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Indonesian Implementation of Nuclear Energy for Sustainable Development

Nur Fitriani Khairunnisa[1] Muhammad Ashri[2] Maskun[3]
1.Postgraduate Student at Postgraduate Program Faculty of Law, Hasanuddin University
2.Professor in International Law Department, Faculty of Law, Hasanuddin University
3.Associate Professor in International Law Department, Faculty of Law, Hasanuddin University

Abstract
As one of the developing country, Indonesia has the willingness to use nuclear energy as one of alternative energy options to meet with the national energy needs, and in the efforts to find a solution to the danger of energy crisis. Nuclear energy is seen as a source of energy with enormous potential that is demonstrated by the development of nuclear energy in the field of technology and safety, also most of the developed countries and in developing countries have implemented the nuclear energy in the form of nuclear power plant, Indonesia is one of the country that will consider the construction of nuclear power plant with all the advantages possessed by nuclear energy.
Keywords: Indonesian implementation, nuclear energy, sustainable development

1. Introduction

The peaceful uses of nuclear energy began in the end of World War II, 1951, when the nuclear power plant *Experimental Breeder Reactor*-I (ERB-1) first generated electricity in Arco Idaho, USA. It caused by the efficiency of nuclear power plant because it can generate enormous energy with a minimum fuel. Nowadays, nuclear energy has accounted for 16% of the world's total electricity demand spread across 30 countries.

In recent years, our industrial civilization runs on energy and 85% of the world's energy is provided by the fossil fuels, coal, oil and gas.[1] The use of oil and gas are limited and estimated to last for a few decades. In burning fossil fuels, we inject 23 billion tons of carbon dioxide every year into the atmosphere – 730 tons per second. This is significantly altering the composition of the atmosphere and seriously affecting the climate of our planet.[2]

The energy crisis, which occurs globally, has created the nation's desire to develop nuclear energy for peaceful purposes, such as power generation, medical equipment, agriculture, and so on. This choice is considered because nuclear energy has a high level of efficiency and effectiveness, compared to other energy sources, although it has a very deep history that affected the planet.[3]

By realizing the current global warming effects, the needs of clean energy and meet environmental safety is an obligation. Nuclear energy is often proposed as a solution or as part of the solution for a sustainable energy power as a key mitigation technology that is currently commercially available.[4] Nuclear energy is essentially carbon-free and contributes to reducing anthropogenic emissions of greenhouse gases that induce global warming as well as local atmospheric pollution.[5]

As one of the developing country, Indonesia has the willingness to use nuclear energy as one of alternative energy options to meet with the national energy needs, and in the efforts to find a solution to the danger of energy crisis. Utilization of nuclear energy program in Indonesia in the field of non-energy has grown onward, whereas Indonesian energy field is in its preparation to implement nuclear energy as the alternative energy.

Nuclear energy is seen as a source of energy with enormous potential that is demonstrated by the development of nuclear energy in the field of technology and safety, also most of the developed countries and in developing countries have implemented the nuclear energy in the form of nuclear power plant, Indonesia is one of the country that will consider the construction of nuclear power plant with all the advantages possessed by nuclear energy. The capability of Indonesian government to build nuclear power plants is demonstrated by preparing the technology and looking for the human resources that have the capacity to develop nuclear energy.

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[1] Bruno Comby, 2015, The Benefits of Nuclear Energy: The only clean, safe energy source capable of ensuring the continuation of our industrial civilization while protecting the environment, TNR Editions, http://www.szkola-ej.pl/pdf2015/05_comby.pdf, p. 1
[2] Ibid, p. 2
[3] Unknown, Peranan International Atomic Energy Agency (IAEA) dalam Statuta IAEA 1957, http://digilib.unila.ac.id/11123/14/14.%20Fix%204.pdf, p. 1
[4] Joshua Pearce, 2012, Limitation of Nuclear Power as a Sustainable Energy Source, Sustainability ISSN 2071-1050, www.mdpi.com/journal/ sustainability, p. 1173
[5] Nuclear Energy Agency, 2000, Nuclear Energy in a Sustainable Development Perspective, https://www.oecd-nea.org/ndd/docs/2000/nddsustdev.pdf, p. 8

