# Indonesian Energy Scenario to 2050: Projection of Consumption, Supply Options and Primary Energy Mix Scenarios

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***Abstract* - This paper describes the profile of Indonesian energy consumption from 1970 until 2009. An analyses is carried out to identify Energy Indicators i.e. consumption per capita, energy intensity, the growth and elasticity of growth of primary energy consumption in total and also for the final energy in total and by sector as well as for the electricity. It also outlines the energy options and the fossil energy and renewable energy potential. The main part of this paper is the projection of energy consumption and the energy mix scenario from 2010 to 2050. The projection made is a snapshot by using a linear model. The main parameter for the projection is the population and GDP growth.The projection of energy consumption was first made for electricity and non electricity final energy consumption. The indicators of the energy use in the past and of the selected countries were used for making the consumption projection of electricity and the final energy by sectors i.e. Industry, Transportation, Household, and Services. Having obtained the final energy consumption, the primary energy consumption is then projected. The energy mix is set by prioritizing the use of new and renewable energy and domestic available supply and by minimizing the use of oil.**

***Index Terms* – Indonesia, final energy consumption, energy mix, projection, 2050.**

## 1. INTRODUCTION

Indonesia is the fourth largest country in term of population and the 13th rank in the primary energy use. Indonesia is an archipelago country consisting of more than 17,000 islands of which 6 islands are the big ones. The current population of Indonesia is 230 million and the total primary energy consumption in 2009 was 140 MTOE. Even though the average growth of primary energy in the past 40 years is quite high i.e. 7.7% per year, the energy consumption of Indonesia in 2009 is only 0.65 TOE per capita while the word's average is 1.7 TOE per capita. Energy access is still limited as about 40% of the population still has no access to the electricity, and the use of kerosene and biomass [wood] for cooking is still very high.

Indonesian GDP is 18th rank in the world, with the GDP per capita in 2009 of US$ 2349. Indonesia's average economic growth for the period of 1971-2008 was 6.1% per year. At this time energy resources especially gas and coal are exported to support the economy. About 35% of national annual budget is coming from energy export income. In the future Indonesia aims to shift its economy from natural resources and agriculture base into industrial and agriculture base. To allow this shift, it is estimated that up to 2050, the economic growth will be averagely over 6% per year and the population will grow to be around 307 million people by 2050. The increasing population and economic growth will contribute to the increasing energy demand in 2050.

Currently the final energy supply is dominated by non-renewable energy resources such as oil, gas and coal which totally achieved 95.8 % of the final energy consumption of 97 MTOE. This situation worrying the government and the energy society as the fossil energy resources and supply will be diminished in the near future. Meanwhile, the new and renewable energy resources [NRE] utilization is still limited due to its high production cost and worsen by the subsidy policy on fossil energy i.e. oil for transportation sector, kerosene and LPG for cooking.

The increasing of Indonesia's energy consumption growth in the future will require a sustainable energy management meaning to provide energy in economic way, secure way and environmentally wise way. An economic way means that that energy management is

aimed at prioritizing the use of competitive energy resources that produce a competitive energy prices. A secure way means that the energy management shall be carried out to secure the supply and the production costs by prioritizing the development and utilization of un-exportable and domestic energy resources that less affected by the global dynamics. Meanwhile an environmentally wise way means that the energy is provided and utilizes wisely that provide energy in lower carbon emission, minimum environmental impacts and give benefits to surrounding people.

The huge share of fossil energy utilization, while the resources are limited and the high energy demand requires an energy management both in demand side and the supply side management. The efforts shall then be performed to increase energy efficiency in the demand side and to enhance the supply side efficiency. Besides that the utilization of NRE shall be encouraged and fully supported in order to improve the energy security and to create energy autonomy.

## 2. INDONESIA ENERGY UTILIZATION PROFILE FROM 1971 TO 2009

### 2.1. Profile of Energy Consumption

Consumption of final energy for period of 1971 to 2009 had a significant growth, i.e. about 14 times bigger from 6.78 MTOE in 1971 to 97 MTOE in 2009 or increased with annual average growth of 7.3 % [2,3]. The highest growth happened during the period of 1974 to 1979 which achieved 15% per year attributable to the robust economic growth during that period. Figure 1 shows the final energy consumption for period of 1971 to 2009.

The figure also indicates that the electricity contributes to one of the highest of energy growth which is 12% per year, in which the highest growth happened in 1996 with 24% growth. In 1971, the electricity consumption was just 0.15 MTOE and it increased about 79 times bigger to 11.86 MTOE in 2009. The rapid growth happened since the Government of Indonesia [GOI] fully supported the electricity infrastructures development. However, the Indonesian electrification ratio at this time is still around 64% in 2009 [4].

In 1971, transportation sector contributed to the most of the final energy consumption [41%], followed by residential [34 %] and industries [26%] [2]. This indicates that energy was used mostly for consumptive activities rather than creating higher value added to support economic growth.

The picture of energy consumption is changed considerably in recent years. In 2009, final energy consumption was dominated by industrial sector [51%], followed by transportation [30%], households [12%], and services [8%]. This change is attributed to government efforts in encouraging the development of larger industries in order to support the economy. .

