Overview of Energy Planning in Indonesia[*)]

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Abstract

The energy sector is one of the most importance sub-sectors in Indonesia because it has been a major source of technological development. The energy resources should be utilize as much as possible for sustain Indonesia future energy supply. Energy planning and modeling activities has been done by some institutions for this purpose. The target of energy development in Indonesia also taken into consideration the relation among energy, economy and environment. The energy demand in Indonesia is estimated will increase from 536.7 million BOE/y in Pelita VI to 1858.6 million BOE/y in Pelita XI. In the near future the most of the final energy consumption is estimated will be from of electricity. With the CO_2 emission constraint on the planning, the future development of power plant will be dominated by coal power plant but accompanied by gas turbine. Nuclear power plant chosen with 5 % share of the total capacity in Pelita VIII.

1. Introduction

The energy sector is one of the most importance sub-sectors in Indonesia because it has been a major source of technological development. The primary commercial energy supply for domestic market in 1994 was accounted around 465 million BOE and was dominated by crude oil with 62.3 percent and by natural gas which contributed 26.7 percent. Coal supplied 6.1 percent of the domestic energy consumption. The remainder was shared by hydropower together with geothermal (4.9 percent).

Electricity consumption in Indonesia for the last 20 years increased very fast (about 14.5 percent per year). In 1971 electricity consumption was 2.5 TWh and increased to 45.5 TWh in 1994. The electricity consumption projected to continue increase according to the macroeconomic growths that reach 7.2 % per year. To meet the electricity demand in the future, the energy resource must be taken into consideration to guaranty the sustainable of electricity supply.

The current commercial energy resources in Indonesia comprise of limited oil resources, sufficient natural gas resources and abundant coal resources. Oil reserves were estimated by Minister of Mine and Energy to be 10.7 billion barrels. The proven and potential gas reserves are estimate at about $101.8*10^{12}$ scf. The total resources of coal are estimated 34.3 billion tones. More than 65 percent of coal resources is lignite. Beside that resource,

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Indonesia still have relatively abundant reserve of renewable energy resources, i.e. hydropower, geothermal, solar energy and biomass.

These domestic energy resources should be utilize as much as possible for sustain Indonesia future energy supply. For combining the availability of energy reserve and its utilization for generating electricity, optimal strategies and planning to the whole energy supply system are very important. Environmental friendly is the national expectation and international requirement. Therefore environmental impact is the important factor in the energy planning such as energy resources, and energy technology.

2. Energy Model in Indonesia

Energy planning and modeling activities has been done by some institutions for various objectives. Typically, the planning and modeling focus on either demand and supply side but some of the model are used only characterized the energy demand. Some of the models and utilization that has been used in Indonesia are:

- MAED (Model for Analysis of Energy Demand)

This model used to projected sectoral energy demand that adapted from MEDEE. The projection base on historical data base, i.e. GDP and population growth and historical energy consumption. This model used by *National Atomic Energy Agency of Indonesia* (BATAN). The version of MEDEE, called MEDEE-S, used by Directorate General of Electricity and New Energy in 1983.

- RESGEN (Reference Energy System Generator)

As the MAED model, this model using historical data to projected energy demand. The sectoral energy demand represented as an energy flow from resource to end-use sector including : mining, refining, transportation, and conversion.

- WASP (Wien Automatic System Planning)

This model particularly for makes planning in electricity sector only and currently used by *State Electricity Company* (PLN). Output of MAED model used as demand driven for WASP model.

- ENPEP (Energy and Power Evaluation Programme)

This is an energy and power evaluation program that used by BATAN. The study finished in 1995 with title *Environmental Analysis Using ENPEP*.

- MARKAL (Market Allocation)

This model has been used to optimized the national energy supply strategies and currently used by *Agency for the Assessment and Application of Technology* (BPPT). MARKAL Model was established within the framework of Indonesian-German governmental scientific co-operation. The study has completed three reports.