2. Indonesian Potential in the Application of Nuclear Energy

Development and application of nuclear technology in Indonesia has been starting from the establishment of the State Committee for Radioactivity in 1954. The State Committee had to investigate the possibility of radioactivity from nuclear weapon testing in Pacific Ocean. The idea of creating the nuclear power plant in Indonesia is based on the consideration that fossil energy source which has become main support in electricity generation start to run out. The increasing electricity demand from various sectors experienced an average increase of around 7% per year; it will be very difficult to rely on the fossil materials. The demand for electricity needs and clean environmental quality are requirements that must be fulfilled in the power generation in the future. Furthermore, in 1964 through Government Regulation No. 65 of 1958, on December 5th 1958 was formed Atomic Energy Board and Atomic Energy Agency, which then refined into National Atomic Energy Agency (BATAN) based on the Law No. 31 of 1964 on Basic Provisions of Atomic Energy.[1]

In the beginning of 1970s, a serious planning of nuclear power plant construction has been done with the establishment of Preparation Commission of Nuclear Power Plant (KP2PLTN). The task of this commission was to conduct a study on matters related to the possibility of nuclear power plant construction in Indonesia. The result of the commission was to set about 14 locations proposed a potential nuclear power plant site to the government. The proposal was then followed up with a feasibility study by the National Atomic Energy Agency, in cooperation with the Government of Italy, United States of America, France and the International Atomic Energy Agency, which carried out until 1986.[2]

The seriousness of Indonesian government in the application of nuclear energy was seen by the re-visible in Indonesian National Legislation through Law No. 10 of 1997 on Nuclear Power which has authorized the Nuclear Energy Regulatory Agency (BAPETEN) to conduct the supervision of the use of nuclear power, which includes licensing, inspection and enforcement of regulations. The Nuclear Act also requires separation between the regulatory body, BAPETEN, and the research body, BATAN.[3]

The study on the feasibility of nuclear power plants in Indonesia from various aspects was carried out in early 1991 to 1996 in the collaboration with New JEC Inc. from Japan. Overall, the selection of nuclear power plant sites will be reviewed from various aspects, such as electricity assessment, transportation, and availability of water, earthquake, geology, hydrology, population, environment and others. The result indicated the best location for nuclear power plants in Indonesia were in Ujung Lemah Abang, Ujung Grenggengan and Ujung Watu. These three locations are located in Jepara district. However the monetary crisis hit in 1997 followed by the political crisis, which causes deterioration in most of the sectors including the electricity sector. As a result many industries have ceased operations and decreased consumption of electricity.[4]

Currently, the nuclear power plant construction plan is seriously undertaken as demonstrated by ratifying several conventions, issuing laws concerning the nuclear power, and issuing the government regulations. Based on the National Energy General Plan, nuclear energy becomes the last choice of Indonesian energy alternative. Although it becomes the last, the plan includes measures to be taken, such as constructing the research power reactor and laboratory research reactor as a place for nuclear expert to strengthening themselves, interact, and work as well as to provide support for the implementation of relevant research and encourage international cooperation in order to follow the technology progress. Nevertheless, according to IAEA, Indonesian commitment is quite high. This can be seen from the government's preparedness on nuclear power.[5]
In addition, the use of nuclear technology and excellent human resources has been done by Indonesia.

3. Regulation

Indonesian government has succeeded in establishing a framework of nuclear and radiological preparedness demonstrated by ratifying conventions, issuing Laws and Government Regulations. Laws and Government Regulations related to the security, safety and nuclear liability are:

1. Law No. 10 of 1997 on Nuclear Power
2. Law No. 1 of 2012 on Ratification of *Comprehensive Nuclear-Test-Ban Treaty*
3. Government Regulation No. 26 of 2002 on the Safe Transportation of Radioactive Substances

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[1] Nuclear Power Plant in Indonesia, National Atomic Energy Agency, accessed from http://www.batan.go.id/index.php/id/infonuklir/nuklir-indonesia-infonuklir/program-pltn/1810-rencana-pembangunan-pltn-di-indonesia, on 6th November 2017, 07:15 WITA.

[2] Ibid.

[3] The History of BATAN, National Atomic Energy Agency, accessed from http://www.batan.go.id/index.php/id/home/sejarah, on 6th November 2017, 07:35 WITA.

