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Assessment of the Boiling Water Reactor in Indonesia

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A B S T R A C T

Indonesia needs to provide a large enough source of energy for development purposes, not only to produce and distribute daily necessities, but also to build industries that improve the nation's competitiveness and the lives of the people. With so many people, Indonesia has the largest energy consumption of any country in the Southeast Asia region and is fifth in the Asia Pacific in primary energy consumption, after the countries of China, India, Japan and South Korea are expected to increasingly encourage Indonesia's energy needs in the future. In Indonesia the main energy source is the fossil fuel, a non-renewable energy source. With the large amount of energy demands in Indonesia, the use of fossil fuels as energy-generating materials is increasing, which results in the depletion of fuel. Besides that, use of fossil fuels in Indonesia produces carbon dioxide in the wild which can endanger the natural environment. From the problems that occur in Indonesia with the limitations and constraints in conventional energy sources, it has been found that the Nuclear Power Plant (NPP) is a viable alternative for providing electricity. The construction of the NPP would spur national industry development because various industries could be involved in the construction of nuclear power plants. One type of nuclear power plant, namely the Boiling Water Reactor (BWR) has already been implemented in several countries with some success and has advantages that could be applied in Indonesia. It is expected that the presence of nuclear power plants in Indonesia would reduce the use of fossil fuels and increase clean and renewable energy in Indonesia

1. INTRODUCTION

In carrying out daily activities, energy is a basic human need(Kholiq, 2015). With the large number of people, Indonesia is the country with the largest energy consumption in the Southeast Asia region and in the fifth place in the Asia Pacific in primary energy consumption, after the countries of China, India, Japan and South Korea. High GDP growth, reaching an average of 6.04% per year during the 2017-2050 period, is expected to further encourage Indonesia's energy demand in the future(PPIPE BPPT, 2018).

Energy is very important in meeting many basic human needs, as well as being fundamental in supporting industrial, transportation and agricultural activities that shape the world of economic growth. The development of a nation's economy depends on a sustainable energy supply that fulfills all the demands needed(Sharvini, Noor, Chong, Stringer, & Yusuf, 2018). Oil fuel / fossil energy is one of the non-renewable energy

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sources which has been a mainstay in meeting energy needs in all sectors of activity(Kholiq, 2015)

Fossil fuel being use as the main raw material for the energy supply in Indonesia, has resulted in the depletion of fossil conditions in Indonesia along with the increasing demand for energy in Indonesia. Use of fossil materials as fuel for energy generation produces CO_2 in nature which can also affect the health conditions of humans in the environment(F. Alam, R. Sarkar, 2019). Energy security and the reduction of environmental emissions have become a higher priority to ensure affordable energy supplies, for sustainable economic growth and development. To overcome this problem, renewable energy plays an important role in the long-term for sustainable development(Kumar, 2016). One renewable energy source being developed in countries today is the field of nuclear technology where output in the process as an energy generator does not produce CO_2 emissions in environment and thus does not accelerate thickening of greenhouse gases and avoid the risk of climate change in the world. The implementation of the NPP has been carried out in several developed countries such as China, the United States, France, Russia, Japan and other countries. These can be role models for Indonesia in order to implement the NPP in a sustainable manner to increase the energy supply in Indonesia.

2. THEORETICAL BACKGROUND

- ***Indonesian population***

In 2019 Indonesia has a population of 270 million with a growth rate of 1.14% (United Nations, 2019) and ranks as the 4th largest in the world regards to population. Energy consumption in Indonesia will continue to grow in accordance with economic growth, population, energy prices, and government policies(PPIPE BPPT, 2018). With the large population of Indonesia, the energy consumption in Indonesia has also increased.