- First report, *Energy Strategies, Energy R+D Strategies and Technology Assessment for Indonesia* was completed in 1988 and under cooperation with KFA-Juelich, Germany.
- Second report, *Environmental Impacts of Energy Strategies for Indonesia* was completed in 1993 and under co-operation with KFA-Juelich, Germany.
- Third report, *Technology Assessment for Energy Related CO_2 Reduction Strategies for Indonesia* was completed in 1995 and under cooperation with GTZ, Germany.

The inter-agency joint project IAEA-BPPT on data bases and methodologies for comparative assessment of difference energy sources for electricity generation (DECADES) called DECADES Project Phase I. The project report : *Comparative Assessment of Electricity Supply Strategies in Indonesia* was completed in 1996. The DECADE Project Phase I is still using MARKAL model although there is DECADE model with DECPAC module for optimization. The DECADE model will be used in DECADE Project Phase II in the near future.

The MARKAL model is an optimization model with multi-period and multi-objective linear programming model. The inputs, apart from the scenario assumptions and demands, are the technical and economic data of the energy resources and the relevant energy technology options. The model calculates minimum cost strategies for the future energy supply and for the associated technology installation programs of the whole Indonesian energy economy. The whole country is divided into four region : Jawa, Sumatra, Kalimantan and other islands.

The MARKAL model was supported by other various computer models. The sub-model MACRO based on the Indonesian input/output table was applied for the macro economic analysis. The future GDP (*Gross Domestic Product*), the industrial production and other macroeconomics parameters were projected with MACRO. While, the demographic sub-model DEMO forecasts population development by regions and by urban/rural areas. Based on the results of MACRO and DEMO the energy demands were calculated with the DEMI sub-model partly in terms of useful energy and partly in terms of final energy.

The spatial distribution of the ground level concentration and the respective deposition are calculated in the DISDEP model. The approach includes an extended Gaussian plume model for point sources, a box model for area sources, and for the traffic sector a model which applies a fading function. While the results are provided by a *Geographical Information System* (GIS) in the form of raster-based maps with a 5 km x 5 km grid covering the whole area of Jawa and the surrounding sea. The GIS is also used for ecological risk assessment to identify critical areas where the pollution level is above a recommended limit.

3. Energy Development

3.1 Energy demand and supply projection

The major factors influencing energy demand are population growth and the economic growth. The population growth rate has decline from 1.8 percent per year at present to 0.87 percent per year at the end of Pelita (*Five Years National Development Plan*) XI due to the success with the family planning program. Average GDP growth rate is about 5.9 percent per year. The energy demand in Indonesia is estimated will increase from 536.7 million BOE/y in Pelita VI to 1858.6 million BOE/y in Pelita XI or will increase in the growth rate of 5 percent per year.

Taking into account biomass energy (as a traditional energy), most of the consumption or about 40 percent of the consumption was dominated by biomass energy source. While oil and gas contributed 34 percent and 11 percent respectively for the final energy consumption. However in Pelita XI, the most of the final energy consumption is estimated will be from of electricity that contributes about 18 percent of the total consumption. While biomass only contributes 15 percent of the total energy consumption. The contribution of biomass to the final energy consumption in the period is below the ADO's (*Automotive Diesel Oil*)

contribution. ADO contributes more than 16 percent of the total final energy consumption. Table 2 shows the final energy consumption in Indonesia from Pelita VI until Pelita XI.

Table 1. Population, GDP, Energy and Electricity Demand Projection [1][2][3]

Period	Pelita	Population		GDP	Energy Demand		Electricity Demand	
		million	growth (%)	growth (%)	million BOE/y	growth (%)	TWh/y	growth (%)
1994-98	VI	200.34	-	5.7	539.6	-	80.1	-
1999-03	VII	216.49	1.56	6.3	691.6	5.1	122.6	8.9
2004-08	VIII	231.97	1.39	5.1	878.4	4.9	180.4	8.0
2009-13	IX	246.45	1.22	6.0	1105.8	4.7	258.7	7.5
2014-18	X	259.61	1.05	6.1	1427.7	5.2	379.4	8.0
2019-23	XI	271.12	0.87	6.2	1866.9	5.5	556.1	7.9