[4] Agus Mustofa, 2006, Indonesia Butuh Nuklir, Surabaya: PADMA Press

[5] Toshimitsu Homma, Nuclear Preparedness Assessment Team (EPREV) IAEA in a mission, in Press Conference in Jakarta, Wednesday, 28 September 2016, quoted from IAEA: Indonesia's Commitment to High Nuclear Preparedness, http://www.antaranews.com/berita/ 587092/iaea-komitmen-indonesia -akan-kesiapsiagaan-nuklir-tinggi, ccessed on October 3, 2017, at 06:15 WITA

4. Government Regulation No. 43 of 2006 on Licensing of Nuclear Reactor
5. Government Regulation No. 33 of 2007 on Safety of Ionizing Radiation and Radioactive Source Security
6. Government Regulation No. 29 of 2008 on License for Utilization of Radiation Source and Nuclear Material
7. Government Regulation No. 46 of 2009 on the Limits of Nuclear Liability
8. Government Regulation No. 54 of 2012 on the Safety and Security of Nuclear Installations
9. Government Regulation No. 61 of 2013 on Radioactive Waste Management
10. Government Regulation No. 2 of 2014 on Licensing of Nuclear Installation and Utilization of Nuclear Material
11. Government Regulation No. 58 of 2015 on Radiation Safety and Security in the Transport of Radioactive Substances

In addition, Indonesian commitment is shown by issuing some specific regulation on nuclear safety, security, and safeguards by the Head of Nuclear Energy Regulatory Agency (BAPETEN) which has shown that Indonesia is ready to build a nuclear power plant.[1] The Regulation of the Head of Nucelar Energy Regulatory Agency includes:

1. Head of Nucelar Energy Regulatory Agency Regulation No. 6 of 2012 on Design System that is Important for Computer-Based Safety on the Power Plant
2. Head of Nucelar Energy Regulatory Agency Regulation No. 2 of 2012 on Protection of Design against the Internal Hazard other than Fire and Explosion of the Power Plant
3. Head of Nucelar Energy Regulatory Agency Regulation No. 1 of 2012 on Provisions of the Design of Fire Protection System and Internal Explosion on Reactor
4. Head of Nucelar Energy Regulatory Agency Regulation No. 7 Year 2011 on Emergency Power Supply System Design for Nuclear Power Plant
5. Head of Nucelar Energy Regulatory Agency Regulation No. 3 of 2011 on Safety Provisions of the Design of Power Plant
6. Head of Nucelar Energy Regulatory Agency Regulation No. 3 of 2010 concerning the Design of Nuclear Fuel Handling and Storage Systems for the Power Plant
7. Head of Nucelar Energy Regulatory Agency Regulation No. 3 of 2009 on Operational Limits, Conditions, and Operating Procedures of the Power Plant
8. Head of Nucelar Energy Regulatory Agency Regulation No. 6 Year 2008 on Evaluation of Reactor Site for External Attack of Human Result
9. Head of Nucelar Energy Regulatory Agency Regulation No. 4 of 2008 on Reactor Site Evaluation for Geotechnical and Reactor Base
10. Head of Nucelar Energy Regulatory Agency Regulation No. 3 of 2008 on the Evaluation of Reactor Site for Determining the Distribution of Residents Across the Power Plant Reactor

4. Infrastructure

4.1 Energy

The Indonesian Nuclear Program is a program to build and utilize nuclear science and technology in both, non-energy and energy for peaceful purposes. The non-energy utilization in Indonesia has been developed quite advanced while in the field of energy (electricity generation), Indonesia is still trying to get public support, although Internationally, Indonesia has been considered as a country that is capable to use the nuclear energy.[2]

Since 1970s, Indonesian government has initiated the idea that nuclear energy used for generating the electricity. The great desire was shown by the number of seminars which involving the universities in Indonesia, Research and Development Institutions, and the Ministry of Energy to gather the ideas of implement the nuclear energy in the field of electricity because of the energy limitation reserves in Indonesia.[3]

In 1987, with great enthusiasm, Indonesia built a highly sophisticated nuclear facility, which linked to the technology control. These reactors are the major facility for research that included the operation technology, development, maintenance and human resources development in operation. Research reactors in Indonesia, are:[4]

- Bandung West Java. Nuclear Research Center (PPTN) Bandung. (Triga Mark II Reactor - with a capacity of 250 kW inaugurated in 1965, then increased its capacity to 2 MW in 2000).
- Yogyakarta, Yogyakarta (Kartini Nuclear Research Reactor - capacity of 100 kW, since 1979).

