in the future.

This paper is relevant to the research conducted by the author, as both focus on the potential of thorium.

However, the difference is that the research by [9] does not address the issue from a legal perspective, whereas this paper is written from a legal perspective. This paper reinforces the author's understanding of the issue of thorium development and the high potential of thorium as a future energy source.

## **2.2 *The Discourse Contest for the Thorium Nuclear Power Plant on Gelasa Island: Between Development, Ecological Damage, and Social Inequality***

This research was written by Budi Darmawan [10], which directly highlights practical issues in Bangka Belitung. The article mentions a government project to explore and study the use of thorium energy on Gelasa Island through the construction of a nuclear power plant. However, this development has sparked discourse triggered by non-governmental environmental organizations that reject the construction and development of thorium.

This paper raises a crucial challenge in the development of thorium in Indonesia, particularly in relation to public acceptance of thorium development. This public apathy cannot be denied as a result of the mental construct of a society that, for the most part, does not understand the concept of thorium development. This limited understanding causes many people to fear the potential for damage.

Based on this article, the author also focuses on the aspect of legal culture as one of the challenges that may arise in the development of thorium in Indonesia. Therefore, a solution to this problem is formulated in the form of intensifying the role of the government in providing the public with an understanding of the potential of thorium energy.

## **2.3 *Indonesian Regulations on Managing Nuclear Energy and Its Impact on the Environment***

This article, written by [11], focuses on the relationship between nuclear energy management in Indonesia and the promotion of the Renewable

Energy Law in Indonesia. The study mentions that nuclear regulations should be specifically regulated due to several additional indicators, such as attention to environmental sustainability and risk mitigation of the impacts caused by its operations.

Based on this paper, the author attempts to reconstruct the legal framework that has not yet been fulfilled. The author believes that special regulations on nuclear energy can be further differentiated based on the specific management elements of each source. Thus, there will be different management regulations between the use of uranium and thorium. In this case, the author formulates this in the form of a proposed revision to the national regulations governing new and renewable energy in Indonesia.

## **3. METHODS**

This scientific article employs the doctrinal research method, which is one of the research methodologies employed in the field of law. This method involves the review of a concept based on the perspective of legislation, comparisons between countries, and conceptual analysis. The extant literature on this subject is drawn from secondary legal sources. The sources are then divided into three categories: primary legal materials, which include laws and regulations; secondary legal materials, which include books, journals, and related literature; and tertiary legal materials, which include legal dictionaries and similar resources. This article employs a descriptive-analytical approach, underpinned by a comprehensive literature review, to elucidate the prospects and configuration of the implementation of thorium-based nuclear power plants in Indonesia.

## **4. RESULTS AND DISCUSSION**

### **4.1 *Existing Conditions of Thorium Utilization and Regulations Governing the utilization of thorium***

As one of the new energy sources, thorium has a number of potentials which are beneficial for the energy transition efforts as carried out by the Indonesian government. One of the potentials of thorium is related to its availability in the earth which is 3 to 4 times greater than uranium and the energy yield produced is greater than uranium [12]. Indonesia itself is a nation that has rare earth minerals that could produce thorium at huge amounts. This meant if Indonesia could mine thorium from its soil this would create energy sustainability for Indonesia and therefore support Indonesia's rapid economic development. Departing from the potential of thorium, the Indonesian government began conducting research activities to study the utilization of thorium for nuclear energy fuel which is targeted to be applied in Indonesia. The study was initiated by the National Atomic Energy Agency (BATAN). BATAN's role in initiating studies on the use of thorium in Indonesia is driven by BATAN's role as a government institution responsible for the development of nuclear energy in Indonesia and has prepared the infrastructure needed to establish Thorium-based nuclear power plants in Indonesia.

One of the roles shown by BATAN is through the construction of a nuclear reactor in the Serpong area, Banten, which is planned to take a combination of uranium and thorium as fuel [13]. The nuclear reactor built by BATAN in the Serpong, Banten area is in accordance with the mission of the BATAN Strategic Plan (Renstra) 2015-2019 which determines that BATAN's mission is to excel in the region and together with other Government institutions in the welfare of society [14]. Departing from this fact, it can be seen that the government has sought the development of thorium as a nuclear energy fuel in Indonesia through study activities initiated by BATAN. However, to optimize thorium development efforts in Indonesia, a clear legal basis is needed

as the basis for the development of thorium-based nuclear energy in Indonesia.

