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Indonesia's Technology Needs Assessment on Climate Change Mitigation

SYNTHESIS REPORT

Updated Version

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Indonesia's Technology Needs Assessment on Climate Change Mitigation
– Updated Version -

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High appreciation goes to Mrs. Masnellyarti Hilman, Deputy Minister for Nature Conservation Enhancement and Environmental Destruction Control, Ministry of Environment, who initiated the development of Indonesia's Technology Needs Assessment on Climate Change Mitigation.

To all coordinating authors and contributing authors, who consistently dedicated their time and effort for developing this document, also to all institutions, departments, private sector organizations and NGOs, who have provided the necessary input and contributed towards the finalization of this report, their contributions are highly appreciated and acknowledged.

Finally, grateful thanks to Mr. Heiner von Luepke, Mr. Chandra Panjiwibowo, Ms. Anandita Laksmi, and Ms. Novita Sari from GTZ, the staff of the Assistant Deputy Minister for Climate Change Impact Control of the Ministry of Environment and the staff of the Deputy Head for Natural Resources Technology Development of BPPT, who were always ready to assist the team in technical facilitation as well as in administrative matters for the finalization process of this report.

FOREWORD

As a Non-Annex I country of the United Nations Framework Convention on Climate Change (UNFCCC), Indonesia is committed to the full implementation of the convention according to the common but differentiated responsibilities principle. Indonesia also observes that under Article 4.5 of the UNFCCC, the Annex I Parties shall support the development and enhancement of endogenous capacities and technologies of developing countries as well as assist in facilitating the transfer of technologies.

In Indonesia, the management of the economic performance and life quality of the people should be strongly linked to the reduction of greenhouse gas emissions and the reduction of energy intensity of economic growth. Based on the National Action Plan Addressing Climate Change (NAP), which was established in 2007, Indonesia formulated three main steps, which should be executed to support mitigation efforts in the energy sector and to achieve the optimal energy mix: energy diversification, energy conservation, and implementation of clean technology. It is expected that a 17% CO_2 emission reduction from the business as usual (BAU) through diversification of energy source (targeting a 17% share of new and renewable energy from national energy composition) and conservation effort can be achieved in 2025.

In the NAP Indonesia's high consideration of mitigation efforts in the forestry and agriculture sector are also emphasized. Indonesia will enhance its effort on forest rehabilitation, reducing deforestation and degradation, combating illegal logging, forest fire prevention, and environmentally logging practice in the forestry sector. Furthermore, agro forestry systems and the utilization of land ex mining for plantations are set as priorities in the agriculture sector.

All issues mentioned above are challenges during the development and deployment of technology. Therefore I believe, that the technology needs assessment (TNA) throughout this report will substantially support Indonesia in the effort of achieving low carbon economic development in several key sectors.

Finally, I would like to thank the Agency of the Application and Assessment of Technology (BPPT), who has served as coordinator during the development of this TNA and also the Working Group of Technology Transfer. I would like to extent my gratitude to the GTZ for the support and the funding of this TNA.

Jakarta, February 2009

State Minister of Environment,
Ir. Rachmat Witoelar

FOREWORD

We are all aware that climate change due to global warming is part of a global concern. Every year the United Nation Framework Convention on Climate Change (UNFCCC) conference is conducted; and delegates from all over the world discuss this important global concern.

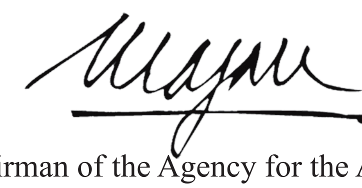
As a member of this world community, Indonesia always commits to mitigating greenhouse gas emissions back to a safe level.
As a government research institution The Agency for the Assessment and Application of Technology (BPPT) is highly responsible to carry out research and development in the field of climate change mitigation, particularly greenhouse gas emissions reduction.

This Update of the Technology Needs Assessment of Indonesia documents the availability of environmentally sound technologies, whose implementation leads to a greenhouse gas emissions reduction, and the potential adoption of technologies in Indonesia, which belongs to BPPT's work in collaboration with other related institutions and parties. This study examines environmentally sound technologies to mitigate greenhouse gas emissions.

On behalf of BPPT, I would like to welcome and endorse this report to a wider audience. Feedback and comments will definitely be appreciated in order to prepare necessary rules and regulations to facilitate technology transfer and modalities to acquire and adopt new technologies, which help to emit less greenhouse gases in a cost-effective way, and yet perform a similar productivity. To this end, institutionalizing the technology transfer mechanisms would be another challenge for Indonesia.

I would like to extend my sincere gratitude to writers, reviewers, contributors and editors of this report, who have made its publication possible. Our sincere thanks go to GTZ for sponsoring and providing the fund. Their effort has initiated the participation of stakeholders and experts from numerous fields from various institutions.

Jakarta, February 2009



Chairman of the Agency for the Assessment
and Application of Technology
Dr. Marzan Aziz Iskandar

FOREWORD

Indonesia's Technology Needs Assessment (TNA) is one of the documents emphasizing Indonesia's commitment to participate in the global effort to cope with climate change. This TNA is comprised of the sectors energy, industry, transportation, agriculture, forest, waste and ocean and leads one more step forward after the first Indonesian TNA "The Identification of Less Greenhouse Gases Emission Technologies in Indonesia", which was carried out by the State Ministry of Environment of the Republic of Indonesia and submitted to UNFCCC in 2001. Even though this second TNA report, which updates the first TNA report, only focuses on mitigation of greenhouse gas emissions, a discussion of the topic of adaptation to the impacts of climate change will be follow in the near future.

The issuance of this second TNA report is one of the activities of the Climate Change Working Group under the State Ministry of Environment, namely the Technology Transfer Working Group under the Climate Change Working Group.

As technology plays a very crucial role for the effort of tackling the adverse effects of climate change issues, this document provides a comprehensive reference for stakeholders in Indonesia. It includes not only the available options of various technologies for key sectors, but also identifies, analyzes and prioritizes technologies, which will form the basis for a portfolio of technology transfer programs. Bearing in mind that technological issues are closely linked with resources management, this document also emphasizes the importance of the identification of human and institutional capacity needs, which will help to ensure the smooth development, transfer and acquisition of technologies.

In the process of preparing this TNA, several meetings, workshops and seminars involving various stakeholders have been carried out intensively. Different government institutions, state-owned enterprises, the private sector, business associations and NGOs contributed actively to the development of substances of this document. Therefore, I would like to express my highest gratitude and appreciation to all authors and contributors for their hard work on finalizing this document. This TNA will surely provide a better preparedness for Indonesia to contribute to the global efforts towards sustainable development and in particular the protection of the climate system.

Jakarta, February 2009

Deputy Minister for Nature Conservation Enhancement
and Environmental Destruction Control, Ministry of Environment
as Chair of Climate Change Working Group,
Masnellyarti Hilman

FOREWORD

We have the honor to be the coordinator of the Technology Transfer Working Group as part of the activities of the Climate Change Working Group under the State Ministry of Environment. Our main task is to develop the Technology Needs Assessment (TNA) on Climate Change Mitigation and Adaptation in Indonesia.

Indonesia's first TNA with the title "Identification of Less Greenhouse Gases Emission Technologies in Indonesia" was reported to the UNFCCC in 2001. That first TNA has been followed by the currently reported TNA activity dealing with exploring the feasible environmentally sound technologies, which will support greenhouse gas emissions reduction in 7 (seven) sectors. This second TNA focuses on the mitigation of the greenhouse gas emissions, whereas the discussion of adaptation to the impacts of climate change will follow. It is expected that Indonesia could eventually adopt new technologies available internationally, which fit to Indonesia's condition while promoting efficient indigenous technologies for mitigating greenhouse gas emissions in several sectors.

This second TNA reports that there are various environmentally sound technologies already available internationally. However, little is known regarding the potential adopting such technologies domestically. This TNA report also attempts to examine appropriate technologies to mitigate greenhouse gas emissions with regard to environmental, economic and social issues.

This document is the result of the joint efforts of the Technology Transfer Working Group comprising of experts from several government- and non-government institutions. I would like to thank all experts, who have participated in the development of this document. Also special thank is directed to GTZ for support and funding, which lead to the success of this work.

Jakarta, February 2009

Deputy Chairman of Technology for Natural
Resources Development, BPPT
As Coordinator of Technology Transfer Working Group,
Prof. Dr. Jana T. Anggadiredja MSc.

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LIST OF ABBREVIATION

BAU	Business as Usual
BCF	Billion Cubic Feet
BOE	Barrel of Oil Equivalent
BRT	Bus Rapid Transit
TOE	Tonnes of Oil Equivalent
BPPT	Badan Pengkajian dan Penerapan Teknologi (Agency for the Assessment and Application of Technology)
CBM	Coal Bed Methane
CCT	Clean Coal Technology
CCS	Carbon Capture and Storage
CDM	Clean Development Mechanism
CFL	Compact Fluorescent Lamp
CNG	Compressed Natural Gas
CO	Can be operated by the industry itself
CP-EE	Cleaner Production-Energy Efficiency
COP	Conference of Party
CPO	Crude Palm Oil
DMO	Domestic Market Obligation
DTO	Minimum dependency to technology owner
EEC	Energy Control Center
EGTT	Expert Group on Technology Transfer
ES	Energy Security
EEC	Efficiency in energy consumption
EPP	Efficiency in production process
EST	Environmentally sound technology
GHG	Greenhouse Gas
GJ	Giga Joule
GJ/t	Giga Joule per Ton
GTZ	German Technical Cooperation
IGCC	Integrated Gasification Combined Cycle
IPCC	Intergovernmental Panel on Climate Change
ITS	Intelligent Transport System
kg/t	Kilogram per Ton
kWh	Kilowatt Hour
LNG	Liquefied Natural Gas
LPG	Liquefied Petroleum Gas
MIC	Mineral in Cement
MJ	Mega Joule
MoA	Ministry of Agriculture
MoE	Ministry of Environment
MEMR	Ministry of Energy and Mineral Resources
MoI	Ministry of Industry
MoF	Ministry of Forestry
MoT	Ministry of Transportation
MBTU	Thousand Btu
MMBTU	Million BTU
MMCF	Million Cubic Feet
MRT	Mass Rapid Transit
MWh	Megawatt Hour

NGO	Non Governmental Organization
PGN	Perusahaan Gas Negara (State-Owned Gas Distribution Company)
PLN	Perusahaan Listrik Negara (State-Owned Electricity Company
PJ	Peta Joule
PV	Photovoltaic
TDM	Transport Demand Management
TNA	Technology Need Assessment
TSCF	Terra Standard Cubic Feet
TT	Transfer of Technology
UNFCCC	United Nation Framework Convention on Climate Change

SYNTHESIS REPORT

INDONESIA'S TECHNOLOGY NEEDS ASSESSMENT ON CLIMATE CHANGE MITIGATION

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CHAPTER

1. BACKGROUND, OBJECTIVE AND PROCESS

1.1. Background

Indonesia is a maritime country with thousands of islands scattered in a tropical region between two large oceans (Pacific and Indian) and two continents (Asia and Australia). In 2006, Indonesia's population counted 222million people While the population growth rate was slowing down from 1.45% p.a. during the period 1990 - 2000 to 1.34% p.a. during the period of 2000 - 2006, the population density of the regions was still unbalanced. The highest population density was observed on the island of Java, where around 59% of the total population occupied 7.0% of the total land area of Indonesia (BPS 2007).

Figure 1.1. Indonesian Archipelago

The climate of the Indonesian archipelago is characterized by strong seasonal variations in the upper oceanic circulation influenced by monsoonal winds. Serving as the lung of world climate, 120million hectares of Indonesia's land area are covered by forest. More than 80% of the country's population lives from agriculture and fishery, 2 sectors, which are highly susceptible to climate variability. The vulnerable agricultural sector has been subjected to several impacts of climate extremes including flood, drought, occurrence of crops pests and diseases with growing frequency and intensity.

A high economic growth rate during the last decades led to a growing demand of energy especially in the sectors industry and transportation. On the one hand the steadily increasing population especially on the most densely populated island of the world requires an industrial growth to satisfy the rising consumer needs. On the other hand this growing demand for energy and consumer goods is accompanied by an increase of waste from the industrial, household and agricultural sectors. To reflect all these factors, Indonesia's Technology Needs Assessment was prepared with focus on seven important sectors: energy, industry, transportation, waste, agriculture, forestry and ocean. The first six sectors were selected, because they are the main source of GHG emissions in Indonesia. The seventh sector, ocean, plays an important role, because 60% of Indonesia's total area is ocean. Based on several references, the ocean is a large carbon sink. Each of these seven sectors will be discussed in its own chapter regarding the existing condition, technology needs and policy requirements.

Indonesia's development planning is reflected by the mid-term National Development Plan prepared every five years. After hosting the COP-13 in Bali in December 2007, there was a consensus to streamline national development policy into a climate responsive policy. In this regard, the TNA functions as a guideline to national policy, preparing the implementation of environmentally sound technology to achieve the target of low-carbon development.

This report summarizes and updates the dynamic national view on a TNA and deals with the latest issues on transfer of technology. Moreover, this report complements the country's previous Technology Need Assessment Report submitted to UNFCCC in 2001, which was entitled "Identification of Less Greenhouse Gases Emission Technologies in Indonesia". The preparation of this document happened in two stages. The draft report was conducted before COP13 in Bali in December 2007. The TNA on mitigating of climate change was then finalized after COP 13.

1.2. Context - Technology Transfer and Technology Needs Assessment

Technology transfer is one of the major agreements in the climate change negotiations. The article 4.5 of the UNFCCC states that developed countries: "*…shall take all practicable steps to promote, facilitate, and finance, as appropriate, the transfer of, or access to, environmentally sound technologies and know-how to other Parties, particularly developing country Parties, to enable them to implement the provisions of the Convention*." In addition article 4.7 of the UNFCCC states that "*The extent to which developing country Parties will effectively implement their commitments under the Convention will depend on the effective implementation by developed country Parties of their commitments related to financial resources and transfer of technology …*"

Moreover, the importance of the transfer of environmentally sound technology (EST) to developing countries - in the context of enabling the participation of developing countries in climate change mitigation efforts - have stipulated in the Bali Action Plan. The Bali Action Plan launched "*a comprehensive process to enable the full, effective and sustained implementation of the Convention through long-term cooperative action [...] by addressing, inter alia: Enhanced action on technology development and transfer to support action on mitigation and adaptation, including, inter alia, consideration of:*

(i) Effective mechanisms and enhanced means for the removal of obstacles to, and provision of financial and other incentives for, scaling up of the development and transfer of technology to developing country Parties in order to promote access to affordable environmentally sound technologies;
(ii) Ways to accelerate deployment, diffusion and transfer of affordable environmentally sound technologies;
(iii) Cooperation on research and development of current, new and innovative technology, including win-win solutions;
(iv) The effectiveness of mechanisms and tools for technology cooperation in specific sectors."

Thus, to obtain support for the transfer of technology, developing countries are supposedly carrying out technology need assessments (TNAs) and report to the UNFCCC. The TNA is the first step in setting up a technology transfer framework. TNA entails the identification and evaluation of technical means for achieving specified ends (UNDP, 2004). Technology transfer is a broad set of processes covering the flows of know-how, experience and equipment for mitigating and/or adapting to climate change amongst different stakeholders in the country such as: governments, private sector entities, financial institutions, NGOs and research/educational institutions. From a climate change and developmental perspective, TNA prioritizes technologies, practices, and policy reforms that can be implemented in different sectors of a country to reduce greenhouse gas emissions and/or to adapt to the impacts of climate change by enhancing resilience and/or contributing to sustainable development goals

1.3. Aims

According to the technology transfer framework, the purpose of technology need assessments is to assist in identifying and analyzing technology needs, and therefore TNAs are central to the work on technology transfer. It follows a country-driven approach, bringing together stakeholders to identify needs and develop plans to meet the needs of the country. Moreover the report shall address the evaluation and selection of priority greenhouse gas mitigation measures of the Republic of Indonesia under the United Nations Framework Convention on Climate Change (UNFCCC) and identification of the main barriers in technology transfer process.

These activities address soft and hard wares, such as mitigation and adaptation technologies, identifying regulatory options and develop fiscal and financial incentives as well as capacity-building. The report shall guide and highlight potential donors or collaborator to work with the Indonesian government or private sectors in implementing easier access for technology transfer that mitigates climate change.

- Contribute to the global efforts towards sustainable development and, in particular, the protection of the climate system
- Communicate Indonesia's needs for environmentally sound technologies (ESTs) to the UNFCCC Conference of the Parties (COP) and the global community
- Resource documents to identify and accentuate ESTs needed by Indonesia and mark those, which require support and co-operation from developed countries
- Set the foundation for a database for ESTs

1.4. Objectives

- Identify, analyze, and prioritize technologies, which could form the basis for a portfolio of Technology Transfer programmes aiming GHG emissions mitigation
- Identify human and institutional capacity needs that ensure the smooth development, transfer and acquisition of environmentally sound technologies
- Enlist interests and commitment from key stakeholders and partnerships to support investment and/or barrier-removal actions for enhancing the commercialization and diffusion of high-priority technologies

1.5. Stakeholder Participation

In 2001 Indonesia submitted the first TNA to the UNFCCC under the title "*Identification of Less*

Greenhouse Gases Emission Technologies in Indonesia". The first draft for updating this submitted TNA was conducted in November 2007. Based on the discussion within the Working Group for Technology Transfer, which consists of members from different departments and agencies, NGOs and the private sector and was established prior to COP-13, the seven key sectors have to be represented in the TNA: energy, industry, transportation, agriculture, forestry, waste and ocean. The second draft was conducted according to the UNDP "Handbook for conducting Technology Needs Assessment for Climate Change", which was recommended by UNFCCC under decision 3/CP.13. The second drafting was started on March 2008 and involved a wide range of stakeholder:

1. Ministries and Government Agencies: State Ministry of Environment (MoE), Ministry of Energy and Mineral Resources (MEMR), Ministry of Transportation (MoT), Ministry of Industry (MoI), Ministry of Agriculture (MoA), Ministry of Forestry (MoF), Ministry of Marine and Fishery Affair, Ministry of Public Works, State Ministry of Research and Technology, Agency for the Assessment and Application of Technology (BPPT);
2. State-owned enterprises: PT. PLN (State Owned Electricity Company) and Pertamina (State Owned Enterprise of Oil and Gas);
3. Non-governmental organization such as: Institute for Essential Services Reform (IESR), Yayasan Bina Usaha Lingkungan, Yayasan Pelangi Indonesia;
4. Universities, Research Agencies; and
5. Industries & Business Association.

All activities in preparation of this TNA were supported by the Germany Government through the German Agency for Technical Cooperation (GTZ) and its Advisory Service for Climate Protection Project (SFF Klima).

1.6. Activities

In general Indonesia's Technology Need Assessment has been drafted through the following activities:

1. Set up of a working group from various stakeholders and representatives of ministries, government agencies, state-owned enterprises, NGOs, private sector;
2. Formulation of a multi-stakeholders' core team and development of a work plan for TNA preparation;
3. Institutional arrangements and wider stakeholder engagement;
4. Preparation:
    a. Preliminary overview of options and resources;
    b. Establishment of criteria for prioritizing mitigation measures;
    c. Definition of priority sectors and sub-sectors;
    d. Selection of priority measures and sectors; and
    e. Preparation of report authors and consultants.
5. In-depth measure and barrier assessment during stakeholder meetings and consultations;
6. Selection of high priority actions for further development and implementation;
7. Needs assessment for sector reports;
8. National and international review process;
9. Consolidation and preparation of the synthesis report; and
10. Final launching.

A Steering Committee (SC) was established to provide guidance and advice for each sector. It comprised of the Deputy Chairman of BPPT, members of staff of the Ministry of Environment and representatives from state-owned enterprises and NGOs. The TNA draft reports for each sector were prepared by a core team, whose members came mostly from the according Ministries. This core team was coordinated by

the sectors' lead authors. This way each of the TNA sector reports was prepared under participation of the according Ministries and assisted by, respectively consulted with the particular stakeholders of each sector.
During the writing process each sector organized a series of meetings, discussion sessions, workshops and seminars. Meanwhile the core team met regularly to discuss the progress of the TNA report, findings and challenges. In addition to the processes on sector level, the core team organized a kick-off workshop and several seminars, where each sector presented its TNA draft sector report to the stakeholders. This process, which involved all stakeholders, lasted almost 8 months.

The TNA draft report was reviewed by a team of international experts provided by GTZ. As a first step the international experts reviewed the TNA draft report and sent their comments. Following the sector authors' work on these comments, the leader of the reviewer team held a series of workshops with the sector authors and the core team during a period of 2 weeks in Jakarta. The revised final draft was reviewed for the second time by the team of international experts to form the final report. The overall process, beginning with the kick off workshop and ending with the conduction of the final TNA report (mitigation part), took more than 6 months of effective work and lasted 11 months in total.

CHAPTER

2. SUMMARY OF SECTOR REPORTS

2.1. ENERGY SUPPLY

1. State of Sector Development

Energy Resources

Indonesia has a wide variety and huge resources of energy, both fossil and non-fossil based energy. Coal is the most abundant fossil energy resource, accounting about 0.5% of the world's proven reserve. Natural gas is the second largest energy resource, accounting about 1.7% of world's proven reserve, followed by petroleum, which accounts for 0.4% of the world's proven reserve (BP, 2008). Coal bed methane (CBM) is a promising energy resource with a potential of 453 trillion standard cubic feet (TSCF). However, further investigation is required for identifying technical resources availability. The states of fossil energy resources of Indonesia in 2008 are presented in Table 2.4.

Table 2.1: Fossil Energy Resources in Indonesia, 2008

Non-Renewable Energy Source	Unit	Potential Resource	Proven Reserve	Production
Crude oil	Billion barrels	56.6	8.4	348.0
Natural gas	TSCF[1]	334.5	165.0	2.8
Coal	Billion ton	90.5	18.7	250.0
Coal bed methane	TSCF	453.0	-	-

Source: Ministry of Energy and Mineral Resources (MEMR, 2008)

Indonesia has a vast potential of renewable energy resources such as geothermal, wind, solar, hydro, biomass, wave and ocean. Renewable energy resources are scattered all over the country, which is located around the equator.

