ANALYSIS COMPARISON NPP THORIUM FUEL AS AN ALTERNATIVE ENERGY SOURCES

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ABSTRACT

ANALYSIS COMPARISON NPP THORIUM FUEL AS AN ALTERNATIVE ENERGY SOURCES. *Electrical energy needs of Indonesia is increasing every year so many power plants being developed to meet the national energy purposes, both of which use fossil fuels, solar, wind and others. One of the sources of energy that has a vital and strategic role to support the resilience of the national electrical energy is nuclear. Besides nuclear energy source that is proven to be safer and environmentally friendly when compared with other types of power plants. Today, it has developed PTLN that uses thorium as a fuel alternative to uranium because thorium is known to have properties superior nuclear and the amount of reserves 3-4 times greater than uranium. The purpose of this research is knowing the advantages of thorium (Th), conducting comparative thorium power plant with other power plants, develop thorium as an alternative energy source. The research method isto comparating power plant in Indonesia.Nuclear power plant with Thorium fuel in 1000 MW have a little amount of Fuel , little Waste, cheap electricity cost (kWh) operation cost and require few area than the other.*

Keywords *: electrical energy, nuclear energy, thorium*

INTRODUCTION

Electrical energy needs of Indonesia is increasing every year so many power plants being developed to meet the national energy purposes, both of which use fossil fuels, solar, wind and others. But in fact there are still many problems that occur in the management of the national electricity system, such as electricity production costs are large, the uncertainty of supply of energy sources for generation, waste and environmental issues, safety systems as well as the geographical conditions of the power plant.

Although many types of energy sources are used, but the main source of electrical energy supply Indonesia still rely on fossil fuels are limited and we also have to face the fact that the availability of fossil fuel reserves becoming increasingly depleted, causing us to have to begin to develop the supply of electric energy sources alternative more effective and efficient.One of the sources of energy that has a vital and strategic role to support the resilience of the national electrical energy is nuclear. Besides nuclear energy source that is proven to be safer and environmentally friendly when compared with other types of power plants.

Nuclear power plant (NPP) is a thermal power plant that uses one or more nuclear reactors as a source of heat. The workings of a nuclear power plant is actually not much different from how the steam power plant (power plant) other fossil fueled. If other types of power plants use the combustion of fossil fuels such as coal, petroleum and so on to generate heat energy, then nuclear power plants use a surrogate form of nuclear reactors. In general, a nuclear reactor using uranium as a source of heat, cleavage reaction (fission) of uranium nuclei were shot with neutrons in the reactor core will generate enormous heat energy. The heat is then used to turn water into steam in the reactor at high pressure. The kinetic energy of the water vapor that is obtained is then used to turn turbines. A turbine wheel is then converted into electrical energy to be transmitted to the transmission network.

At the power plant other kinds, from the combustion to produce heat in the form of exhaust gases and heavy metals that will be emitted into the air and has the potential to pollute the environment, can cause acid rain and global temperature increase while the nuclear power plant produces no exhaust emissions and metals heavy.

Today, it has developed PTLN that uses thorium as a fuel alternative to uranium because thorium is known to have properties superior

nuclear and the amount of reserves 3-4 times greater than uranium. As this study aims to:

1. Knowing the advantages of thorium (Th)
2. Conducting comparative thorium power plant with other power plants
3. Develop thorium as an alternative energy source.

Electrical energy is a major component in supporting the growth of a region. The electricity had been integrated into daily life, can be used in work, study, or just entertainment. The process of electricity production in Indonesia such as generation, transmission, and distribution of electrical energy in Indonesia are conducted by the State Electricity Company (PLN). Provision and sale of electricity by PLN divided into four customer sectors, namely:

a. Household
b. Industry
c. Business / commercial
d. Public Affairs

National electric power production is dominated by non-renewable energy. Most of the electricity power production depends on coal resources whose production is nearly half the total production of the electricity. Electric power generated from renewable resources are very limited.

Table 1. Electric power consumption per capita in Indonesia

Year	Total population (person)	Consumption Electic Power (MWh)	Consumption Electic Power /capita (MWh)
2009	231.369.500	151.334.000	0,65
2010	237.641.320	165.969.000	0,70
2011	241.990.700	178.279.000	0,74
2012	245.425.200	194.289.000	0,79
2013	248.818.100	208.935.000	0,84
2014	252.164.800	221.296.000	0,88

Source: Electricity statistics 2014, Ministry of ESDM.

