FUTURE ENERGY OPTIONS FOR INDONESIA

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Abstract

As the largest nation in Southeast Asia Indonesia have major problems in energy consumption. Most of Indonesia energy consumption goes to supplied the high density populous area of Java Island, thus the infrastructures of energy storage and distribution is much more advanced in Java Island compare to other islands. Blessed by bountifull energy resources the nation primarily depended on fossil fuel energy for the last 30 years. In recent times, as import for fossil fuel energy increased, utilization of other source of energy are developed. Into the future the nation most likely would depend on energy from natural gas and renewable resources such as geothermal and hydroelectric to reduce the consumption of fossil fuel energy.

Keywords: Indonesia Energy, Natural Gas, Energy Options

Abstrak

Sebagai negara terbesar di Asia Tenggara, Indonesia memiliki permasalahan pada bidang energi, khususnya pada konsumsi energi. Konsumsi energi Indonesia sebagian besar digunakan untuk mencukupi kebutuhan energi di daerah padat penduduk di Pulau Jawa. Dengan demikian infrastruktur energi di Pulau Jawa lebih maju daripada daerah lainnya. Dianugrahi oleh sumber energi yang besar, Indonesia bergantung pada sumber energi fosil selama 30 tahun terakhir. Pada saat ini dengan impor sumber energi fosil yang terus meningkat, pemanfaatan sumber energi lain telah dikembangkan. Di masa datang, Indonesia kemungkinan besar akan memanfaatkan energi dari gas alam dan sumber energi terbarukan seperti panasbumi dan hidrolistrik untuk mengurangi konsumsi energi bahan bakar fosil.

Kata kunci: Energi Indonesia, Gas Alam, Opsi Energi

1. INTRODUCTION

Indonesia is the largest Southeast Asia nation in term of area, population and economy. In the world, Indonesia is the forth largest population after China, India and United States and rank 15 of area. It is also consider as the world third-fastest growing economy [4]. The geographical features of Indonesia is an archipelago nation that located at the equator thus takes benefit from tropical climates. According to CIA fact sheet Indonesia total area is 1,904,569 km2 consists of 1,811,569 km2 of land and 93,000 km2 of water. Most of the population concentrate in western part of Indonesia especially in the island of Java (53%), one of the five major islands of Indonesia archipelago. The other major islands are Sumatra, Kalimantan, Sulawesi, and Papua (eastern half part belongs to Indonesia and the western half part belongs to Papua New Guinea). Accordingly most of Indonesia energy consumption goes to supplied the high density populous area of Java Island, thus the infrastructures of energy storage and distribution is much more advanced in Java Island compare to other islands.

2. CURRENT ENERGY SOURCE AND THE FUTURE

Indonesia have a lot off sources of energy, however since the last 30 years its primarily depend on fossil fuels energy sources not only for transportation but also for industry and electricity generation. However, in recent times, this type of energy shows depletion and without finding new oil field Indonesia will have to rely on import or forced to change its primary source of energy and diversified the energy sources. Natural gas has become much more important in Indonesia today as its become reasonable substitutes to oil and become the second important energy source in Indonesia. Along with natural gas, geothermal and coal as sources of energy have been study and implemented, in near future more power generation will rely on geothermal energy as well as coal. The government of Indonesia also view the renewable energy sources such as wind and ocean drive energy sources as solution, however the implementation rely on technology and mostly liquid funding.

2.1. Fossil Fuel Sources

2.1.1. Oil

Currently Indonesia is a net importer both crude and refined oil. Since 1998 the crude oil production of Indonesia has been declining due to the failure to develop new major oil field while the largest oil fields in the country getting mature. Then since 2004 Indonesia start become net importer of both crude and refined oil. It result on the decision of the government of Indonesia (GOI) to suspended the membership of Organization of Petroleum Exporting Countries (OPEC) that held from 1962 in January 2009.

Generally, the upstream oil industry of Indonesia is dominated by several major international company such as BP, Chevron, Conoco Phillips, Exxon, and Total. The largest single oil producer from these international companies with 40% of the country's total crude production is held by Chevron. Then the second largest producer is held by PT Pertamina, a state-owned integrated energy supply company with around 15% production of crude and condensate.