Geothermal energy is one of the abundant renewable resources with a technical potential of 27,000MWe. Counting also medium- and low heat-temperature sources the geothermal potential would even exceed 100,000MWe. Medium wind speeds, which are suitable for wind power, are measured in the eastern part of Indonesia only, whereas solar energy with an intensity of 4.5kWh/m^2 to 5.0kWh/m^2 could be used in most of the countries' parts. Micro- and mini hydropower sources are mostly located in remote areas. Most of them are small scale. Despite this potential, the utilization of renewable energy for energy services is relatively low.

[1] TSCF: trillion standard cubic feet

Table 2.2: Renewable Energy Resources in Indonesia, 2008

Renewable Energy Source	Potential Resource	Installed Capacity
Hydro Power	75,670MW	4,200MW
Micro and Mini Hydro	450MW	84MW
Geothermal	27,150MW	1,042MW
Biomass	49,810MW	300MW
Solar Power	4.8kWh/m²/day/0.0006MW/m2[2]	8MW
Wind Power	9,280MW	0.5MW

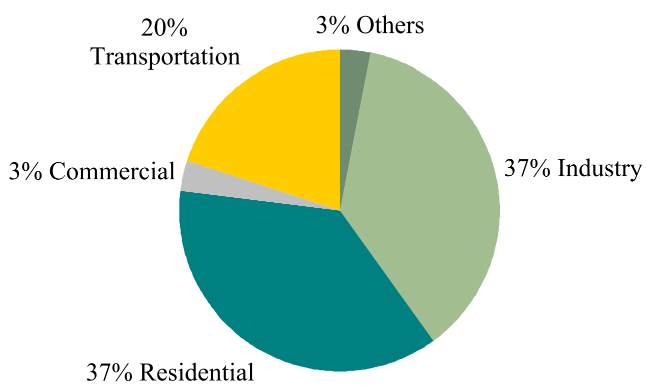
Source: Ministry of Energy and Mineral Resources (MEMR, 2008)

Energy Production

Most of fuel required for energy utilization is produced domestically. Still, Indonesia imports up to 160 million barrel of crude- and refined oil per year. Despite its vast natural gas resources, Indonesia also imports LNG from middle-eastern countries. Indonesia produces 230million ton coal per year.

Energy Consumption

Energy consumption in the end use sector is dominated by the use of petroleum fuels and electricity. Petroleum fuels are mainly distributed to consumers in Java, Bali and Nusa Tenggara (59%), Sumatra (23%) and regions in central and eastern Indonesia (18%). In 2006, the total final energy consumption counted 853.8million BOE. The major consumers were the industry sector (37%), residential sector (37%) and transportation sector (20%).



Source: Ministry of Energy and Mineral Resources (MEMR, 2007)

Figure 2.1: Final Energy Consumption by Sector including Biomass in Indonesia, 2006

Energy consumption in the end user sector offers a large reduction potential. The Directorate General Energy and Electricity Utilization (DGEEU) of the Ministry of Energy and Mineral Resources estimated in 2002, that the energy efficiency potential in the industry, residential, and commercial building sectors range between 10% and 30%. The following table presents the energy savings potential estimated in the scope of the energy conservation program in 2002.

[2] Assuming an average duration of sunshine of 8 hours per day

Table 2.3: Energy Conservation Potential by Sector, 2002

Sector	Consumption	Energy Conservation Potential	
	10^3 BOE	10^3 BOE	%
Industry	194,356	29,153 – 58,307	15 - 30
Transportation	169,730	42,432	25
Residential	134,630	135,630	10 - 30

Source: Ministry of Energy and Mineral Resources (MEMR/ DGEEU, 2007)

Energy Policy and Regulation

Energy Act No. 30/2007 on Energy Development

In 2007 the Government issued this new Energy Act, which is expected to guide the entire energy sector. The act incorporates several provisions, which will impact the development of the energy sector and support energy conservation and the development of new and renewable energy through incentive mechanisms. The four elements of national energy policy are:

1. Securing energy supply to meet national energy demand;
2. Prioritizing the developing of energy resources;
3. Optimizing the utilization of national energy resources;
4. Setting up national energy reserve strategies.

Presidential Decree No. 5/2006 on National Energy Policy

Indonesia's national energy mix policy, formulated in this Presidential Decree, targets the reduction of current oil consumption from 51.6% to less than 20% in 2025 by substitution from other energy sources such as coal and renewable energy. This national energy mix policy reflects the consideration of the importance of alternative energy utilization, energy conservation, and energy security aims to enable secure energy supply. The previous primary energy mix, set up in the National Energy Blueprint document in 2005, will herewith be optimized according to energy diversification and conservation means.

2. GHG Emissions Inventory

In 1994 the total amount of GHG emissions in Indonesia counted 323,262Gg without land-use change and forestry and 487,380Gg with the inclusion of emissions from land-use change and forestry (LUCF). The energy sector contributed 222,102Gg to this GHG emissions inventory, which translates into a contribution of 68.7% of the total GHG emissions without LUCF or 46% of the total GHG emission with LUCF.

In 2006 the energy sector emitted 362,000Gg CO_2. The emissions from the industry, power generation and transportation sectors grow very rapidly in the wake of industrialization and economic growth. Emissions are expected to rise even further due to the development new coal power plants with a capacity of 10,000MW as planned under the Accelerated Coal Power Plant Development Program (2006 - 2010).

GHG emission projections in this report are generated using the MARKAL model. The activity data input is based on the estimation of the specific fuel consumption per sector and year. Emission and conversion coefficients are applied according to the Tier 2 methodology suggested by the Intergovernmental Panel of Climate Change (IPCC). Due to the insufficiency of data and information the calculations are limited to CO_2 emissions only.

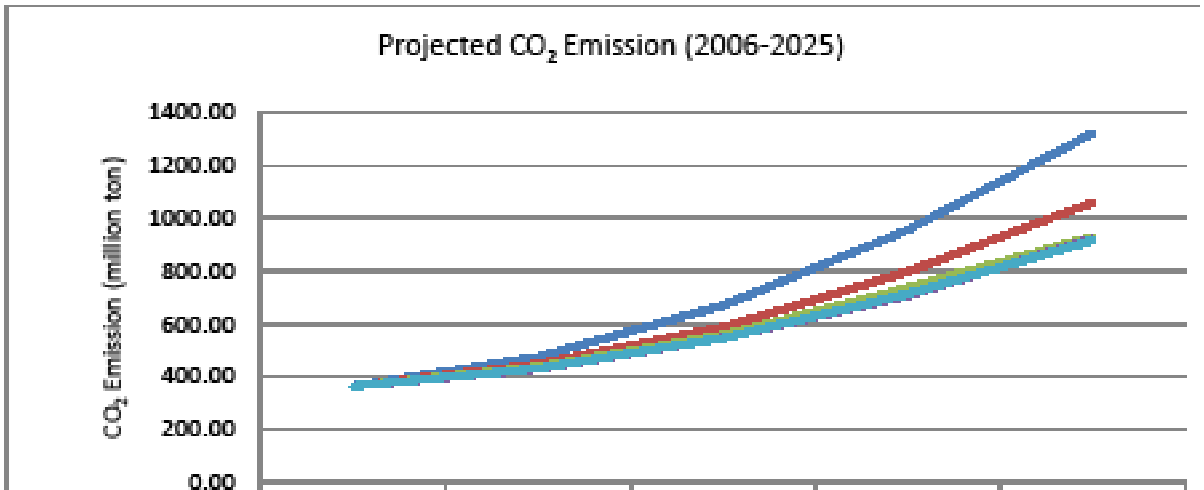
Two reference cases are simulated. The first case (Ref-1) refers to an oil price of 60US$/barrel, whereas the second case (Ref-2) assumes an oil price of 120US$/barrel. Under the Business-as-Usual scenario and the assumption of the first case, CO_2 emission are projected to raise nearly four times in the next 25 years from about 362,000Gg CO_2 in 2006 to about 1,324,000Gg CO_2 in 2025. Expecting the incidence of the second case 1,365,000Gg CO_2 are expected in 2025.

A further assessment using the MARKAL model[3] is carried out to give a more realistic overview of different emission reduction scenarios and the impact of the application of several technology for the current and future energy system of Indonesia. Based on the two described reference cases, expecting different long-term oil prices, scenarios have been applied to assess the impact of various technologies on CO_2 emission reduction efforts.

1. BASE case scenario describes the business as usual (BAU); assuming that no energy conservation or energy efficiency measures are applied and electricity generation is fully based on coal fired power plants.
2. The Moderate Energy Efficiency (RIKEN) scenario assesses the impact of the National Energy Conservation Program's target set in 2005. For this scenario it is assumed, that energy efficiency will improve by 15%. GHG emissions could be reduced to 1,100,000Gg CO_2 in 2030, which is 200,000Gg less than BAU.
3. The Maximum Energy Efficiency (RIKEN MAX) scenario assumes, that energy efficiency improves by 30% (maximum). GHG emissions are estimated with 100,000Gg CO_2 less than RIKEN and 300,000Gg CO_2 less than BAU in 2025.
4. The Alternative Power Plant (PEMBALT) scenario is based on the application of advanced thermal power plants, nuclear and renewable technology. Advanced clean coal technology is set to 6 units (3 x 600MW for integrated gasification combined cycles and 3 x 600MW advanced coal power plants). This scenario will lead to a result similar to RIKEN MAX scenario in terms of GHG emission reduction.
5. The Carbon Capture and Storage (CAPTURE) scenario is based on the application of advanced thermal power plants with Carbon Capture Technology and leads to a result similar to PEMBALT.

The result of all scenarios regarding their impact on GHG emission reduction is presented in the following figure for the Ref-1 case. It shows, that energy efficiency measures can reduce CO_2 emissions between 20% (Moderate Energy Efficiency scenario) and 30% (Maximum Energy Efficiency scenario), which translates into a reduction of 264,000 - 396,000Gg CO_2 compared to the BAU scenario. An even higher reduction can be achieved, if geothermal power plants and/ or clean coal technologies are imposed to the system.

[3] MARKAL is a generic model tailored by the input data to represent the evolution of a specific energy system at national, regional, state/ province, or community level over a period of usually 40 to 50 years. The basic components in a MARKAL model are specific types of energy or emission control technologies. Each is represented quantitatively by a set of performance and cost characteristics. A menu of both, existing and future technologies, is put into the model. Both the supply and demand sides are integrated, so that one side responds automatically to changes in the other. The model selects those combinations of technologies, which minimize total energy system costs. Thus, unlike some "bottom-up" technical-economic models, MARKAL does not require -- or permit -- an a priori ranking of GHG mitigation measures as an input to the model. The model chooses the preferred technologies and provides the ranking as a result. Indeed, the choice of mitigation measures often depends on the degree of future requirements regarding GHG emissions mitigation. For more information: http://www.etsap.org/markal/main.html.

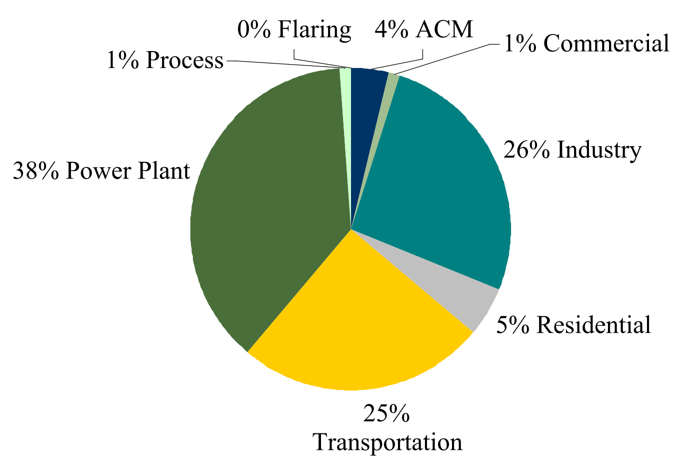


	2006	2010	2015	2020	2025
BASE	362.60	475.94	671.10	956.07	1324.09
RIKEN	362.60	448.90	587.70	798.31	1060.01
RIKEN MAKS	362.60	437.60	557.20	736.64	929.81
PEMB ALT	362.60	429.20	547.55	708.01	921.72
CAPTURE	362.60	431.91	546.74	714.07	915.04

Source: Output MARKAL (BPPT & MEMR, 2008)

Figure 2.2: Projected CO_2 Emissions from Energy Consumption, 2006-2025 (Ref-1 Case)

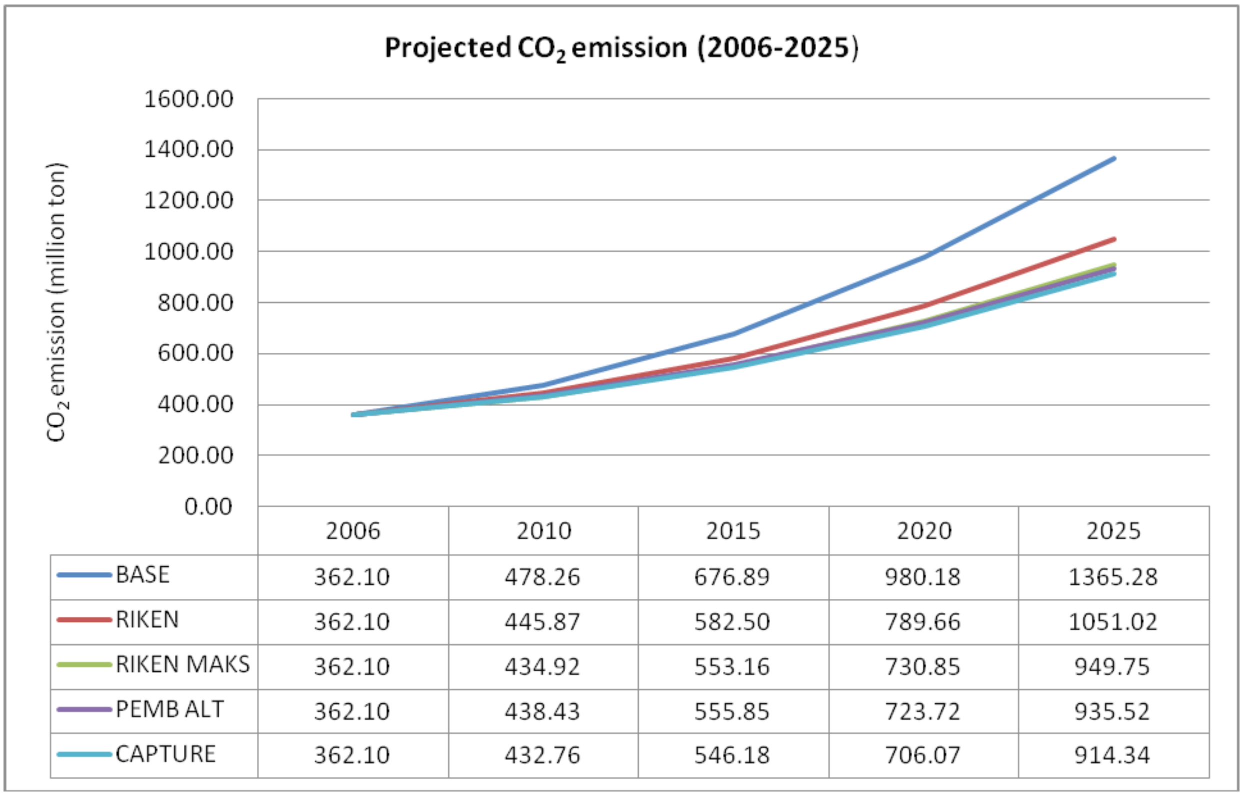
The model suggests that in 2025 89% of the CO_2 emissions from energy consumption will be emitted by power plants, industrial processes and transportation. The highest emission growth rate is expected for electricity generation, mainly from coal power plants, and for transportation. The following figure presents the sources of CO_2 emissions from energy consumption by sub-sector.



Source: Output MARKAL (BPPT & MEMR, 2008)

Figure 2.3: Projected CO_2 Emissions from Energy Consumption by Source, 2025 (Ref-1 Case, BASE Scenario)

The result of all scenarios regarding their impact on GHG emission reduction is presented in the following figure for the Ref-2 case. It shows, that energy efficiency measures can reduce CO_2 emissions between 23% (Moderate Energy Efficiency scenario) and 31% (Maximum Energy Efficiency scenario), which translates into a reduction of 314,000 - 416,000Gg CO_2 compared to the BAU scenario. An even higher reduction can be achieved, if geothermal power plants and/ or clean coal technologies are imposed to the system.

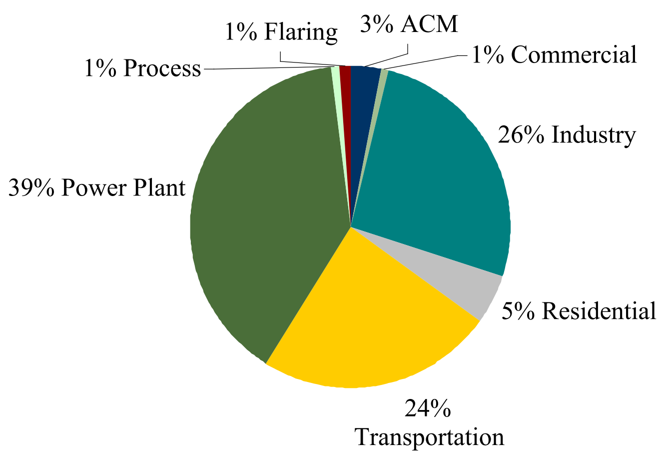


	2006	2010	2015	2020	2025
BASE	362.10	478.26	676.89	980.18	1365.28
RIKEN	362.10	445.87	582.50	789.66	1051.02
RIKEN MAKS	362.10	434.92	553.16	730.85	949.75
PEMB ALT	362.10	438.43	555.85	723.72	935.52
CAPTURE	362.10	432.76	546.18	706.07	914.34

Source: Output MARKAL (BPPT & MEMR, 2008)

Figure 2.4: Projected CO_2 Emissions from Energy Consumption, 2006-2025 (Ref-2 Case)

Compared to the Ref-1 case, total CO_2 emissions will be higher in 2025. This is due to the increasing demand for electricity and its supply from coal power plants. However, a higher oil price does not seem to make clean coal power plants (CCTs) competitive, unless a carbon value is introduced to the technology. In this case, a limited number of CCTs is imposed to the system, to maintain it optimal. Due to this limitation CO_2 emissions will increase. The following figure presents the sources of CO_2 emissions from energy consumption by sub-sector.



Source: Output MARKAL (BPPT & MEMR, 2008)

Figure 2.5: Projected CO_2 Emissions from Energy Consumption by Sector, 2025 (Ref-2 Case, BASE Scenario)

Under the Ref-1 case, system costs are estimated with 2,800billion US$. Energy efficiency measures add the total system cost by only 50-100billion US$. Imposing CCTs and carbon capture and storage (CCS) into the system will increase the total system costs by 15% to 18% compared to the BASE scenario. Total system costs by scenario are presented in the following figure for Ref-1.

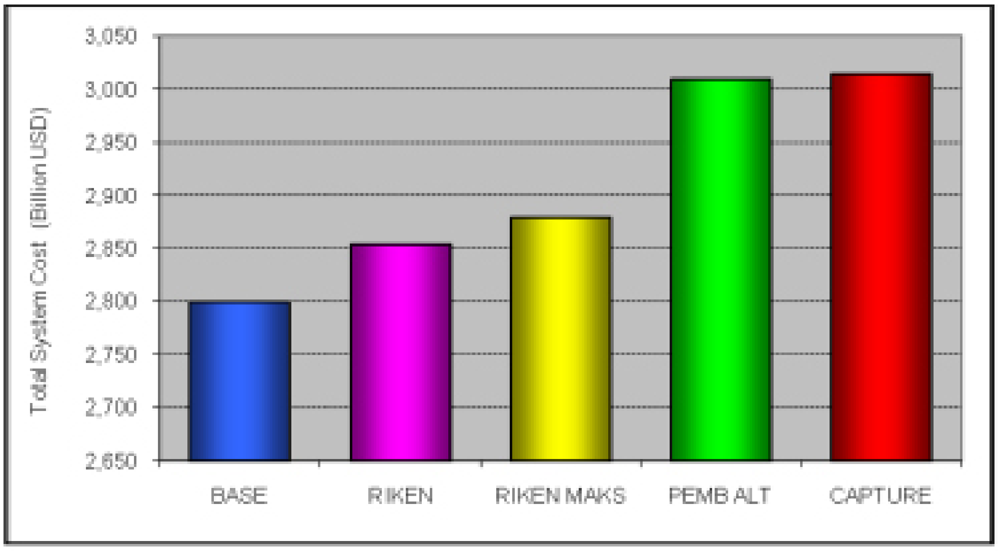


Figure 2.6: Projected total System Costs by Scenario, 2025 (Ref-1 Case)

Under Ref-2 case total system cost will be higher than under Ref-1 case. However, in Ref-2 case, the application of new technology such as CCTs, renewable energy and CCS gives only a minor increment to the cost of the BASE scenario. Total system costs by scenario are presented in the following figure for Ref-2.