No less important than the discussion of culture and structure, the legal basis regarding the development of thorium-based nuclear energy must also be discussed. The main legal basis for nuclear energy development in Indonesia is Law Number 10 Year 1997 on Nuclear. However, the Nuclear Law has not provided comprehensive arrangements regarding the development of nuclear energy in Indonesia. However, based on Article 8 paragraph (3) of the Nuclear Law, it is stated that research and development on nuclear safety needs to be considered to reduce the negative impact of nuclear power utilization. The provisions in Article 8 paragraph (3) of the Nuclear Law can provide opportunities for the development of thorium as a nuclear energy fuel considering that thorium can also reduce the negative impact of nuclear power utilization.

In addition to the Nuclear Law, another legal basis for the development of nuclear energy in Indonesia is Government Regulation No. 52/2022 concerning Safety and Security of Nuclear Excavation Material Mining. PP No. 52/2022 is important to support the development of nuclear energy in Indonesia because this PP provides a legal basis for procedures for mining minerals that will be used as nuclear fuel, one of which is Thorium. This PP also opens the possibility for further mining activities for minerals, considering that this PP provides the possibility of mining activities by other parties who hold radioactive mineral mining licenses. However, the development of thorium cannot be carried out in a hurry, because it requires prior readiness in terms of effective nuclear energy implementation in Indonesia. One of the things that greatly affects the application of nuclear energy is the public perception of the application of nuclear energy in

Indonesia. The construction of nuclear power plants in Indonesia has indeed become a sensitive issue that forms various kinds of social dynamics in the community regarding the construction of nuclear power plants [15]. The social dynamics regarding the construction of nuclear power plants in the community are then influenced by community perceptions. Public perception regarding the development of NPPs in Indonesia depends on a number of factors such as education level, social status, age, and public knowledge. Support from the community for the construction of nuclear power plants and the utilization of nuclear energy in Indonesia will

ultimately determine the future of Thorium use in Indonesia.

The overall conception that has been explained includes the maturity of the legal substance, the structure of the NPP implementer, to the public perception of the development of NPPs affecting the successful application of thorium-based nuclear energy in Indonesia. But apart from that, an academic study is still needed to find out the extent of the potential use of thorium as a nuclear power plant fuel. The following table illustrates the advantages, challenges, and solutions of thorium development.

Table 2. Review of Advantages, Challenges, and Solutions for Thorium Development (Source: author's preparation)

<b>Advantage 1</b>	Increase electricity supply significantly [16].
<b>Challenge 1</b>	The increase in electricity consumption in Indonesia is predicted to be around 4.6% per year to triple by 2030. However, on the other hand, power plants in Indonesia consisting of petroleum, wind, coal, and water are still ineffective to increase electricity production.
<b>Discussion 1</b>	Nuclear energy can be a new energi to significantly increase electricity supply. The benefits of nuclear energy can be optimized using Thorium given that thorium has reserves 3 to 4 times greater than uranium.
<b>Advantage 2</b>	Increased Exploration of Technology and Renewable Energy as well as Increased Human Resource Potential related to Thorium technology
<b>Challenge 2</b>	Energy use in Indonesia is currently still dominated by the use of non-renewable energy derived from fossils [1]. This fact shows that technological exploration activities and renewable energy are still not running effectively. One of the reasons why technological exploration and renewable energy activities are still lacking in Indonesia is Indonesia's Human Resources which are still less qualified due to a number of factors such as education and the economy [17].
<b>Discussion 2</b>	The application of nuclear energy in Indonesia through the utilization of thorium will encourage the exploration of technology and renewable energy in Indonesia considering that nuclear is one of the new energies in Indonesia. The application of nuclear energy in Indonesia through the utilization of thorium will also encourage efforts to increase human resources in Indonesia in order to apply nuclear through the utilization of thorium in Indonesia
<b>Advantage 3</b>	Exploration of technology and renewable energy in Indonesia considering that nuclear is one of the new energies in Indonesia. The application of nuclear energy in Indonesia through the utilization of thorium will also encourage efforts to increase human resources in Indonesia in order to apply nuclear through the utilization of thorium in Indonesia
<b>Challenge 3</b>	Indonesia is currently still not managing rare earth metals in Indonesia due to a lack of understanding of rare earth metals in Indonesia [18].
<b>Discussion 3</b>	The application of nuclear energy in Indonesia using thorium will encourage Rare Earth Metal mining operations considering that the resource contains thorium. With the establishment of nuclear power plants, there will be a need for resources for nuclear power plant fuel, one of which is thorium, thus encouraging Rare Earth Metal mining activities.