The regulation of upstream industry in Indonesia is served by Badan Pengelola Minyak dan Gas - Regulator Body of Oil and Gas (BPMigas) a state-owned legal entity with objectives to manages and implements agreement in oil and gas upstream industry. The agreement it self, which largely known as production sharing contruct (PSC) is open to market through the Ministry of Energy and Mineral Resources (Kementrian Energy dan Sumber Daya Mineral - ESDM). Before 2001 the PT Pertamina as a state-owned company has large responsibility, not only to explores and produces oil and gas but also manage the contracts and regulations. Since 2001 oil and gas law (UU No 22/2001 tentang Minyak dan Gas Bumi) the Indonesia's upstream oil and gas sector has significantly restructured by passing the role of regulatory of the Pertamina to BPmigas. The law also limited the PT Pertamina influence in national gas and oil industry although the PT Pertamina is remained state-owned company.

The PT Pertamina also have activities in downstream, as almost all of Indonesia refinery capacity, procures crude and products imports, and supplies product to the domestic market are run by the PT Pertamina. Nowadays, with the decision to remove the fuel subsides to private vehicle from December 2010, the PT Pertamina competes directly with product retailers. Before 2004 the PT Pertamina monopolize the retail market however it remain become the only supplier of subsidized fuels until early 2010.

Indonesia as of January 2011 estimated had 3.5 billion barrels of proven oil reserves (Figure 1). Total averaged oil supply in 2010 barely reach one million barrels/day. From this number around crude oil and lease condensate production was account of 943,000 barrels/day. From between 2000 and 2010 the production of crude oil and lease condensate has declined at the rate of 4.1% per annum.

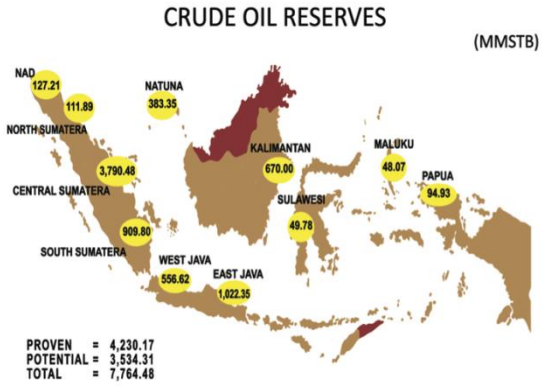

Figure 1. Indonesia Crude Oil Reserves by 2010

Chevron operates two largest oil field in Indonesia, Minas and Duri fields at the Riau Province, eastern coast of central Sumatra. Under the Rokan Production Sharing Agreement both fields operates with 100% interest for Chevron. Both fields producing since 1950s and even with immense enhanced oil recovery program the fields producing was declining.

To increased the production, Indonesia try to develop new fields, one of the promising field is the Cepu block of Central and East Java. The Cepu Production Sharing Contract (PSC) is operate by Exxon Mobil with 45% interest in joint venture with PT Pertamina E&P with 45% interest and four local government companies take the 10% interest. The Cepu block estimated to produce 165,000 barrel/day at its peak from 600 million barrels of recoverable liquid. Currently, due to several project delays, only Banyu Urip field is producing in the Cepu PSC with production level of 18,000 barrel/day. With the delays Exxon Mobile revise the peak production from 2012 to 2014.

To increased the country's upstream sector the government of Indonesia and BPMigas have introduced policies such as investment incentives and improving the PSC bidding process. However some policies such as Parliament's attempts to mandate cost recovery caps to PSC and the government shipping regulation that requiring all marine vessels to carry the Indonesian flag have become hindrances. Suspended such policies, however, does not have much effect on the investment as Indonesia failed to meet its 2010 production goal of 965,000 bbl/day of crude and condensate and also signed only 21 new oil and gas PSC compare to 34 in 2008.

PT Pertamina owned eight refineries that spread across the nation with majority in Java and Sumatra, the total production of these refineries are slightly over 1 million barrel/day. The refineries output go primarily to domestic market however only 70% of market demand can be provides by the PT Pertamina. By 2017 PT Pertamina plan to cut down the product import by upgrading refineries, expansion and greenfield project, however due to low refining margin and lack of government financial incentives international investment were deterred from the projects thus delayed the improvement of domestic supply.

One of the program is to study the upgrade of the third largest plan capacity, Balongan refinery in West Java (the largest refinery is Cilacap Refinery in Central Java and the second largest is Balikpapan Refinery in Eastern Kalimantan) with the help of Kuwait Petroleum Corporation in August 2008. The company also approach Saudi Aramco to build a new 200,000 - 300,000 barrel/day refinery in East Java and Iran's Oil Refining Industries Development Company and Malaysia's Petrofield Refining to build 300,000 barrel/day refinery in West Java. The projects mention above are supported by guaranteed crude supply from Kuwait Petroleum Corporation, Saudi Aramco, and the National Iran Oil Company respectively, however due to reasons that state above the project was held and expected to be online in 2015. However uprading the largest oil refinery in Cilacap is appears on track to be completed in 2014.

