# THE GREEN HOUSE GAS ABATEMENT STUDY FOR INDONESIA

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ABSTRACT

The energy demand in Indonesia is projected to increase in the future. Based on the tentative results of the comprehensive assessment of different energy source for electricity, the demand will grow and reach the figure of about 8,200 Peta Joules in the year 2025. With regards to the energy supply in connection with climate change resulting from increasing Greenhouse Gases (GHG) in the atmosphere, and in line with the national energy policy which stresses on diversification, conservation, energy price and environmental awareness in energy supply development.

The main objective of this study is to analyse GHG abatement by introduction various clean energy options such as renewable and nuclear energy in the Indonesian energy system by using IAEA Tool and to calculate the cost of GHG emission avoided.
For the purpose of the case study, two cases were developed with some aggregations and assumptions for simplification. The first case **Baseline case**, which represents the current energy network (doing nothing case) and the second case defined **GHG mitigation** in the electric sector by replacing fossil power plants (600 MWe + 400 MWe) with various clean energy options GHG abatement technology (1000 MWe Nuclear PP).

The result of the study shown that the total of CH4 reduction until the end of study period of about 1180.8 tons and 271.6 million tons for CO2. The average reduction of the greenhouse gas are 4.4% per year for CH4 and 7.3% per year for CO2, starting from introduction of nuclear power plant in year 2012.
It is believed that, the economic competitiveness of nuclear power could significantly increase if GHG mitigation program were taken into account in the national energy planning. GHG abatement technology choice has to be made on the basis of economic aspects and its efficiency, so that the type of technology that is chosen is the most optimum as viewed from all aspects of the economy and the environment. Applying fuel diversification in the electric generation mix, nuclear and renewable energy, energy conservation as well as the demand side management can be carry out by mitigation of CH4 and CO2 in the energy sector.

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## I. INTRODUCTION

The possibility of widespread climate change resulting from increasing atmosphere concentration of Green House Gas (GHG) is now a major global concern. The United Nations framework Convention on Climate Change (UNFCCC) states that its "ultimate objective is to achieve stabilization of greenhouse gas concentration in the atmosphere at a level that would prevent dangerous anthropogenic interference with the climate system". The emission limits established in the 1997 Kyoto Protocol are a first step toward that goal.

To reduce the risk of global climate change, industrialized countries (Annex 1) under Kyoto Protocol have agreed to reduce their GHG collective emissions during 2008-2012 by at least 5.2% below 1990 levels.

A principal source of GHG, particularly carbon dioxide, is the fossil fuels burned by the energy sector. World energy demand is expected to increase dramatically in the 21st century, especially in developing countries, where population growth is fasted and, even today, some 1.6 billion people have no access to modern energy services. Without significant efforts to limit future GHG emission from the energy sector, therefore, the expected global increase in energy production and use could well destabilize the global climate.

In Indonesia, the energy demand is projected to increase in the future. Based on the tentative results of the comprehensive assessment of different energy source for electricity demand will grow and reaching the figure of about 8,200 Peta Joules in the year 2025. With regards to the energy supply in connection with climate change resulting from increasing GHG in the atmosphere and in line with the national energy policy which stresses diversification, conservation, energy price and environmental awareness in energy supply development, the technologies for energy supply in Indonesia (would be considered) are identified as follows:

a. The technology to produce substitute for oil, as oil is non-renewable and limited resources.
b. The technology to support a more sustainable energy supply.
c. The technology for clean and efficient energy to support environmental programs and toward a sustainable development.

In order to ensure that nuclear power is given fair consideration in the international debate on climate change, IAEA project INS/0/016 was proposed by RCA Member States. The primary goal of the project is to assess RCA Member States in Conducting GHG abatement cost studies and assessing the potential role of nuclear power as a Clean Development Mechanism under the Kyoto Protocol.