Pelita : Five Years National Development Plan

Table 2. Final Energy Consumption (million BOE/y) [1][2]

Type of Energy	PelitaVI	PelitaVII	PelitaVIII	PelitaIX	PelitaX	PelitaXI
Electricity	48.46	74.11	109.02	156.33	229.15	335.75
Coal	21.54	33.65	49.61	73.65	116.18	190.68
Gas	65.02	89.01	118.82	152.34	195.12	249.52
Kerosene	51.47	51.05	61.93	75.39	91.61	103.00
LPG	25.36	46.48	63.27	81.89	109.78	152.92
ADO	71.05	103.17	142.60	180.50	233.77	302.90
FO	11.54	15.11	20.18	26.83	36.10	45.29
Mogas	51.41	63.55	80.53	107.58	142.23	183.14
Biomass	190.54	211.06	226.46	243.63	263.53	290.10
Lube	3.23	4.42	5.93	7.71	10.22	13.66
T o t a l	539.61	691.61	878.35	1105.85	1427.70	1866.96

Total final energy consumption increase sharply with the growth rate of 4.8 percent per year until Pelita XI. There are shifted in the dominant share of energy consumption from household sector in Pelita VI to industrial sector in Pelita XI. In Pelita VI, most of energy consumption or more than 51 percent is consumed by household and governmental sector, and most of energy source for household sector is consumed from biomass energy source. While in Pelita XI, most of the energy consumption or 41 percent is consumed by industrial sector, and most the energy source for industrial sector is consumed from fossil fuels. Transportation sector has the fastest growth rate of energy consumption, but the share of energy consumption in the sector in Pelita XI is not big as that of the industrial sector. All of energy consumption for transportation sector is consumed from fossil fuel.

The primary energy supply in Indonesia is estimated will increase from 742.9 million BOE/year in Pelita VI to 2791.9 million BOE/year in Pelita XI . Coal is the most promising energy source in Indonesia. Coal energy supply is estimated will increase in the growth rate of 10 percent per year in the periods of Pelita VI until Pelita XI. In Pelita XI coal will dominate most of primary energy supply in Indonesia.

With the CO_2 emission constraint on the planning, the future development of power plant will be dominated by coal power plant but accompanied by gas turbine. Most of coal fired steam power plant in Pelita XI is already using denitrification and desulfurization. Nuclear power plant chosen with 5 % share of the total capacity in Pelita VIII. Another power

plant chosen are gas combined cycle, geothermal, hydropower, oil-gas fired, cogeneration, diesel, and biomass steam power plant.

Table 3. Primary Energy Supply (million BOE/y) [1][2]

Energy Type	Pelita VI	Pelita VII	Pelita VIII	Pelita IX	Pelita X	Pelita XI
Geothermal	15.29	16.83	16.65	15.94	14.90	13.20
Nuclear	0.00	0.00	0.00	0.00	0.00	0.00
Natural gas	157.11	200.64	215.59	268.68	307.91	352.21
Oil	283.50	309.47	361.35	441.62	592.35	804.43
Hydropower	16.43	48.89	71.05	75.48	76.89	76.26
LPG	20.24	33.45	47.96	67.22	95.46	134.43
Biomass	190.53	211.06	226.45	243.63	263.52	290.10
Coal	59.79	140.36	287.10	456.04	719.19	1121.33
T o t a l	742.90	960.71	1226.15	1568.62	2070.23	2791.98

3.2 Environmental consideration

Recently there is increase concern about environmental problem and for the energy decision maker the relation among energy, economy and environment become a new consideration. Therefore, the target of energy development in Indonesia taken into account the new consideration. The target is to support the sustainable development of the nation through increasing the living standard, maintaining the energy supply and minimizing the environmental impact. To achieve the target, the policy objective on energy development are prepare as follows :

- Secure and maintaining the supply of energy for domestic uses
- Providing the energy for export in valuable price for along time
- Accelerating the energy conservation
- Development of the renewable energy
- Enhancing of the environmental preservation programs
- Providing and managing energy resources that will increase the national security.