From 1995 to 2005 the consumption growth of the refined products steady at the average of 4.7% per annum however due to the cut of subsidized fuel implemented in 2005 the rate declined to 2% from 2006 to 2007. Fuel subsides account for about ten percent of the government tax revenue for about ten billion dollars in 2010. The parliament of Indonesia has approved a measure to remove the fuel subsides for all vehicles excluding motorcycles and public vehicles. To limit the economic disadvantages due to the subsides removal cash transfers will be used. The Policy will be implemented nation wide by 2013.

2.1.2. Natural Gas

Until January 2011, Indonesia proven natural gas reserves was 108 trillion cubic feet (TCF). In the world Indonesia is the fourteenth largest gas proven reserves and the third largest in Asia Pacific region. Since 2004 the natural gas domestic consumption was doubled however Indonesia remain as major exporter of pipeline and liquified natural gas (LNG).

As with oil, since the restructures of oil and gas industry in Indonesia, natural gas in Indonesia is regulate with oil and gas law under BPMigas. Fifty percent of natural gas production of Indonesia came from PT Pertamina while international companies such as Conono Phillips, Exxon Mobil, and Total dominate the upstream gas sector. The distribution activities and natural gas transmission are conducted by Perusahaan Gas Negara - PGN (National Gas Company) a state-owned company.

Natural gas in Indonesia over the period of twenty years has grown 1.5% per annum, in 2009 Indonesia produced 2.6 TCF of dry natural gas placed at number eleven in gas producer of the world. From the number, half of the production came from offshore although the government estimated 70% of the natural gas reserves is in offshore area.

The problem with natural gas development in Indonesia is the geography barrier that separate the major gas field (Sumatra, Kalimantan, and Papua Island) with their major demand markets in Java Island. The current significant natural gas production in Indonesia are East Kalimantan's offshore fields (particularly the Mahakam PSCs that operated by Total), South Sumatra (particularly the onshore Corridor PSC operated by Conoco Phillips), Aceh and North Sumatra (including declining offshore Arun field operated by Exxon Mobil), South Natuna Sea (offshore

Block B operated by Conoco Phillips), and West Papua (Tangguh Project that operated by BP). A third of gross production of 2009 was accounted to East Kalimantan's offshore PSCs.

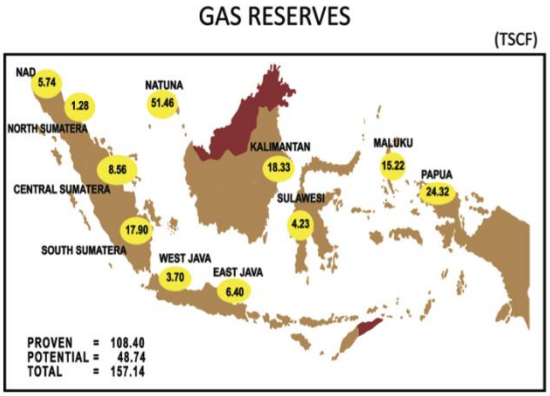

Figure 2. Indonesia Gas Reserves by 2010

In the next decade several major natural gas projects has been planning, in addition to current projects. One of the project is joint project between PT Pertamina and Exxon Mobil with recently back up by Total and Petronas (Malaysia) to develop East Natuna Sea Natuna D-Alpha field. East Natuna estimated to have 46 TCF of natural gas and PT Pertamina expects the project will run in 2021. The problem with this project is the higher concentration of CO2 (70%) that significantly tightening production margin.

The other project is Gendalo-Gehem Project which is the first Indonesia deep water natural gas project. The project conducted by Chevron in associated with Eni (Italy) an Sinopec (China). The project may produce up to 400 billion cubic feet per annum at its peak that will covers four PSC block. The project, according to BPMigas, may start as early as 2014 and the first stage of the project will be commence from Bangka field. Masela Block project in Arafuru sea which estimated has 14 TCF of natural gas will be developed by Inpex (Japan) as the company received permission from the government of Indonesia. The production expected to commence in 2016 and will serve export market trough associated LNG terminal planned.

Indonesia also developed its unconventional natural gas resources such as coal-bed methane (CMB). Indonesia estimated holds 453 TCF of CMB that extracted from associate coal beds. The CMB resources are located relatively close to the centres of population (onshore), primarily in South Sumatra and Kalimantan. Since 2008 the government began awarding PSC's tough most of the early projects were end as exploration phase. The production phase of those project expected to start late 2011 or early 2012. Mainly Indonesia CMB PSCs are local company, however international company such as Eni, BP and Dart Energy (Australia) also interested to developed CMB project in Indonesia.