## II. ENERGY NETWORK DESCRIPTIONS

In generall, energy network is divided into two groups of main sector, those are demand and supply sectors. The demand sector consists of Transportation, Export, Household, Manufacture, Services, Agriculture-Construction-Mining and Electricity of Other Island sector. The main supply sector consists of oil, gas, coal, refinery and electricity sectors. The electricity supply in Indonesia, especially for the Java-Bali interconnected system, represents 80% of the whole Indonesian electricity consumption. The reasons are more intensive economic development in Java and the availability of an interconnection grid. The electricity power generator consists of coal, gas, fuel oil, hydropower and geothermal power plants. Coal will dominate the domestic energy mix in the future, but contributed high substantial GHG emission, beside fuel oil and gas. Therefore, to reduce this environmental problem, Indonesia needs more efficient and clean technology. For this purpose, this study will implement renewable and nuclear option as electricity power generator in future.

The main objective of the study is to analyse Greenhouse Gases (GHG) abatement with the introduction of various clean energy options such as renewable and nuclear energies in the Indonesian energy system by using IAEA Tool and to calculate the cost of GHG emission avoided.

## III. CASE DEFINITION

The whole Indonesia energy network is very complex. For the purpose of this case study, two cases were developed with some aggregations and assumptions for simplification, namely:

a. Baseline case, which represents the current energy network-doing nothing case
b. The second case is defined as GHG mitigation in the electric sector by replacing fossil power plants (600 MWe + 400 MWe) with introduction of various clean energy options as GHG abatement technology (1000 MWe Nuclear PP).

Two assumption were used, namely:

a. Schedule in introducing GHG abatement technology was defined based on previous study on WASP IV Optimum Solution in generating expansion planning
b. Target of reducing cumulative net carbon emission was defined based on previous study on Economics of Greenhouse Gas Limitation was carried and by the Ministry of Environmental – Republic of Indonesia.

## IV. STRUCTURE OF INDONESIA ENERGY SYSTEM

The energy structure consists of demand, electricity supply, and energy resources supply. The demands are Mining-Agriculture-Construction (MAC), Services (SERV), Household (HH), Manufacturing (MANF), Transportation (TRANP), Export (EXP), and Electricity demand for outside Java-Bali electricity system (DELOI). The electricity supplies are electricity system on Java Bali Island (ELEJB) and all systems outside Java Bali as a system (ELEOI). The energy resources consist of oil, gas, coal including the imported energy, geothermal and hydro as resources in electricity supply. The main structure of the energy system as shown on Figure 4.1.

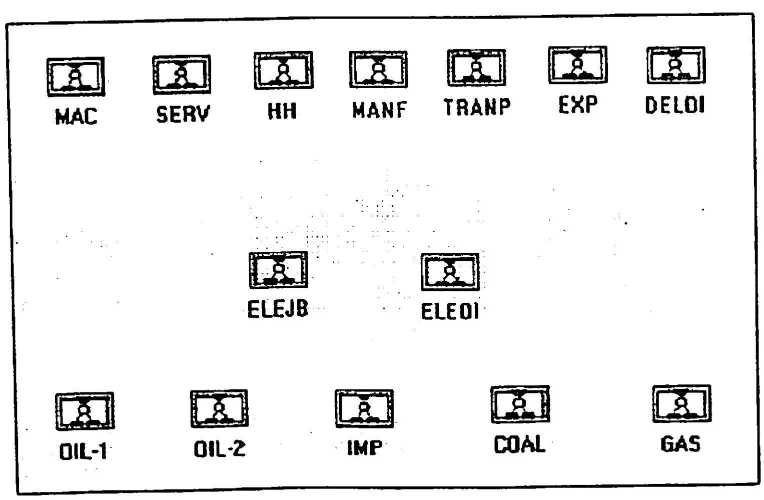



**Figure 4.1. Energy System Main Structure**

## V. ELECTRICITY SYSTEM

Nearly 65.5% of the average electricity produced (PLN and private industry/captive power) was generated in Java. The reasons were the more intensive economic development in Java and the availability of an interconnection grid. The fuels for electricity generation are coal, gas, middle distillate, fuel oil, hydropower and geothermal power generation. Coal is Indonesia's cheapest primary energy resources up to certain level of use, where ash disposal or air pollution problem becomes the limitation. However, more efficient technology and clean technology can mitigate the problem. One of the options is that nuclear power generation for future electricity supply strategy for efficient and clean technology.