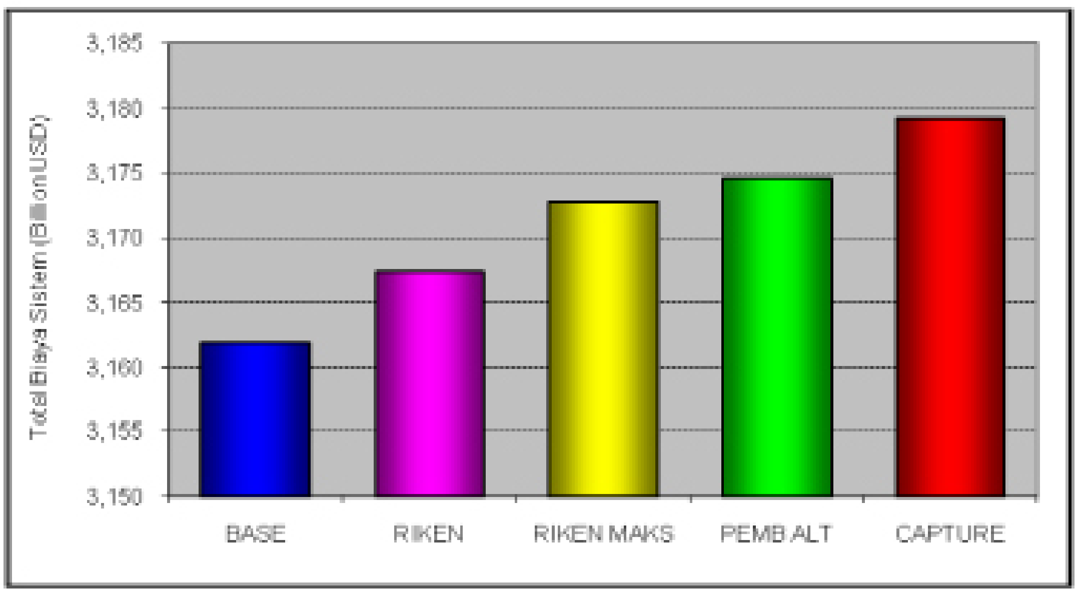


Figure 2.7: Projected total System Costs by Scenario, 2025 (Ref-2 Case)

3. GHG Emissions Mitigation Strategy

The main sources of GHG emissions from the energy sector are activities in mining, processing, transporting and distributing fuels. The combustion of fossil fuels for electricity and heat production, their transmission and distribution are major sources of GHG emission from energy supply. Under normal conditions energy is produced according to the demand; thus a higher demand leads to a higher supply unless there are supply disruptions.

Potential climate change mitigation technologies for both, the supply side (energy generation, transmission and distribution) and the demand side (end-user), are available. Effective GHG emissions mitigation scenarios describing different measures such as technologies and policies, should be able to address both demand and supply side. A summary of mitigation technologies for energy supply and demand side are listed in Table 2.4 and Table 2.5, and an abatement cost curve for environmentally sound energy sector technology is presented in Figure 2.8.

Table 2.4: Environmentally Sound Technology – Energy Supply Side

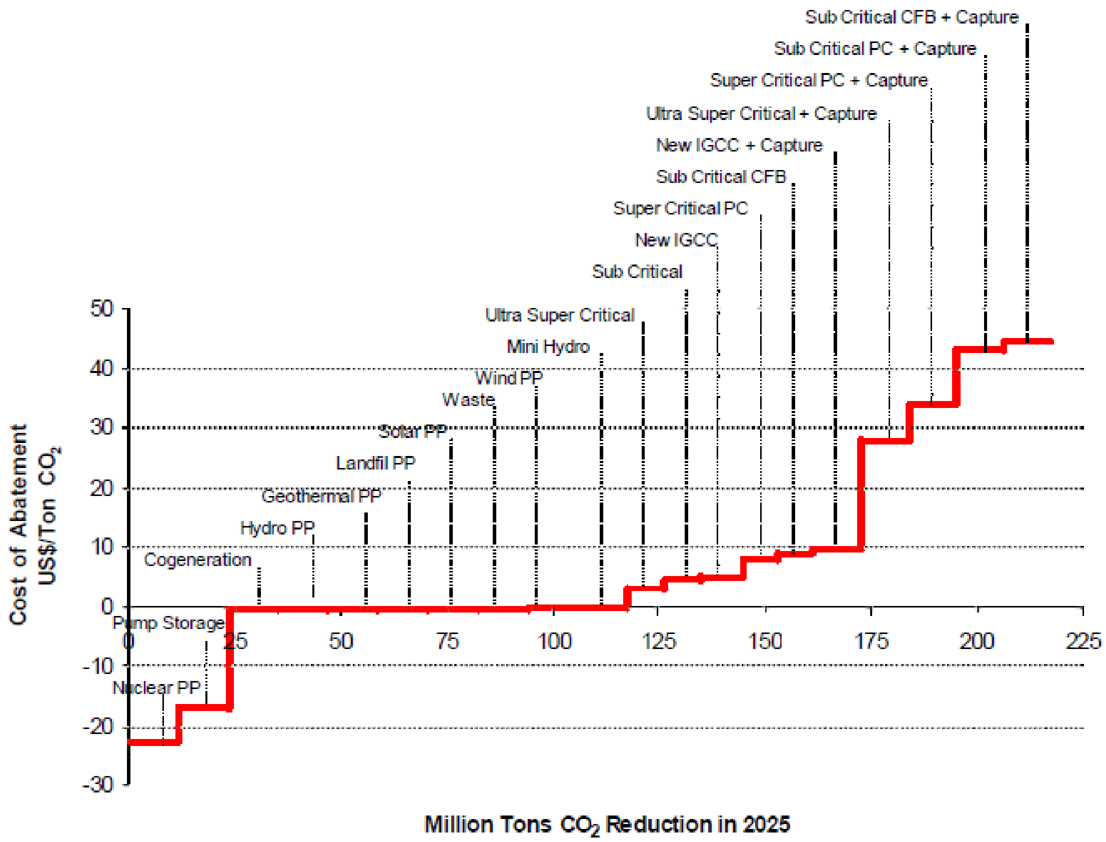
Identified Technology	Present Situation	Technology Input	Emission Reduction Potential	Investment Cost	Abatement Cost	Remark
			ton CO_2/MWh	US$/kWe	US$/ton CO_2	
Advanced thermal power technology/ Clean coal technology	Pulverized Coal Power Plant, 33% efficiency, 1ton CO_2/MWh	Sub-critical Pulverized Coal Power Plant, 36% efficiency	0.700 (no CO_2 capture) 0.830 (CO_2 capture)	1,200 2,300 –2,400	10 - 15 40 - 50	With and without CO_2 capture
		Supercritical and Ultra Supercritical Pulverized Coal Power Plant, 40% - 46% efficiency	0.170 (no CO_2 capture) 0,891 (CO_2 capture)	1,300 – 1,400 2,300 – 2,400	5 - 10 27 - 35	With and without CO_2 capture
		Cogeneration	0.325	1,000 – 1,100	0 - 5	Heat and electricity production
		Integrated Gasification Combined Cycle (IGCC), 38% – 41% efficiency	0.168 0.898	1,100 – 1,300 1,800	10 15	With pre-combustion, without CO_2 capture
		Coal upgrading	Vary depending on quality of coal	Depending on size of plant and production capacity	n/a	5% emission reduction to conventional PC
		Improving efficiency of coal power plant	-	Depending on investment	n/a	1% efficiency increase reduces 2% - 2.5% CO_2 emission

Identified Technology	Present Situation	Technology Input	Emission Reduction Potential	Investment Cost	Abatement Cost	Remark
			ton CO_2/MWh	US$/kWe	US$/ton CO_2	
Fuel switching	Combine Cycle Gas Turbine to replace HSD Generator	Gas to replace HSD	n.a	n.a		
		Coal to gas (50%)	0.500	750	8.5	
Utilization of renewable energy technology	More than 95 % of primary energy supplied by fossil fuels: oil, coal and gas	Biomass Power – Direct combustion			0 - 5	
		Biomass Power – Co-firing	15% - 20% emission reduction depending on main fuel		0 - 5	
	Government-set target for oil reduction by increasing use of new and renewable energy up to 15 % of total primary energy mix	Biomass power- gasification	Reduced coal emission per energy produced			
		Geothermal - Flash Steam	0.900 – 1.000 (Baseline: typical PC power plant)	1250 – 1300	5 - 10	Baseline dependant
		Geothermal - Binary Cycle		1600 – 1700	10 - 20	
		Geothermal - Hot Dry Rock		4500	n.a	
		Photovoltaic – Single Crystal/ Mono Crystal		5500 - 6000	20 - 30	
		Wind turbine		1600 – 2000	10 - 15	Small and medium wind power
		Micro and Mini Hydro		2500 – 3000	5	
		Advanced Hydro Power			5 - 10	Large hydro, multi-purpose dam
		Nuclear Power: PWR/BWR 2nd Generation	0.850 - 0.900 (Baseline: typical PC power plant)	1500 – 2500	n.a	
		Nuclear Power: PWR/BWR 3rd/3+ generation		5500 - 8000	n.a	

Table 2.5: Environmentally Sound Technology – Energy Demand Side

Technology	Efficiency Measure	Result	Sector
CFL (Compact Fluorescent Lamp)	Replacement of incandescent bulb with CFL	Reduction of energy use by up to 80 %	Household and commercial
Use of solar water heater	Use of solar water heater for producing hot water	Reduction of electricity consumption by up to 50 %	Households, commercial, and some industries
Electronic Ballast	Replacement of magnetic ballast with electronic ballast	Reduction of energy use by up to 20 %	Household and commercial
High efficiency air conditioner (AC)	Replacement of standard AC (CoP = 2.5)* with high efficiency AC (CoP = 3.3)*	Reduction of energy consumption by up to 50 %,	Households
Hydrocarbon refrigerant	Replacement of CFC with hydrocarbon refrigerant	Reduction of electricity consumption by up to 20 %.	Households and commercial
BAS (Building Automatic System)	Application of BAS to monitor lightning and energy use in buildings	Reduction of electricity consumption by 10 % – 20 %	Commercial
Variable speed drive (VSD)	Application of VSD in fan system	Reduction of electricity consumption by up to 20%	Industry
High efficiency chiller	Replacement of normal chiller (CoP = 4.0)* with high efficiency chiller (CoP = 5.0)*		Commercial and industry
High efficiency electric motor	Replacement of normal electric motor with high efficiency electric motor	Reduction of energy consumption by up to 25 %.	Industry

)* Coefficient of Performance (CoP)



Source: Output MARKAL (BPPT & MEMR, 2008)

Figure 2.8: Abatement Costs for Various Energy Technologies, 2025 (Ref-2 Case)

4. Criteria for Technology Selection

Technology transfer priorities are assessed and selected using multiple criteria analysis. Two sets of criteria are determined: general criteria and specific criteria. The general criteria are based on national-wide interests and priorities, while specific criteria are reflecting the priorities, current policies & objective and the situation of the energy sector. The selection of general criteria is made through a broad consensus of the Energy Working Group on Technology Transfer (WGTT), whose members are representatives from the different stakeholder groups of the TNA. Specific criteria are determined and selected by the energy sub-group.

Table 2.6: General Criteria for Technology Selection

General criteria	Sub-Criteria
a. Conformity with national regulation and policy	• Food security (FS) • Natural resource security (NR) • Energy security (ES) • Incentive for participation (IP)
b. Institutional and human development	• Capacity building (production & know how) (CB)
c. Technology effectiveness	• Mature degree of technology • Advanced degree of technology • Reliability of technology (RT) • Applicability of technology • Easiness of wider use of technology, including local contribution support of technology application (ET)
d. Environmental effectiveness	• Greenhouse gas emissions reduction (GR) • Improvement of local environmental quality (LE)
e. Economic efficiency and cost effectiveness	• Capital and operational costs relative to alternatives (COC) • Commercial availability (market) (CA)

Table 2.7: Specific Criteria for Technology Selection – Energy Sector

Specific Criteria	Sub-Criteria
a. Consistency with national policy & target and specific local situation	• Relevant to existing energy policy & target (EP) • Utilization of local energy resources (LER)
b. Economics and cost-effectives of technology	• Total capital cost (TC) • Internal Rate of Return (IRR) • Payback period (PR) • Abatement cost (AC)
c. Technology development	• Advance but proven technology (AD) • Possibility for local manufacturing & production (PLB)
d. Social acceptability	• Good impact for socio-economic development (LED)

The technology selection is determined by applying the described general and specific criteria across all technologies. As a result of this selection process for the energy sector a matrix was formed showing the available technologies vis-a-vis the selection criteria, both for energy supply and demand side.

5. Technology Selected

a. Supply Side Technology

The selection using specific criteria suggests that for the supply side technology, high priority for technology transfer shall be given to:

- Advanced coal technology/ Clean Coal Technology
- Geothermal technology
- Biomass technology, in particular for direct combustion technology and co-firing

technology

Those technologies are selected due to their strong relation to the current government policy, which targets an increased use of coal and renewable energy sources for electricity generation replacing diesel and marine fuel oil. The aim of this policy is the assurance of energy security. Still, an increased use of coal will lead to an increased amount of GHG emission. Therefore GHG emissions reduction and/or offsetting from electricity generation should become the main consideration. At the same time the energy system cost and the economic effectiveness of adopting related technologies play an important role.

Clean Coal Technology

Clean Coal Technologies (CCTs) such as coal upgrading technology and Sub-critical Fluidized Bed Combustion (Sub FBC) technology are highly relevant for the current government policy and electricity sector planning targeting the utilization of low rank coal resources for electricity generation. 60% of the coal reserves in Indonesia comprise of such low rank coal. In addition to the implementation of CO_2 capture and sequestration technology such Carbon Capture and Storage (CCS) can reduce the large quantity of GHG emissions from coal from this type of power plants in the near future. Other CCTs such as Supercritical Pulverized Coal and Ultra Supercritical Pulverized Coal are important to anticipate the increased utilization of medium rank coal. These technologies can substitute the soon decommissioned old coal power plants of the Java-Madura-Bali electric power system and also outside the system.

Advanced coal technology can reduce the environmental impact and GHG emissions caused by conventional Pulverized Coal technology, which has been applied widely recently. Still electric power generation with coal keeps releasing a large quantity of GHG emissions; therefore such technologies should be considered as an interim solution only, before cleaner and more effective technologies for electric power generation will be available in the market. In the mid-term (10 years), Supercritical and Ultra Supercritical Coal Power Plant technology should be prioritized in the National Electricity Development Plant.

Integrated Gasification Combined Cycle (IGCC) technology is still less competitive compared to CCTs due to the high cost of investment and the development state of technology itself. However, the integration of IGCC technology with other energy production facilities such as oil refineries will improve the economic feasibility of this technology.

Geothermal

Geothermal technology is selected due to the abundant resources of geothermal energy in Indonesia. The utilization level of this technology is still low. Increasing this level aligns with the current government policy and energy sector planning, which projects a geothermal development between 6,000MW – 8,000MW over the next 10 years. The deployment of advanced geothermal technology such as binary cycle might be suitable for those areas on different Indonesian islands, which provide medium temperature geothermal reserves. The deployments of binary technology will add up to 100,000MW to the geothermal energy utilization potential.

Biomass Technology

There are abundant biomass resources from agricultural waste in Indonesia, which have not been utilized so far. Several biomass technologies such as direct combustion and co-firing technology can help to use these resources.

For the last fifteen years, several biomass plant projects such as biomass power generation using rise husk or straw have been introduced. The result was mostly poor and unsustainable. The main problem was the inability of the plants' management to organize continuous biomass supply from the areas surrounding the plants. A strong need for such a database arose from these experiences, which informs about the technical potential of biomass resources in Indonesia and is updated regularly. Besides the provision of sufficient information, the strengthening of certain policies such as a feed-in-tariff are considered important and will become attractive factors for biomass plant developers.

Renewable Energy Technologies as National Priority
Beside the selected technologies, priority should also be given to renewable energy technologies such as wind, micro and mini hydro power and photovoltaic (PV) technology as well as technology to manufacture and produce bio-fuel, in particular the second generation of bio-fuel. Wind, mini and micro hydro-power and PV are suitable to be developed in remote and rural areas utilizing locally available energy resources to set up decentralized energy system.

For wind power technology the efficiency and reliability of low-speed wind turbines as well as the use of light-weight materials for blades, control systems, motors and other main parts are important to ensure efficient and low-cost electricity generation.

For the manufacture of photovoltaic technology a technology transfer is needed for both silicon based and advance thin film PV modules. The technical capacity for the installation of large-scale PV systems or PV systems, which can be connected to the grid, needs to be developed. Large-scale and grid-integrated PV systems have already been installed in some developed countries, such as Germany, Spain, Japan and the USA. Another need for PV technology transfer is the necessity of Building-Integrated PV modules, which can work as electric power generators within a building.

The main barriers for renewable energy deployment are technical limitations, high capital costs and long payback periods, which make related technologies unfavorable and economically not competitive compared to other conventional fossil fuel based technologies. However, such renewable energy technologies are very suitable for supplying remote sites with energy and as distributed generation systems. Technology transfer in this area shall therefore focus on the development of local mass production lines of renewable energy technologies

Transfer of advanced coal power plant and geothermal plant technology can be realized through:

- Market based mechanisms such as the development of turnkey plants, direct investment and technical licensing agreements;
- Non-market mechanisms such as pilot projects between the state-owned electricity company and technology vendors and technical assistance by foreign vendors;
- Public- private partnerships (PPP) can be used to facilitate the investment of advanced and clean technology.

b. Demand Side Technology

The priority for technology transfer for the energy demand side should be set on energy efficient technologies for the industry and residential and commercial buildings.

1. Energy efficient technologies for industry:
    - Lightning system
    - Pump and Fan
    - Industrial Motor
    - Cogeneration
2. Energy efficient technology for residential and commercial building:

- Lightning equipment (CFL and electronic ballast)
- Cooling system

3. Soft technology:
    - Energy Audit
    - Energy Rating and Labeling
    - Energy Management

Given that most of the energy efficient appliances and equipment to reduce energy consumption in industry, residential and commercial building are widely available in the market; technology transfer in the form of hard technology as mentioned above is not a priority. Instead technology transfer is required in the form of soft technology meaning capacity building in the areas of energy management and energy audit and the access to energy efficiency technology databases. Such capacity building will help to improve the knowledge, skills, and capacity of public and private institutions, which promote and facilitate energy efficiency and Demand-Side-Management programs.

Energy conservation can be started by implementing low cost measures such as the replacement of inefficient lamps by energy efficient CFL, the improvement of production processes and the installation of new and more efficient equipment. Regarding these measures technology transfer is less important, but actions through measurable projects and programs are needed to reach the targeted GHG emission reduction.

Transfer of technology should be encouraged and prioritized especially for those technologies, which are related to industrial processes of energy intensive industry sub-sectors such as iron & steel, pulp & paper, cement, chemicals, textiles, and petroleum refining. A detailed description of technology options and policies supporting energy efficiency in the industry sector is given in the Industry Sector TNA.

6. Barriers and Policy Needs for Technology Transfer

The barriers and subsequent policy and action needs are presented in the following table.

Table 2.8: Barriers and Policy & Action Needs – Energy Sector

Identified Barrier	Policy and Action Need
Institutional and Policy	
Insufficient long-term policy, regulation and target	Set clear long-term policy and target on energy, which is based on long-term economic objectives, technology maturity and resources availability.
Insufficient operational policy	Develop and implement detailed operational policies, which enable the support of projects utilizing new and renewable energy technologies.
Insufficient inter-agency policy and measures	Develop an effective coordination mechanism for National Energy Committee (DEN) and National Commission on Climate Change (DNPI) and key sector agencies and ministries.
Lack of environmental mandate policy and regulation	Develop policy and regulation, which encourage domestic industry to produce energy efficient appliances and stimulate the power sector to reduce GHG emissions (supply side) and consumers to use energy efficient technology (demand side).
Economic, Investment and Market	
Limited public financial resources	Improve climate investment for private sector, actively looking for grants and technical assistance for R&D, and pilot project.

Identified Barrier	Policy and Action Need
Poor investment climate	Create of an environment supporting private investment.
Limited financial instruments and incentive mechanisms for RE and Energy Conservation	Create RE & Energy Conservation Fund. Establish Energy Service Company (ESCO).
Unpredictable economic feasibility of new technologies	Establish a set of parameters for the investment cost of each technology, such as: cost of capital, rate of return, payback period, etc. and secure package to minimize the risk of investment.
Energy pricing does not reflect true cost of production, long-term resource availability and externalities	Develop and implement pricing policy, which reflect cost of production and energy supply. Create effective and well-targeted subsidy mechanism for the low income and the poor user.
Human Resources and Industrial Support	
Lack of professionals, who are skilled in new, renewable and advanced fossil fuel and DSM technologies	Organize series of trainings on energy conservation and energy efficiency techniques, good practices and renewable energy. Bring the energy efficiency and RE topic into the curriculum of engineering and science studies at Indonesian universities.
Limited industrial base support and service provider locally	Enhance cooperation and technical assistance with particular countries for technologies needed. Develop pilot projects.
Limited R&D in GHGs mitigation technologies both conventional and new technologies	Enhance R&D cooperation for new and advanced technologies with countries and other institutions. Pursue for joint research projects with industrial application possibility.
Information and Awareness	
Limited database on renewable energy potential	Establish a database on the base of measurement, analysis, data collection and pilot projects.
Lack of information among investors on potential low carbon technology market	Establish a specialized information system for market and investors.
Lack of information and awareness among governmental organization, private companies and the public on the benefits of energy efficient technologies	Develop awareness raising campaign to keep different stakeholders informed of the potential technology market and the benefits of the energy efficiency and energy saving technologies. Organize TV and radio programs and advertising campaigns (public relation).

7. Implementation Plan for Technology Transfer

To enhance the technology transfer program and include environmentally sound technologies for the energy sector, the following activities need to be carried out:

- Further identification of needs for advanced and new technologies and energy service utilities, which might be required to adopt those technologies. Assessment of institutional capacity on national level to run and manage environmentally solid technology transfer program.
- Development of an integrated renewable energy inventory database by Ministry of Energy and Mineral Resources in collaboration with the Ministry of Agriculture, the Ministry of Forestry and BPPT.
- Design of an action plan for technology transfer in the energy sector to be integrated in National Energy Development Plan and National Electricity Development Plan
- Initiation of a feasibility study for a pilot/ demonstration project by energy utilities and the private sector

2.2. TRANSPORTATION

1. State of Sector Development

Transportation is one of the most important issues in the modern age. In Indonesia, the dominant mode of transportation is land transportation, mostly by motorized vehicles. The transportation sector is the biggest consumer of primary energy in Indonesia. In 2005 transportation means consumed 48.0% of the country's primary energy while the industrial, household and power sectors consumed 21.9%, 19.1%, and 11.0%, respectively. Land-based transportation consumes the highest share of primary energy in the country, in total 47.5%, whereas non-land transportation (by air and sea) needs only 0.5% of Indonesia's total primary energy.

Passenger cars dominate the energy consumption at 36%, followed by trucks, buses, and motorcycles at 32%, 19%, and 13% respectively (Figure 2.9). Exhaust gases and pollutants from motorized vehicles are one of the major sources of air pollution in urban areas in Indonesia and affect public health badly.