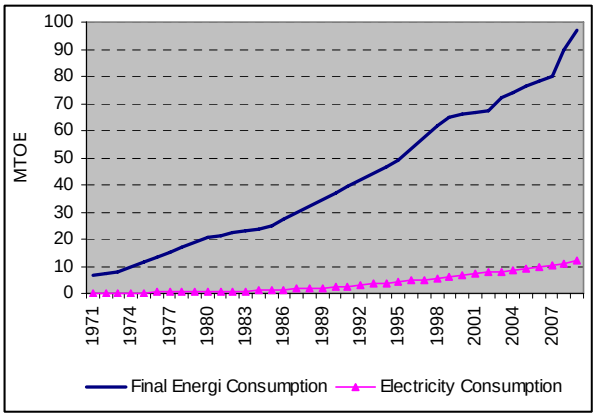


Figure 1. Final Energy and Electricity Consumption during 1971 to 2009

In 1971, most of energy demands were supplied from domestic energy source in which oil was the biggest component for the energy mix [94 %] while the rest was gas [3%], coal [2%] and renewable energy – RE [1%]. The GOI was fully aware of this condition and issued a National Energy Policy [NEP] in 1981 focusing on intensification [increase the amount of primary energy share], diversification [substitute oil to other energy sources such as coal, gas and RE] and energy conservation. The NEP focus was then elaborated by adding energy price and environmental aspects in 1998.

The NRE development has changed the national energy mix gradually. In 2009, the

share of oil was down to 48%, coal and gas increased to 28% and 21%, while the rests were geothermal and hydro electric power.

In line with final energy consumption growth, the domestic primary energy consumption has significantly increased from 8.8 MTOE in 1971 to 147 MTOE in 2009, as shown in Figure 2. During those periods, the average domestic primary energy growth was 7.7% per year.

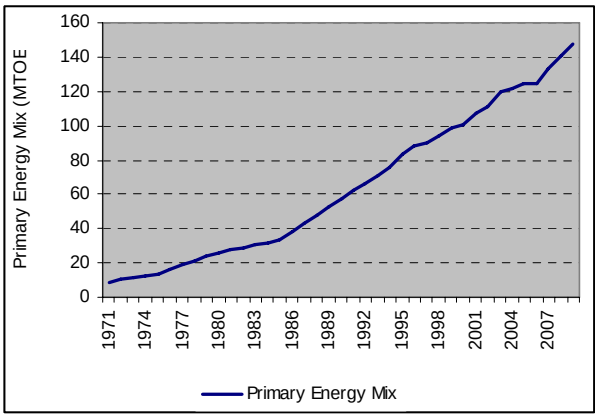


Figure 2. Domestic Primary Energy Mix during 1971 to 2009

## 2.2 Energy Economic Indicators

During 1971 to 2009, Indonesia has doubled its population from 120.4 million people in 1971 to 230 million people in 2009. Although there was a significant increase on population, in fact the population growth experienced a slight decreasing. For instance, for period of 1980 to 1990 the growth per year was about 1.97%. It then decreased for period of 1990 to 2000 i.e. 1.45% per year, and decreased again for period of 2000 to 2008 i.e. 1.36% per year [1].

During those periods, the gross domestic products [GDP] of Indonesia have increased 8.7 times bigger, from US$29.5 billion to US$ 255.4 billion [CY 2000 Price] or average growth of 5.8% per year. The profile of energy use i.e. growth, elasticity and consumption per capita is shown in Table 1.

With the average growth of final energy consumption from 1971 to 2009 of 7.2% per year and the average GDP growth of 5.8% per year the average demand elasticity is 1.21.

TABLE 1

INDONESIAN ENERGY INDICATORS

Such conditions contribute to the average energy elasticity of more than 1 from 1971 to 2009, although the elasticity fluctuated in recent years as affected by sectoral GDP growth from non manufacturing industries, which consumes less energy. The energy consumption per capita has increased from 0.06 TOE per capita in 1971 to 0.65 TOE per capita in 2009. The elasticity for electricity is also still more than 1. This is mainly caused by the low of electric consumption per capita in Indonesia, and the low of electrification ratio in the country.

The final energy consumption against GDP has doubled from 299 TOE per Million US$ [C.Y. 2000 Price] in 1971 to 577 TOE per Million US$ in 2009. The slight growth of energy intensity against GDP shows that the GDP growth is less aggressive than that of final energy growth. In other words, the final energy utilization is mainly intended to create productive goods rather than the consumptive ones. This in turn will contribute to the growth of final energy consumption. In addition, the $CO_2$ emission per capita was still less than 2 ton $CO_2$ in 2006.

The Indonesian energy indicators above are generally much below the ones of the developed countries such as Japan, USA, and OECD countries and even are still below China and Asia. The Indonesian and the World Energy characteristic is as shown in Table 2.

TABLE 2

INDONESIAN ENERGY AND WORLD ENERGY CHARACTERISTICS 2006 [2]

Note: Primary Energy per GDP: TOE per US$ Million [C.Y. 2000 Price]

## 2.3. Distribution of final energy by region

Indonesia is an archipelago country with 17,504 islands, of which Sumatera, Java, Kalimantan, Sulawesi and Papua are among the biggest ones [5]. Although there are many islands, however, the population is not evenly distributed in each region. For example, in 2009 Java with the area of 7 % of Indonesia land area is inhabited by about 124.5 million [54%] [[6], while the rests are living at Sumatera [21%], Kalimantan [5%], Sulawesi [7.2%], Papua and others [5.9%] [7].