Factors that affect the Supply and Demand of electricity in Indonesia

Indonesia has the potential of diverse energy resources. The discovery of the resources that have not been extracted showed that energy reserves of Indonesia is still quite deep.

Tabel 2. Fossil energy resources

Resources	Unit	Value
Crude oil	Billion Barel	151
Nature Gas	TSCF (*Trillion Short Cubic Feet*)	487
Coal	Billion Ton	120,5

Source: Energy Outlook Indonesia 2015, BPPT

The data showed that the fossil energy resources that are still stored in Indonesia, in the form of petroleum, natural gas, and coal, buried in large quantities.

Tabel 3. New energy resources and renewable

Type of Resources	Unit
Geothermal	12383 MWe
Air	75000 MW
Biomassa	32654 MWe
Solar	4,8 kWh/m^2/day
Wind	970 MW
Uranium	3000 MW
Gas, Methane, Coal	456,7 TSCF
Shale gas	574 TSCF
Wave	1995,2 MW (practice potensial)
Ocean Thermal energy conversion	41012 MW (practice potensial)
Tidal energy	4800 MW (practice potensial)

Source: Energy Outlook Indonesia 2015, BPPT

On the other hand, renewable energy reserves owned by Indonesia is very diverse. Geothermal, water flow, solar power, until the movement of sea waves show a variety of potential ways that can be taken by Indonesia to develop clean energy industry.

Estimation*Demand* Electric Power in Indonesia on 2040

The population of Indonesia increase every year . From Table 3, in 2030 an estimated population of Indonesia is approaching a population of 296 million. With this level of education and higher welfare of the Indonesian population will certainly require much energy to consumse. Population projections predict that by 2040, Indonesia's population will reach more than 312 million people.

Tabel 4. Projection total population on 2010-2040

Year	Total Population (person)
2010	238.518.800
2015	255.461.700
2020	271.066.400
2025	284.829.000
2030	296.405.100
2035	305.652.400
2040	312.044.247

Sumber: BPS

Based on standard electricity consumption / capita set by the government amounted to 1,500 kWh / capita, so electricity requirement in Indonesia o n 2040 is as follows:$1.500\ \text{kWh} \times 312.044.247 = 468.066.370.500\ \text{kWh} = 468.066{,}37\ \text{GW}$

Large requirement was counted 468,066.37 KW, more than double the national electricity consumption in 2014 (221 296 GWh).The fulfillment of these requirements can be done, such as using of non-renewable energy resource reserves like utilizing coal, oil, and natural gas are owned by the state.

Table 5. Estimated energy reserves of non-renewable energy resources

Resources	Reserve	Energy Production Standard (U.S. EIA)	Estimation of Energy Reserves
Crude Oil	151 billion barel	578 kWh/barel	87,2 juta GWh
Nature Gas	487 TSCF	99 kWh/MCF	48,2 miliar GWh
Coal	120,5 miliar ton	1.927 kWh/ton	232 miliar GWh

Source:Energy Outlook Indonesia 2015(BPPT), U.S.Energy Information Administration

If we only only see in the adequacy of the resources , we can show that Indonesia's energy security is assured. Resources is more than enough to fullfill the energy needs for hundreds of years. However, the reality is not that easy. Large investment costs need to be able to extract the resource buried and there are environmental impact generated by oil or coal. In days of environmental insight excessive coal use contrary to the purpose of maintaining the quality of the environment, except they find a way to take advantage of clean coal.Another option is to use the other energy sources that are more environmentally friendly such as hydro, solar, or other. Beside that, the issue of climate change has become a global attention. In the middle of the instability of the price of fossil energy resources such as oil and coal, the development of renewable energy technology got the urge to go forward. The investments in the development is not only considering as a gamble, but also promising. If the development of renewable energy technologies being developed, it is expected the application of technology can be more reached so that more likely to be practiced in Indonesia.

The power plant is part of the industrial equipment used to produce and generate power by utilizing various sources of energy, such as steam, nuclear, hydro, solar, wind and others.The power plant has a major part in the form of generators, namely spinning machine that has the function of converting mechanical energy into electrical energy using the principle of magnetic fields and electrically conductive. Generator machine is operated by a variety of energy sources are utilized in a power plant.