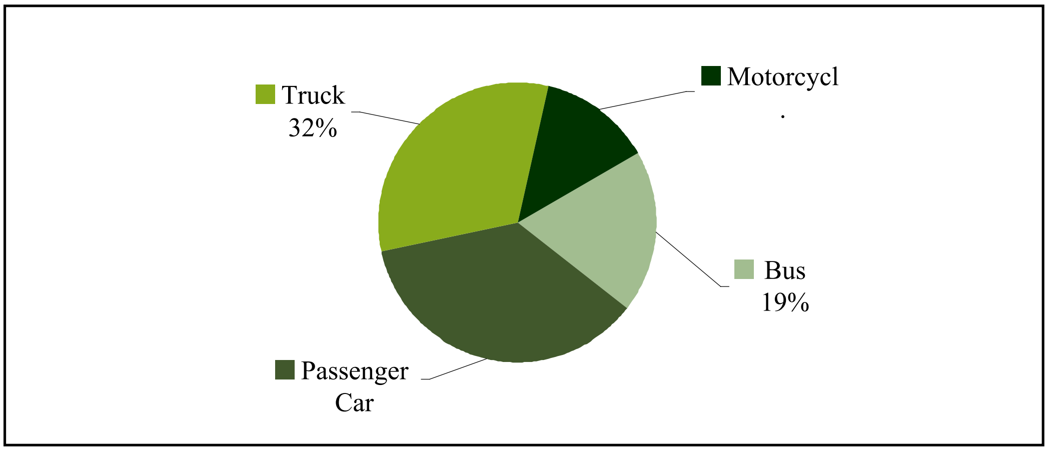


Figure 2.9: Primary Energy Consumption by Mode of Road Transportation, 2005

According to research results of the Environment Protection Agency in 2005, in cities such as Jakarta, Bandung, Semarang and Surabaya – all on Java island – motorized vehicles are the main source of air pollution. The transportation sector contributes 98.8% of total GHG emissions in Jakarta, including 73.4% of released nitrogen oxides (NO_x) and 88.9% of released hydrocarbons (HC). The use of leaded gasoline by most of the vehicles contributes to air pollution and has a pejorative affect on public health.

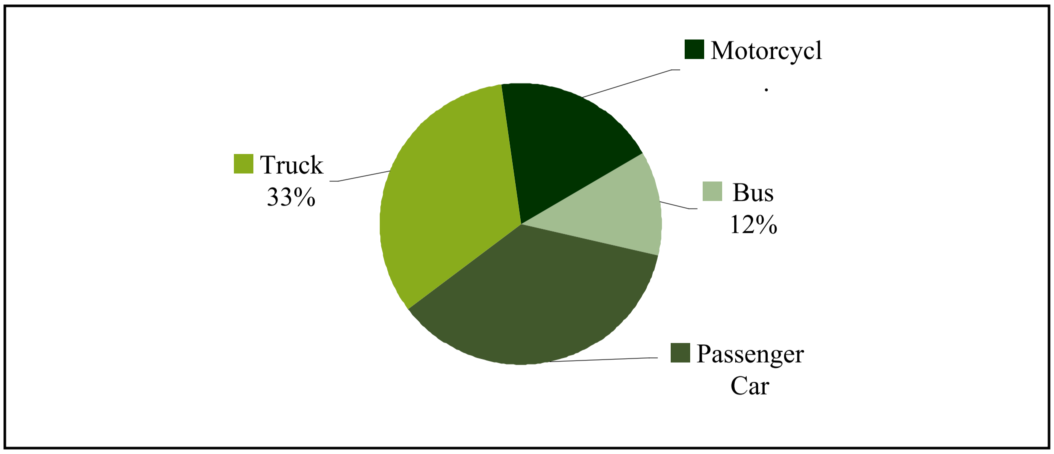


Figure 2.10: CO_2 Emissions by Mode of Road Transportation, 2007

2. GHG Emissions Inventory

The quantity of vehicles used for road transportation in Indonesia is shown per mode of transportation in Figure 2.11. The number of motorcycles is the highest, compared to other vehicles. The ease in purchasing a motorcycle in Indonesia, the comparatively low price, and low fuel consumption has enticed many people to use motorcycles. During 2000 - 2007 the number of vehicles grew significantly, in particular the number of motorcycles (250%) and cars (90%). Meanwhile the amount of buses and trucks grew less fast compared to motorcycles and cars. In average the number of vehicles grew by 12% per year during that period. In 2025, motorcycle numbers are predicted to reach more than 60million units. Cars will rank second at a number of 23.7million units in 2025, while trucks and buses rank third and fourth, respectively.

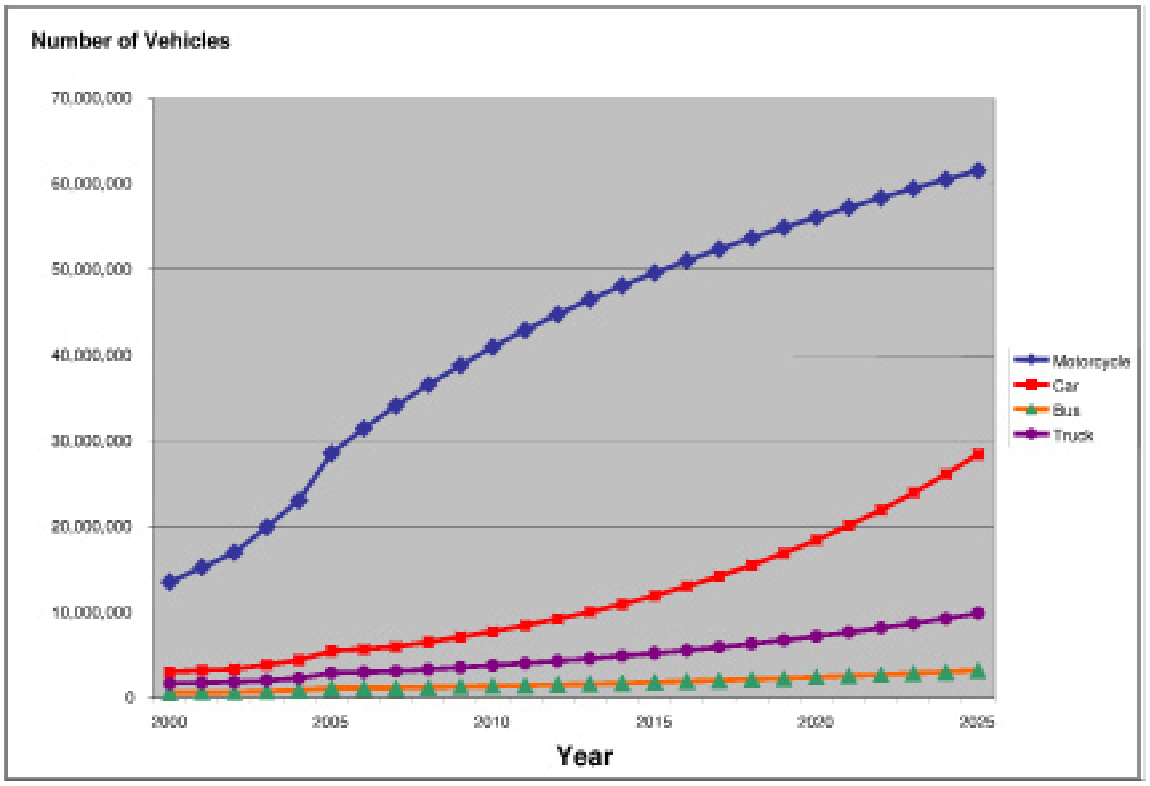


Figure 2.11: Projected Quantity of Vehicles by Mode of Road Transportation, 2000-2025

The quantity of vehicles and CO_2 emissions from the transportation sector increased significantly in the period of 2000 – 2007 (Table 2.9). In 2000 CO_2 emissions were estimated with approximately 40 million tonnes CO_2. In 2007 the amount of GHG emissions counted already double the amount of 2000, with up to 80million tonnes CO_2. The rapid emissions growth resulted primarily from cars and trucks. GHG emissions from motorcycles also grew in high pace due to the rapidly growing number of motorcycles.

Table 2.9: Quantity of Vehicles and CO_2 Emissions by Mode of Road Transportation 2000 - 2007

Year	Motorcycle		Car		Bus		Truck	
	Units	Tonnes CO_2	Units	Tonnes CO_2	Units	Tonnes CO_2	Units	Tonnes CO_2
2000	13,563,020	6,034,691	3,038,913	14,528,401	666,280	5,461,729	1,707,134	14,227,982
2001	15,275,070	6,796,446	3,261,807	15,594,010	687,770	5,637,890	1,759,547	14,664,814
2002	17,002,140	7,564,883	3,403,433	16,271,094	714,222	5,854,726	1,865,398	15,547,021
2003	19,976,380	8,888,233	3,885,228	18,574,454	798,079	6,542,131	2,047,022	17,060,753
2004	23,055,830	10,258,395	4,464,281	21,342,784	933,199	7,649,757	2,315,779	19,300,689
2005	28,556,500	12,705,847	5,494,034	26,265,815	1,184,918	9,713,185	2,920,828	24,343,425
2006	31,463,480	13,999,271	5,716,421	27,329,000	1,186,479	9,725,981	3,015,784	25,134,828
2007	34,094,730	15,170,011	5,992,350	28,648,158	1,188,416	9,741,860	3,133,602	26,116,774

GHG emissions from the transportation sector are predicted to grow even further during the next 20 years due to the growing number of vehicles. Total CO_2 emission from road-based transportation will reach 270million ton CO_2 in 2025. More than 50% of these emissions will be generated by passenger cars, 30% by trucks and the rest by motorcycles and buses.

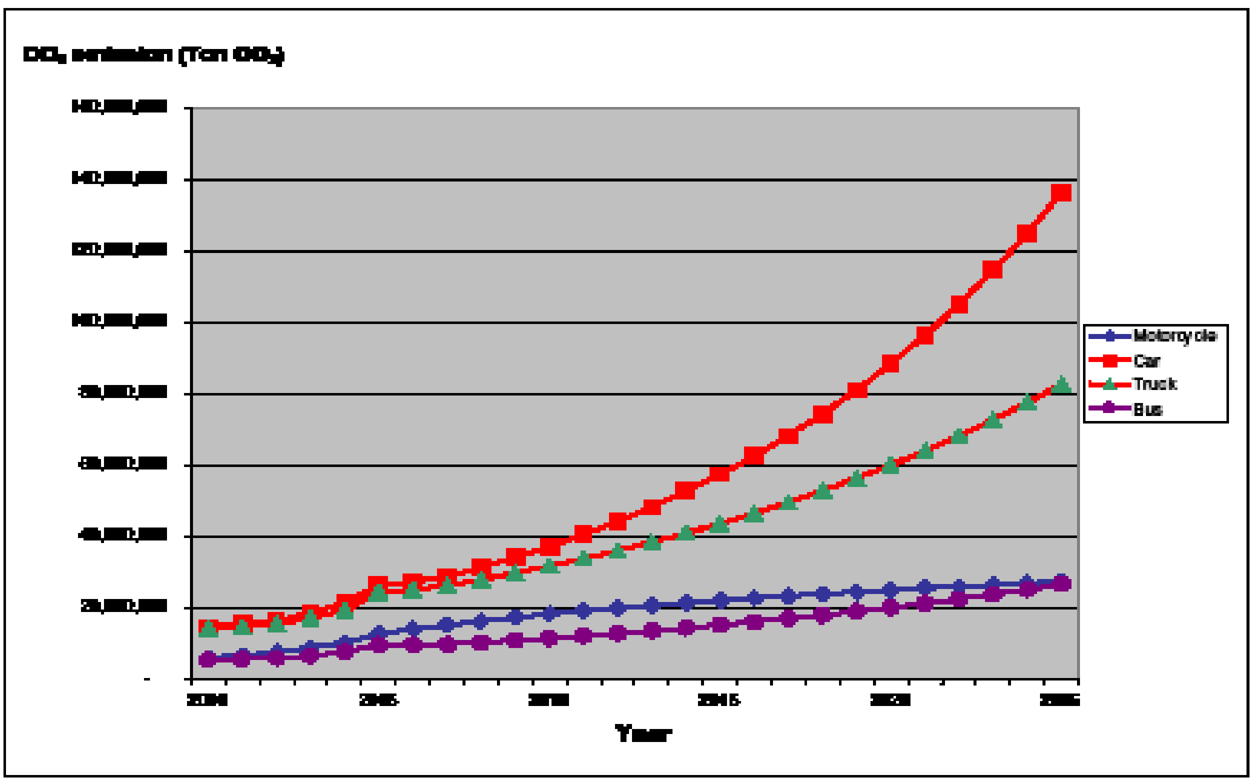


Figure 2.12: Projected CO_2 Emissions by Mode of Road Transportation, 2000-2025

3. GHG Emissions Mitigation Strategy

In Indonesia road transportation vehicles are commonly fueled by gasoline and diesel fuel; diesel-fueled and electric-powered trains for rail transport, diesel-fueled vessels for maritime transport, and gas-fueled aircrafts for air transport. Road transport potentially emits more gaseous emissions into the atmosphere especially in the metropolitan cities, so the use of low emission vehicles and the implementation of effective and efficient traffic management and systems could be envisaged and assessed.

GHGs emission emitted from motorized transport vehicles are determined by three main factors: engine technology, type of fuel used, and engine running condition. Engine technology determined the effectiveness of energy transformation and conversion inside the engine system. The types of fuel define the efficiency and type of combustion gases. Engine running condition defines how good combustion quality is taking place, and in turn it will define the types of combustion gases that release GHG emissions.

Land transport with small and medium power engine generally use gasoline-fueled and diesel-fueled motor engines. Transport fleets with small power engines used in Indonesia like motorcycles, city transport cars, and private cars, generally use gasoline engines and diesel engines. Transport fleets with medium power engines like buses, minibuses, and trucks, are generally run by diesel engines. Mitigation of GHG emissions from the transportation sector, in particular from motorized vehicles can be achieved through the introduction of technologies, systems and measures, as follows:

a. Use of advanced vehicle materials, control systems and engine technology
Advanced vehicle materials involve lightweight materials for body and structure to reduce the weight of vehicles as well as to improve their aerodynamics, both leading to a reduction of fuel consumption. The regular efficiency improvement of current combustion engines, as achieved by the vehicle producers, is assumed to reduce fuel consumption by 1% per year for all vehicles, including motorcycles.

Advanced control systems such as econometers, adaptive cruise control, and transmission technologies like continuous variable transmission (CVT) and 6-speed automatic transmission improve the efficiency of engines and reduce fuel consumption. Technologies such as gasoline direct injection and no-torque converters also lead to an engine efficiency increase and to reduced fuel consumption. Those technologies are available in the market and can be used by manufacturers.

For passenger cars, hybrid vehicle technology is proposed to reduce CO_2 emission. Whereas, for buses and trucks bi-fuel vehicles, which run either on gasoline/ diesel or on CNG, are considered as GHG emissions mitigation options. Electric engines technology is also available in the market, including more reliable battery systems to support the existing engines. However, the infrastructure to support electric vehicles on large scale is still limited. Hydrogen car are not yet commercially available. But fuel cell technology has been tested and might be commercially available in the near future.

b. Use of alternative fuels
For conventional combustion engines a substitution of fossil fuels, which are used to run the vehicle, could reduce GHG emissions. Examples for such a substitution are fossil fuel based energy sources such as compressed natural gas (CNG), which are cleaner alternatives to conventional gasoline. The GHG emissions mitigation potential is dependant on the engine design. But compared to conventional gasoline the use of CNG can lead to a reduction of emissions of up to 90% - 97% of carbon monoxide, 25% carbon dioxide, 35% - 60% of nitrogen oxide; 50% - 75% non-methane hydrocarbon.

Liquid alternative fuel options include ethanol, biodiesel and cellulosic ethanol, which can be used for the production of up to E-85 biofuel (a blend of 85% of ethanol and 15% gasoline). These fuel types will reduce the amount of GHG emissions of vehicles. Other technologies and engines such as hydrogen, fuel cells, electric cars run by battery and plug-in hybrids might be commercially available in the near future. More information on fuel technology and engines is available in the full report of the Transportation Sector TNA.

c. Transport Demand Management

The improvement of the transportation management system, including an application of intelligent transportation systems (ITS), is assumed to reduce the fuel consumption of all vehicles by 15% per year. The term intelligent transportation system (ITS) refers to efforts to add information and communication technology to transport infrastructure and vehicles in an effort to manage factors, which are typically at odds with each other. Examples for the latter are vehicles, loads and routes, which need to be managed more efficienctly to improve safety and to reduce vehicle wear, transportation times and fuel consumption. An interest in ITS results from the problems caused by traffic congestion and a synergy of new information technology for simulation, real-time control and communications networks. Traffic congestion has been increasing worldwide as a result of increased motorization, urbanization, population growth and changes in population density. Congestion reduces the efficiency of transportation infrastructure and increases travel time, air pollution and fuel consumption.

The improvement of public transport systems by coordinating schedules of buses and trains on long journeys will reduce the travel time of passengers. A reduced travel time can also be achieved by an increase of the frequency of urban busses and the introduction of smaller busses for poor serviced areas.

The modal mix travel, i.e. travelling by different travel modes, can have large impacts on the energy use, in particular in urban and sub-urban areas. To encourage multi-modal shift, an integrated infrastructure of non-motorized and public transport systems and regulations to discourage the use of private cars should be in place. An improvement can be achieved by the combination of several approaches:

- Bus Rapid Transit (BRT) system;
- Mass Rapid Transit (MRT) system;
- Bicycle lines and walking corridors;
- Road pricing and congestion pricing.

d. Non-Motorized Measure

The promotion of non-motorized vehicles in urban/ city centers and residential areas bears the potential to reduce the demand for motorized vehicles, which will help to reduce GHG emissions from combustion. Non-motorized vehicles are available in Indonesia such as cycling rickshaw (becak), horse cart (bendi/ dokar) and bicycle. Such promotion of these non-motorized measures needs to be supported by policies, regulations and urban planning.

4. GHG Emissions Mitigation Strategy

Regarding GHG emissions reduction and the calculation of the reduction potential, three scenarios are assessed:

- Using advanced engines for motorcycles, cars, trucks and buses;
- Imposing Transport Demand Management; and
- Combining measures 1 and 2.

Motorcycle scenario - In 2025 27.5million ton CO_2 emissions will be generated. The implementation of TDM and the deployment of advanced engines with a higher efficiency of fuel consumption and less exhaust emissions will reduce CO_2 emissions by up to 20% in 2025 compared to Business-as-Usual (BAU).
Passenger car scenario - An optimistic prediction for 2025 calculates a CO_2 emissions reduction potential

of up to 12.8% from BAU. The strategy to achieve such high emission reduction consists mainly of plans for the deployment of hybrid vehicles starting from now on. Implementing TDM and deploying new engines will result in a 30% GHG emissions reduction in the same year compared to BAU.

Bus and truck scenario – It is planed to reduce CO_2 emissions from buses and trucks by using bi-fuel vehicles, which run on gasoline/diesel or CNG. In 2025, the implementation of the aforementioned scenario can reduce CO_2 emissions by 36.1%.

5. Criteria for Technology Selection

In order to select environmentally sound technologies, general and specific criteria were developed. The applied general criteria are similar for every sector (Table 2.9). The specific criteria reflect the uniqueness of the transportation sector (Table 2.10).

Table 2.10: Specific Criteria for Technology Selection – Transportation Sector

Specific Criteria	Sub-Criteria
a. Consistency with national policy & target and specific local situation	• Relevant to existing energy policy & target (EP) • Utilization of local energy resources (LER)
b. Economics and cost-effectives of technology	• Total capital cost (TC) • Internal Rate of Return (IRR) • Payback period (PR) • Abatement cost (AC)
c. Technology development	• Advance but proven technology (AD) • Possibility for local manufacturing & production (PLB)
d. Social acceptability	• Good impact for socio-economic development (LED)

5. Technologies Selected

Technologies selected to mitigate GHG emissions from the transportation sector can be divided into four categories: advanced material & engine technology, alternative fuel use, transport demand management and non-motorized measures.

a. Use of advanced vehicle materials, control systems and engine technology

Vehicle technology is selected based upon its potential for fuel saving as presented in the table below. The implementation of advanced technology in vehicles could lead to fuel saving between 3% and 7%. The application of hybrid engine technology results in higher fuel saving of 30% to 40%.

Table 2.11: Energy Conservation Potential of various Vehicle Technologies

Technology	Fuel savings	Cost
	(%)	(US$)
Gasoline direct injection (DI)	3 – 4	125 – 175
6-speed automatic transmission	4 – 5	100 – 500
Continuously variable transmission (small cars)	~ 7	150 – 200
No-torque converter	3 – 4	N.A.
Hybrid vehicles without torque converter	30 – 40	3,000 – 5,000

b. Alternative fuel technology

The selected types of alternative fuel are listed in Table 2.12. In the short-term, the substitution of fossil fuels with alternative fuel will reduce GHG emissions from engines. Switching from gasoline to CNG is the fastest realizable option, for which a modification of engine fuel storage and the combustion system is needed. Still the infrastructure for CNG needs to be built. Biofuels such as ethanol and biodiesel can replace gasoline and diesel oil. Biofuels have the potential to reduce the use of petroleum-based fuel by up to 10% over the next 10 years. However, biofuels supply remains a challenge, as well as the environmental impact of biofuel production, which still needs to be resolved. The use of cellulosic ethanol might lead to high GHG emission reductions, if the technology is once matured and commercially available.

Table 2.12: CO_2 Emissions Reduction Potential of Alternative Fuels in Transportation Sector

Technology	Potential CO_2 Reduction
Cellulosic Ethanol	90% of BAU scenario
Biodiesel Fuel	70% of BAU scenario
Ethanol from Sugar cane	60% of BAU scenario
CNG	30% of BAU scenario
LNG	20% of BAU scenario
LPG	20% of BAU scenario

Transfer of technology is needed for the more efficient production of first- and second generation biofuels. It is needed for the development of technologies applying biofuels such as spark ignition engines with flexible fuel capability and compression ignition engines.

c. Transport Demand Management

Technologies selected for the transportation sector are integrated public transport systems and the use of intelligent transport systems. Both technologies are needed and suitable for cities in Indonesia. Implementation of both measures may reduce time of travel, fuel consumption and congestion.

d. Non-motorized measures

Non-motorized measures can be integrated and support multi-modal transport systems in particularly in urban areas. For non-motorized measures, transfer of technology is not necessary, since the technologies are simple and already available.