[1] Dedik Eko Sumargo, Director of Preparedness and Technical Support of the Nuclear Energy Regulatory Agency (BAPETEN), in an interview with Antara News, quoted from the IAEA: Indonesia's Commitment to High Nuclear Preparedness, http://www.antaranews.com/berita/ 587092/iaea-komitmen- indonesia-akan-kesiapsiagaan-nuklir-tinggi, accessed on October 3, 2017, at 06:21 WITA

[2] Eko Madi Parmanto, Head of Legal, Public Relations, Cooperation and National Atomic Energy Agency-BATAN, Interview, BATAN Head Office, Kuningan Barat, Mampang Prapatan Jakarta 12710, 11 September 2017.

[3] Ibid.

[4] Ibid.

- Serpong (Banten). (RSG-GA Siwabessy Nuclear Research Reactor - 30 MW capacity, inaugurated in 1987).
- Various locations has been studied its feasibility as a potential site to build a reactor to produce nuclear power plan in Muria, Central Java and Bangka, Bangka Belitung Province.

Beside the reactor construction, there are also the facilities for the management of radioactive waste, which become the public concern, as well as facilities for a nuclear fuel, a safety development facility in the form of simulator used for BATAN researchers if there is anomaly or deviation from he normal condition, improved and lower capacity trials, and the blackout trials which need a serious effort, so if someday Indonesia has a nuclear power plant, Indonesia can operate the nuclear power plant safely and safety in the field of technology. In natural resources, BATAN has collaborated with experienced agencies to conduct explorations in various places in Indonesia, such as in Kalimantan, Sulawesi, Papua and mapping out the uranium that Indonesia has. The mapping results will be processed to determine the supply needs of Indonesia.[1]

4.2 Non-Energy

4.2.1 Agriculture

Nuclear technology can be one of the technologies used in food security by increasing productivity, preventing disease or food pests, to prevent the climate change, to the plant mutation, and food preservation, so that with the radiation technique the seeds of food crops can be strengthened, increase its production, be a resistant to drought, and can be used for vulnerable post-harvest foodstuffs.[2]

4.2.2 Industry

In the industrial field, nuclear technology is used for oil and gas exploration processes, to determine the nature of lithography[3] and porosity[4], nuclear energy radiation systems can also help for designing the road construction, measure moisture and soil density, asphalt and concrete.

The radiation system of nuclear technology is used for industrial radiography, determination of process homogeneity, environmental management in the feasibility study of tools and materials of companies engaged in engineering, modification of materials for producing high quality plastics by irradiation process, radiocarbon utilization to determine the archeological object, a logging technique for measuring the depth of drill holes with underground depths to observe the presence of gas and petroleum in a soil layer, controlling the thickness of the material, preserve the wood and arts, and to know if there is any defect in the material.[5]

4.2.3 Environment

In the field of environment, there are several industrial areas that are often found to dispose their waste to the place that is not appropriate. By using neutron analysis activation techniques, it can analyze the sample. The sample is fired with neutrons and the light spectrum so that it can show what elements and how much the content measure. If this can be done by taking the samples of air, sea, river, we could know the pollutant contained, and it can easily help the Indonesian government in monitoring the environmental conditions against pollutant and become a policy consideration.[6]

4.2.4 Health

In the field of health, nuclear technology is used for nuclear medical science, which use an opened-source radiation from disintegration of artificial radionuclides to learn the changes in physiology, anatomy and biochemistry, so it can be used for diagnostic, therapeutic and medical research. In nuclear medicine, radioisotope can be inserted into the patient's body (in-vivo studies) or simply reacted only with biological materials including blood, gastric fluid, urine, etc., are taken from the patient's body, better known as the in-vitro study (in experiment glass). The examination of nuclear medicine helps in supporting the diagnosis of various diseases such as coronary heart disease, thyroid disease, kidney function disorder, determining the stage of cancer by detecting its spread on the bone, detecting bleeding in the digestive tract of food and determining its location, and much more that can be obtained from diagnosis with the adoption of nuclear technology that is currently growing rapidly.