Based on the energy source, the types of power plants are as follows:

1. Hydroelectric Power Plant (HEPP)

Hydroelectric Power Plant (HEPP) is a plant that converts water to a certain altitude and discharge it into electricity, using water turbine and generator. Hydroelectric power output can be calculated as follows:

$$P = \rho.Q.h.g$$

Where : P = electric power generated theoretically (watt)
ρ= the density of the fluid used (kg/m^3)
Q= water discharge (m^3/s)
h= effective height (m)
g= gravity (m/s^2)

Output power of the generator can be obtained from the multiplication efficiency of turbines and generators with power coming out theoretically. As can be understood from the above formula, the generated power is the product of high falls and the discharge of water, therefore the success of the hydropower plants depend rather than attempt to get high water fall and large discharge effectively and economically.

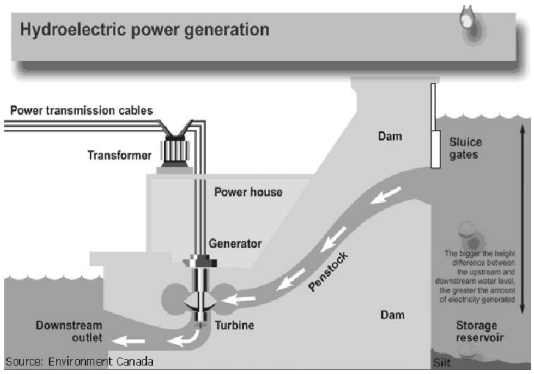

Figure. 1 Hydroelectric power plant

The main component of hydropower plant:

1. Dam, served to collect water
2. Turbine, function converts the kinetic energy of falling water into mechanical energy
3. Generator, function converts mechanical energy from the turbine into electrical energy into
4. The electricity transmission line, is used to distribute electrical energy generated toward generating electricity substation.

2. Diesel Power Plant (DPP)

Diesel power plant is a power plant that uses a diesel engine to produce mechanical energy that will play generator. Then, the mechanical rotor energy is converted by a generator into electrical energy.

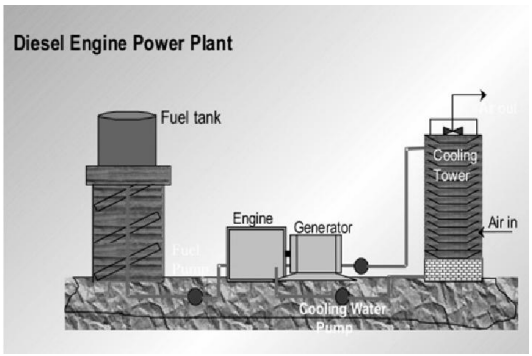

Figure. 2 Diesel power plant
source
http://www.slideshare.net/yurremm/internal-combustion-engine-power-plant

3. Wind Power (Wind Power Plant)

Wind power plants are power plants that use the wind as an energy source to generate electricity. The working principle of this tool is to harness the wind to turn turbines. Turbine rotation causes the rotor rotates, the generator then converts this mechanical motion of the rotor into electrical energy.

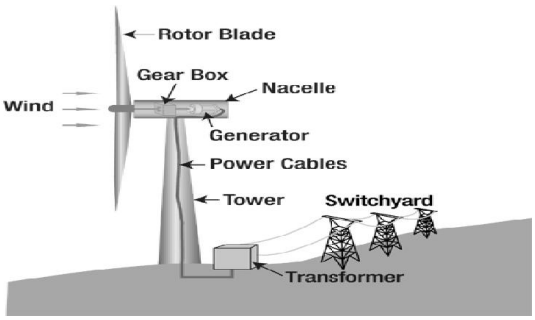

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Figure 3 Wind power plant
Source https://www.tva.gov/Energy/Our-Power-System/Renewables

4. Solar Power Plant (SPP)

Solar Power Plant (SPP) is the plant that utilizing solar cells to convert sunlight review Become WITH Electrical energy utilizing photovoltaic Effect, That a Securities can be change Direct sunlight Being Electrical energy.

The working principle From solar panels That is if sunlight Regarding the solar panels, so Electron-Electron The ADA AT solar cells will Moving From N Ke P, so it will be out of energy electricity Exodus From the terminal, which is big discharge voltage depends WITH Timeframe The solar cells. Solar panels mounted on the hearts and the amount of sunlight shining on the solar panels of the Yang.