Table 2.13: Selected Technologies/ Measures – Transportation Sector

Technology Name	Mitigation Measures	Cost
1. Vehicle Technology		
Fuel cell technology	Fuel efficient operation of car	3,000 – 5,000US$/car
Lightweight material	Improve fuel economy (4% - 8% savings)	200 – 500US$/car
Gasoline direct injection (GDI)	High fuel efficiency (3% - 4% savings)/ low GHG emissions load	125 – 175US$/car
Continuously Variable Transmission (CVT)	10% - 15% gain over manual transmission	150 – 200US$/car
2. Alternative Fuel		
LPG	Reduce damage to ozone layer	0.350US$/kg

Technology Name	Mitigation Measures	Cost
LNG	Low emissions/ Energy density 60% lower than diesel	0.500US$/kg
Biodiesel fuel	Low emissions/ Non-petroleum based fuel	0.500US$/liter
CNG	Low emissions/ Energy density 25% lower than diesel/ Mostly for bus and truck	0.155US$/kg
3. Transport Demand Management (TDM)		
Improvement of public transport	Lower cost per km per passenger/ Less fuel consumption/ Reduced traffic congestion	10mio US$/corridor
Intelligent Transportation System (ITS)	Improved travel time/ Less cost/ Less fuel consumption	978mio US$ per 600 km^2 (the whole system)
4. Non-motorized system		
Bicycle	Zero emission (human-powered)	100US$/bicycle for 1 person
Tricycle	Zero emission (human-powered)	400US$/tricycle for 3 persons
Cart	Zero emission (horse-powered)	1,000US$/cart for 5 persons
Walking	Zero emission (human-powered)	No cost

6. Barriers and Policy Needs for Technology Transfer

The process of transfer and deployment of environmentally sound technologies faces institutional, economics, financial and social barriers. Institutional barriers such as weak regulatory mechanisms to enforce regulations and standards became a main issue. Moreover, difficulties in policy coordination among government agencies complicate the establishment of effective climate change-related policies, which are essential to set up a technology deployment and -transfer framework. Table 2.14 lists the barriers, policies and actions, which are needed for the deployment and transfer of environmentally sound transportation technology.

Table 2.14: Barriers and Policy & Action Needs – Transportation Sector

Identified Barrier	Policy and Action Need
Institutional and Policy	
Insufficient long-term policy, regulation and target	Set clear long-term policy and target on efficient transportation systems and technologies based on long-term economic objectives, technology maturity and resources availability.
Insufficient operational policy	Develop and implement detailed operational policies, which support projects on new efficient transportation systems and technologies.
Insufficient inter-agency policies and measures	Develop effective coordination mechanism between the National Transportation Committee (DTN), the National Council for Climate Change (DNPI) and key sector agencies and ministries.

Identified Barrier	Policy and Action Need
Lack of environmental mandate policies and regulations	Develop policies and regulations, which encourage the domestic industry to produce efficient transportation systems and technologies.
Economic, Investment and Market	
Limited public financial resources	Improving investment climate for the private sector, actively looking for grants and technical assistance for R&D, and pilot projects.
Poor investment climate	Create an environment for private investment.
Limited financial instruments and incentive mechanism for efficient transportation systems and technologies	Create a Public Transportation Fund. Establish a Public Transportation Service Company (PTSCO) under the local government.
Unpredictable economic losses/ benefits of new technologies	Establish a set of parameters to assess the investment cost of each technology, such as: cost of capital, internal rate of return, payback period, etc. and secure package; to minimize the risk of investment into transportation systems and technology.
Fuel prices do not reflect true cost of production, resource availability and externalities	Develop and implement fuel price policies, which reflect the cost of production and fuel supply. Create effective and well-targeted subsidy mechanisms for the low income/ poor user, and students.
Human Resources and Industrial Support	
Lack of skilled workers and professionals for new transportation systems and technologies.	Organize a series of trainings on new transportation systems and technologies. Bring the topic of efficient transportation systems and technologies into the curriculum of science and engineering studies at universities.
Limited base of transportation industry and local service providers	Enhance cooperation and technical assistance on transportation systems and technologies between Indonesia and particular countries. Develop transportation systems and technologies pilot projects.
Limited R&D on GHG emissions mitigation measures both for conventional and new transportation technologies.	Enhance the cooperation on R&D for new and advanced technologies between Indonesia and other countries/ institutions. Pursue s joint research project with potential for industrial application.
Information and Awareness	
Limited database on efficient and effective transportation systems and technologies	Establish a database (enhance measurement and analysis, support data collection) and introduce pilot projects.
Lack of information among investors on potential transportation systems and technologies application	Establish a specialized information system for market and investors.
Lack of information and awareness among governmental organizations, private companies and the public on the benefits of efficient transportation systems and technologies	Develop an awareness raising campaign to keep different stakeholders informed about the potential technology market and the benefits of efficient transportation systems and technologies. Organize TV and radio programs and advertising campaigns (public relation).

The enhancement of the deployment of environmentally sound technology in Indonesia's transportation sector needs strong policies and measures from the related sector and key institutions. This involves ministries, environmental agencies, which are responsible for environmental standards such as air quality standard, and local authorities (city or district government), which are responsible for spatial and transportation system planning at the local level.

There are many parties involved in the development of a low carbon development strategy for the transportation sector, including the key stakeholders:

Table 2.15: Key Stakeholders for Climate Change Mitigation in Transportation Sector

Key stakeholder	
1. Central Government	• Ministry of Energy and Mineral Resources
	• Ministry of Communication/Transportation
	• Ministry of Finance
	• Ministry of Industry and Trade
	• Ministry of Environment
	• Ministry of Labor and Transmigration
	• Oil and Gas Executing Body for Upstream Activity
	• Oil and Gas Authorizing Body for Downstream Activity
2. Local Government	• Office of Traffic and Land Transportation
	• Local Environmental Impact Management Agency
3. Natural Gas Producer/ CNG Filling Station Owner	• PT. Pertamina (National Oil Company)
	• PT. PGN (National Gas Company)
	• CNG Filling Station Owner
4. Private sector/engine and vehicle manufacture	

These key stakeholders need to collaborate to overcome the identified barriers and to enhance the transfer and deployment of environmentally sound technologies in the Indonesian transportation sector.

7. Implementation Plan for Technology Transfer

Environmentally sound transportation technologies and policies play a major role in promoting economic development, while minimizing the local costs of traffic congestion, road accidents and air pollution. Programmes towards environmentally sound transportation involving advanced vehicle technologies, alternative fuels, transport demand systems and non-motorized solutions offer long-term global climate benefits in tandem with immediate improvements in local air quality.

Hybrid vehicles, powered flexibly by gasoline/ diesel and electricity, and vehicles running on bio-fuel or bi-fuel (CNG) emit low amounts of GHG. Their implementation needs investment, intense assessment and careful planning though. But they are already used in other countries. Furthermore, conventional vehicles could run with mixed, less carbon intense fuels, i.e. mixing between gasoline/diesel and 10% of bio-ethanol or 5% of bio-diesel. Thus by introducing and using mixed fuels in conventional vehicles in the short-term, an adoption of new technology e.g. hybrid vehicles becomes less urgent. Bi-fuel vehicle technology has been partly introduced and used in Indonesia already, but needs further assessment as to which systems are suitable for Indonesia.
Fuel switching and alternative fuels such as solar energy, propane (LPG), CNG, ethanol and methanol can substitute carbon intense diesel as an energy source for vehicles and help to reduce GHG emissions. They could also be applied in the public transport as a pilot project for thoughtful application.

The improvement of public transport systems is one of the alternatives for GHG emissions mitigation measures, which is urgent.

2.3. INDUSTRY

1. State of Sector Development

Based on the "Statistics of Large and Medium Industry" (Badan Pusat Statistik), the total number of national large and medium sized industries was about 21,000 units in 2006 throughout Indonesia. The growth of the industry sector goes parallel to the growth of the national economy.

Most industrial activities are drawn on fossil fuels, which are used for electricity and heat production and as feedstock in industrial processes such as natural gas for the Fertilizer industry, coal for the Steel industry and kerosene and gasoline for the Chemical industry. Based on the "Handbook of Energy and Economic Statistics of Indonesia" (Ministry of Energy and Mineral Resources), the industry sector's share of total commercial final energy consumption in Indonesia is about 53% (including feedstock for industrial processes), or about 47%, if the natural gas utilization for feedstock of the fertilizer production process is not included.

Generally, energy utilization in the Indonesian industry sector is not yet as efficient in average as in other countries, because aged technologies are still applied in the industry sub-sectors. Due to the high commercial energy consumption in the industry sector and the relatively low efficiency of energy utilization, it is necessary to analyze the potential for energy conservation per industry sub-sector and to find options for technology improvement in terms of efficiency and productivity.

2. GHG Emissions Inventory

Based on energy demand projections GHG emissions were calculated using IPCC methodology. Please see the full Industry Sector TNA report for a detailed presentation of methodology, assumptions and energy demand projections.

The figure below shows the calculated CO_2 emissions of Indonesia's industry sector in 2005, which counted round 110million tonnes CO_2. The highest share of the industry sector's GHG emissions was produced by three energy intensive industry sub-sectors: Cement & Non-Metallic Minerals, Pulp & Paper, and Iron & Steel.

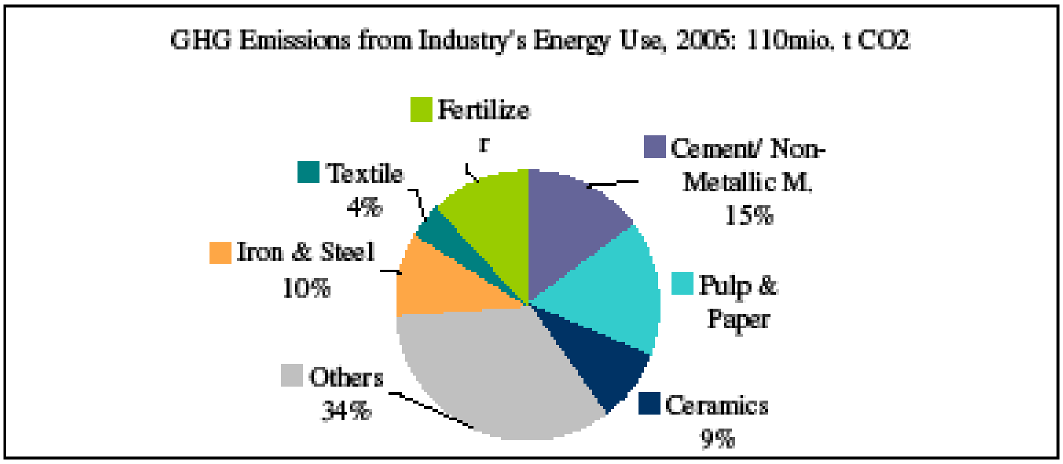


Figure 2.13: GHG Emissions from Energy Use of Indonesian Industry Sector, 2005

In addition to GHG emissions released from energy use, GHG were also emitted during the industrial processes of clinker (Cement industry), ammonia (Fertilizer industry) and steel (Iron & Steel industry) production. Total GHG emissions of industrial processes in these three industry sub-sectors were estimated with 23.06million tonnes CO_2 in 2006. The share of each of the three industry sub-sectors is depicted in the following figure. It shows that clinker production is responsible for the largest share of GHG emissions, while steel production can be accounted for the smallest share.

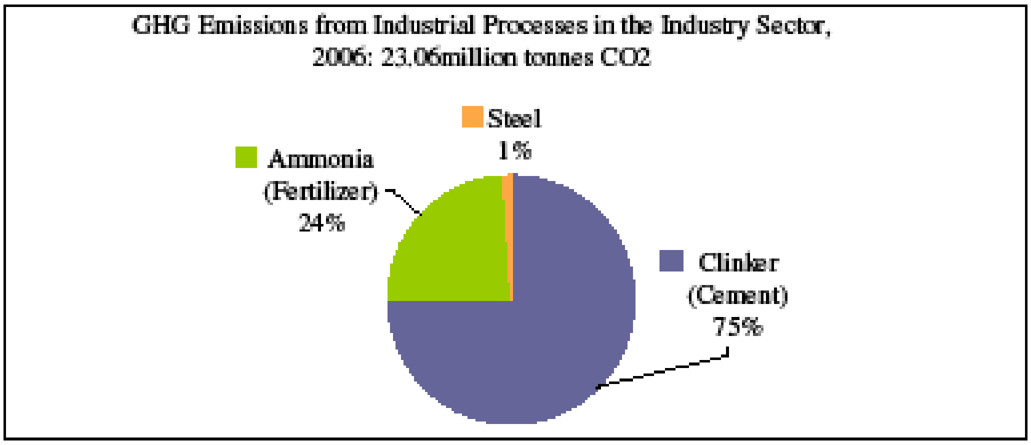


Figure 2.14: GHG Emissions from Industrial Processes of Indonesian Industry Sector, 2006

3. GHG Emissions Mitigation Strategy

The analysis of potential GHG mitigation in the Indonesian industry sector is conducted by establishing two energy demand projection scenarios, i.e. the Business as Usual (BAU) scenario and the improved energy efficiency and energy diversification (EFFICIENT) scenario.

Energy Use - Under BAU, the energy demand will develop according to the 2006 (base year) pattern until 2025. Any effort to reduce energy consumption, such as improved efficiency or the implementation of demand side management and energy diversification, are not considered and excluded from this scenario. Energy demand of various industry sub-sectors is expected to increase and to follow their production capacity growth. (Calculated figures do not involve natural gas used as feedstock in the Fertilizer industry or coal used as a reducing agent in the Steel industry. Both will be discussed in the industrial process section. Fuel demand for captive power generation and for vehicles in the industry sector is also excluded from the estimations and will be discussed in the Energy- and Transport Sector TNA instead.)

The EFFICIENT scenario considers existing opportunities for implementing energy conservation activities, environmentally sound technology and energy diversification in the Indonesian industry sector. The potential a certain technology bears, to make a production process more efficient and optimize energy use, depends on the state of advancement of an industry sub-sector particularly on the technology, which is currently in use. The review of the condition of technology used in Indonesia will be limited to those energy intensive industry sub-sectors, which technology examples are provided for. Generally, technologies to reduce GHG emissions from the industry sector can be grouped as follows:

- **Energy efficiency -** Improve energy efficiency of current boiler, furnace, motor drives, and captive power technologies:
    - Electrical facilities: lighting, water facilities, loads, receiving and distribution systems, air compressors;
    - Heat facilities: heat insulation, steam system, combustion and flue gas, exhaust gas heat recovery; and
    - Utility facilities: heat pump system, cogeneration system, air conditioning, upgrading and process improvement.

- **Fuel switching/ alternative fuels -** Substitute refinery products by fuels with a lower emission factor such as biomass fuels
- **Recycling** - Recycling is the best-documented material efficiency option for the industry sector
- Introduce new technology concepts with lower GHG emissions

***Industrial Processes* -** In some industry sub-sectors, GHG emissions are not only produced from energy use but also during industrial processes or from raw material. Currently, information on industrial process types and commodity utilization is limited. Accurate information is available about natural gas used as feedstock/ raw material for ammonia production in the Fertilizer industry and coal used as a reducing agent in the Iron & Steel industry. In addition, there is information on clinker production in Cement industry. Compared to other industry sub-sectors, the GHG emissions from industrial processes of the three mentioned industrial sub-sectors are relatively high.

Cement Industry
The Cement industry belongs to the energy intensive industry sub-sectors, utilizing fossil fuels for energy use and during industrial production processes. In 2007 nine cement companies with a total capacity of 47.47million tonnes cement operated in Indonesia. The average cement demand per capita was 157.77kg cement/person per year. Cement consumption will raise continuously in relation to the national economy growth, which is assumed with 6.5%/year through 2025. Hence, the cement demand per capita will increase up to 170.86 kg/person per year until 2025.

The following figure shows the GHG emissions reduction scenario (EFFICIENT) for Cement industry. By installing measures and technologies for energy efficiency improvement, alternative fuel use, product change such as cement blending and recycling, Cement industry's GHG emissions can be gradually reduced by 17.41% until 2025 compared to BAU scenario.

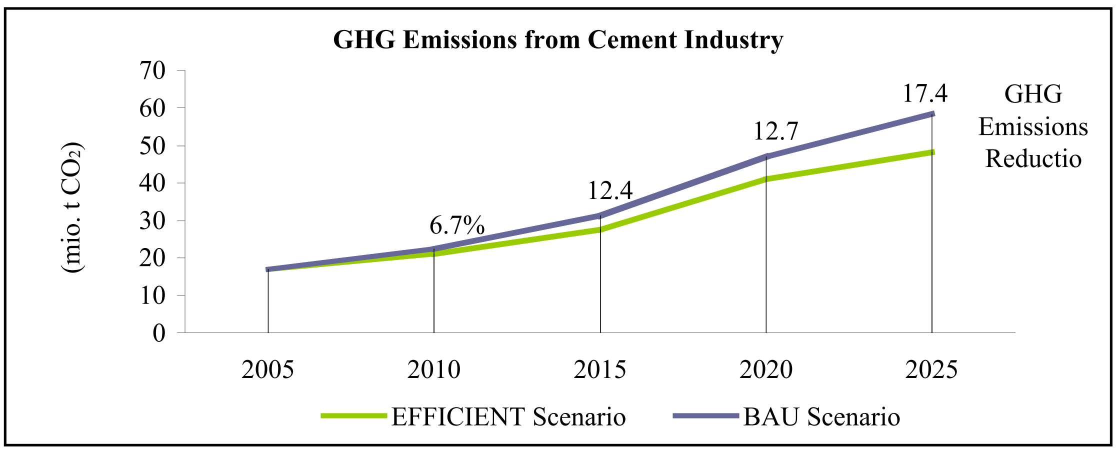


Figure 2.15: Projection of GHG Emissions from Indonesian Cement Industry, 2005 - 2025

Iron & Steel Industry
The steel industry belongs to the energy intensive industry sub-sectors, utilizing fossil fuels for energy use and as reducing agents in the industrial production process. The World Steel Association ranked Indonesia as the 37th among the world's major steel producing countries in 2007. Currently there are 71 Iron & Steel plants operating in Indonesia, having a production capacity of 15.4million tonnes/year (2007). According to the Ministry of Industry most Iron & Steel producing companies have not yet implemented energy efficiency measures in their production lines; therefore bearing a significant optimization potential.

The following figure shows the GHG emissions reduction scenario (EFFICIENT) for Iron & Steel industry. By requiring energy audits and in the following introducing measures and technologies such as energy management systems and other energy efficiency improvements, alternative fuel use and recycling, Iron & Steel industry's GHG emissions will be gradually reduced to 15.36% compared to BAU scenario.

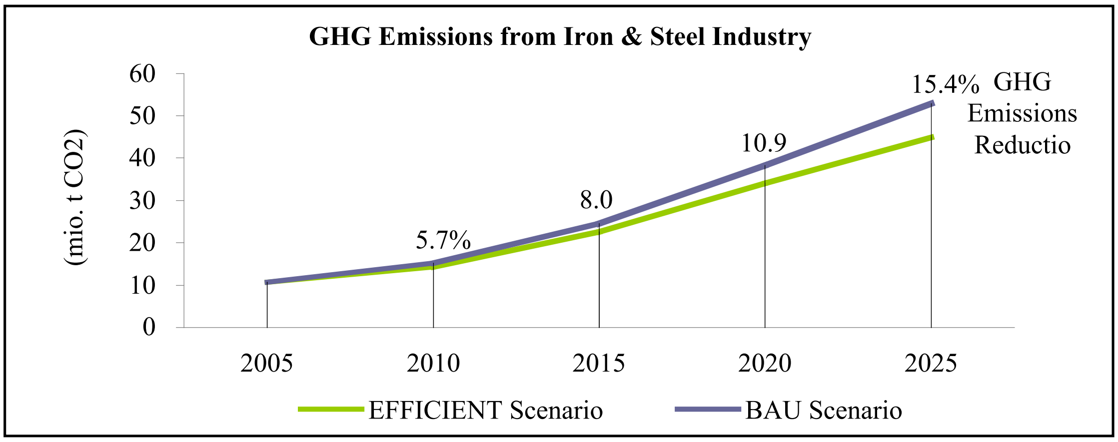


Figure 2.16: Prijection of GHG Emissions From Indonesia Iron & Steel Industry, 2005 - 20025

Pulp & Paper Industry

Pulp & Paper production is a highly diverse, increasing global industry and belongs to the energy-intense industries. In Indonesia there are 81 Pulp & Paper companies with a total production of 17million tonnes of Pulp & Paper in 2007. According to the Ministry of Industry most Pulp & Paper producing companies have not yet implemented energy efficiency measures in their production lines; therefore bearing a significant optimization potential.

The following figure shows the GHG emissions reduction scenario (EFFICIENT) for Pulp & Paper industry. By installing measures and technologies for energy efficiency improvement, combined heat and power, alternative fuel use and recycling, Pulp & Paper industry's GHG emissions will be gradually reduced by up to 17.52% compared to BAU scenario until 2025.

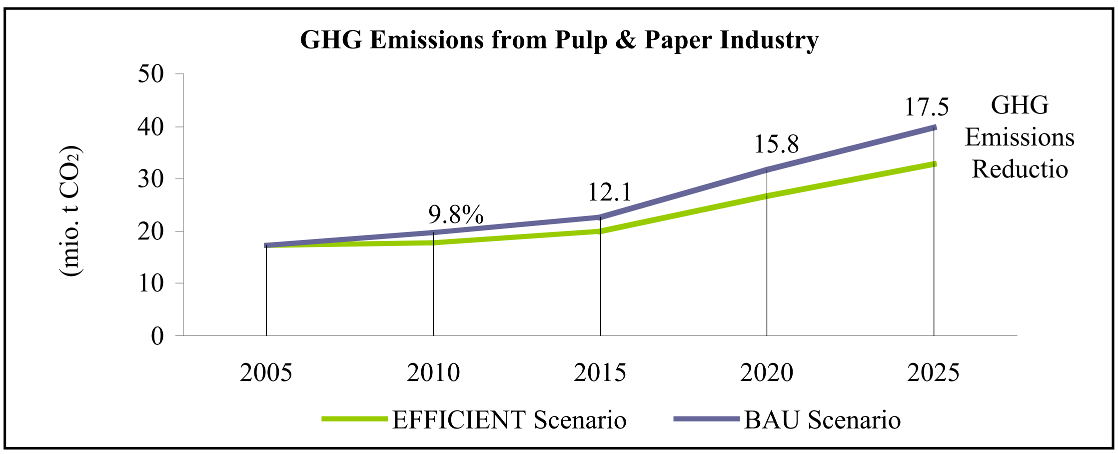


Figure 2.17: Projection of GHG Emissions from Indonesian Pulp & Paper Industry, 2005 - 2025

Furthermore, the Pulp & Paper industry produces large volumes of wastewater, which contain high levels of degradable organics. Besides GHG emissions from energy use, the industrial sub-sector emits therefore also methane (CH_4) from industrial wastewater. Reducing water consumption automatically reduces the fibers that run off into the effluent and hence reduce CH_4 emissions.