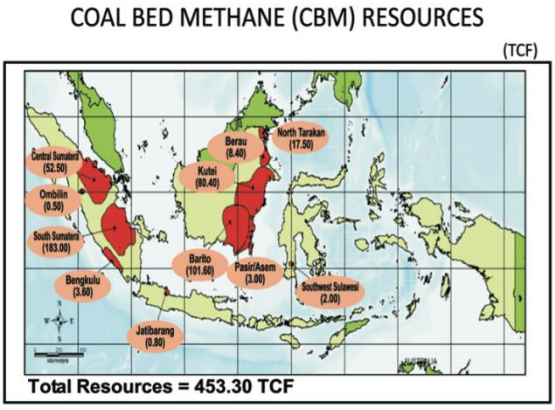

Figure 3.. Indonesia Coal Bed Methane (CBM) Resources by 2010

In 2009 Indonesia was at the number six of natural gas exporter. Most of the Indonesia natural gas exports (three quarters) are transport as LNG to Japan (65%), China, South Korea and Taiwan. However a quarter of its exports are trough pipeline to Singapore, there are two pipeline connections to Singapore, first from West Natuna offshore field and second from South Sumatra Grissik Processing Plant. Total capacity of the pipe lines are approximately 400 BCF per day. The Indonesia contract with Singapore is long term contract that will end in 2020. Due to the high domestic demand, the government of Indonesia approach Singapore to reduce the contract capacity.

Due to declining of oil production, the demand of gas as alternative to oil has increased in domestic market. In 2009 Indonesia domestic market consumed 1.3 TCF of its natural gas production, which is half of Indonesia total dry gas production. The significant growth of the domestic demand come from industry sector which is the higher consumer and power energy sector that drove the domestic demand. According to PGN, although currently operates more than 3,500 miles of natural gas transmission, in 2009 there was 400 BCF unmet demand for domestic industrial and power generation for those who located outside the existed PGN's strategic business units.

Since 2008 PGN operate South Sumatra - West Java pipeline that become important link between gas producing region of South Sumatra and high density industry area of West Java. Another domestic important pipeline is the Grissik - Duri line that provide Chevron's Duri field steamflooding and power generation activities. Transmission breakdown on September 2010 consider as accounted to the failure of Indonesia to meet its 2010 oil production goals.

In 2009 Indonesia was the third largest LNG exporter following Qatar and Malaysia. With total production capacity of arround 1.6 TCF per annum, Indonesia has three operational liquifaction terminals. Indonesia exported arround 980 BCF of LNG in 2009.

Indonesia three liquifaction terminals are Bontang LNG Terminal in East Kalimantan, Arun LNG Terminal in Aceh, and Tangguh LNG Terminal in West Papua. The Bontang LNG Terminal, one of the largest LNG terminal in the world, liquified around 1.1 TCF/y of natural gas was delivered its first shipment in 1977 and shortly after followed by the Arun LNG Terminal shipment in 1978. The Arun LNG Terminal production declined in recent year due to lack of natural gas supply and expected to stop the production by 2014. The newest LNG plant of Indonesia is Tangguh LNG Terminal in West Papua. Operated under BP, the terminal came online in 2009 and in 2010 exported nearly 330 BCF of LNG. The terminal planned will have three terminals however only two terminal were finished and the plan to built third terminal not yet proceed. In addition to existing LNG terminal and to compensate Arun declining LNG production, Indonesia planned to build two other LNG Terminal in 2014 in Central Sulawesi (Donggi - Senoro) and arround 2016 in Arafuru Sea (Masela) with production capacity of 102 BCF/y and 122 BCF/y respectively.

In Indonesia, LNG exports has become political issue due to the export based of LNG industry that neglected the domestic market. With the growth of natural gas domestic market and currently unmet demand its lead to government policies to securing local market domestic natural gas supply. The Donggi - Senoro LNG Terminal only approved by the government after 30% of its producing dedicated to domestic market supply. This policies also implemented to Masela floating LNG Terminal as well as the consideration to reoriented Bontang LNG Terminal production towards domestic market supply and no longer for overseas market by 2020.

To increase the flexibility of LNG exports as well as fulfill the domestic demand several LNG regasification terminals planning are underway. The first regasification terminal, joint venture between PGN and PT Pertamina, with capacity of 143 BCF/y will start production in 2012 to supply greater Jakarta area market. Another terminal with the same capacity planned to serviceEast Java region is under go bidding process. Furthermore, PT Pertamina and PT Perusahaan Listrik Negara (PLN) a state-owned power company announced to develop eight mini regasification terminals by 2015 that intended to secure the natural gas supply for power generation will scattered at the eastern part of Indonesia.