In term of industrial sector, Indonesia has 20,235 medium and large scale industries, of which are mainly located in Java island [84%], followed by Sumatera [11%], Sulawesi [3%], Kalimantan [2%], and Papua and others [1%] [7].

The number of vehicles in 2006 was 44.08 million units of which 74% were motor-cycles [1]. The regional distribution of vehicles are almost the same pattern as that of the population in which 64%was in Java, 21% in Sumatera, 7% in Kalimantan, 5% in Sulawesi, and 3% in Papua and other islands [1].

Based on population, industrial activities, vehicles, energy sales and other distribution indicators, the total final energy consumption in 2009 of 97 MTOE was distributed in Java [67%], Sumatera [15%, Kalimantan [11%], Sulawesi [4%], and Papua and other islands [3%], as shown in Figure 3.

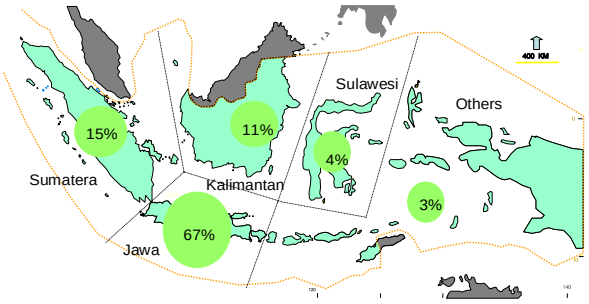


Figure 3. Distribution Share of Final Energy Consumption by Region in 2009

## 3. PROJECTION OF ENERGY DEMAND 2010-2050

### 3.1. Final Energy Projection

The projection is made by considering historical energy indicators and future energy indicator targets adjusted with energy elasticity. In this case, final energy consumption per capita is targeted to be:

- In 2020 towards the world's average.
- In 2030 above the world's average.
- In 2040 towards a developed country.

Besides targeting the final energy consumption per capita, it is also targeted a 100% of electrification ratio which is expected to occur around year 2025. Future energy indicators are influenced by assumption of GDP and population projection up to 2050. The projection is made by taking into account the suggestion from 34 institutions representing ministries, professional associations, agencies, companies, universities, and other bodies.

The GDP projection is divided into 2 scenarios i.e. high GDP and low GDP projection, while the population projection is same for both GDP projections. Table 3 shows the assumptions for GDP, population, targeted energy intensity, electricity share per sector, and energy elasticity growth. The assumptions are taken in order to accelerate the process to develop Indonesia to become an industrial country.

TABLE 3

ASSUMPTIONS FOR GDP, POPULATION, ENERGY INTENSITY, ELECTRICITY SHARE PER SECTOR AND ELASTICITY GROWTH BASED ON HIGH AND LOW SCENARIO

| Scenario | Unit | 2010 | 2020 | 2030 | 2040 | 2050 |
|---|---|---|---|---|---|---|
| **High** | | | | | | |
| GDP | % | 5.6 | 8 | 7.5 | 7 | 6 |
| Population | Million | 238.4 | 261.5 | 284.4 | 299.2 | 307 |
| Intensity | TOE/Cap | 0.41 | 0.76 | 1.35 | 2.21 | 3.08 |
| Com. | % Elec | 72.8 | 79.9 | 81.0 | 80.3 | 80.0 |
| Ind. | % Elec | 11.5 | 14.8 | 18.9 | 23.8 | 31.3 |
| HH. | % Elec | 46.5 | 55.8 | 65.9 | 74.2 | 76.7 |
| Transp. | % Elec | 0.0 | 0.0 | 0.8 | 1.6 | 3.3 |
| Total | % Elec | 14.1 | 16.9 | 20.0 | 23.8 | 30.0 |
| Elasticity | | 0.92 | 0.88 | 0.82 | 0.65 | 0.48 |
| **Low** | | | | | | |
| GDP | % | 5.5 | 7 | 6.5 | 6 | 5.5 |
| Population | Million | 238.4 | 261.5 | 284.4 | 299.2 | 307 |
| Intensity | TOE/Cap | 0.41 | 0.73 | 1.21 | 1.85 | 2.46 |
| Com. | % Elec | 72.8 | 80.0 | 80.4 | 79.5 | 79.3 |
| Ind. | % Elec | 11.5 | 14.6 | 18.2 | 22.7 | 29.7 |
| HH. | % Elec | 46.5 | 55.6 | 64.9 | 72.6 | 76.3 |
| Transp. | % Elec | 0.0 | 0.0 | 0.8 | 1.6 | 3.2 |
| Total | % Elec | 14.1 | 16.9 | 19.6 | 23.2 | 29.6 |
| Elasticity | | 0.93 | 0.91 | 0.83 | 0.64 | 0.45 |

Based on the above approach, it is estimated that the final energy demand in 2050 will reach 946 MTOE for high scenario and 754 MTOE for low scenario as shown in Figure 4, excluded non-commercial energy demand [biomass].

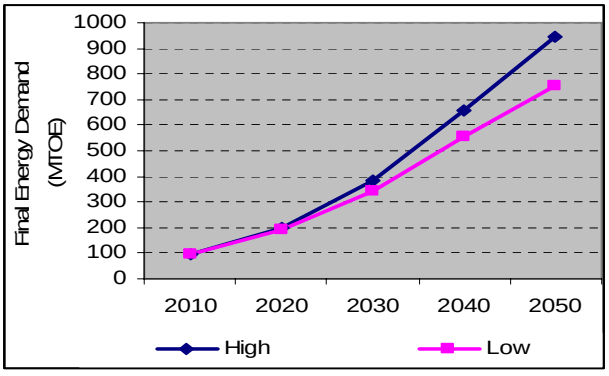


Figure 4. Projection of Final Energy Demand by Scenario

In 2010 with high scenario, it is projected that the final energy demand will be dominated by industrial sectors [51%], either as fuel or raw material [gas]. The rests are for transportation [30%], household [11%], commercial [5%], and others sector [4%], as shown in Figure 5.