Textile Industry

The textile industry belongs to the less energy-intensive industry, but runs one of the longest production chains in manufacturing industry. The fragmentation and heterogeneity of its outputs makes it difficult to classify industrial practices and to compare Indonesian practices with international norms. Products are numerous and depend on the type of fibres used, the density and quality of the thread, the colours and the process being operated. In Indonesia the textile industry ranks among the most important industries due to its size, encompassing more than 2,700 medium- and large-scale textile plants.

The following figure shows the calculation of the GHG emissions reduction scenario (EFFICIENT) for Textile industry. By installing measures and environmentally sound technologies for energy efficiency improvements, introducing energy management systems and using alternative fuels, Textile industry's GHG emissions will be gradually reduced to 27.79% in 2025 compared to BAU scenario.

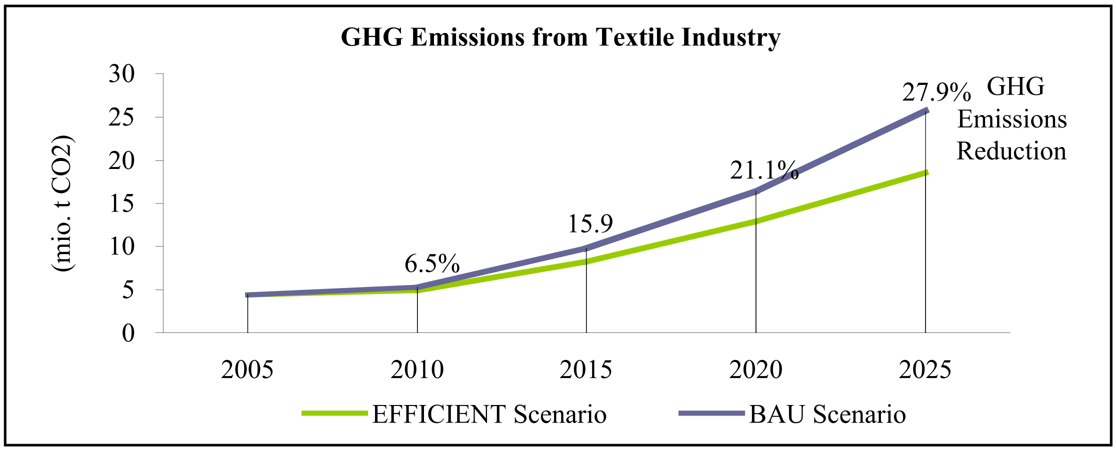


Figure 2.18: Projections of GHG Emissions from Indonesia Texstile Industry, 2005 - 2025

Besides GHG from energy use, the textile industry also releases methane (CH_4) from industrial wastewater of the production process. Mitigation options for GHG emissions from industrial wastewater need to be discussed further.

Potential for GHG Emissions Mitigation

The average energy demand growth during 2006 - 2025 period is estimated with 6.5% per year. Between 2006 – 2025 accumulated GHG emissions under the BAU scenario sum up to 4,453million tonnes CO_2. Energy demand projections under EFFICIENT show that an implementation of the mentioned measures can reduce energy demand by 8,545PJ compared to BAU during 2006 - 2025. The average energy demand growth under EFFICIENT is projected with 6.3% per year. During 2006 – 2025 accumulated GHG emissions under the EFFICIENT scenario sum up to 3,808million tonnes CO_2. This means, that an implementation of energy conservation activities and energy diversification in boilers, furnaces, and motor drives will reduce GHG emissions by 14.49% in 2025.

A comparison of GHG emissions under the BAU- and EFFICIENT scenario is presented in the following figure for various industry sub-sectors. It shows, that the highest GHG emission reduction after the implementation of energy conservation activities and energy diversification can be expected in the Chemical industry (excluding Fertilizer), followed by Fertilizer, Cement, Iron & Steel, and Pulp & Paper industry.

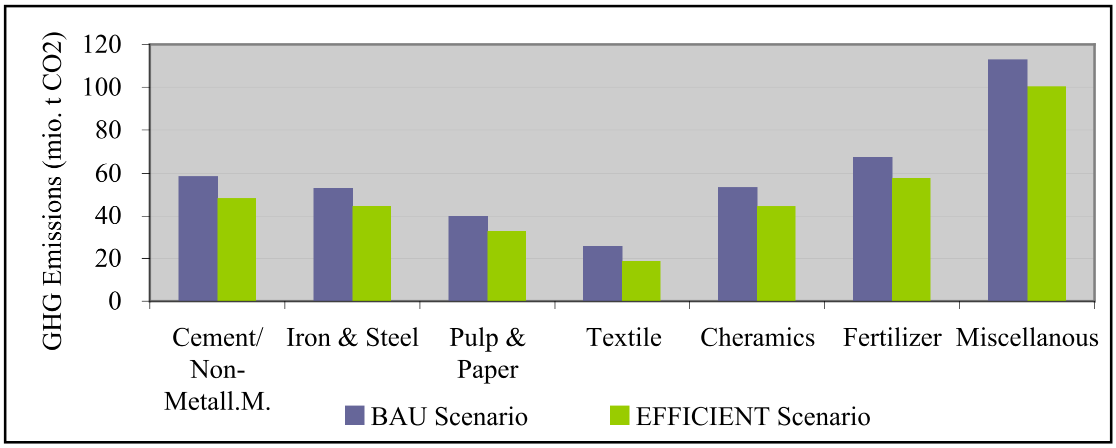


Figure 2.19: Projection of GHG Emissions from Energy Use by Indonesian Industry Sub-Sector, BAU and EFFICIENT in 2025

GHG emissions from industrial processes were analyzed for Cement, Iron & Steel and Fertilizer industry. Under the BAU scenario GHG emissions from industrial processes will increase from 23.1million tonnes CO_2 in 2006 to 36.3million tonnes CO_2 in 2025 - with clinker production contributing 69% to that, followed by natural gas as the fertilizer industry's feedstock contributing 29% and by coal as the Iron & Steel industry's reducing agent contributing 2%.
In 2025 the GHG emissions estimated under the assumptions of the EFFICIENT scenario will count 14% less than GHG emissions under BAU. Cumulative GHG emissions during 2006 – 2025 for BAU- and EFFICIENT scenario will be 567.2million tonnes CO_2 and 500.3million tonnes CO_2, respectively.

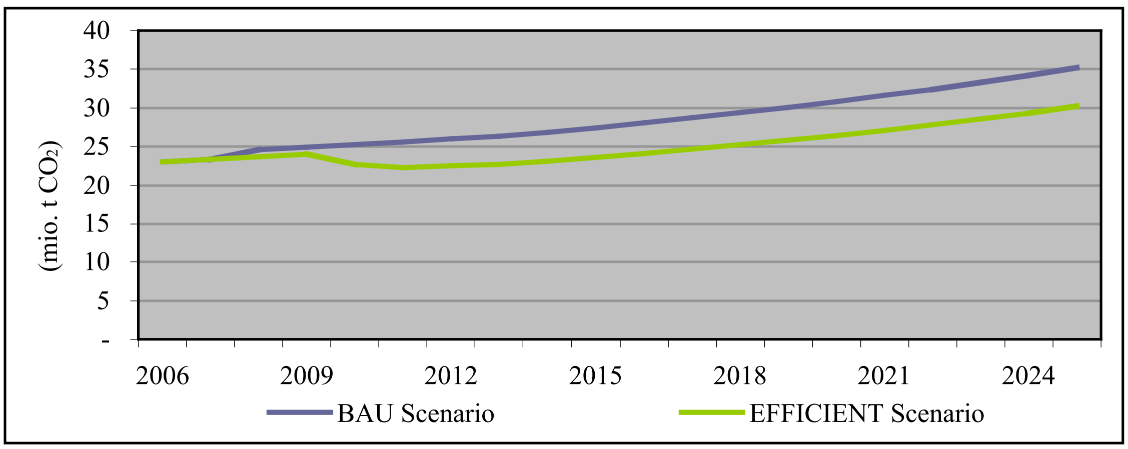


Figure 2.20: Projection of GHG Emissions from Industrial Processes in Indonesia, 2006 - 2025

4. Criteria for Technology Selection

Selection of technology is carried out by applying general and specific criteria on the technology. General and specific criteria are determined by expert group.

The general selection criteria for technology selection in the industry sector are the same as in the other sectors (Table 2.9). Specific selection criteria reflect the priorities and situation of the industry sector as listed below:

Table 2.16: Specific Criteria for Technology Selection – Industry Sector

Specific Criteria	Sub-Criteria
a. Availability in the market	• Possible for local manufacturing and production (LM) • Proven technology (PT) • Minimum dependency on technology owner (DTO)
b. Operation of technology	• Can be operated by the industry itself (CO)
c. Efficiency improvement in production process and consumption	• Efficiency in production process (EPP) • Efficiency in energy consumption (EEC)
d. Technology Application	• Implementation in Indonesia (IMI)

5. Technologies Selected

The selection process, using general and specific criteria in this Industry Sector TNA, is limited to Cement, Iron & Steel and Pulp & Paper industy, due to incomplete information for other industry sub-sectors. In Textile and Sugar industry the prioritization of options follows the recommendations and policies of the Ministry of Industry.

Table 2.17: Selected Technologies/ Measure – Industry Sector/ Cement

No.	First Priority	Second Priority	Third Priority
1.	Use of limestone with low $CaCO_3$.	Alternative fuels	Kiln burner modification
2.	Reducing clinker-to-cement ratio by substituting clinker with materials such as fly ash, etc.	Energy management and process control system	Conversion to grate cooler
3.	Mineral components in Cement (MIC)	Waste heat recovery of cement kiln exhaust gas for raw meal pre-heater	Install meter in every section and "reroute" power cable
4.	Preventative maintenance (insulation, compressed air system, maintenance)	High-efficiency classifiers	Optimization of hydraulic roller crusher
5.	Install variable speed drive	Optimization of compressed air systems	Install vibrating screen cement pre-grinder
6.	Kiln shell heat loss reduction	Refractories	
7.	Minimize ingress of false air	High-efficiency motor drives	

Table 2.18: Selected Technologies/ Measure – Industry Sector/ Iron & Steel

No.	First Priority	Second Priority	Third Priority
1.	Slabs/ billets hot charging	Preventative maintenance	Variable speed drive: flue gas control, pumps, fans
2.	Thin slab mills technology (hot rolling)	Energy monitoring and management system	De-dusting system optimization (steelmaking)
3.	Optimization in laddle pre-heating	Zero reformer	Energy-efficient drives (rolling mill)
4.	Oxygen lancing at electric arc furnace (steelmaking)	Waste heat recovery	Heat recovery on the annealing line
5.	Scrap pre-heater (steelmaking)	Process control in hot strip mill	Reduced steam use (pickling line)
6.	Power demand control	Recuperative burners	Automated monitoring and targeting system
7.	Fuel substitution	Insulation of furnaces	Controlling oxygen levels and VSDs on combustion air fans
8.	Adopt continuous casting	Energy Control Center	

Table 2.19: Selected Technologies/ Measure – Industry Sector/ Pulp & Paper

No.	First Priority	Second Priority
1.	Changing paper press surface from groove to drill/ groove type	Waste heat recovery
2.	Refiner improvement: Refiner blade replacement	Optimization of regular equipment
3.	Using shoe press machine	Blow-down steam recovery
4.	Use chemicals in pulp refinery system	Steam trap maintenance
5.	Steam traps treatment	Increase use of recycled paper
6.	Condensate heat recovery	Energy management and process control system
7.	Continuous digesters	
8.	Continuous digester modifications	
9.	Boiler maintenance	
10.	Leak repair	

Due to the use of outdated technology in both, Indonesian Textile and Sugar industry, the option selected for these industry sub-sectors is machinery replacement and for Sugar industry the implementation of advanced and efficient technology for combusting bagasse as an alternative fuel.

6. Barriers and Policy Needs for Technology Transfer

Some barriers for accelerating the transfer of technology have been identified, as follow:

1. Currently there is no schema to minimize import taxes on environmentally sound technology;
2. GoI's role is not optimal in order to facilitate financial loan schemes;
3. There exist difficulties in identifying companies, which are willing to replace equipment;
4. The calculation of investment required to replace existing technology with environmentally sound technology is problematical;
5. Energy management has not yet become a priority;
6. A lack of human resources with knowledge about energy management is experienced in the Indonesian industry sector;
7. An energy saving culture is not developed yet;
8. Incentives and disincentives for energy users are not established yet. This conclusion also applies to measures such as incremental cost mechanisms (incentives for companies, which implement energy conservation measures through financial loan schemes);
9. There is no technology transfer system supporting the reduction of GHG emissions;
10. Cost schemes, which regulate the correlation between income taxes and import taxes on environmentally sound technology are not yet developed.

Institutional set-up/ changes and policies needed in order to accelerate technology transfer are:

1. The Government of Indonesia supports the implementation of environmentally sound technology in the industry sector via policies and regulations such as tax incentives, etc.
2. Motivation is built in the Indonesian industry sector for implementing energy conservation measures and energy diversification.
3. Energy audits are provided for the industry.
4. "Energy efficient technology and low carbon technology" are promoted.
5. Enterprises are assisted to use renewable energy
6. The concept of an energy manager is promoted.

7. Implementation Plan for Technology Transfer

An implementation of the technology needs for reducing GHG emissions in the Indonesian industry sector has been outlined in the chapters above for seven industry sub-sectors. It has to be accomplished, in several steps including short-term and medium-term implementation.
Short-term implementation is obliged for the technology needs listed as "First Priority" in Table 2.17, Table 2.18 and Table 2.19 above. Whereas, medium-term implementation is requested for technology options listed as "Second priority" and/or "Third Priority". The exceptions are Textile and Sugar industry, where replacement of machinery with advanced and efficient technology was set an urgent priority. Also important for the Sugar industry is the implementation of advanced and efficient technology for combusting bagasse as an alternative fuel.

Besides the mentioned technologies, capacity building and awareness raising has to happen in the Indonesian industry sector, to emphasize the importance of implementing environmentally sound technology, explain accrued benefits and reiterate simple methods for GHG emissions reduction.

Financial support and technology transfer are substantial, to assist the Indonesian industry sector with implementing the mentioned technology options. Other measures required for GHG emissions reduction in the Indonesian industry sector are:

- Strengthen regulations on process emissions and energy intensity standards;
- Introduce demand side management systems with minimal impact on the environment;
- Redesign those facilities, which produce high emissions;
- Provide incentives to promote eco-processing;
- Introduce and spread the use of low emission and fuel-efficient technologies.

2.4. FORESTRY

1. State of Sector Development

Forests play a unique role in Indonesia, their management is complex, and in most cases barriers of proper forest management are caused rather by institutional issues than by technology insufficiencies. Addressing climate change issues in the forestry sector cannot be separated from the effort in tackling the challenges in forest management, which includes: institutional especially governance issues, the gaps between available domestic funds and the magnitude of the problem to be dealt with, and market failure for forest products and services. Sustainability of forest resources is crucial for the continuation of national development, as well as in mitigation and adaptation to climate changes.

Indonesia is a country with forest land of 120.3million ha (~ 60% of the country's land area), spreading into seven geographical areas started from beach forest, peat forest, mangrove forest, low land tropical rain forest, savanna, and mountain to alpine forest. Traditionally, forest land had been a resource, which many Indonesian people depended on for their subsistence and customary activities. Later, along with the shift of the national development direction during 1970s, forestry also generated employment as well as business opportunities. In the early 1990s the forestry sector provided direct employment for 1.35% of the labor force or even 5.4% if indirect employment is also counted. The Ministry of Finance (MoF, 2005) estimated that 17% of Indonesia's total population relied on the forestry sector both in formal and informal sectors. The forestry sector had been the second back bone of national economic development between 1980 and 1990 and will continue to be one of the prime movers of economic development.

Climate change mitigation in forestry can be achieved through activities, which enhance carbon sinks and reduce greenhouse gas emissions. Sink enhancement can be achieved through forest plantation and rehabilitation of degraded protection forest and conservation forest, while emissions reduction can be achieved through management improvement of natural forests (production forest/HPH, protection forest, and conservation forest).

To effectively address climate change in forestry, the mentioned issues need to be brought to the main stream of forestry sector policy as well as national policy. Ideally, any increase in CO_2 emissions due to national development will be balanced through increasing CO2 emissions sequestration. However, there remain challenges to be tackled. Some barriers do not occur because of lacking technology support, but the need for capacity building and awareness raising. Technology support and capacity buildings shall be covered by a broad array of programmes and activities, which contribute to mitigation of (sink enhancement and emission reduction) and adaptation to (increasing resilience of forest ecosystem and increasing adaptability of forestry sector) climate change.

2. GHG Emissions Mitigation Strategy

GHG emissions mitigation options for the forestry sector programme are identified in the following table.

Table 2.20: CO_2 Emissions Mitigation Potential of various Measures in Forestry

Program	Cumulative Area (million ha) and CO_2 Absorbed/ Stored (million ton/ha)			
	2007 - 2009	2009 - 2012	2012 - 2025	2025 - 2050
Sink Enhancement				
Forest Plantation				
HTI	3.6 (105.5)	7.2 (210.9)	9.31 (272.8)	11.62 (340.5)
HTR	3.6 (105.5)	5.4 (158.2)	9.00 (263.7)	12.98 (380.3)
HR	2.0 (58.6)	4.0 (117.2)	8.00 (234.4)	8.00 (234.4)
Forest Rehabilitation				
Protection Forest	0.5 (na)	1.0 (na)	5.0 (na)	17.9 (na)
Conservation Forest	1.5 (na)	2.0 (na)	5.0 (na)	11.4 (na)
Emission Reduction: Management and Improvement of Natural Forest				
Production Forest (HPH)	23.12 (3.4)	23.12 (3.4)	23.12 (3.4)	23.12 (3.4)
Protection Forest	13.39 (19,643.1)	14.39 (21,110.1)	19.39 (28,445.1)	31.29 (45,902.4)
Conservation Forest	10.24 (15,022.1)	15.39 (22,577.1)	20.39 (29,912.1)	21.66 (31,775.2)

3. Criteria for Technology Selection

Technology transfer priorities are assessed and selected using a multiple criteria analysis. Two sets of criteria are determined: general criteria and specific criteria. The general criteria are based on national-wide interests and priorities (Table 2.9), while specific criteria are reflecting the priorities, current policies & objectives and the situation of the forestry sector.

The specific technology criteria used for the Forestry Sector TNA were adopted from general criteria for sustainable forest management (especially for natural forest, plantation forest, and community based forest), which have been enforced by the Ministry of Forestry to be implemented in Indonesian forest management. They are also used by the Indonesian Eco-labeling Institute (LEI) for voluntary forest certification.
The criteria, based on expert judgment, are relevant to the assessment of the technology needs carried out. Moreover, the development of the criteria for sustainable forest management had been carried out through intensive stakeholders consultation on REDD and other forest-climate issues both at the national and provincial/ district level.

Table 2.21: Specific Criteria for Technology Selection – Forestry Sector

Specific Criteria	Sub-Criteria
a. Sustainability of production function	• Sustainability of forest resources • Sustainability of forest products • Sustainability of business
b. Sustainability of ecological function	• Stability of ecosystem • Survival of endangered/ endemic/ protected species
c. Sustainability of social functions	• Secure community-based forest tenure system • Assure resilience and development of economy • Assure continuity of social and cultural integration • Assure nutritious status and health of community • Assurance of mutual work agreements
d. Technology	• Availability of Technology • Applicability • Least cost • Provide good result to increase production of forest

4. Technology Selected

Prioritized technologies for GHG emissions mitigation in forestry sector are divided into category sink enhancement and emission reduction.

For the sink enhancement selected technologies include silvicultural technology, growth and yield modeling technology, advanced tree improvement, pest, disease, weed and fire management, site species matching, and carbon related measurement and monitoring for carbon sequestration activities. Those technology options are selected for an activity programme in industrial forest plantation (HTI), small scale forest plantation (HTR, HR) and rehabilitation/ restoration.

For the GHG emission reduction selected technology include RIL in production forest, use of Molecular Biology to support chain of custody (e.g. DNA analysis for log tracking), zero burning technology and carbon related measurement and monitoring for reduced emission activities.

The prioritized technologies for the forestry sector are presented in the following table.

Table 2.22: Selected Technologies/ Measures – Forestry Sector

No.	Program/activities	Selected technology
1	**Sink Enhancement**	
1a	Industrial Forest plantation (HTI)	Silvicultural technology,
		Growth and yield modeling technology
		Advanced Tree improvement
		Pest, disease, weed and fire management
1b	Small scale forest plantation (HTR, HR)	Silvicultural technology,
		Site species matching
		Pest, disease, weed and fire management
1c	Rehabilitation/restoration	Site species matching
1d	1a, 1b, 1c	Carbon related measurement and monitoring for carbon sequestration activities
2	**Emission Reduction**	

2a	Management improvement of natural forests	RIL in production forest
2b	Curbing Illegal Logging	Use of Molecular Biology to support chain of custody (e.g. DNA analysis for log tracking)
2c	Forest fire prevention and control	Zero burning technology
2d	2a, 2b, 2c	Carbon related measurement and monitoring for reduced emission activities

5. Barriers and Policy Needs for Technology Transfer

As mentioned earlier the use of forest resources in Indonesia follows the rules applied to each of the four forest functions/ categories.