Outside Jawa, load dependency of electricity generation is neglected; no use of concepts such as base load, peak load, peak time, off-peak time is made. Rather, small units of coal, oil, gas-fired steam plants, hydro power plants as drawn up in the installation schedules or in potential studies, and diesel generator sets are the options. As in reality, power plants outside Jawa are operated at comparably low capacity factors that slightly grow over the time horizon.

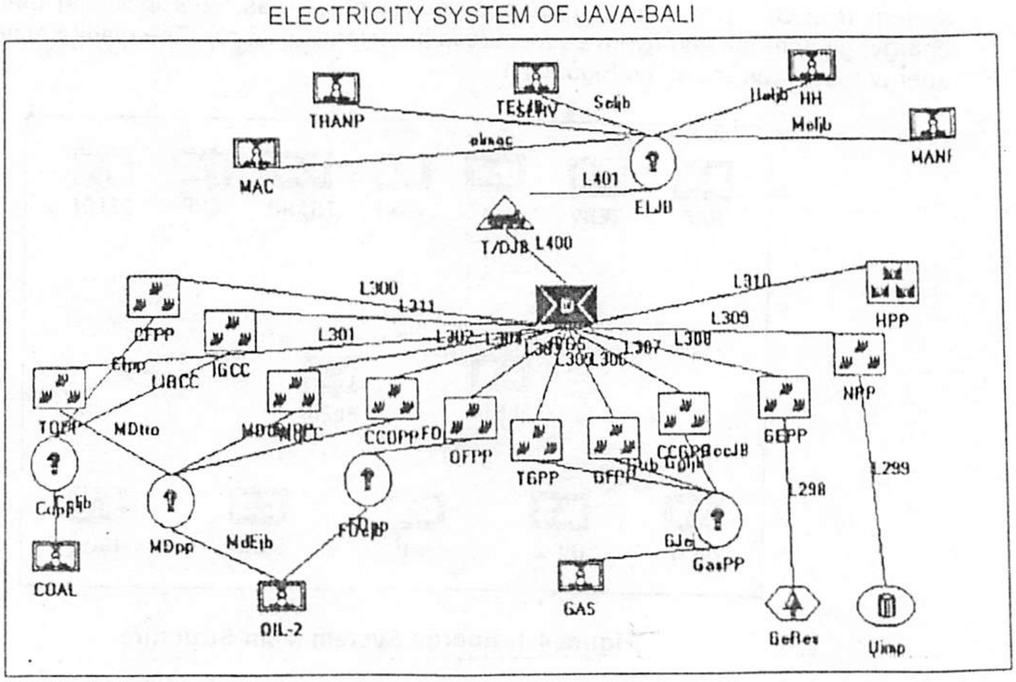
**Table 5.1. Demand Projection in Electricity by Sector (PJ)**

| | | | | | | |
|---|---|---|---|---|---|---|
| Manufacturing | 214.8 | 206.0 | 268.0 | 388.7 | 539.5 | 748.1 |
| Transportation | 0.000 | 0.014 | 0.048 | 0.115 | 0.434 | 0.865 |
| Household | 90.4 | 112.3 | 147.5 | 190.0 | 240.7 | 305.6 |
| Service | 40.8 | 47.4 | 58.3 | 74.3 | 93.3 | 118.8 |

### V.1. ELECTRICITY SYSTEM OF JAVA-BALI

The Java-Bali system consists of various types of fuel, type of plant and capacity of the power generation. The 600 MWe coal power plant is the largest capacity and there are some diesel power plant for local peaking. The electricity sending to transportation, mining-agriculture-construction, household, services and manufacture sectors. The largest consumers are household, manufacture and services sector.