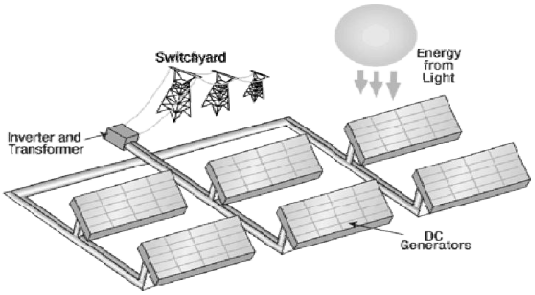

Figure 4. Solar power plant
Sourcewww.nexteraenergyresources.com

5. Nuclear Power Plant (NPP)

Nuclear power plants (NPP) are power plants that use nuclear energy as a heat source to produce electrical energy. Heat on NPP is

generated from atomic fission chain with neutrons occurring in a nuclear reactor. The resulting heat is used to generate high-pressure steam, and the steam is used to drive a turbine. Turbine is converted into electrical energy and is forwarded to the transmission network. Fuel of NPP is Uranium or Thorium.

The use of thorium as a fuel nuclear power plant, has many advantages when compared to uranium. Thorium is more secure, inexpensive, and can be used to meet the needs of supply of electrical energy increases. If the reactor that uses uranium fuel produces many tons of toxic waste for 10 thousand years, then the thorium reactors produce 90% less toxic waste to be discharged decompose in about 500 years. In addition thorium can not be misused for weapons purposes because it does not produce plutonium in the nuclear reaction process. Mineral type is also considered to be more stable than uranium but thorium can not stand alone as a fuel. Thorium require uranium 235 to be converted into uranium 232 and ready to be used as an energy source. Then the thorium development must first begin with the development of uranium.

For comparison, 1 tonne of thorium fuel would produce energy equivalent to that produced by 200 tons of uranium, or 2.5 million tons of coal, without the environmental effects of coal in the atmosphere or the risks associated with uranium wastes. Thorium-powered nuclear reactor can never melt. This is because thorium is slightly lighter than uranium and fissile not - meaning we can stack them and will not undergo a chain reaction runway. In contrast, only need to inject energy into thorium reactors to power up or kick off.

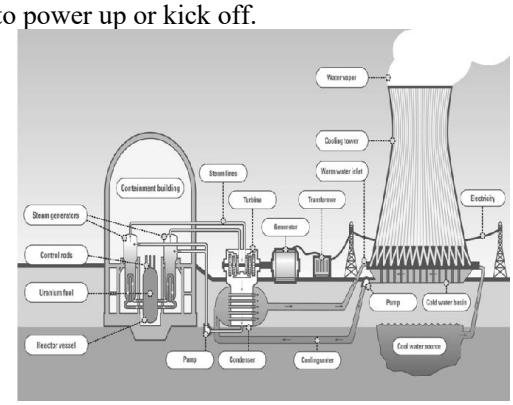

Figure 5. Nuclear power plant
Source www.nuclear-power.net

The advantages of thorium:

1. Thorium is 3 to 4 times more abundant than uranium, widely distributed in nature as an easily exploitable resource in many countries and has not been exploited commercially so far.
2. Thorium fuel cycle is an attractive way to produce long term nuclear energy with low radiotoxicity waste.
3. The absorption cross-section for thermal neutrons of 232Th (7.4 barns) is nearly three times that of 238U (2.7 barns).
4. For the 'fissile' 233U nuclei, the number of neutrons liberated per neutron absorbed (represented as η) is greater than 2.0 over a wide range of thermal neutron spectrum, unlike 235U and 239Pu.
5. Thorium dioxide is chemically more stable and has higher radiation resistance than uranium dioxide. The fission product release rate for ThO2–based fuels are one order of magnitude lower than that of UO2.
6. ThO2 is relatively inert and does not oxidize unlike UO2, which oxidizes easily to U3O8 and UO3.
7. Th–based fuels and fuel cycles have intrinsic proliferation-resistance due to the formation of 232U via (n,2n) reactions with 232Th, 233Pa and 233U.
8. For incineration of WPu or civilian Pu in 'once-through' cycle, (Th, Pu)O2 fuel is more attractive, as compared to (U, Pu)O2, since plutonium is not bred in the former and the 232U formed after the 'once-through' cycle in the spent fuel ensures proliferationresistance.
9. In 232Th–233U fuel cycle, much lesser quantity of plutonium and long-lived Minor Actinides (MA: Np, Am and Cm) are formed as compared to the 238U–239Pu fuel cycle, thereby minimizing the radiotoxicity associated in spent fuel.