1. Conservation forest aims to conserve biological diversity, the source of genetic resources needed for food crops, medicinal plants, wood and non-wood forest species domestication.
2. Protection forest is important to maintain hydrological function, watershed protection and soil conservation.
3. Production forest provides timber and non-timber products, and is managed through selective cutting for natural forest and clear cutting for plantation forests.
4. Production forest can be converted for other land uses.

6. Implementation Plan for Technology Transfer

Preliminary action in the forestry sector includes social and environmental aspects for sustainable forest management. This would require technology of silviculture, biotechnology and tree improvement to improve quality and quantity of woods as a carbon sink as well as technology in forest protection (from pest, decease, weed and fire). However, because the vulnerability of forest resources also relate to human activities, welfare and consequently to other sectors, not only the technologies applied in forestry but also capacity building and awareness need to be initiated and improved. Nevertheless, more advanced applicable technology than the current one is required.

2.5. AGRICULTURE

1. State of Sector Development

About 80 percent of the Indonesian population lives from agriculture. Various sub-sectors including food crops, estate crops, and cattle have contribute remarkably to the national income. In addition, various industry sub-sectors such as the food industry need raw materials from the agriculture sector. While the population is increasing, the demand for agricultural products in many aspects of life grows. This is the reason that the agriculture sector is still one of the priority sectors in the development program of the country.

Extreme climate has become a threatening factor for agricultural vulnerability in Indonesia in recent years. Floods and droughts have had serious impact on agricultural productivity, especially food crops. The Government of Indonesia (GoI) has directed efforts to create awareness of the impact of climate variability and the dynamics of extreme climate. At the same time the GoI formulated a strategy for handling the impact. The implementation of action plans to these ends is expected to lead to sustainability in the agriculture sector in the country.

Greenhouse gas (GHG) emissions mitigation efforts to reduce the cause of climate change are urgent and should be executed comprehensively and as an integrated action together with climate change adaptation activities. Several GHG emissions mitigation strategies may be introduced. These strategies can be differentiated into:

- **Land- and water management -** Intermittent irrigation for rice fields is one of the strategies of land- and water management, which may reduce methane (CH_4) emission. It is urgent to assist farmers in implementing water management systems for their rice fields. In general, farmers prefer to maintain the water standing in the rice fields as high as 20cm instead of draining it after a period of 2 - 4 weeks. As a result a large amount of CH_4 is emitted from the rice fields.
- **Introduction of crop varieties -** The variation of crops can result in less GHG emissions.
- **Integrated crops-livestock management -** Integrated crops-livestock management is another strategy, which helps to reduce GHG emissions. Manure can be converted into compost to be used as fertilizer later. Fresh manure, which may not emit GHG such as CH_4, can be converted into biogas to produce energy for electricity, cooking and other purposes.

Each strategy shall be implemented in consideration of local farming characteristics.

Despite their importance for food security, agricultural resources can also be used as alternative sources of energy. Since the limitation oil resources became a critical issue in the last decade, alternative energy sources have to be used to fulfill the increasing energy demand. It has to be considered though, that alternative energy sources originate among others from agricultural products such as maize, cassava, etc., which might become a threat for the provision of food security. The use of non-food crops can be a strategy to achieve both food and energy security.
The use of manure for biogas production is one of the best alternatives to produce energy. This should be in line with the program of livestock development at the village level. Other materials such as crop residues, “jarak pagar” (jathropa curcas), and other agricultural by-products are also recommended. It would be unwise to produce energy from food crops, which are still relatively limited.

2. GHG Emissions Inventory

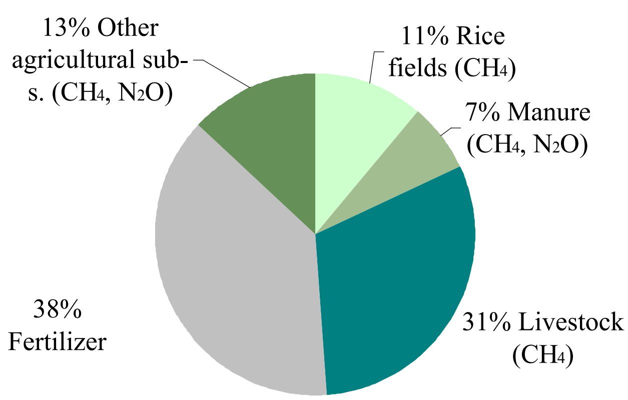
The agriculture sector contributed 14% of the total GHG emitted in Indonesia in 1990. The same GHG emissions inventory showed, that GHG emissions from fertilizer and rice fields were the largest source of GHG emissions among the major sources in the agriculture sector. 3,649.2Gg CH_4 have been emitted from rice fields, crop residue burning and livestock. 25.5Gg Nitrous Dioxide (N_2O) originated from the application of fertilizers and the burning of crop residues. The latter also resulted in the emission of 564.4Gg Carbon (CO) and 22.8Gg Nitrogen Oxides (NO_x). as presented in the following table. These numbers are assumed to have increased over the past few years.

Table 2.23: GHG Emissions from Agriculture, 1990

Source	GHG emissions (Gg)			
	CH_4	N_2O	CO	NO_x
Rice fields	2,758.0	-	-	-
Fertilizers	-	24.7	-	-
Burning of crops residues	26.8	0.6	564.4	22.8
Livestock	864.4	-	-	-
Total	3,649.2	25.5	564.4	22.8

Source: (State Ministry of Environment, 1996)

The World Resources Institute (WRI, 2006) reported that various sources of non-CO_2 emissions originate from the agriculture sector. The application of fertilizers contribute 38% of N_2O, livestock 31% of CH_4, rice fields 11% of CH_4, manure 7% of CH_4 and N_2O, and other agriculture sub-sectors 13% of CH_4 and N_2O as presented in the following figure.



Source: World Resource Institute (WRI, 2006)

Figure 2.21: GHG emissions from Agriculture by Source, 2006

3. GHG Emissions Mitigation Strategy

Optional mitigation and adaptation activities need to be defined to combat climate change. The determination and selection of options are based on the communication among stakeholders and the feedback from the existing technology users. Through the communication between the existing technology producers (research centers, etc.) and technology users (farmers, agriculture offices, etc.) technology needs can be assessed. Several GHG emissions mitigation options for the agriculture sector are listed below:

- **Crop varieties development -** Rice varieties with a lower CH_4 emission potential have been developed. For example, the Way Apo rice variety has a lower CH_4 emission potential than the Cisadane rice variety.
- **Intermittent irrigation for rice fields -** Farmer cultivate rice by using water in the rice fields, which stands 20cm above the soil surface. This results in a higher amount of CH_4 emissions compared to dry conditions. Intermittent irrigation is an alternative way to reduce CH_4 emissions, because this irrigation technique supports alternating dry and wet conditions during the cycle of irrigation.
- **Drip and sub-surface irrigation for estate crops -** Controllable drip and sub-surface irrigation, at certain moisture conditions may provide circumstances that balance moisture and air in the soil, helping to avoid frequent conditions of soil reduction and reducing CH_4 emission.
- **Appropriate fertilizers and fertilizer-management -** Producing slow release N-fertilizer such as Sulphur-coated Urea, Urea tablet, Urea stick, etc. can be an alternative to N-fertilizer.
- **Composting manure and crop residues -** Substantial amounts of manure are produced from community cattle breeding. Without processing this manure, GHG emissions are relatively high. Composting is an alternative way to reduce these GHG emissions.
- **Biogas production for energy use -** Production of biogas means converting manure into gas, which can be used as an energy source and therefore reduces GHG emissions.
- **Bio-fuel production -** Agricultural resources such as jatropha, agro-industrial waste and other agricultural residues are used to produce bio-fuels.

4. Criteria for Technology Selection

The selection of technology is determined by applying general and specific criteria, which are used in a selection matrix.

Table 2.24: General Criteria for Technology Selection – Agriculture Sector

General Criteria	Sub-Criteria
General concern	• Reducing GHG emissions (RGHG) • Increasing adaptability of crops and livestock (ACL) • Promoting resource conservation (RC) • Promoting sustainable biodiversity (SB) • Promoting green energy (GE) • Sustaining food security (FS) • Promoting energy alternative (EA)

Table 2.25: Specific Criteria for Technology Selection – Agriculture Sector

Specific Criteria	Sub-Criteria
General concern	• Promoting local technology for mitigation (LW) • Sustaining site-specific germ plasms (GP) • Promoting simple and cheap technology for poor farmers (SCT) • Promoting less water requirement crop varieties (LWRC) • Substituting an organic with organic fertilizers/compost (SOF) • Water-use efficiency in dry areas (WUE) • Reduce CH_4 emissions (RCHE)

For a description of the detailed process of selection, please refer to the full report of the Agriculture Sector TNA.

5. Technologies Selected

The priority technologies to be used in the agriculture sector to mitigate GHG emissions are presented in the following table. More environmentally solid technologies for the agriculture sector are listed in the full report of Agriculture Sector TNA.

Table 2.26: Selected Technologies/ Measures - Agricultural Sector

Agriculture sub-sector	Climate Prediction	Adaptation Technology	Mitigation Technology
Rice field/ Horticulture	a. Climate database Management b. Climate information technology c. Climate model development	a. Crops tolerant to drought and flood b. Early mature crops varieties c. Cropping calendar d. Water harvesting e. Efficient irrigation	a. Appropriate fertilizing b. No tillage c. Intermittent irrigation
Perennial crops		a. Introducing estate crops varieties tolerant to drought and flood b. Appropriate Crop sheltering c. Correct planting distance d. Optimum crops density	a. Appropriate Fertilizing b. No tillage c. Appropriate slash and burn d. Bio-fuel
Livestock		a. Adaptable cattle to dry and wet climate b. Communal livestock sheltering	a. Composting manure b. Biogas production
Peat Land		a. Minimum tillage b. Balance fertilizing c. Appropriate soil amelioration d. Drainage control e. Subsidence control	a. Overcoming slash and burn b. Avoiding over drain c. Maintaining soil moisture

6. Barriers and Policy Needs for Technology Transfer

Several climate change mitigation and adaptation activities have been conducted by various institutions. Integrated activities have been classified as urgent. In order to prepare appropriate action programs the sectors Agriculture, Energy, Health, Industry, Transportation, Forestry, Ocean, and Waste must be analyzed. Coordination among the institutions is essential for the implementation of comprehensive action programs. Related barriers and policy needs are presented in the following table.

Table 2.27: Barriers and Policy & Action Needs - Agriculture Sector

Barriers	Policy Needs
Climate Prediction	
• Less distributed climate stations outside Java	• Need of vast and dense climate station network especially outside Java
• Absence of network between climate station and users	• Improvement of users' access to climate data
• Limited accuracy of climate prediction model for longer period (> 6 months)	• Improvement of climate prediction model • Use model for prediction in shorter period (3 months), repeated for the subsequent 3 month period
• Lack of validation for climate prediction	• Improvement of model validation for different climate zone
Adaptation/ Mitigation	
• High time expenditure to produce crop varieties tolerant to drought and flood	• Improvement of crops breeding
• Adaptation technologies are not widely known to farmers	• Need of fare distributed dissemination technology
• Cost of adaptation technology implementation is relatively high for farmers	• Select simple and cheap adaptation technologies
• Limited knowledge of farmers	• Improvement of training
• Limited capital of farmers to implement adaptation technology	• Need for government support on financing adaptation technology implementation
• Expected benefit and beneficiaries	• Introducing high economic values of commodities
Dissemination	
• Limited awareness of farmers	• Improvement of awareness
• Limited knowledge of extension workers working on climate change, adaptation and mitigation	• Need for special training and on-the-job training
• Lack of proper information system for dissemination	• Need for information technology
• Gap of linkage between researchers and extension workers	• Need for an umbrella program of dissemination
Capacity Building	
• High cost of capacity building in adaptation and mitigation	• Need for government support in financing capacity building
• Limited knowledge of trainers	• Improvement of training of trainers (TOT)
• Lack of skilled professional in capacity building in adaptation and mitigation	• Need for special training
• Lack of personnel for introducing and implementing adaptation and mitigation technologies	• Need for recruitment of skilled professional personnel
• Gap of information technology for capacity building	• Improvement of information technology

7. Implementation Plan for Technology Transfer

To enhance the technology transfer program and include environmentally sound technologies for the agriculture sector, the following activities need to be carried out:

- Appropriate planning of the cropping season is essential. Patterns have to be implemented with regard to climate variability. Vast and dense climate station networks need to be organized to obtain reliable data for predictions and forecasts. Adaptation and mitigation technologies are required to support planning programs.
- High-yielding crop varieties, adaptable to drought and flood have to be used and early-mature varieties have to be introduced.
- Since irrigation water is scarce, efficient water use has to be implemented when dealing with irrigation management.
- The strengthening of water management institutions (example: "*Perkumpulan Petani Pemakai Air*/P3A") is also valuable for water resources management, when adapting agriculture to climate change.
- Accentuating the increasing incidence of water use and proportional water sharing are another approach since the number of water users is increasing.
- Water conservation and water harvesting technologies have to be implemented.

2.6. OCEAN

1. State of Sector Development

Indonesia is the largest archipelagic state in the world with estimated a total of 17,504 islands, of which only about 6,000 are inhabited. The Indonesian sea area is four times greater than its land area. The sea area is about 7.9million sq km (including the exclusive economic zone, EEZ) and constitutes about 81% of the total area of the country. Five main islands and 30 smaller archipelagos are home to the majority of the population. Around 140million Indonesians live along 60km of the coasts nowadays, mostly within the large coastal cities that occupy a predominant position in the national economy. Indonesia's marine and coastal areas are vulnerable to the impacts of climate change, need mitigation technology support and measures of climate change. The aims of climate change mitigation in the ocean sector are to appraise its carbon sink potential and to promote the emission reduction technologies.

2. GHG Emissions Inventory

The estimated potential of carbon absorption and sequestration by Indonesian seas is quite large. Referring to an assessment of the United Nations Environment Programm (UNEP) and World Meteorological Organization (WMO) in 1995 (Figure 1.3), marine organism potentially utilize 3billion tonnes of CO_2/year. Throughout Indonesia's archipelago, sea grass covers at least 30,000km^2, which can potentially absorb 56.3million tonnes CO_2/year. Sea surface water in Indonesia can potentially absorb 40.4million tonnes CO_2/year.

3. Criteria for Technology Selection

Two sets of criteria are determined for technology selection: general criteria and specific criteria. The general criteria are based on national-wide interests and priorities (Table 2.9).

The specific criteria for selecting the mitigation measures and set technology priorities in the ocean sector are used for a discrete Multi Criteria Analysis (MCA) method. The process involves scoring and Analytical Hierarchy Process (AHP). AHP is a mathematical technique for multi-criteria decision making [Saaty 1980, 1990, 1994] and is used for relative critical weighting of indicators and relative critical weighting of evaluators.

Table 2.28: Specific Criteria for Technology Selection – Ocean Sector

Specific criteria	Sub-Criteria
a. Development benefits	• Security and legality • GDP growth, income equity, job creation • Coastal and small island community development • Capacity building
b. Environmental protection	• Sustainable fisheries and aquaculture • Marine resources protection, conservation, rehabilitation
c. Market potential	• Business scale development • Added value of marine & fishery products • Development & intensification • Marketing (commercial readiness)

The selected technologies must pass the MCA and AHP selection processes by involving stakeholders of the ocean sectors.

4. Technology Selected

Based on priorities and criteria set for selecting and implementing various technologies for climate change mitigation in the ocean sector, the following preferred technology options have been selected; seaweed; mangrove and coastal vegetation; coral reefs; Indonesian ocean observing system; marine fisheries; ocean and coastal renewable energy; sea grass and marine plankton. The technologies are selected based on the AHP analysis and barriers and policy needs.

Table 2.29: Selected Technologies/ Measures – Ocean Sector

No	Technology Priority selection	Priority of action plan	Period of action
1	Seaweed	Development of potential areas for seaweed cultivation	2009 – 2015
		Seaweed culture management	2009 – 2015
		In-situ and laboratory measurements on carbon sink potential of seaweed culture	2010 – 2012
		Detailed mapping of potential areas for seaweed culture development	2010 – 2012
2	Mangrove and coastal vegetation	Topic will be covered by the Forestry Sector TNA	-
3	Coral reefs	Identification stage	2009 – 2015
		Coral replanting and transplantation	2009– 2015
		Remote sensing for estimation of net primary production (NPP) and total carbon sink	2010 – 2011
		Modeling of carrying capacity for technology implementation	2010 – 2011
		In-situ and laboratory measurements on carbon sink potential	2011 – 2013
4	Indonesian ocean observing system	Monitoring marine environment condition	2009 – 2015
		Establishment of ocean and coastal stations to observe Indonesian waters	2009 – 2015
		Operational Ocean Observing System	2010 – 2015
		Study on water mass transport in related to oceanic carbon budget	2012 – 2015
5	Marine fisheries	Development of low energy fishing vessels with bio fuels and other energy alternative	2010 – 2015
		Implementation of technology and fishing supporting device that consume low energy	2009 – 2015

No	Technology Priority selection	Priority of action plan	Period of action
6	Ocean and coastal renewable energy	Tidal current	2009 – 2015
		Wave	2009 – 2015
		Ocean thermal gradient	2015 – onward
		Solar	2009 – 2015
		Wind power	2009 – 2015
7	Sea grass	In-situ and laboratory measurements on carbon sink potential of sea grass beds	2012 – 2015
		Sea grass cultivation and rehabilitation	2014 – onward
		Generation of non-conventional energy from sea grass	2014 – onward
8	Marine Plankton	Satellite remote sensing technology for estimation of net primary production (NPP) and total carbon sink	2009 – 2011
		Numerical modeling of oceanography parameters for measuring ocean primary productivity	2009 – 2011
		In-situ and laboratory measurements to find out the absorption effectiveness	2011 – 2015
		Ecological modeling for marine plankton as carbon source or sink	2011 – 2015
		Identification of potential plankton species to absorbs carbon	2011 – 2015
		Phytoplankton culture in photo bioreactor	2011 – 2015

5. Barriers and Policy Needs for Technology Transfer

Some barriers for technology transfer have been identified in the ocean sector:

- Limited technical data on mitigation measures and technologies in ocean sector.
- Limited data and advanced research on ocean carbon budget, marine and coastal resources as carbon sinks – emission reduction potential.
- Limited in-situ/ field observation of Indonesian marine waters.
- Lack of quantitative data on marine plankton in Indonesian waters as oceanic carbon sink potential.
- Lack of data on the role of marine plankton in Indonesian water in the ocean carbon budget.
- Lack of data on seaweed species and seaweed culture areas as carbon sink potential.
- Limited data on ecology and distribution of sea grass in Indonesian coastal waters
- Lack of data on sea grass species and sea grass beds as carbon sink potential.
- Lack of data on the role of coral reef as coastal carbon sink or source.
- Limited data on renewable ocean and coastal-based energy resources potential in Indonesia.
- Indonesia is in the early stage of research and development of low emission power generation from ocean and coastal based energy potential.

6. Implementation Plan for Technology Transfer

Preliminary action for the ocean sector started in 2009 (year 1) and is planned until 2015 (year 7). The project includes laboratory experiments, modeling, pilot- and demonstration projects on various selected technology options. The project started in 2009 and will hopefully be completed in the 2015. The implementation plans need to be adapted as explained thoroughly in the detailed Ocean Sector TNA report.

2.7. WASTE

1. State of Sector Development

The waste sector was selected as one of the sectors discussed in the TNA, because it bears a large GHG emissions reduction potential, but needs technology transfer to fully tap this potential. This applies especially to the sub-sectors municipal solid waste (MSW), wastewater and agro-industrial waste, such as palm oil, tapioca, sugar cane waste and also waste from livestock.

Currently there are more than 400 final disposal sites (Tempat Pembuangan Akhir/TPA), locations where **municipal solid waste** is accumulated. Since the new Solid Waste Act No. 18/2008 came now into effect, the national intention was drawn to this issue. It is predicted, that annual amount solid waste generated will have increased five times by the year 2020. Based on the total number of 218,868,791capita (SUPAS, 2005), the total amount MSW generated in Indonesia was estimated with 48.8 Mt/year in 2005. Most of the MSW (40%) generated in urban areas is transported to the solid waste disposal sites (SWDS/ 'landfills'). The remaining 60% of MSW are illegally dumped (8%), composted and recycled (2%), openly burned (35%) or disposed in other ways (15%).
GHG emissions from MSW are commonly methane (CH_4) generated from the SWDS and composting. Carbon Dioxide (CO_2) is generated from open burning. Emissions from open burning are more difficult to control than emission from TPA.

Wastewater was also identified as an important issue in the Waste Sector TNA, because of the CH_4 and Nitrous Oxide (N_2O) emissions generated by the large quantities of wastewater in Indonesia. Almost 80% of total wastewater in Indonesia results from households. The remaining 20% are generated by the industry sector (15%) and offices or commercial waste (5%) (BPPT, 2007). The development of a municipal solid waste and wastewater infrastructure belongs to the responsibility of the Department of Public Work.
The amount of domestic wastewater is directly related to the size of the population. A growth of the population will automatically increase the clean water consumption. This implies, that the amount of discharged water will increase too.

The agro-industry sub-sector plays a strategic and important role in the national development. It contributes to the prosperity and community welfare, foreign exchange income, labor extension field, added value gain and competition, domestic consumption needs and also the optimization of sustainable resources.
Agro-industrial waste, both wastewater and solid waste, plays an important role in the Waste Sector TNA due to the large amount produced and its large potential for GHG emissions reduction, if the appropriate mitigation technology is adopted.
GHG emissions from the agro-industry sub-sector result from fossil fuel burned during the transportation of raw materials and products, from exhaust gases of industrial processes and also from wastewater treatment. The amount of emissions depends on the type of industry and production process, waste characteristics and the kind of waste management applied. Another major source of GHG emissions from the agro-industry sub-sector results from the farm waste, which is treated in anaerobic landfills or discharged to the environment.