2.1.3. Coal

Indonesia main coal mines are located in Sumatra and East and South Kalimantan, the recoverable coal of Indonesia estimated around 104,944 million tons with proven reserves of 21,132 million tons (Picture 5). According the government and the industry the base resources much more higher than the estimated number. Indonesia coal production primarily is from bituminous and/or sub-bituminous rather than more higher quality such as steam coal or anthracite. The coal mining production in Indonesia increase quadrupled since 2000 to 333 million tons in 2009. At the same time, the domestic market consumed only 77 million tons of coal which is a quarter of Indonesia coal production, however this number increased three times from 2000 domestic consumption [4]. Nearly two-third of domestic consumption in 2009 goes to power plants, by 2014 it is expected that the demand on coal from this sector will be more than double due to addition of several coal burner generator.

Indonesia coal production is projected towards export market, however the increased on domestic market demand makes the government to take action in secure domestic supply. Thus, the government of Indonesia has set a domestic market obligation (DMO) of 24% for producers. Indonesia, after Australia, is the second largest

coal exporter in the world and for the thermal coal that is used to generate electricity, Indonesia is the largest exporter. Indonesia main coal markets that account 70% of production are China, Japan, and Taiwan. Indonesia is a leading importer of coal to China.

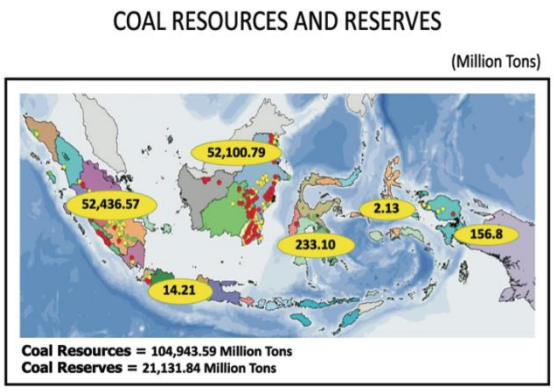

Figure 4. Indonesia Coal Reserves by 2010

2.2. Electricity and Renewable Energy

Majority (86%) of electricity in Indonesia came from conventional thermal sources such as oil, natural gas and coal where oil account of 19% of the sources, natural gas and coal account of 33% and 47% respectively. The rest of Indonesia electricity resources are 8% came from hydroelectric and only 6% came from renewable sources such as geothermal and wind farm. Total in 2008 Indonesia generated 122 billion kilowatthours (Bkwh) of electricity, as for installed generating capacity Indonesia had 27.8 gigawatts.

In Indonesia the most significant company in the electricity sector is the state-owend PT. PLN. The company, through its subsidiaries, owns and operates 86% of the Indonesia generating capacity maintains effective monopoly (until 2009) to the distribution activities. The 2009 Indonesia Electricity Law (UU no 30/2009 Tentang Ketenaga Listrikan) end the PT. PLN monopoly, although its need more effort to maintain the law.

Regardless the increased of Indonesia's generating capacity in ten years by more than a quarter into 2009, the electricity in Indonesia only reach 65% of its population as well as power shortages in grid-connected area due to the electricity demand higher than the capacity growth. The problem behind this situation is because the lagged of investment in Indonesia power sector due to inadequate supporting infrastructure, difficulty obtaining land-use permissions, subsidized tariffs, and uncertainty in regulation.

In 2006 to solve the problems of electricity access and electricity shortages, the government of Indonesia conduct the first stage of a fast-track plan. The plan is to added 20 gigawatts more capacity to the grid by 2014. The first stage that scheduled to complete in 2010 was rescheduled to complete in 2013 due to several delays, it intended to install 10 gigawatts of primarily coal based generation. The reason to install coal based generator because of the abundant resources of coal and to reduce the use of costly diesel and oil fuel.

The second stage of another 10 gigawatts electricity capacity to be completed by 2014, however due to the delay of the first stage the time of completion of the second stage is under evaluation. The second stage intended to generate electricity from cleaner sources such as natural gas and renewables).

One of the renewables sources is geothermal energy, Indonesia is notable as using a significant level of geothermal power as it placed at the third largest geothermal power generation country in the world. The geothermal energy in Indonesia estimated to be sufficient to generate 28 gigawatts of electricity. The second stage will used nearly four gigawatts of geothermal capacity that will be operated by independent power producers. Considering the cleaner energy sources, the government of Indonesia plans to increase the used of renewable energy to 15% by 2025 that focused on the utilization of geothermal energy.