RESEARCH METHODS

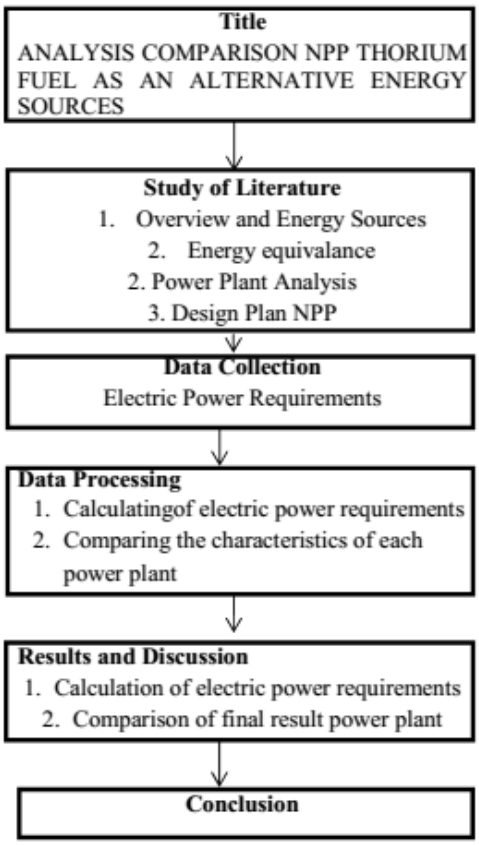

Figure 6.Research procedure

RESULTS AND DISCUSSION

Supplying the energy needs of 1,000 MW, there are several alternative power plants built in Indonesia, such as thorium, uranium, wind, sun, water, diesel and coal. From the various power plants,we did comparation as shown in Table 6 below.

Table 6. Comparation Power Plants

Power Plant	Amount of Fuel	Waste	Electricity Cost (kWh)	Operation Cost (million)	Area
Thorium	1 ton		100	$ 0,5	2 km^2
Uranium	200 ton	Pu	100	$ 20	2 km^2
Wind	-	CO	1000-1500		
Solar	1.200.000 panel		2500-3000		12 km^2
Hydroelectric	800 ton		787	$ 250	300 km^2
Diesel	2 million ton	CO_2, NO_X, SO_x	1800	$ 320	
Coal	2,5 million ton		500-600	$250	113 km^2

From Table 6, in amount of fuel we can seen that the use of Nuclear Power Plantuse thorium fuel is better than the other fuels PLT. Generating1000 MW, Nuclear Power Plant thorium is more superior than the other because of the amount of thorium fuelis 1 ton, in Nucler Power Plant uranium fuel need 200 tons, Solar Power Plant require 1.2 million solar panels, Hydroelectric Power Plant 800 tonswater, Diesel Power Plant require 2 million tons of diesel and Coal Power Plant 2 million tons of coal. Although Wind Power Plant does not require fuel supply the geographical conditions of tropical Indonesia makes Wind Power Plant is not developed because the wind speed is very small compared with not tropical countries.

In electricity costNuclear Power Plant use thorium and uranium require of 100 rupees per kWh. When compared with the other, Nuclear Power Plantis cheaper than the other,Wind Power Plant reach 1000-1500rupiah, , Solar Power Plant reach 2500-3000 rupiah, Hydroelectric Power Plant reach 787 rupiah, Diesel Power Plant reach 1800 rupiah and Coal Power Plant reach500-600 rupiah.

In operating costs, Nuclear Power Plantuse thorium require cost $0.5 million, it is cheaper thanNuclear Power Plantuse uranium of $ 20 millionHydroelectric Power Plant reached $ 250 million, Diesel Power Plant reach $ 320 million and Coal Power Plant reach $250 million.

CONCLUSION

Nuclear power plant with Thorium fuel in 1000 MW have a little amount of Fuel , little Waste, cheap electricity cost (kWh) operation cost and require few area than the other.

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