In addition for helping to establish a diagnosis, nuclear medicine also plays a role in the therapies of certain diseases, such as thyroid cancer, the thyroid gland hyper functions on non-radiation drugs, red cell malignancy, inflammation, and the uncontrolled hinge using ordinary drug therapy. In diagnostic purposes, radioisotopes are

[1] Ibid.
[2] Eko Madi Parmanto, Head of Legal, Public Relations, Cooperation and National Atomic Energy Agency-BATAN, Interview, BATAN Head Office, Kuningan Barat, Mampang Prapatan Jakarta 12710, 11 September 2017.
[3] Lithography is a printing technique which involves the image onto an intermediate surface before the final sheet. The process is 'offset' because the plate does not come in direct contact with the paper, which preserves the quality of the plate by using Micro Electro Mechanical Systems.
[4] Porosity is the size of the empty space between the materials, and is the fraction of the volume of empty space to the total volume, which is between 0 and 1, or as a percentage between 0-100%.
[5] Ibid.
[6] Ibid.

given in tiny doses, and then the radioisotope therapy is deliberately given in large doses especially in cancer tissue treatment in order to eliminate the cells that make up the tissue.[1]

Not only nuclear technology is used in medical science, but also in neutron activated technique, determined the bone density by using bone densitometer and three-dimensional conformal radiotherapy (3d-Crt), also to sterilize the medical tools.

5. Human Resources

The preparation of Human Resources is an early work in the context of nuclear power plant development; Indonesia is a country that is carrying for generating electricity by using nuclear energy, so that the preparation of human resources must be handled seriously.[2] On the basis of practical implications, Indonesia has developed the human resources through universities, educational and training institutions, including BATAN Training Center which has nuclear facilities in Indonesia (nuclear reactor and laboratory). Cooperation between Pusdiklat BATAN with other agencies related to nuclear power plants, such as BAPETEN, State Electricity Company, Department of Energy and Mineral Resources can form the Training of Introduction to Nuclear Energy as an effort to prepare nuclear qualified human resources.[3] Systematic Approach to Training is an education and training system to produce qualified human resources in the nuclear field required by a nuclear power plant project. Nuclear power countries have used this system, because it has been proven to produce and maintain the human resource competence in the nuclear field. The International Atomic Energy Agency itself has recommended Systematic Approach to Training as an education and training system used by countries that will start nuclear power projects.[4]

Listed on Law No. 17 of 2007 on the Long-Term Development Plan of 2005-2025 that Indonesia has begun to utilize nuclear power for power plant by considering the strict safety factor in Medium Term Development Plan III between 2015-2019. Since the human resource development program is an activity that requires long-term commitment, the preparation human resources must be implemented immediately, although until now there has been no official decision from the government to start the construction of nuclear power plants. Thus, the Ministry of Energy and Mineral Resources in 2008 formed a national "human resources development" team, in cooperation with the Ministry of Labor, Ministry of Research and Technology, BATAN, BAPETEN, and State Electricity Company.

The Head of BATAN, Djarot Sulistyo Wisnu Broto said that Indonesian human resources are able to build and manage nuclear power plants. Based on a survey conducted by BATAN in 2015, Indonesian people acceptance of nuclear power plants is increasing. A survey involving 4000 respondents indicates that the level of public acceptance of nuclear power plants increased to 75% from 70% in 2014.[5]

The definite step taken by BATAN to develop Indonesian human resources in nuclear technology is to establish human resources development infrastructure which in cooperation with nuclear education in domestic universities such as:[6]

- Gajah Mada University – Yogyakarta: offers a course of Nuclear Engineering at the Department of Physical Engineering – Faculty of Engineering for Bachelor Program.
- Bandung Institute of Technology – Bandung: offers specialization of Physics Reactor in Physics Department – Faculty of Mathematics and Natural Sciences and specialization of nuclear power plant in new and renewable energy program – Faculty of Engineering for Bachelor, Master and Doctoral Program.
- University of Indonesia – Jakarta: offers Medical Physics study program in Physics Engineering Department – Faculty of Engineering for Bachelor and Master Program.
- Padjadjaran University – Bandung: offers a specialization nuclear medicine in the Faculty of Medicine for Master Program (specialist I).