3. FUTURE ENERGY OPTIONS

The potential future energy options for Indonesia can be categorized as two, fossil fuel energy sources and renewable energy sources. As previously explain, Indonesia is still depend on fossil fuel especially oil however due to high price of this type of energy source the government of Indonesia try to changes the dependency to oil by substitute with natural gas and coal that relatively abundant in Indonesia. Nevertheless the view of cleaner energy sources as well as the potential of these kind of energy in Indonesia encourage the government to study the feasibility of such kind energy source and result in the National Energy Conservation Master Plan that should achieved its objectives by 2025, this

category includes nuclear power. Figure 5 shows the primary energy mix changes in Indonesia by 2025 and Figure 6 shows the energy development projection in Indonesia by 2025.

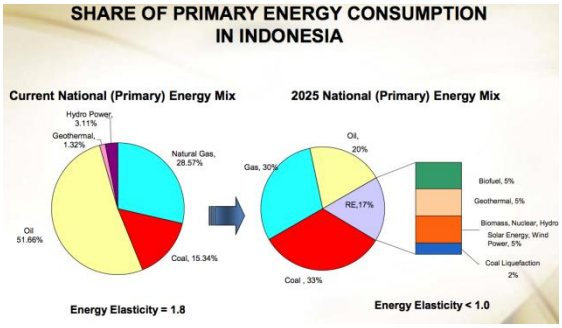

Figure 5. Indonesia Primary Energy Mix Changes

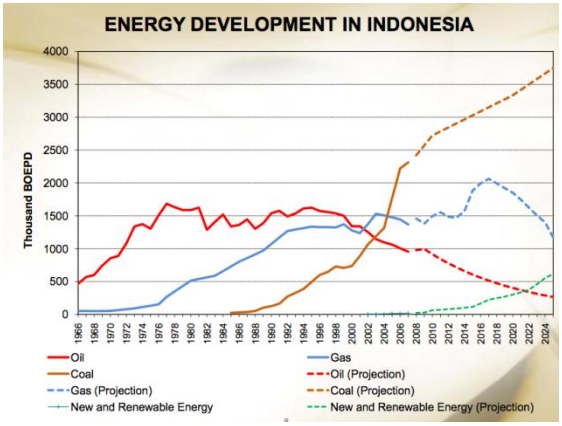

Figure 6. Indonesia Energy Development by 2025

3.1. Fossil Fuel Options

In the future Indonesia will try to use less oil as source of energy as the price and the availability become scarce. Using natural gas and coal consider as a direct substitution for oil as well as explore more unconventional fossil fuel resources such as coal bed methane and shale gas. The oil will be primarily use as transportation fuel and back up with natural gas and biofuel. Natural gas and coal will be primarily to support power generation and industries.

3.2. Renewable Options

3.2.1. Geothermal Energy

The geothermal energy is thermal energy that stored in rock and fluids beneath the Earth. The source of geothermal energy is from the magma deep in the Earth core that heated rock and fluids in it during the magma flows. The sites that have potential of this type of energy is recognizable from the features such as hot spring, volcano and geyser. The geothermal energy may come from shallow ground associated with hot water and deep ground associated with hot rock. The geothermal energy release its heat through magma conduits, hot springs, hydrothermal circulation or combination of the systems. Generally, except the traditional usage as hot spring pool or heater, geothermal energy used as power generation. The idea is to use the heat from the Earth to move the generator by utilize the vapor or hot water. The heat is taken from the geothermal reservoir then transferred to the surface trough drilling well and pipe line to the power plant.

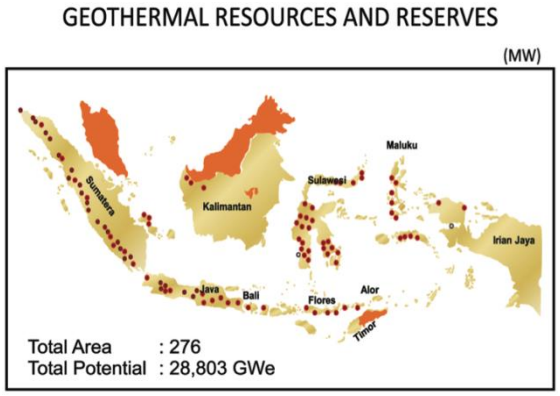

Figure 7. Indonesia Geothermal Resources and Reserves by 2010

Indonesia considered as potential for development of geothermal energy due to the geographical position in the region what so called “Pacific Ring of Fire”, the region that where the volcanic activities exist due to the plate tectonic movement. Indonesia geothermal system describes as hydrothermal system (other system is hot rock system) with two different types, one phase and two phase. The one phase system can be differ as vapor dominated or water dominated.