ELECTRICITY SYSTEM OF JAVA-BALI

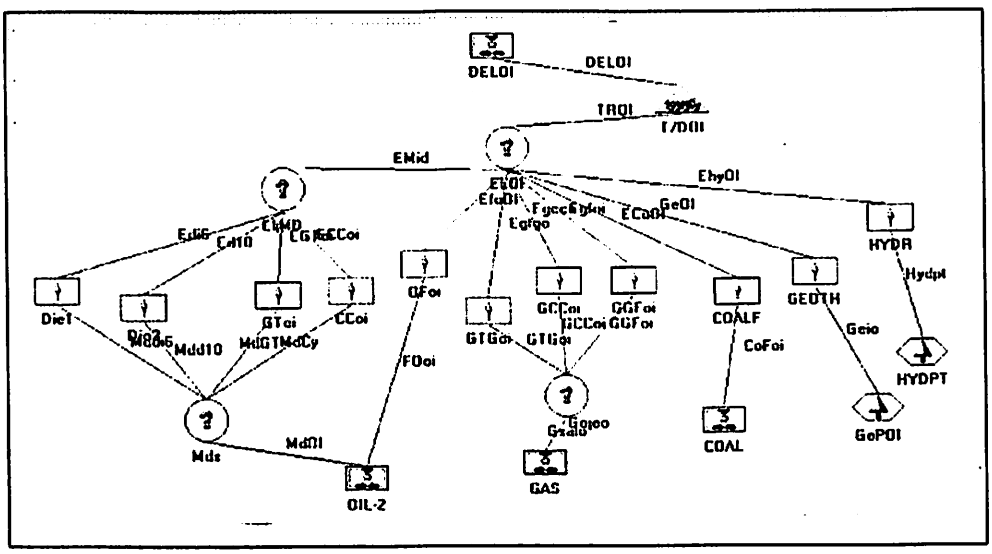


V.2. ELECTRICITY SYSTEM OF OUTSIDE JAVA-BALI

The electricity system in Sumatra, Kalimantan, Sulawesi, and others, assumed as one system, called the outside Java-Bali system. The system consists of various types of fuel, type of plant and small capacity of the power generation. There are a lot of small diesel power plants, less than 1 MWe which supply the system for peaking. The four (4) units of 65 MWe coal power plant are the largest capacity located in Sumatra, as a mine-mouth power plant. Most of the electricity is consumed by household and services sectors.

To make a simple the network, the system is assumed as a process node based on the type of generation which are consisted of multi-unit plant.

ELECTRICITY SYSTEM OF OUTSIDE JAVA-BALI

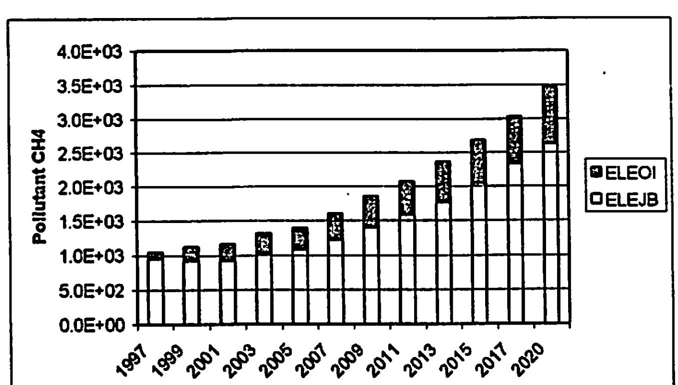



## VI. RESULTS & COMPARATION OF GHG EMISSION ON ELECTRICITY SYSTEM

### VI.1. Emission on Baseline

The results of the first case (baseline case) are presented in Figure 6.1 for projection of $CH_4$ emission, while Figure 6.2 for the projection of $CO_2$ emission.