Environmental problem in Indonesia arise primarily from increasing coal fuel in industrial sector, electricity and household sector. Coal and refinery product are the main contributor to man-made air pollution. The main pollutants are SPM *(Suspended Particulate Matter*), NO_X, SO_2 and VHC (*Volatile Hydrocarbon*). The other man-made emision gas that related to the global warming is CO_2 emission.

Concerning the environmental impact, comparing emission using *business as usual case* (BAU) and *emission reduction case* (ERC) described as follow :

- IN BAU, the SO_2 emission from Pelita V to Pelita XI is estimated will increase about eight times. However in ERC, the SO_2 emission in the same period of time only increases about three times. In Pelita XI, the level of SO_2 emission in ERC only 43 percent of that emission level in BAU.
- In BAU, NO_2 emission from Pelita V to Pelita XI is estimated will increase about 7 times. However in ERC, the NO_2 emission in the same period of time only increases about three times.

- In BAU, VHC emission from Pelita V to Pelita XI is estimated will increase about more than 3 times. In Pelita XI, the emission level of VHC in ERC is only about 66 percent of the emission level of VHC in BAU.
- In BAU, SPM emission from Pelita V to Pelita XI is estimated will increase about three times. In Pelita XI, the emission level of SPM in ERC is only 42 percent of the emission level of SPM in BAU.
- CO_2 emission in Indonesia from Pelita V to Pelita XI is estimated will increase from 155 million ton/year to 1,121 million ton/year or increase with the growth rate of 6.8 percent/year.

Table 3. Total Emision of Pollutants from Energy Activities [1][2]
(Million ton/year)

Type of Pollutant		Pelita V	Pelita VII	Pelita VIII	Pelita IX	Pelita XI
SO_2	BAU	0.35	0.56	0.91	1.36	2.78
	ERC	0.35	0.45	0.50	0.65	1.20
NO_2	BAU	0.56	1.08	1.53	2.10	3.95
	ERC	0.56	0.81	0.84	1.03	1.73
VHC	BAU	0.28	0.41	0.49	0.63	1,02
	ERC	0.28	0.32	0.34	0.43	0.67
SPM	BAU	0.85	1.31	1.57	1.83	2.56
	ERC	0.85	1.05	1.04	1.09	1.09
CO_2*		155.00	2289.00	4405.00	533.00	1,121.00

*) CO_2 emission is for Indonesia, other emissions are for Jawa Island only.

In BAU, pollutants dispersion and disposition will affect some areas in Jawa Island. High acidity on the soil will inhibit plant growth that would happen at 14 percent of Jawa Island in the period of Pelita XI. While another 40 percent of the island would become a critical land. In the period, soil water contamination would be a problem for about 27 percent of the Jawa Island area. As pollutants emission from energy utilization starts passing the tolerated level of the environment in the Pelita VII, all of environmental clean technologies have to be applied in that period.

Table 4. Standard Emission for Coal-Fired Power Plant in Indonesia

No.	Parameters	Standard Emission (mg/m^3)	
		1995-2000	year 2000 onward
1	Total Particulate	300	150
2	Sulfur Dioxide	1500	750
3	Nitrogen Dioxide	1700	850
4	Opacity	40 %	20 %

(Source : Minister of the Environment Decree KEP-13/MNLH/3/1995)

With regard to the legal framework in the development of power plant, the impact of pollutant emission has been regulated by Decree of Minister of Environment No. KEP-13/MENLH/3/1995 as shown in Table 4. Without installation of abatement technology in coal-fired power plant such as FGD, the SO_2 emission standard in the year 2000 (750 mg/m^3)

would only be met by coal with maximum S content of 0.33 percent, while in the year 1995 (1500 mg/m^3) can be met by coal with maximum S content of 0.60 percent.