- ***Indonesian energy supply***

National electricity supply at the end of 2017 amounted to 254,657.39 GWh, PLN provided energy of 181,422.67 GWh, in the industrial sector 71,744.13 GWh, the household sector 95,583.52 GWh, the commercial sector or large business 41,601,108 GWh, the public sector 3.503.47 GWh and the social sector 11,142.47 GWh(Geometry & Analysis, n.d.)**.**

- ***Indonesian energy source***

Energy has an important role for Indonesia because it is still a developing country that requires energy in all sectors. Energy sources in Indonesia currently come from non-renewable energy such as coal, oil, and gas which are included in fossil fuels(PPIPE BPPT, 2018). Indonesia is one of the countries with the largest energy consumption in Asia(Geometry & Analysis, n.d.), and has become the fifth largest coal producer(Lakshmi et al., 2017). Coal as one of the non-renewable fossil materials is sought to be used as a last resort for meeting domestic needs after maximizing the use of renewable energy, minimizing the use of petroleum, and optimizing the use of new energy and natural gas(PPIPE BPPT, 2018).

Indonesia's oil reserves in 2016 were 7,251.11 MMSTB or decreased by 0.74% in 2015. Similar to petroleum, natural gas reserves also decreased against last year by 5.04. The oil that has been produced is around 92.1% of the total reserves, while the natural gas reserves that have been produced are 34.5% of the total reserves *(SKK Migas Indonesia,2018*). Current petroleum production is 338 million barrels Taking into account the proven oil reserves available, it is estimated that proven oil reserves will run out in another nine years. Natural gas will run out in 42 years Coal production for domestic needs and exports continues to increase making coal reserves decrease by 11.8%. With the current coal production level of around 417 million tons, all types of coal reserves (lignite, subbituminous, bituminous) will run out within 68 years. The decline in national fossil energy reserves is one factor in the implementation of the fuel diversification program.

- ***Impact on environment***

Power plants in Indonesia use fossil materials, one of which is burning coal. This contributes to very large greenhouse gas emissions ranging from 50-70%(Team,

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2018)(IRENA,2017)(Ministry Of Energy and Mineral Resources Republic of Indonesia, 2016)**.** Global warming has devastating consequences, manifestied in an increased intensity of storms, floods, melting glaciers, and forest fires, as well as ecological structural changes that affect migration of animal species and their extinction, such as increasing the temperature of the earth(Prieto-Guerrero & Espinosa-Paredes, 2018).

- ***Renewable energy***

With the number of contributors to greenhouse gases emissions from coal combustion to be used as electricity generation materials and the decreasing energy reserves, then if Indonesia implements low or zero carbon power plants, fuel production and transportation will help reduce emissions from coal combustion. In Indonesia renewable energy is still dominated by bioenergy in the last use sector such as industry, building and transportation (IRENA,2017),(Dutu, 2016) One of the other low-carbon power plants that is currently still a hot topic is nuclear power plants(Lovering, Yip, & Nordhaus, 2016)which have been used by several developed countries in the world.

Nuclear energy is a nearly carbon-free technology that has progressed through several generations of development and which can compete profitably with alternatives to basic load electricity generation and increase energy supply security (Prieto-Guerrero & Espinosa-Paredes, 2018). Studies by the Intergovernmental Panel on Climate Change and the International Energy Agency have identified nuclear power technologies as reducing carbon emissions(International Atomic Energy Agency, 2014). The International Energy Atomic Agency establishes the nuclear power security and safety system well in the face of increased preparedness and response to the risk of nuclear accidents. Details of the NPP were developed by experts who have expertises in the nuclear field(International Atomic Energy Agency, 2014).The NPP it self has several types of reactors that can help the performance of the NPP to be more optimal, on of which is the NPP using the Boiling Water Reactor (BWR) system. The NPP have the ability to meet more than 20% of the electricity needs in the world(Li et al., 2016). Green house gas emissions produced by nuclear power are lower than fossil energy. Compared to other energy sources, nuclear energy is cleaner and safer energy to be carried out sustainably(Li et al., 2016) in Indonesia. The NPP have important characteristics: they can produce high energy densities without removing GHG sources of CO_2 that do not emit(Prieto-Guerrero & Espinosa-Paredes, 2018).