Source: Processed from various Sources

Thorium as a fuel for nuclear has been applied in a number of countries in the world. One of the countries that has started using thorium as a nuclear fuel is China. The use of thorium by China is driven by China, which controls 97% of the world's rare earth metal supply (Rhodes. 2013). This condition then makes China able to develop the application of nuclear energy with its own thorium. This was realized by China by building a *Liquid Fluoride Reactor* (LRF) which has been active since 2020. However, the application of nuclear energy through thorium in China is not without problems. Mining and *smelting* activities of thorium in China have caused air pollution in the area around the mines and *smelters* of Rare Earth Metals [19]. This thorium pollution can occur because thorium can be released into the atmosphere through natural and artificial means and can result in increased radiotoxicity and chemotoxicity in the environment which adversely affects health. Another country that also implements nuclear energy through thorium is India, indicated by a comprehensive thorium financing plan and also a plan to build 62 thorium-powered nuclear reactors which are planned to be completed and operational by 2025.

#### 4.2 *Thorium Conceptualization in the Draft New Renewable Energy Law*

The readiness to establish energy security and independence as well as the commitment to create an emission-free country, makes Indonesia have to continue to explore various natural resources that can be used as the country's energy source. Thorium's existence as one of the energy-producing materials makes it like a hidden treasure. However, in its application, a series of conceptions and strategic plans are needed to realize it. The most important note to realize the use of this energy is that there must be a

nuclear power plant operating in Indonesia.

This is supported by the opinion of the Head of BATAN 2012-2018, Prof. Dr. Djarot Sulistyو Wisnubroto, stating that the utilization of thorium as a nuclear fuel still has to take a long process because there is still no thorium-fueled nuclear power plant created. However, optimism in the construction of thorium-fueled nuclear power plants still has a number of positive projections. In relation to this opinion, Rohadi Awaludin said that the most important thing in the process of developing thorium as a source of energy is related to the 3S (Safety, Security, Safeguards) aspects that must be guaranteed to be implemented from the mining process, residue processing, to reactor damage risk management.

The commitment of thorium-based nuclear power plant development in practice can be started from the establishment of juridical rules that become the legal umbrella for its implementation. This commitment has actually been sufficiently conceptualized through the initiative of the legislative body to form a law relating to nuclear development in Indonesia, namely through the Draft Law on New and Renewable Energy (RUU EBT) which in 2025 has been included in the Priority National Legislation Program (Prolegnas) (Thea DA, 2025). The presence of RUU EBT is a strengthening of the existence of the Nuclear Law, which can be identified from Article 9 paragraph (1) of RUU EBT, which includes nuclear as one of the new energies in Indonesia. In order to accommodate thorium regulation, it is further necessary to regulate the content related to the details of types of nuclear excavation material as well as the purpose of its regulation. In simple terms, the changes in the content appear in the following chart:

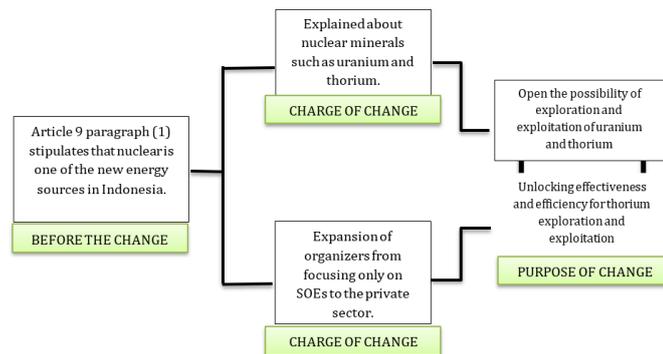


Figure 2. Amendment of Content in RUU EBT (Author's Process)