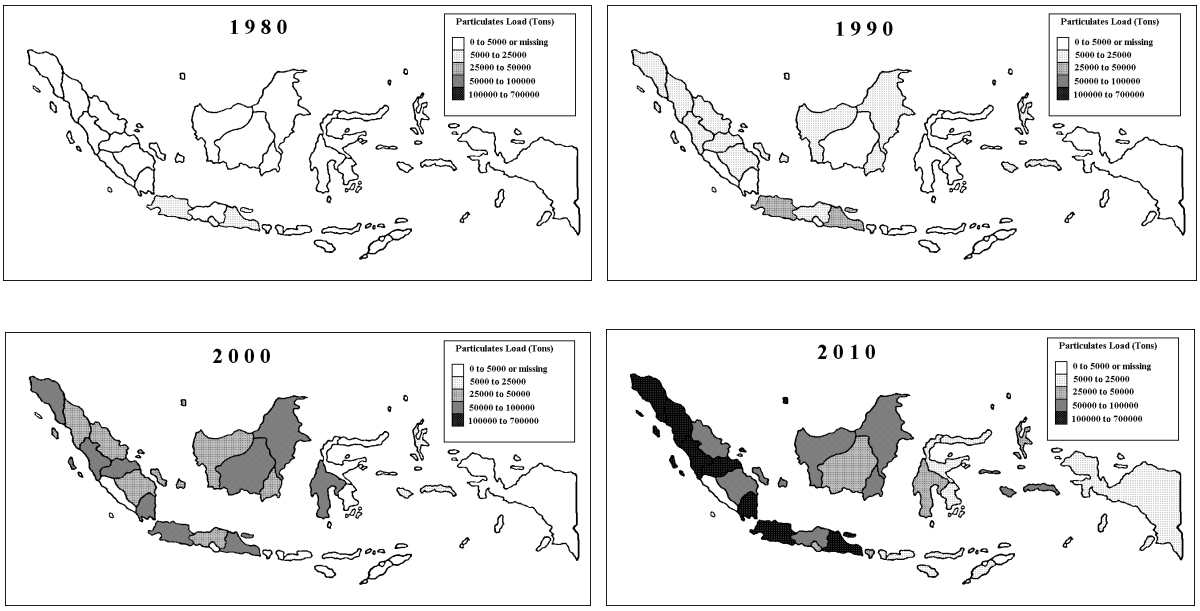

Figure 1. Total Load of Particulate in Indonesia
(Source : World Bank)

4. Overview of DECADES Phase I

Common development of the modeling technique needs for analyze more comprehensive energy system that can analysis some important parameter together. Analyse the energy resource, energy technology, and its environmental impacts together make database become complex and the all parameter of the energy reserve and technology must completely include in the database. The general technique can not handle the complexity of database. Therefore the common model, such as DECADES, can solve this complex problem. The DECADES model propose to be used for the electricity planning in Indonesia in the near future.

The DECADES software that has been installed in BPPT, Indonesia is DECADES Version Beta. This software running well under Windows 95 with Pentium processor. Paradox software that used by DECADES running rather slowly under Windows 3.11 with 468 processor. Therefore, the Windows 95 with Pentium processor is an optimal solution to use DECADES software. The Version Beta of DECADES software have some *bug* that some of the option can't running, including the DECPAC sub-model.

5. Conclusion

The energy consumption in Indonesia increase by the growth rate almost 5 percent per year until the next 30 years. Fossil fuels such as coal, oil, and gas have the largest contribution to the energy consumption in Indonesia. Energy used especially fossil fuels releases pollutants

emission such as SO_2, NO_2, SPM, and VHC to the atmosphere that has negative impact to the environment.

In the near future the most of the final energy consumption is estimated will be from of electricity. The target of energy development in Indonesia also taken into consideration the relation among energy, economy and environment. With regard to the legal framework in the development of power plant, the impact of pollutant emission has been regulated by Decree of Minister of Environment No. KEP-13/MENLH/3/1995.

With the CO_2 emission constraint on the planning, the future development of power plant will be dominated by coal power plant but accompanied by gas turbine. Nuclear power plant chosen with 5 % share of the total capacity in Pelita VIII.

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