3. DISCUSSION

Therearecurrently75BoilingWaterReactors (BWR)deployedglobally(WNA, 2018). In the world of nuclear reactor technology there are four generations, namely Gen-1, Gen-2, Gen-3, and Gen-4 reactors(Gu, 2018). BWR is a complex system in which the source of instability varies and has various characteristics. The two basic principles of BWR as a power plant reactor are 1.) a large amount of boiling air occurs on the reactor core, 2.) the steam produced from boiling on the reactor core is then channeled directly to the turbine used, which is released by the turbine(Fennern, 2018). For example, there are certain anomalous behaviors in the recirculation loop flow in BWR jet pumps known as vortices that can be absorbed by the emission-repairable flow(Prieto-Guerrero & Espinosa-Paredes, 2018)**.**Besides that BWR is also called a non-linear, deterministic and stationary system(Gavilan Moreno, 2016). For BWR safety, it is very important that the water surface be kept continuously above the top of the active fuel, and always ensure adequate cooling from the reactor core(Janne, 2017).

Fuels that are commonly used in the NPP is using uranium (U), where the NPP with the BWR system can obtain the utilization of neutrons and combustion of uranium(V, 2017). Natural uranium materials if exposed to humans, can accumulate in human bones (66%), kidneys (8%), and liver (16%), and can cause severe damage due to particles of uranium(Z. Gu, 2018). The advantage of using uranium fuel, in terms of its technical advantages, is that when using light water,

namely H_2O, it absorbs more neutron terms(Pencer, J., Mcdonald, M. H., Roubtsov, D., & Edwards, 2017). Besides using uranium fuel, the BWR system can also use thorium fuel (Th). The existence of thorium is relatively abundant on earth and presents a number of nuclear properties and intrinsic chemistry that make it a potentially interesting nuclear fuel. But thorium does not have a fission isotope which is a major weakness for thorium, because it is not possible to initiate a pure fission chain reaction in natural thorium - and consequently any nuclear system that uses thorium will initially depend on the generation of previous fissile material(Michel-Sendis, 2015). Thorium has very promising physicochemical characteristics which are good candidates for improving fuel performance, especially in the form of thorium dioxide, which has high thermal conductivity, low coefficient of thermal expansion and high melting temperature(Van Gosen & Tulsidas, 2016).

Thorium fuel waste can cause smaller actinide production per unit of energy produced, although this depends on the fissile seeds used(Michel-Sendis, 2015). The use of this power plant necessitates exposure to radiation, but the highest level of radioactive radiation in a person is around 65mSv(Foulkes, Millward, Henderson, & Blake, 2017)(Lim Yk, 2015)**.** The NPP with BWR systems recycle (or reuse) part or all of liquid waste. Recycling liquid waste in BWR is one reason why waste from BWR is generally lower than that of PWR(*Discharges from boiling water reactors*, 2016). One of the disadvantages of BWR is that it is very difficult to repair because production is canceled or the use of approved rods during core thinning results in axial variations in power and flux(Galahom, 2016).

In the future the revolution of the power plant using BWR will continue to develop, one of which is the Resource-renewable BWR (RBWR). The RBWR will use transuranic elements (TRU) as fuel to reduce radioactive waste materials, designed on "Y" control rod assemblies that can be used to reduce corrosion and increase the breeding ratio of U-238(World Nuclear Association, 2017). Nuclear reactor safety can be achieved through remote location selection, nuclear reactor content, accident prevention and accident mitigation in a row(Gu, 2018). The NPP have several advantages such as increasing fuel sources, reducing dependence on fossil fuel imports, and developing immunity to disturbances in Indonesian power(Zhao & Smidts, 2019). The need for climate change mitigation by reducing greenhouse gas emissions - especially carbon dioxide. to reduce air pollution from the process of fossil fuels used by Indonesia, by taking advantage of the absence of air pollution from nuclear plants. This is a way to prepare for the transition to a hydrogen economy .

4. CONCLUSION

From the results of the discussion above, that the NPP is one of the better solutions to be used in Indonesia, can reduce the use of fossil fuels which causes an increase climate change in the world because carbon dioxide is released from combustion to produce electricity. In addition the reaction results in the reactor do not emit carbon dioxide emissions or can be referred to as a zero carbon power source. In Indonesia can implement the NPP using BWR systems with several considerations so that the performance of the NPP works so well. In addition, waste from the fuel can be managed properly so that it does not directly pollute the environment due to radioactive radiation with certain restrictions.

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