The projection shows that in 2050 the final energy composition is relatively not much change compared to 2010. The final energy demand for households and transportation faces a slight decrease, of 2% each. The decrease in households final energy demand is mainly caused by "saturation" of electric energy needs, represented by a slow of electricity share in households during 2040-2050. Meanwhile, a slight decrease on transportation final energy demand is caused by the increasing utilization of mass-transportations attributed to the increasing of electricity share i.e. 3% of total final energy demand of transportation sector. Due to the decreasing final energy demand on households and transportation sectors, there will be a slight increase in commercial and other sectors.

Even though final energy demand for industrial sector is relatively stable, however, there will be a significant increase of electricity demand from 11.5% in 2010 to 31.3% in 2050. The reason is because of shifted industrial structure, from manpower-intensive industries to technology-intensive industries.

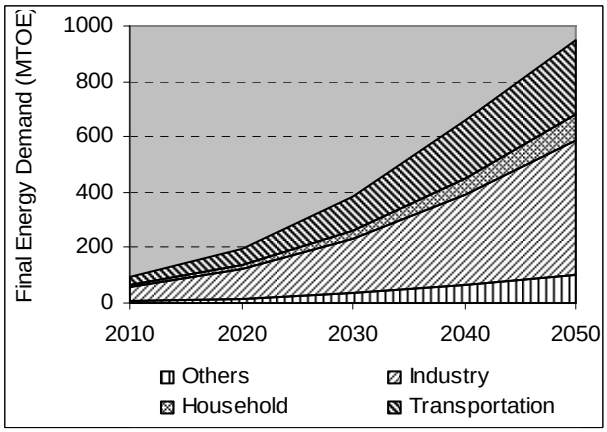


Figure 5. Projection of Final Energy Demand for High Scenario

## 3.2. Comparison with other countries

Compared to China, average of Asian countries, OECD countries, Japan and USA, Indonesian energy consumption is relatively still low. In 2009, Indonesian electricity consumption was 635 kWh per capita, where

the average of ASEAN countries was 863 kWh per capita. In 2006, the electricity consumption in Japan and USA was 7,851 kWh per capita and 12,744 kWh per capita, respectively, while Indonesia is 517 kWh per capita [2]. The Indonesian GDP per capita was US$ 973 [C.Y. 2000 Price], while both Japan and USA reached more than US$ 37,000. Based on the assumption listed in Table 3, per capita electricity demand in 2050 will be 12,987 kWh per capita with GDP per capita US$ 12,850 [C.Y. 2000 price per capita].

Although Indonesian GDP grows at 7.22% per annum in average during the next 40 years [2010-2050], it is predicted that in 2050 Indonesian GDP per capita will only be one third of that of Japan and USA of 2006. The relation between GDP per capita and kWh per capita from several countries is shown in Figure 6.

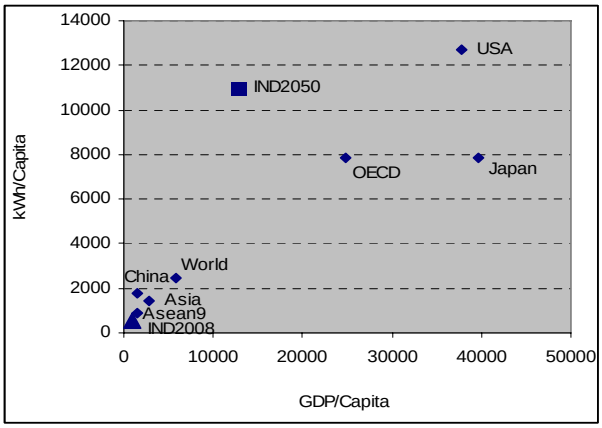


Figure 6. Indonesian kWh per capita versus GDP per capita in 2008 and its projection in 2050

The projection estimates that the Indonesia's final energy demand per capita in 2050 will be nearly equal to average OECD countries, as shown in Figure 7. Figure 6 and 7 indicate that Indonesia will be an industrial country with medium scale of GDP per capita in 2050.

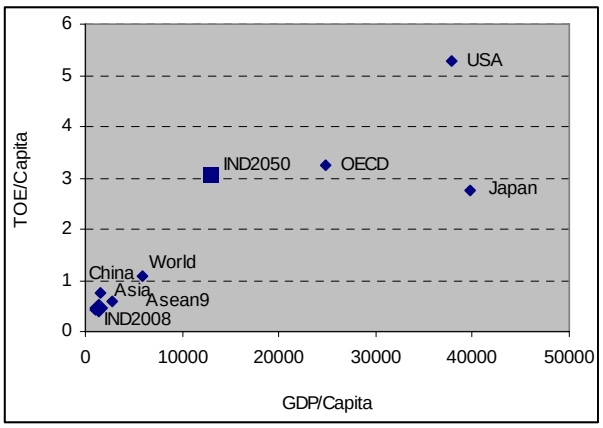


Figure 7. Indonesian TOE per capita versus GDP per capita in 2008 and its projection in 2050

### 3.3. Distribution of final energy by region

As explained in previous section, the industrial and population distribution are concentrated in Java Island. To overcome this problem, GOI has issued some regulations related with regional autonomy to widely open the regions having huge energy resources potential.