Besides the university, BATAN also has an official school, the Nuclear Technology College (STTN) in

[1] Eko Madi Parmanto, Head of Legal, Public Relations, Cooperation and National Atomic Energy Agency-BATAN, Interview, BATAN Head Office, Kuningan Barat, Mampang Prapatan Jakarta 12710, 11 September 2017.
[2] Song Suk Chae, 1995, End Of Mission Report, Support For The The First Nuclear Power Plant (INS/4/028-08), IAEA, Viena.
[3] Tecdoc 525, 1998, Guide Book On Training To Establish And Maintain The Qualification And Competence Of Nuclear Power Plant Oprations Personnel, IAEA, Vienna, pp. 11- 21, 146-151.
[4] Wisnu Arya Wardhana, 2006, Preparation of Human Resources for Preparation, Development and Operation of Nuclear Power Plant In Indonesia, Research Results for Scientific Oration Widyaiswara Utama, PudiklatBATAN Jakarta, p. 128
[5] Djarot Sulistyo Wisnu Broto, September 2016, Indonesian Human Resources are Able to Build Nuclear Power Plant, Library of Nuclear Energy Regulatory Agency - BAPETEN, quoted from https://perpustakaan.bapeten.go.id/ accessed on October 10, 2017 at 14:01 WITA
[6] Hendriyanto Haditjahyono, 2010, Human Resources Preparation for First Nuclear Power Plant in Indonesia-ISSN 1978-0176, STTN_BATAN, Faculty of Science and technology UIN SUKA in National Seminar Human Resources Nuclear Power VI, Yogyakarta, p. 845

Yogyakarta. The Nuclear Technology College is a diploma 4 (D4) level education, which has 3 (three) study programs: electromechanical, instrumentation, and techno chemistry. Education and Training Center of BATAN established in 1980 and has the task to carry out education and training in nuclear science and technology. The Training Center conducts nuclear training for BATAN staff as well as for the nuclear technology user community.[1]

6. Nuclear Energy and Climate Change Linked in National Determined Contribution

In line with the ratification of Paris Agreement by Indonesia, the Government of Indonesia pledged to reduce emissions by 26% (41% with international support) against the business as usual scenario by 2020. The current administration, under President Joko Widodo, has determined priority actions within the national *Nawa Cita* (Nine Priority Agendas) framework, which includes protecting Indonesia's citizens, encouraging rural and regional development, improving the quality of life, and improving productivity and global competitiveness. These core missions are consistent with the national commitment towards a low carbon and climate change-resilient development path, in which climate change adaptation and mitigation constitute an integrated and cross-cutting priority of the National Medium-Term Development Plan.[2]

Given its pivotal geographic position in the global ocean conveyor belt (thermohaline circulation), the largest archipelagic country and its extensive tropical rainforests with high biodiversity, high carbon stock values and energy and mineral resources, Indonesia is recognized its role to play in combatting global climate change. Nevertheless, Indonesia is vulnerable to natural disaster that will likely be exacerbated by climate change, especially in low-lying areas throughout the archipelago. Therefore Indonesia views comprehensive land and ocean-based climate change adaptation and mitigation efforts as a critical strategic consideration in achieving climate resilience in food, water and energy.[3]

Indonesia's Nationally Determined Contribution (NDC) outlines the country's transition to a low carbon and climate resilience future. The NDC describes the enhanced actions and the necessary enabling environment during the 2015-2019 period that will lay the foundation for more ambitious goals beyond 2020, contributing to the concerted effort to prevent 2^{o}C increase in global average temperature and to pursue efforts to limit the temperature increase to 1.5^{o}C above pre-industrial levels. For 2020 and beyond, Indonesia envisions achieving archipelagic climate resilience as a result of comprehensive adaptation and mitigation program and disaster risk reduction strategies. Indonesia has set ambitious goals for sustainability related to production and consumption of food, water, and energy. These goals will be achieved by supporting empowerment and capacity building, improved provision of basic services in health and education, technological innovation, and sustainable natural resource management, in compliance with principles of good governance.[4]