### 4.3 Thorium Conceptualization in the Draft New Renewable Energy Law

However, the provisions concerning nuclear energy in RUU EBT is still require amendments to enable the exploration of the potential for thorium-based nuclear energy in Indonesia. The initial update that can be implemented is the incorporation of provisions concerning thorium and uranium as fuel sources for nuclear energy. The following text is intended to provide a comprehensive overview of the subject matter. The incorporation of thorium and uranium provisions as fuel sources in RUU EBT has the potential to stimulate exploration activities related to thorium. It is recommended that provisions regarding thorium and uranium as fuel sources for nuclear energy be incorporated within the provisions governing the mining of nuclear excavation materials.

It is imperative that the second reform is carried out in order to provide legal certainty for nuclear excavation material mining activities by private business entities. The provisions stipulated in RUU EBT are still only focused on the implementation of nuclear excavation material mining activities by State-Owned Enterprises (BUMN). Regulations pertaining to legal certainty for private business entities should also be provided for the activities of construction, operation, and

decommissioning of nuclear power plants. The establishment of legal certainty provisions for private business entities is supported by the provisions in Article 9 paragraph (2) of the Nuclear Law, which provides opportunities for private business entities to carry out general investigation, exploration, and exploitation of nuclear excavation materials through cooperation with the implementing agency. In regard to the construction, operation and decommissioning of nuclear power plants, the Job Creation Regulation also provides opportunities for private business entities. In addition, the Nuclear Law also recognizes nuclear installation entrepreneurs, which means individuals or legal entities responsible for operating nuclear installations. This provides an opportunity for private business entities to be actively involved in the construction, operation, and decommissioning of nuclear power plants.

In addition to the formulation of substance, the regulation of thorium in Indonesia must also be studied based on social, economic, and ecological perspectives, especially with regard to public acceptance of the idea. The application of thorium, which is still unfamiliar to the public, makes it difficult to implement. Most people still think that the establishment of Thorium-based NPPs can cause environmental

damage and health problems. One of the cases of rejection of the establishment of nuclear power plants in Indonesia occurred on the islands of Bangka and Belitung, where the community rejected the establishment of nuclear power plants around them because they were worried that if there was a leak or explosion of nuclear power plants that could disrupt their daily lives (Mongabay, 2022). However, these obstacles can be resolved through the formation of legislation first. After it was formed, the government slowly began to socialize to the community regarding the blueprint of Thorium- based NPP development to provide benefits to the community.

## 5. CONCLUSION

The Indonesian government has identified the need for increased energy production as a priority, with the search for new energy sources being a key component of this strategy. In recent times, a novel energy source has been identified that has the potential to serve as an alternative energy source. The energy source employed in this process is a nuclear radioactive material known as thorium. Thorium represents a significant new natural discovery, with a number of potential applications. The utilisation of thorium in Indonesia is advantageous due to its high availability, reduced residue processing time, enhanced efficiency, and safety in the production of electrical energy.

Presently, the processing of thorium remains a salient concern in the domain of thorium project preparation planning. However, the implementation of this process has not been realised to any

significant extent. In order to facilitate the implementation of energy source readiness through thorium, there are several preparatory measures that must be given full consideration. The primary consideration is the establishment of regulations that are pivotal to the implementation process. At present, the regulatory framework pertaining to thorium, a form of nuclear material, is confined to the Nuclear Law. However, the legislation does not provide a comprehensive regulatory framework for the utilisation and exploration of thorium itself.

In addition to the legal implications, socio-cultural aspects of the community, which are still unfamiliar with the use of thorium as a new energy source, must also be taken into consideration. It is suggested that the exploration of thorium may encounter impediments due to its continued rejection by certain individuals. Concrete problems related to socio-cultural aspects are, for example, the rejection of the establishment of nuclear power plants in their area on the grounds of security and environmental sustainability by the local community.

Despite the numerous challenges and the protracted nature of the process, it would be imprudent to underestimate the potential of thorium. Further exploration is required to ascertain the full scope of the phenomenon. The primary consideration in the context of the development of thorium-based nuclear power plants is the legal framework, specifically the amendments to the RUU EBT that are intended to establish regulatory mechanisms for the promotion of thorium development in Indonesia as a prospective energy source.

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