Most of energy resources in Indonesia are located outside Java Island. For instance, oil, gas, coal bed methane [CBM] and coal resources exist in Sumatera and Kalimantan, hydro is in Sulawesi and other regions as shown in Table 4. Such condition suggests the development of energy resources based industries at nearby the resource locations including its all related infrastructures. It is expected that local people will gain economic benefit appropriately from energy resources development in their region.

Due to increasing of income, urbanization will be formed at those regions, so that there will be a significant increase in energy demand in outside of Java. Although it is predicted that the most of energy demand will be still dominated in Java in the future, however, the amount can be reduced as the result of the increasing energy use in outside of Java, especially in Sumatera and Kalimantan.

TABLE 4

DISTRIBUTION OF ENERGY BY REGIONS [8]

| Energy Types | Status | Sumatera | Jawa | Kalimantan | Sulawesi | Others |
|---|---|---|---|---|---|---|
| Crude Oil | Reserves | 69% | 19% | 9% | 1% | 2% |
| Natural Gas | Reserves | 55% | 6% | 14% | 2% | 24% |
| CBM | Resources | 53% | 0% | 47% | 0% | 0% |
| Coal | Resources | 50% | 0% | 50% | 0% | 0% |
| Geothermal | Resources | 47% | 34% | 0% | 8% | 10% |
| Hydro | Resources | 21% | 6% | 29% | 14% | 31% |

## 4. DOMESTIC FOSSIL AND RENEWABLE ENERGY OPTION AND POTENTIAL 2010-2050

### 4.1. Domestic Fossil Energy

Indonesia has various fossil energy resources. It is noted that the oil potential resources achieves 56.60 billion barrels, while the reserve is 7.99 billion barrels, consisting of proven reserve as much as 4.30 billion barrels and potential reserve as much as 3.69 billion barrels. The reserve and production [R/P] ratio is about 12 years [3]. In 2007, the proven reserve of Indonesia's oil was about 0.36% of world's proven reserves [2]. Most of oil wells have been very old more than 50 years and the new exploration is relatively limited. In 2009, the oil production was less than 1,000 mbopd and it was predicted to decrease by ratio of 5% per year.

In terms of coal resource availability, in 2007 the coal potential was still huge which is 126.07 billion ton while the proven reserve was 0.51% of world's coal proven reserves [2]. The coal production in 2008 was 229 million ton of which about 70% was exported [3]. It is predicted that the coal production in the future will be double and step-by-step the export portions will be reduced to cover the increasing domestic demand.

In 2008, gas production was about 3 TCF with R/P ratio of 36 years [3] and 53% of that was exported in the form either of LNG or piped gas. In medium-term, gas production is estimated to increase about 3% per year. However,in long-term scenario, the production will slightly decrease. Gas will still be exported to fulfill the existing contracts and to encourage the domestic economic growth. In 2007, Indonesian gas proven reserve contributed around 1.69% of world's proven reserve. Table 5 shows the reserve and resource potentials in Indonesia.

TABLE 5

INDONESIA ENERGY RESERVES AND RESOURCES [8]

| Energy Type | Unit | Reserves and Resources | |
|---|---|---|---|
| | | Reserves | Resources |
| Crude Oil | 10^6 Brl | 7,990 | 56,600 |
| Natural Gas | TCF | 160 | 335 |
| Coal | 10^6 Ton | 21,130 | 126,070 |
| Coal Bed Methane | TCF | n.a | 453 |
| Nuclear | Ton U | n.a | 34,112 |
| | Ton Th | n.a | 1,500 |
| Biofuel | 10^6 KL | 30 | 203 |
| Geothermal | MWe | 2,300 | 28,528 |
| Hydro | MWe | 6,000 | 76,170 |
| Ocean [sea] | GWe | n.a | 240 |
| Solar *] | GWe | n.a | 1,200 |
| Biomass Waste | MWe | n.a | 49,810 |
| Oth Renewable **] | MWe | n.a | 10,000 |

Note:

*] Average solar radiation intensity is 4.8 KWh per $m^2$ per day.

**] Including wind energy with average velocity at 50 meter is 4.27 meter per second.

According to reserve availability and tendency of previous fossil energy production, GOI through Ministry of Mineral Resources [MEMR] predicts that coal will be a future energy resource for Indonesia, as shown in Figure 8.

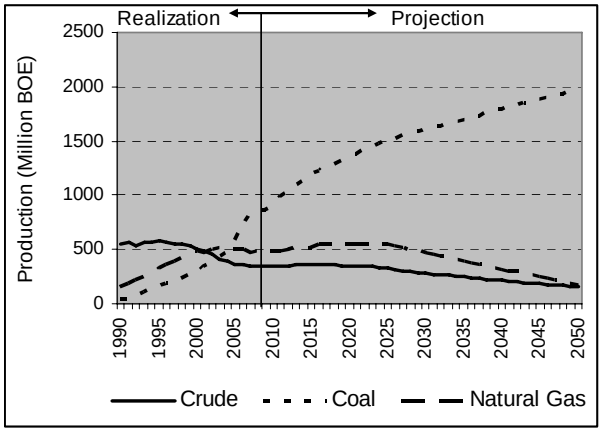


Figure 8. Realization and Projection of Indonesian Fossil Fuel Production

### 4.2. New and Renewable Energy [NRE]

Besides oil, coal and gas, Indonesia is also endowed with NRE resources such as CBM, nuclear, geothermal, hydro, wind, solar, biomass, biofuel, and ocean energy. Until 2008, the resources which have been utilized

and developed were geothermal, hydro, wind, solar, biofuel and biomass energy.