According to the data from the Indonesia Ministry of Energy and Mineral Resources (Figure 5), in 2010 the potential of geothermal energy in Indonesia is 28,803 MWe (megawatts equivalent) that account of approximately 40% of the world geothermal energy reserves from total 276 sites. Currently, Indonesia has seven geothermal power generation plants which five in Java island (Kamojang, Darajat, Salak, Wayang Windu, and Geodipa), Sibayak in North Suamtra and Lahendong in Central Sulawesi. Total the geothermal plants provide 3.7% of

national production with capacity of 1,904 MW in 2010. This makes Indonesia ranks third in the world geothermal energy production under USA and the Philippines. There is a plan from the government of Indonesia to reach 9,000 MW from geothermal resources by 2025 [6].

3.2.2. Biomass Energy

Biomass product such as agricultural and forestry industry as well as organic waste are abundant in Indonesia. According to the energy statistic data from the Indonesia Ministry of Energy and Mineral Resources, Indonesia produces 146.7 million tons of biomass per annum that is equivalent to around 470 GJ per annum or equivalent to around 50GW of electricity. Every part of Indonesia provide the portion of biomass sources, how ever the major sources of biomass are Kalimantan, Sumatra, Papua, and Sulawesi.

The main source of the biomass would be rice residues, rubber wood residues, sugar mill residues, palm oil plant residues, and forestry industry residues. To generate electricity from the biomass a stable supply is needed, thus palm oil residue, sugar mill residue and rice residue are considered as the main supply. Indonesia have around 76 sugar mills that produce 8 millions tons bagasse and 11.5 millions tons of sugar cane residue, as the largest palm oil producer in the world Indonesia has 47 palm oil plantations and mils that will provides enormous residue [13].

Other potential source of biomass is municipal wastes that come from mostly household especially organic kitchen waste. At present the wastes are burn or collected to the designated dumping area. Due to population pressure most of cities in Indonesia are suffering from the waste disposals problems [13].

3.2.3. Hydropower Energy

Indonesia has potency of 75,000 MW of hydropower energy from which only under 8% of this value were utilized. The less than 8% of the hydropower energy is mostly come from hydro energy power generation. The problems of implement new hydro energy power generation are environmental issues and demand. The source of water especially big river is among the pristine nature of Indonesia forest and also in those area there were no industrial area nor high population area such as in the Membramo River in Papua Island. However considering penetration of electricity to the non grid area and the hydropower potential a different kind of hydro energy generation is introduced. Microhydro or picohydro power genertion are suggested to the rural area of Indonesia. These kind of hydropower can use small stream or water ways as well as irrigation infrastructures.

3.2.4. Wind Energy

Indonesia as an archipelago country have potency for utilization of wind energy, however the average rate of wind velocity in Indonesia is only 4-5 m/s that is bellow the economical value [7]. Regardless the economical efficiency, Indonesia has average potency of 73 GW of wind power with optimum capacity of 25 MW and only 0.6 MW is used today [12]. Design engineering of new type of wind mill that preferable for low velocity region and combining the wind mill with ocean energy power generation would be the answer for the issue.

3.2.5. Solar Energy

There are two types utilization of solar energy, first the more common type is photovoltaic cell and the second the grandeur type is heat engines. The principle of photovoltaic cell is by converting the solar radiation into direct current electricity while the principle of heat engine is by converting the heat from the solar into mechanical works.

In Indonesia the utilization of solar energy is mostly the photovoltaic cell type while the heat engine type not yet developed. The intensity of solar radiation in Indonesia is about 4.8 kWh/m2/day with the installed capacity is 8 MW [12]. The solar energy in Indonesia mainly used in rural area or remote area were the electrical grid cannot reach.

3.2.6. Ocean Energy

The ocean energy can be divide into wave energy, tidal energy, ocean current energy, ocean thermal energy, and salinity gradient energy [10]. The wave energy generation is transferring the motion of wave due to the wind energy into mechanical works. Tidal energy generation is utilizing the different level of tidal rise and tidal fall into mechanical works (tidal range energy) and by filling and emptying of coastal regions (tidal currents energy). Ocean current energy generation is by used ocean circulation to generate power while ocean thermal energy generation is utilized the temperature difference

between surface and deep water (below 1,000m). The salinity gradient energy generation or osmotic power generation is by used the salinity difference between fresh water and salt water at the river mouths.

As an archipelago nation with sea area three times of land area, Indonesia has 727,000 MW electricity potency from utilization of ocean energy, from the value 49,000 MW can be practically utilized with recent technology and capability which 6,000 MW from the wave energy and tidal range energy can be directly installed [9]. The barrier to used the ocean energy is technology.