***Methane ($CH_4$)***




Note : ELEJB : Electricity in Java-Bali System
ELOJB : Electricity Outside Java-Bali System

**Figure 6.1. The Projected $CH_4$ Emission Without GHG Abatement Technology in Electricity (Ton)**

*Carbon Dioxide ($CO_2$)*

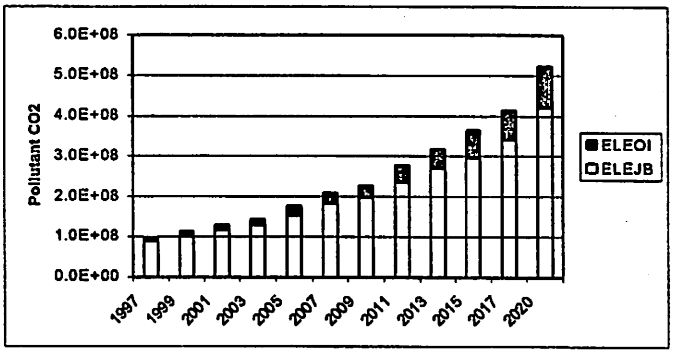



**Figure 6.2 The Projected $CO_2$ Emission**

**Without GHG Abatement Technology in Electricity Sector (Ton)**

**VI.2 GHG Mitigation with Introduction of GHG Abatement Technology in Electricity Sector**

The results of second case (GHG mitigation with introduction of GHG abatement technology) are presented in Figure 6.3 for the projection of $CH_4$ emission, while Figure 6.4 for the projection of $CO_2$ emission.

*Methane ($CH_4$)*

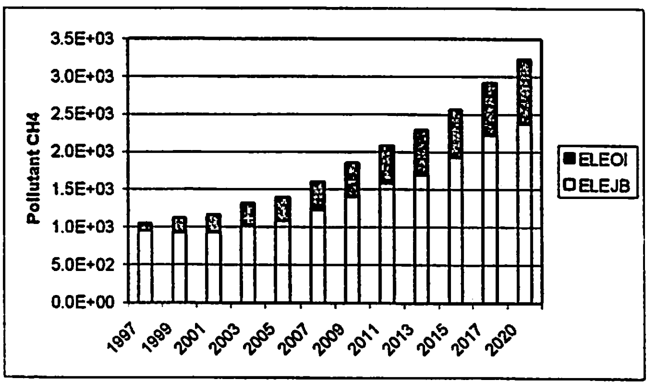



**Figure 6.3 The Projected $CH_4$ Emission**
**With Introduction of GHG Abatement Technology in Electricity Sector (Ton)**

*Carbon Dioxide ($CO_2$)*

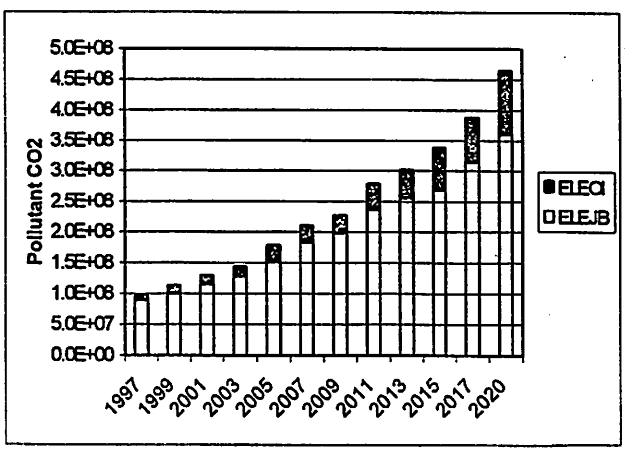



**Figure 6.4 The Projected $CO_2$ Emission**
**With Introduction of GHG Abatement Technology in Electricity Sector (Ton)**

### VI.3. Comparison Two case Study

The total of CH4 reduced until the end of study period about 1180.8 ton and 271.6 millions ton for CO2. The average reducing of the greenhouse gas 4.4% per year for CH4 and 7.3% per year for CO2, starting from introduction of nuclear power plant in year 2012.