Indonesia's geothermal resource is the biggest in the world. It is predicted that the resource equal to 28.53 GWe. However, the utilization remain very low at around 1.2 GWe [4%] in 2009. Total hydro power potential resource is 76.17 GWe, of which 4 GWe or 5.5% was utilized. The same condition also happen to solar power, micro hydro and wind energy in which in 2009 the utilization was 5.52 MW, 3.03 MW and 1.02 MW, respectively. The wind speed in Indonesia is relatively slow ranging from 3 – 6 m/s measured at 50 meter above ground level. Total solar energy is estimated to 1.2 GWe and average potential solar power in Indonesia is 4.80 kWh per $m^2$ per day. Biofuel potential in Indonesia is predicted to 203 million kiloliter [shown in Table 5].

Such limited of NRE utilization is caused, among others, by improper land use and fuel subsidy making NRE becomes not competitive. -. However, in line with the effort to minimize environmental impacts, it is predicted that in the future the NRE utilization will be maximum.

Besides NRE, Indonesia has a good prospect on developing nuclear energy potential. The potential of uranium and thorium resource is 34,112 ton and 1,500 ton, respectively. Even though the plan to build a nuclear power plant [NPP] has been declared long time ago, a commercial NPP construction has not yet been started. The reason is because the plan has been facing public resistant, especially from local people living nearby the proposed sites. At present, a preparation team has been established and it is expected in 2020s the first NPP can be operated.

Coal bed methane [CBM] is one of new energy resources available in Indonesia. The potential resources amounted to 453.30 TCF. The CBM utilization is expected to be effectively used in 2011.Some new regulations and tender of work-areas have been prepared and hopefully it will become new energy in the future. Besides CBM, biomass potential is also huge which is 49.81 GWe covering wood and its waste, crop waste, industrial and households waste. The biomass resource that is suitable to be developed as an electric power resource in the future is municipal solid waste.

As an archipelago country, Indonesia is covered by ocean for almost two third of total area. It is estimated that the ocean based energy resources may produce about 240 GWe. Some research and studies have been carried out to utilize the ocean energy which is mainly divided into tidal energy, ocean thermal energy conversion [OTEC] and ocean wave current. This energy resource is expected to be realized in the near future.

## 5. PRIMARY ENERGY MIX SCENARIO

### 5.1. Scenarios

As on final energy demand projection, domestic primary energy projection is conducted by taking into account the suggestion from 34 related institutions in Indonesia. Based on energy supply profile in the past, existing national energy policy, energy resources availability and suggestions from 34 related institutions, directions for future domestic primary energy are to maximize the utilization of NRE, minimize oil use, optimize gas use and balance coal utilization. Balancing coal utilization means that coal will become a balancer for domestic primary energy supply or provisionThe above considered factors become an input for the analysis of domestic primary energy mix. This analysis is required to fulfill the need of final energy demand projection. In this case, the analysis was taken for meeting requirement of final energy projection with high GDP scenario. In order to sharpen the result, analysis of domestic primary energy projection was carried out for 2 scenarios, as listed in Table 6.

The energy supply scenarios are arranged according to the directions of national energy policy in the future. The scenarios mainly involve the utilization of nuclear energy which is schemed into 2 cases i.e. with NPP and without NPP. The objective is to view the different $CO_2$ emission resulted in from the electricity production. A computer-aided simulator, Markal-Answer Model, is used for

analyzing the model in which the approach is as shown in Figure 9.

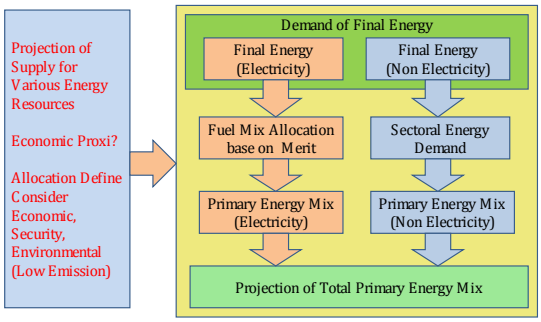


Figure 9. The Approach for Primary Energy Mix Projection

## 5.2. Primary Energy Mix

*Scenario without Nuclear Power Plant*

Markal – Answer model simulation focuses on energy demand projection with high GDP scenario, technical – economical of energy technology, existing national energy policy, and other parameters mentioned in Table 6. It is then resulted in primary energy demand for period of 2010 to 2050, as described in Figure 9. Figure 10 shows the primary energy demand projection with Scenario I [without NPP] and Scenario II [with NPP]. It can be seen that Scenario I will require less primary energy than that of Scenario II. This is due to the fact that the NPP efficiency is less than that of coal fired power plant. In this case, NPP is a substitution from coal fired power plant.