3.2.7. Nuclear Energy

Nuclear energy power generation is the utilization of nuclear fission to generate heat and the heat then use to power generator through steam. Nuclear energy considered as renewable energy as only need a small amount of radioactive material such as uranium to generate power in relatively long time. A kilogram of uranium-235 can releases nearly three million times of energy than a kilogram of coal.

Recently Indonesia already own three research reactor, the first reactor Triga Mark II located in Bandung West Java Province was operated in 1965 with capacity to generate 250 kW and then in 2000 the capacity was increased to 2 MW, the second reactor Kartini with capacity of 100 kW was operated since 1979 located in Babarsari Special Region Yogyakarta Province, and the third reaktor MPR RSG-GA Siwabessy with capacity of 30 MW was operated in 1987 located in Serpon Banten Province. Indonesia has plan and prepare location for the first commercial nuclear reactor, there were two option first is in Muria Central Java Province and the other is in Gorontalo Province. The two places become the candidates because of the area relatively stable from the geological point of view as Indonesia is the country with relatively high volcanic and tectonic activities.

Indonesia has around 7,100 ton of reasonably assured resources of uranium, 1,700 ton of estimated additional resources category I of uranium and 4,000 ton of speculative resources of uranium. Additional source of uranium can be obtain from other country such as Russia, Canada, and Australia.

4. DISCUSSIONS

The Indonesia future energy options will move towards renewable energy sources or at least reduce the dependency on fossil energy sources especially oil and its derivates. Mostly this policy is due to the high cost of crude oil and the depletion of Indonesia oil fields as well as the global issue of climate changes. This policy has been implemented in a fast-track plan to secure and fulfill the electricity supply by added 20 gigawatts of electricity by 2014 and a grand policy of “the National Energy Conservation Master Plan” to increased the used of renewable energy in Indonesia to 15% by 2025.

Recently Indonesia mainly depends on oil as the sources of energy in every sectors. The second largest energy sources is natural gas and followed by coal and biomass respectively. Although Indonesia considered as the third largest geothermal electricity production in the world, geothermal only 3.7% of national production capacity. Renewable energy such as solar energy, wind power and ocean energy only give a fraction of national electricity as the sources are under developing stage or pilot project.

By 2010 Indonesia has total of 7,764.5 MMSTB crude oil reserves which are 4,230 MMSTB proven reserve and 3,535.5 MMSTB potential reserve this reserve without finding new oil field are declined. The natural gas total reserves of Indonesia is 157 TSCF by 2010 which are 108 TSCF of proven reserve and 49 TSCF of potential reserve. As for coal reserves Indonesia has 21,132 Million Tons of coal from the 104,944 Million Tons of resources by 2010. Indonesia has potential of 28.8 GWe (gigawatss equivalent) of electricity from geothermal sources however only 1,904 megawatts capacity were installed by 2010.

From the National Energy Conservation Master Plan beside the more utilization of natural gas, coal and geothermal energy, the utilization of bio energy, solar energy, wind power, ocean sources energy and coal liquefaction as well as the possibility of nuclear power were considered. These will result in reduction of crude oil as the primary source of energy from around 52% to 20% (Figure 5). Beyond 2025 the usage of coal as well as new and renewable energy such as nuclear power will increased as the use of oil and gas as energy source declined (Figure 6).

Relating to the utilization of nuclear power, although the technology and the nuclear fuel resources are feasible to build commercial nuclear power reactor in Indonesia, however the political issues might become hindrance to build the reactor by 2025 as the recent earthquake disaster devastated the Fukushima nuclear reactor in Japan. Most likely the people of Indonesia will reject the idea of nuclear power in Indonesia due to the understanding of the dangerous of nuclear radiation after the Chernobyl and Fukushima incident and especially because of the understanding of the location of Indonesia as the region with high probability of eruptions and earthquakes. However in far future nuclear power might be the best answer for the electricity problems in Indonesia.

5. CONCLUSIONS

Indonesia has potential renewable energy to used in the future.

By 2025 Indonesia will increased the used of natural gas, coal, geothermal, and other renewable energy source such as wind power, solar energy, and ocean energy sources.

By 2025 Indonesia will decreased the used of crude oil as primary energy source.

Although by 2025 most likely will not build in Indonesia, however due to the technology capabilities and the Indonesia nuclear fuel reserves it is a logical decision to build nuclear power plan in far future beyond 2025.

From 2025 most likely Indonesia will rely on renewable energy as well as new energy such as nuclear power and geothermal energy as energy sources as the reserves of gas and oil were depleted.

Coal might become the new primary energy source for electricity however the pollution issues most likely become hindrance.

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