**Table 6.1 Comparison of Emission $CH_4$ With and Without GHG Abatement Technology in Electricity Sector (Ton)**

| Year | CH4 Baseline (Without GHG Abatement) | CH4 Mitigated (With GHG Abatement) | $CH_4$ Reduced | Percentage (%) |
|---|---|---|---|---|
| 1997 | 1,050 | 1,050 | - | - |
| 1999 | 1,127 | 1,127 | - | - |
| 2001 | 1,168 | 1,168 | - | - |
| 2003 | 1,322 | 1,322 | - | - |
| 2005 | 1,402 | 1,402 | - | - |
| 2007 | 1,610 | 1,610 | - | - |
| 2009 | 1,861 | 1,861 | - | - |
| 2011 | 2,081 | 2,081 | - | - |
| 2012 | 2,236 | 2,163 | 73.0 | 3.3 |
| 2013 | 2,371 | 2,298 | 73.0 | 3.1 |
| 2014 | 2,520 | 2,477 | 43.1 | 1.7 |
| 2015 | 2,687 | 2,570 | 117.7 | 4.4 |
| 2016 | 2,816 | 2,699 | 116.6 | 4.1 |
| 2017 | 3,037 | 2,921 | 116.5 | 3.8 |
| 2018 | 3,229 | 3,039 | 190.0 | 5.9 |
| 2019 | 3,366 | 3,178 | 188.2 | 5.6 |
| 2020 | 3,493 | 3,230 | 262.8 | 7.5 |

**Table 6.2 Comparison of Emission $CO_2$ With and Without GHG Abatement Technology in Electricity Sector (Ton)**

| Year | CO2 Baseline (Without GHG Abatement) | CO2 Mitigated (With GHG Abatement) | $CO_2$ Reduced | Percentage (%) |
|---|---|---|---|---|
| 1997 | 97,201,200 | 97,201,200 | - | - |
| 1999 | 114,018,717 | 114,018,717 | - | - |
| 2001 | 129,468,662 | 129,468,662 | - | - |
| 2003 | 144,106,761 | 144,106,761 | - | - |
| 2005 | 178,032,876 | 178,032,876 | - | - |
| 2007 | 209,877,284 | 209,877,284 | - | - |
| 2009 | 227,542,269 | 227,542,269 | - | - |
| 2011 | 278,783,036 | 278,783,036 | - | - |
| 2012 | 298,542,761 | 282,180,352 | 16,362,409 | 5.48 |
| 2013 | 318,668,471 | 302,282,881 | 16,385,589 | 5.14 |
| 2014 | 334,903,492 | 318,594,750 | 16,308,741 | 4.87 |
| 2015 | 365,815,443 | 339,452,167 | 26,363,276 | 7.21 |
| 2016 | 382,383,992 | 356,207,471 | 26,176,520 | 6.85 |
| 2017 | 414,756,745 | 388,624,729 | 26,132,015 | 6.30 |
| 2018 | 443,383,226 | 400,834,398 | 42,548,828 | 9.60 |
| 2019 | 478,387,537 | 435,988,294 | 42,399,243 | 8.86 |
| 2020 | 524,121,456 | 465,211,232 | 58,910,225 | 11.24 |

## VII. CONCLUSIONS

1. In the long term, the economic competitiveness of nuclear power could significantly increase if GHG mitigation program were taken into account in the national energy planning.
2. GHG abatement technology choice has to be made on the basis of economic aspects and its efficiency, so that the type of technology that is chosen is the most optimum as viewed from all aspects of the economy and the environment.
3. Applying fuel diversification in the electric generation mix, nuclear and renewable energy, energy conservation as well as the demand side management can carry out mitigation of $CH_4$ and $CO_2$ in the energy sector.

## VIII. REFERENCES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