The Scenario I developed with the vision to create an autonomous primary energy supply for the future of Indonesia. Thus, the dependency on oil and gas shall be reduced on gradual basis due to supply constraint in the future [see Figure 8]. The simulation also projected CBM as a new energy resource to meet around 0.4% of total primary energy in 2050.

TABLE 6

PARAMETERS AND ASSUMPTION OF EXPLOITABLE INDONESIA ENERGY RESERVES [8]

| Parameter | Scenario I | Scenario II |
|---|---|---|
| Discount rate | 10% | 10% |
| Base Year | 2008 | 2008 |
| Year of Projection | 2010-2050 | 2010-2050 |
| Coal Production | ≤ Resources | ≤ Resources |
| Crude Production | ≤ Reserves | ≤ Reserves |
| Natural Gas Production | ≤ Reserves | ≤ Reserves |
| CBM Production | ≤ 10% Resources | ≤ 10% Resources |
| Gas Export | as contract | as contract |
| Gas Import | ≥ 2BCFD | ≥ 2BCFD |
| Coal Export | ≤ 220 million ton per year | ≤ 220 million ton per year |
| Biofuel Use | ≤ Resources | ≤ Resources |
| Energy Price | Market Price | Market Price |
| Crude Oil Price | 80 $/barrel | 80 $/barrel |
| Crude and Fuel Import | As Demand | As Demand |
| Use of Technology Efficient | Yes | Yes |
| Utilization of Solar Power | 10% in HH and 3% in COM Sector | 10% in HH and 3% in COM Sector |
| Utilization of Nuclear Power | No | Yes |
| Utilization of Hydro Power | ≤ 30% Resources | ≤ 30% Resources |
| Utilization of Geothermal Power | ≤ 90% Resources | ≤ 90% Resources |
| Utilization of Biomass Power | Max 20 GW | Max 20 GW |
| Utilization of Ocean Power | Max 6 GW | Max 6 GW |

Since electricity demand growth is larger compared to non-electricity final energy demand, fuel demand for power plants will double from about 29 % of primary energy supply in 2010 to 48% in 2050. When Scenario I is applied, in 2050, 53% of energy supply will be from coal. The high role of coal will take place until 2050 even though NRE resources have been utilized [see Table 6 and Figure 11]. This is because total energy demand for all type power plants in 2050 will be 767 GW or 25 times of 2010 condition, including solar panel which contributes to 56 GW.

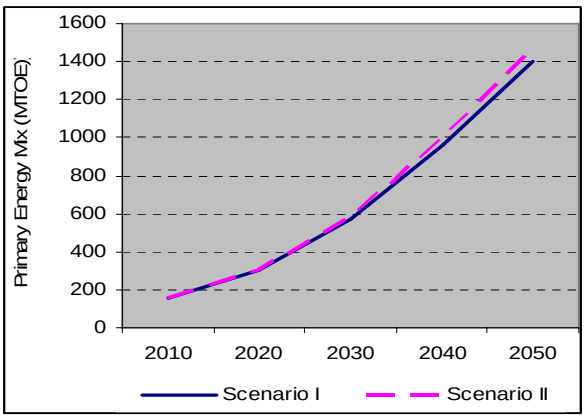


Figure 10. Projection Primary Energy Mix by Scenarios

TABLE 6

PRIMARY ENERGY MIX BY SCENARIOS

| Scenario | Primary Energy Mix [%] | | | | |
|---|---|---|---|---|---|
| Energy | 2010 | 2020 | 2030 | 2040 | 2050 |
| **Scenario I** | | | | | |
| Oil | 45% | 33% | 27% | 24% | 19% |
| Gas + CBM | 21% | 16% | 14% | 14% | 14% |
| Coal | 30% | 39% | 46% | 49% | 53% |
| NRE for PP | 4% | 9% | 8% | 7% | 7% |
| Biofuels | 1% | 3% | 5% | 6% | 7% |
| Nuclear | 0% | 0% | 0% | 0% | 0% |
| **Scenario II** | | | | | |
| Oil | 45% | 33% | 27% | 24% | 19% |
| Gas + CBM | 21% | 16% | 14% | 14% | 14% |
| Coal | 30% | 39% | 30% | 29% | 34% |
| NRE for PP | 4% | 9% | 8% | 7% | 7% |
| Biofuels | 1% | 3% | 5% | 6% | 7% |
| Nuclear | 0% | 1% | 16% | 19% | 19% |

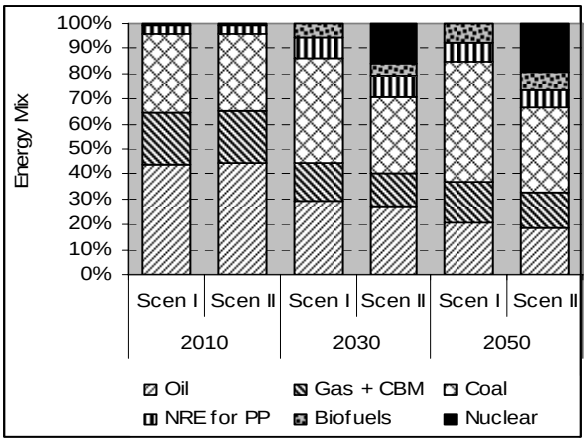


Figure 11. Primary Energy Mix by Scenarios

In terms of its potential resource, the dominant role of coal in energy mix does not give a bad impact to the energy supply as its potential resource achieves 126 billion ton. However, it can significantly influence to the coal shipping and transportation, the reliability of power plants and the environment. Coal shipping and transportation are important part because most of coal resources are located in less developed regions [± 30%], so it will require a barge or vessel to transfer the coal to Java islands. Total coal demand in 2050 is over 1 billion ton. This huge amount will create a heavy traffic transportation which is really sensitive to the climate condition such as during heavy rain season. When the coal supply to the power plants is delayed due to climate factor, the reliability of electricity systems will be affected. Besides that, coal utilization will also contribute to the increasing of $CO_2$ emission.