Mitigation program done by taking significant steps to reduce emissions in land use sector by instituting a moratorium on the clearing of primary forests and by prohibiting conversion of its remaining forests by reducing deforestation and forest degradation, restoring ecosystem functions, as well as sustainable forest management which include social forestry through active participation of the private sector, small and medium enterprises, civil society organizations, local communities and the most vulnerable groups, especially adat communities (Indonesia: *Masyarakat Hukum Adat*, internationally known as Indigenous People), and women – in both the planning and implementation stages. A landscape-scale and ecosystem management approach, emphasizing the role of sub-national jurisdictions, is seen as critical to ensure greater and more enduring benefits from these initiatives.[5]

In energy sector, Indonesia has embarked on a mixed energy use policy. Indonesia has also established the development of clean energy sources as a national policy directive. Collectively, these policies will eventually put Indonesia on the path to de-carbonization. Government Regulation No. 79/2014 on National Energy Policy, set out the ambition to transform, by 2025 and 2050, the primary energy supply mix with shares as follows: [6]

1. New and renewable energy at least 23% in 2025 and at least 31% in 2050;
2. Oil should be less than 25% in 2025 and less than 20% in 2050;
3. Coal should be minimum 30% in 2025 and minimum 25% in 2050;

[1] Ibid. p. 846
[2] National Determined Contribution Indonesia, quoted from http://www4.unfccc.int/ndcregistry/PublishedDocuments/Indonesia%20First/First%20NDC%20Indonesia_submitted%20to%20UNFCCC%20Set_November%20%202016.pdf, p. 1
[3] Ibid. p. 1
[4] Ibid. p. 2
[5] National Determined Contribution Indonesia, quoted from http://www4.unfccc.int/ndcregistry/PublishedDocuments/Indonesia%20First/First%20NDC%20Indonesia_submitted%20to%20UNFCCC%20Set_November%20%202016.pdf, p. 2
[6] Ibid. p. 3

4. Gas should be minimum 22% in 2025 and minimum 24% in 2050.

For the waste management sector, the GOI is committed to develop a comprehensive strategy to improve policy and institutional capacity at the local level, enhance management capacity of urban waste water, reduce landfill waste by promoting the "Reduce, Reuse, Recycle" approach, and the utilization of waste and garbage into energy production. The GOI is committed to further reduce emissions from the waste management sector by 2020 and beyond, through comprehensive and coherent policy development, institutional strengthening, improved financial and funding mechanisms, technology innovation, and social-cultural approaches.[1]

Adaptation is done by the significant efforts towards developing and implementing a National Action Plan on Climate Change Adaptation (RAN-API), which provides a framework for adaptation initiatives that has been mainstreamed into the National Development Plan.[2]

The Government of Indonesia will implement enhanced actions to study and map regional vulnerabilities as the basis of adaptation information system, and to strengthen institutional capacity and promulgation of climate change sensitive policies and regulations by 2020. The medium-term goal of Indonesia's climate change adaptation strategy is to reduce risks on all development sectors (agriculture, water, energy security, forestry, maritime and fisheries, health, public service, infrastructure, and urban system) by 2030 through local capacity strengthening, improved knowledge management, convergent policy on climate change adaptation and disaster risks reduction, and application of adaptive technology.[3]

The mitigation and adaptation in reducing greenhouse gas emissions are also associated with the use of nuclear energy. Nuclear energy, essentially, is carbon-free energy and contributes to reducing the anthropogenic emissions from Greenhouse Gases inducing global warming and local atmospheric pollution. Thus, nuclear energy is seen as a prerequisite for tackling the effects of climate change.

7. Conclusion

Indonesian potential in the application of nuclear energy as the energy for sustainable development is done by ratifying international Conventions, issuing Laws and Government Regulations, also issuing regulations from the Nuclear Energy Regulatory Agency. In the field of infrastructure, Indonesia has had 3 (three) research reactors used for technology mastery, also supported by human resources owned by Indonesia. Indonesian commitment is also written in the National Determined Contribution of Indonesia where Indonesia is committed to reduce 26% of greenhouse gas emissions by 2020, and up to 41% with international support.

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[1] Ibid.
[2] Ibid. p. 4
[3] Ibid. p. 5

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