*Scenario with Nuclear Power Plant*

To eliminate the above impacts, the utilization of nuclear energy becomes an important option. According to the International Atomic Energy Agency [IAEA], NPP investment cost significantly varies. However, National Nuclear Energy Agency of Indonesia [BATAN] predicts that the NPP investment cost in Indonesia would be the same as of South Korea i.e. about US$ 2,600 per kW [9].

With such investment cost, NPP will be competitive if it's compared to supercritical coal-fired power plant when the coal price [for caloric value less than 5,000 kcal per kg] is more than US$ 67 per ton. This coal type is projected to be used in the future in Indonesia.

It is the fact that the coal price is influenced by oil price. Current oil price is in the range of US$ 70-80 per barrel, and in the long-term period, the price may rise-up due to high demand with more limited supply and higher extraction costs. Therefore, it is predicted that a fluctuated coal price will follow oil price fluctuations.

The above problem will likely not to happen on nuclear fuel price, although in the long-term period it is estimated to increase as well, but the nuclear fuel price will not increase as much as that of coal. The decreasing of NPP investment cost and increasing of coal price will help make NPP in medium-term period

[2030] more competitive compared to coal-fired power plant.

In this simulation, NPP will be contributing to 9 ton $CO_2$ per capita, matching with the today's developed countries obligation on $CO_2$ emission reduction. Based on this approach, it's required NPPs with total capacity of 200 GW by 2050. With this amount of NPP capacity, $CO_2$ emission per capita in 2050 is about 9.7 ton and $CO_2$ emission per TOE primary energy will be 2.15 ton. If scenario without nuclear is taken, the $CO_2$ emission will be 12.7 ton $CO_2$ per capita, and the CO2 emission per TOE primary energy consumption will be 2.83 ton. Figure 12 shows the comparison of CO2 emission per capita for both scenarios.

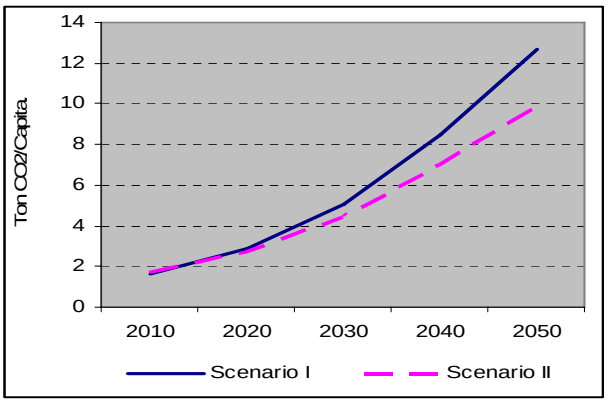


Figure 12. Projection of $CO_2$ Emission per Capita By Scenarios

The simulation shows that NPPs utilization will contribute to 19% of total primary energy supply. Thus, the NRE resources share will become 33% of total primary energy. In the Scenario I the dependency on coal is very high and the share of coal energy can be over 50%. In scenario II some of the share of coal is taken by nuclear and then the share of coal can be kept below 40%. This will give better security of supply.

## 6. ACKNOWLEDGMENTS

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## 7. CONCLUSIONS

1. Within the past 40 years, Indonesia primary energy consumption has been growing averagely 7.7% per year. Nevertheless today's Indonesia per capita consumption is still below the world average and is far below the one of the developed countries.
2. Indonesian fossil energy reserve seems quite big. However the reserve per capita of oil, gas and coal are all below the World's average. For Indonesia it is important to change the mindset that Indonesia is not rich of fossil energy resources.
3. The final energy consumption in 2030 will be about 400 MTOE [4 times of 2010] and in 2050 will be over 900 MTOE [2 times of 2030]. With this projection the energy indicators showing that Indonesia in 2050 is about the average of OECD countries in 2005.
4. The electricity generation capacity in 2030 will be about 400 GW [10 times 2010] and in 2050 will be over 700 GW [1.75 of 2030]. With this projection the consumption per capita in 2030 will be about the world's average and in 2050 will be about the today's of OCDD countries.
5. The Indonesian renewable energy [i.e. geothermal, hydro, solar, biomass and ocean energy] potential that can be exploited towards 2050 is about 300 MTOE per year. This can contribute up to 20% of primary energy supply.
6. The energy mix policy of Indonesia will be likely to; [i] maximize the use of renewable for electricity; [ii] minimize the use of oil; [iii] optimize the use of biofuel for transport; [iv] optimize the use of gas; [v] balance the rest by coal and nuclear power.
7. Energy Scenario without nuclear will be dominated by coal [53%]. Under this scenario, $CO_2$ emission in 2050 would be around 12.69 ton per capita and emission per TOE primary energy will be 2.83 ton. Energy Scenario with nuclear will give better security in which coal will contribute below 40% and the emission profile will be

better i.e. per capita will be 9.7 ton, and emission per TOE primary energy will be 2.15 ton.

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