According to the research conducted by BPPT in 2007, three agro-industry sub sectors contribute the major amount of GHG emissions: palm oil, tapioca and sugar cane.
In 2005, Indonesia was the second largest palm oil exporter in the world after Malaysia. Currently there are 320 units belonging to palm oil factories. Between the years 2000 and 2005 they operated with an average capacity of 9,816,393tons fresh fruit bunch (FFB) per year. Furthermore, 6 seed producers with a capacity of 124 million seeds per year work in Indonesia. In the same period the total amount of palm oil industry's solid waste counted 4.2million ton per year in average and the volume of palm oil wastewater

was 6.5million m^3. GHG emissions from palm oil industry's waste are mainly CH_4 emissions, which result from liquid wastewater and from empty fruit bunch.

2. GHG Emissions Inventory

As described above the Waste Sector TNA focuses on the sub-sectors municipal solid waste, wastewater and waste from agro-industry, especially palm oil, tapioca, sugar cane, pulp & paper and livestock. The estimation of GHG emissions from the waste sector underlie the following assumptions:

The population will grow with a growth rate of 1.3%/year. Using the default methane correction factor of 0.8 as suggested by the "Guidelines for National Greenhouse Gas Inventories" (IPCC, 2006) and a waste production factor of 0.61kg/capita/day, the average GHG emissions from **SWDS** were estimated with 578Gg/year for the period 2000 to 2005 (IPCC First Order Decay/ FOD method). Under the Business-as-Usual (BAU) scenario the emissions will increase to 588Gg/year by 2010, 594Gg/year by 2015 and 600Gg/year by 2020.

GHG emissions from domestic **wastewater** in Indonesia are estimated by using the population size and the biochemical oxygen demand (BOD) per capita per day as an input. Total GHG emissions from domestic wastewater are estimated with 488Gg CH_4/year (average between 2000 and 2005). Under the BAU scenario the GHG emissions increase to 540Gg CH_4/year in 2010, to 568Gg CH_4/year in 2015 and finally to 592Gg CH_4/year in 2020.

The GHG emissions potential from livestock and **agro-industrial waste** are listed in the two table below.

Table 2.30: CH_4 Emissions from Waste by Animal Type

No.	Animal Types	Number of Animals*	GHGe from enteric fermentation	GHe from manure management	Total GHGe
			(Gg CH_4)	(Gg CH_4)	(Gg CH_4)
1.	Beef Cattle	8,121,691	381.72	8.12	389.84
2.	Dairy Cattle	265,744	16.21	8.24	24.45
3.	Buffalo	1,766,248	97.14	3.53	100.68
4.	Sheep	7,414,965	37.07	1.48	38.56
5.	Goat	12,613,108	63.07	2.77	65.84
6.	Pig	5,247,200	5.25	36.73	41.98
7.	Horse	412,919	7.43	0.90	8.34
8.	Poultry:				
	- Native Chicken	261,132,020	-	5.22	5.22
	- Broiler	534,810,990	-	10.70	10.70
	- Layer	69,702,890	-	1.39	1.39
	- Duck	29,674,120	-	0.59	0.59
	TOTAL		607.89	79.69	687.58

Source: Second National Communication, KLH, 2008

* The population size of beef cattle, dairy cattle and buffalo is expressed in animal units; other animals are counted by 'head'

Table 2.31: CH_4 Emissions from Waste by Type of Agro-Industrial Waste

Waste type and origin	GHG emissions	Global warming potential
	(Gg CH_4/year)	(Gg CO_2e/year)
Palm Oil		
- Empty bunch	27.093	569
- Shell	9.423	198
- Fiber	14.135	297
- Wastewater	61.224	1,286
Tapioca/ Cassava	288.572	6,060
Livestock waste	687.580	14,439
Sugar cane waste	5.238	110
Pulp & Paper	n/a	n/a

Source: BPPT, 2007

3. GHG Emissions Mitigation Strategy

a. Municipal Solid Waste

According to the national strategic plan, which was developed by the Department of Public Work, waste should be reduced from the source, so that the total annual volume of waste can be decreased by 20% by 2010. By 2015, referring to the Millennium Development Goals (MDGs), 80% of the MSW in urban areas and 50% of the MSW in rural areas should be transported to the final disposal site. As stated in Solid Waste Management Act No. 18/2008 and in accordance with the raw water protection regulations, the improvement of landfill quality, ranging from open dumping to sanitary landfills or controlled landfills, and the development of regional landfills are the priority programs with national financial support as an initial investment

CDM-OD scenario - Furthermore, efforts have been made to recover landfill gas (LFG) from the existing open dumpsites in the scheme of CDM. If every year the LFG of one more open dumpsite can be recovered, GHG emissions will be reduced by 5% in 2025.

3R scenario – Techniques for “reusing, reducing, recycling” (3R) will lead to a decreasing amount of waste on the final disposal site and reduce GHG emissions from final disposal sites by 5%.

SWDS/SL scenario - The most significant reductions of GHG emissions will be achieved by closing the open dumpsites and developing sanitary landfills with LFG recovery technology. Based on the Solid Waste Act, all open dumpsites should be closed by 2015. Achieving this target will result in a 50% GHG emissions reduction in the landfill sub-sector. The scenario aligns to the described MDGs. The projected GHG emissions reduction potential underlies uncertainties.

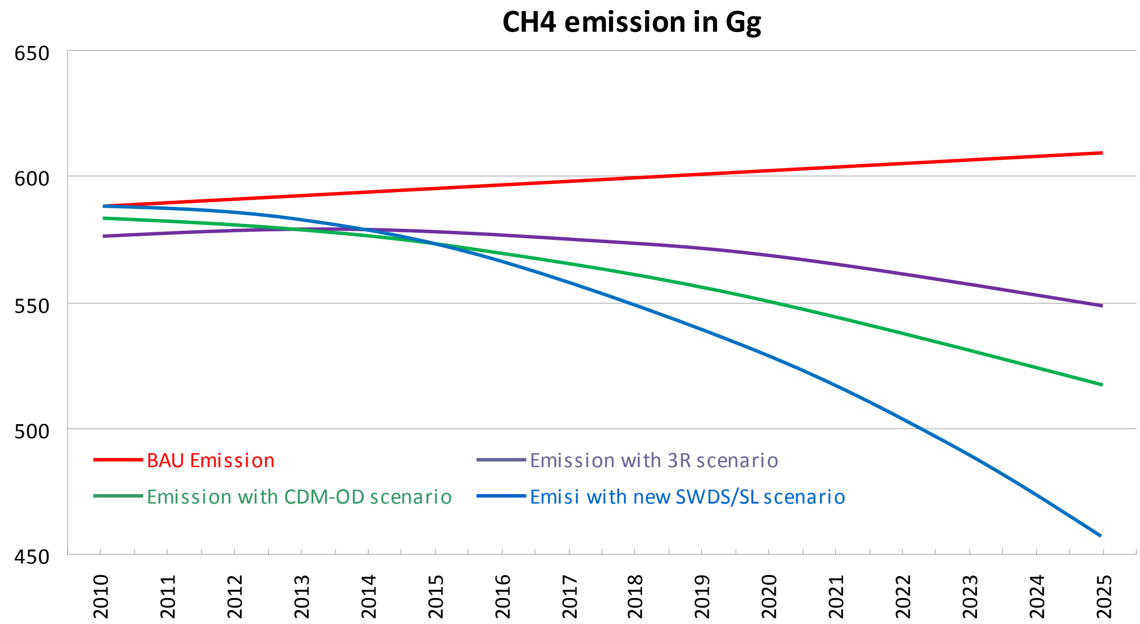


Figure 2.22: Projected CH_4 Emissions from Waste, 2010-2025 (Municipal Solid Waste Scenario)

b. Wastewater

The GHG emissions reduction scenario for the wastewater sub-sector assumes the implementation of GHG emissions recovery in communal wastewater plants and industries. CH_4 emissions reduction cannot be achieved by individuals or households using septic tanks. Instead, such emissions reduction will only be possible, if the sewerage treatment plants increase their services. If this strategy succeeds, the amount of GHG emissions in 2020 will be 20% lower than the emission level in 2005. The figure below shows the scenario projections.

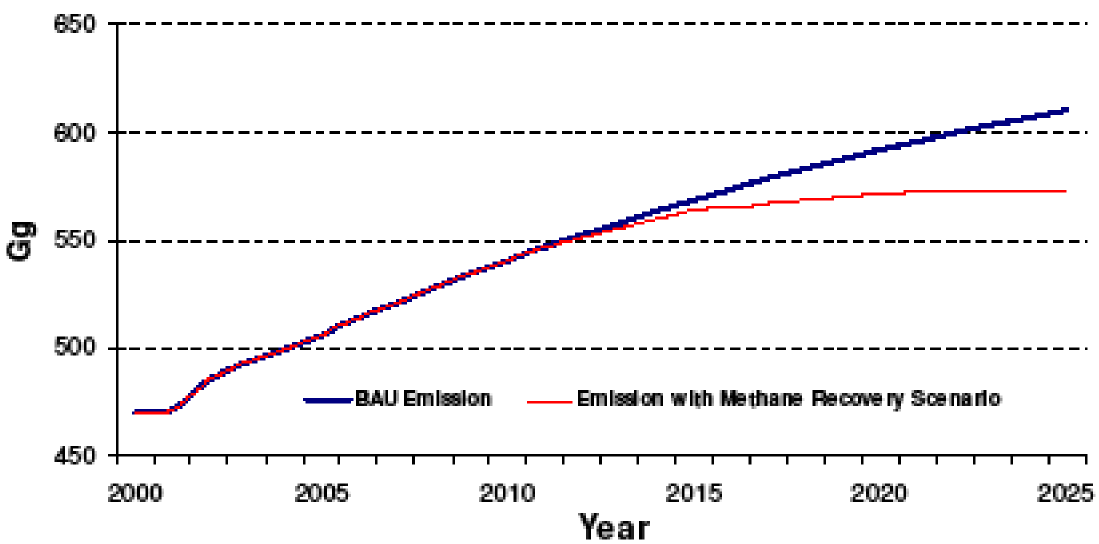


Figure 2.23: Projected CH_4 Emissions from Waste, 2000-2025 (Wastewater Scenario)

c. Agro-industrial waste

The GHG emissions reduction scenario for the agro-industry especially for palm oil production was developed for the period 2010 to 2012. According to the world production and consumption balance, vegetable oil production will grow up to 108,512,000tonnes in 2012. 30.8% of these will come from palm oil. On the other hand, vegetable oil consumption will reach 132,234,000tonnes. In Indonesia only 450,000ha of plantation area can be developed, which will consist of 350,000ha new planting area and 100,000ha plant rehabilitation/ replanting. If the whole amount of waste from palm oil production is treated as raw material for energy utilization, palm oil industry will generate GHG emissions only from burners and electricity use.

4. Criteria for Technology Selection

Two sets of criteria are determined for technology selection: general criteria and specific criteria. The general criteria are based on national-wide interests and priorities (Table 2.9). The specific criteria reflect the priorities, current policies & objectives and the situation of the waste sector.

Table 2.32: Specific Criteria for Technology Selection – Waste Sector

Specific Criteria	Sub-Criteria
General concern	• Close connection to the local market (solid waste) • Support of sustainability • Alignment with regulations • Accommodation for scavenger (solid waste) • Alignment with traditional characteristics (wastewater)

5. Technology Options and Selection

a. Municipal Solid Waste

Sanitary landfill with landfill gas recovery - Globally landfill gas (LFG) recovery has become a more common technology to reduce CH_4 emissions from SWDS. In Indonesia the transfer of LFG recovery technology and its methodology is still needed. Such LFG recovery technology should be suitable for CH_4 recovery both in open dumpsites and sanitary landfills. Although some research institutes together with foreign partners have tried to explore the potential of CH_4 recovery, Indonesia's experience is still limited.

The country also needs sanitary landfill technology, which is suitable for Indonesian conditions and can replace the currently used open dumpsites. Based on the experiences of sanitary landfill development in Bangli and Gorontalo and on other research results, the application of sanitary landfill technology in remote areas (inland areas) need a budget of 300,000US$/ha – 500,000US$/ha (1US$ = 9,300Rp.). In coastal areas a budget of 400,000US$/ha – 600,000US$/ha has to be calculated.

Composting - The low-tech system of composting is widely used in several Indonesian cities using windrow composting systems. If an open windrow system is treated in the proper way, it will generate a high quality compost. Such system is operated manually involving the support of scavengers to segregate the waste. Based on best practice of composting, an application of low-end composting technology needs an upfront investment of 10,000US$ – 20,000US$/tonne cap/day. The associated costs for maintenance and operations are calculated with 20US$/tonne – 40US$/tonne. High-end composting technology requires an upfront investment of 25,000US$ – 50,000US$/tonne cap/day with associated costs for maintenance and operations of 30US$/tonne – 50USD$/tonne MSW.

Anaerobic digestion - Technologies involve low-solid anaerobic digestion, high-solid anaerobic digestion and combined high-solid anaerobic digestion/ aerobic composting. The transfer of these specific technologies to Indonesia is still needed. Based on the reference of countries, which have already applied the technology, the investment cost for anaerobic digestion lays between 900US$/m^3 – 1000US$/m^3 waste.

Mechanical-biological treatment - Mechanical-biological treatment (MBT) of waste is becoming popular in Europe. During MBT, the waste material is processed in a series of mechanical and biological operations with the aim to reduce its volume, as well as to stabilize it. GHG emissions from the final disposal site can be reduced that way.
The application of low-mechanical intensity MBT technology needs an upfront investment of 10,000US$ – 20,000US$/tonne cap/day and maintenance and operations costs of 20US$/tonne – 40US$/tonne. For high-mechanical intensity MBT technology investment costs are calculated with 25,000US$ – 50,000US$/ tonne cap/day and cost for maintenance and operations with 30US$/tonne – 50US$/tonne.

Incineration - Big capacity incinerators or incinerator flue gas treatment has not been implemented in Indonesia yet. Such system can potentially be applied in metropolitan cities like Jakarta, Surabaya and Medan. If incinerators are planned to be used for burning MSW, they must be chosen considering their efficiency of combustion and a low concentration of resulting pollutants. Incineration systems are combustion (stoichiometric air) such as mass-fired, RDF-fired, fluidized bed; gasification (substoichiometric air) such as vertical fixed bed, horizontal fixed bed, fluidized bed; and pyrolysis (no air) such as fluidized bed system. The erection of mass burn fields or the application of modular technology need an upfront investment of 80,000US$ – 120,000US$/tonne cap/day. Maintenance and operations costs are calculated with 40US$/tonne – 80US$/tonne.

b. Wastewater
GHG emissions from wastewater can be decreased by realizing the national service degree target and implementing technologies, which are sufficient for either on-site or off-site sanitation. According to the national target at least 60% of the community will be able to access wastewater processing services in 2015. Using biological processing to treat wastewater can reduce pollutants by up to 90% as shown in the table below.

Table 2.33: BOD Removal Efficiency of Biologically Treatment Systems for Wastewater

No	Type of Treatment	BOD Removal efficiency (%)
1	Activated sludge (standard)	85 – 95
2	Step aeration	85 – 95
3	Modified aeration	60 – 75
4	Contact stabilization	80 – 90
5	High rate aeration	75 – 90
6	Pure oxygen process	85 – 95
7	Oxidation ditch	75 – 95
8	Trickling filter	80 – 95
9	Rotating Biological Contactor	80 – 95
10	Contact aeration process	80 – 95
11	Biofilter Anaerobic	65 – 85
12	Stabilization ponds	60 – 80

Based on best practice, the cost of wastewater treatment varies and depends on the respective technology as described below:

Table 2.34: Cost of Wastewater Treatment Systems

No.	Type of Treatment	Cost (US$/$m^3$)
1	Aerated Lagoon	800 – 900
2	UASB	900 – 1,000
3	RBC	925 – 1,000
4	Oxidation ditch	400 – 750
5	Stabilization ponds	400 – 550
6	Communal decentralized	200 – 300

Source: BPPT

The investment costs for off-site systems lay between 685US$/$m^3$ (68US$/capita) and 840US$/m^3 (84US$/capita) according to the Department of Public Work.

c. Agro-industrial waste

Palm oil waste - Some of the technologies, which can be used to treat the waste of palm oil production are composting, incineration/ gasification, particle board making and anaerobic- or aerobic biological system to treat the waste water. Such technology can reduce CH_4 emission by up to 80%.

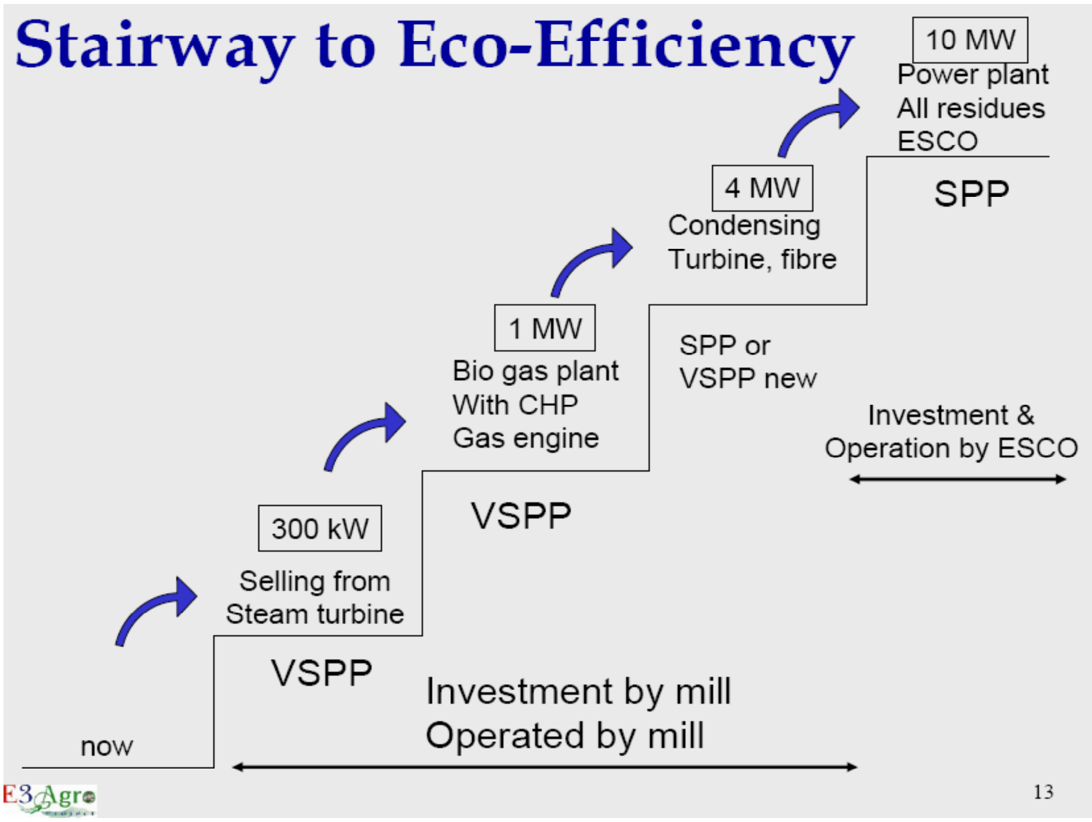
Table 2.35: Technologies for CH_4 Emissions Reduction from Palm Oil Production Waste

Waste	Estimated GHGe/ GWP*	Technology input	GHGe Reduction Potential (80%)
(t/year)	(t/year)		(t CO2e/year)
Empty Bunches 2,257,770	27,093t CH_4/year or 568,958t CO_2e/year	• Composting • Advanced/ Efficient power generation technology (PGT) • Particle board • Mulch • Thermal gasification super critical for hydrogen	455,166
Shell 785,311	9,423t CH_4/year or 197,898t CO_2e/year	• Composting • Advanced/ Efficient PGT • Mulch	158,318
Fiber 1,177,967	14,135t CH_4/year or 296,847t CO_2e/year	• Advanced/ Efficient PGT	237,477
Wastewater 6,478,819m^3/year	61,224t CH_4/year or 1,285,721t CO_2e/year	• Anaerobic treatment producing biogas • Aerobic treatment • Covered lagoon	1,028,577

* Greenhouse gas emissions (GHGe)/ Global Warming Potential (GWP)

Composting – The implementation of low-end composting technology needs an upfront investment of 10,000US$ – 20,000US$/tonne cap/day. The associated maintenance and operations costs (O&M) lay between 20US$/tonne – 40US$/tonne. Composting in palm oil industry might be either more expensive or cheaper, depending on the technology and the distance of the composting plants to the fields.

Advanced and efficient power generation - The most urgent need for reducing GHG emissions from palm oil solid waste in Indonesia is the implementation of advanced, efficient and integrated technology for steam and power generation. It can be used for internal consumption in crude palm oil (CPO) plant or send to the grid. According to the study of the E3 Agro Project in Thailand, "Biomass Energy, Possibilities in Palm Oil Industries", CPO plants with a capacity of 45tonnes fresh fruit bunch/ hour can generate 10MW electricity from production residues using advanced, very efficient technology.



Source: E3 Agro, Thailand

Figure 2.24: Integrated Power Generation using Waste of Crude Palm Oil Production

Particle Board - Empty bunch and fiber from palm oil fruits can be used for particle board- or material based fiber production.

Livestock Waste – The two tables below summarize the technical aspects and the effectiveness of the options of livestock waste treatment to reduce greenhouse gas emissions. Some considerations for their application in Indonesia are also described regarding technology costs, strengths, weaknesses and the relevant research available in Indonesia

Table 2.36: Technologies for CH_4 Emissions Reduction from Livestock Waste

Option	CH_4 Reduction (%)	Considerations for application in Indonesia		
		Cost	Strength	Weakness
1.Covered Lagoons	80	Cheap	Simple	Environmental hazard
2.Digester	70	Expensive	Double benefit	Need investment
3.Spread on pasture and rangeland	100	Cheap	Simple	No energy recovered

Table 2.37: Appropriate Technologies for CH_4 Emissions Reduction from Waste developed in Indonesia

Techniques Available	Status	CH_4 Reduction (%)	Cost	Strength	Weakness
1. Compost production	Advanced research	Decrease	Cheap	Easy to apply, low CH_4 emissions	No energy used
2. Direct spread as fertilizer	Advanced research	Decrease	Cheap	Increase soil fertility, no CH_4 emissions	Depend on slope of land, limited manure utility
3. Small scale digester	Advanced research	Decrease	Expensive	Double benefit, energy used	Need investment, complicated application
4. Integrated farming system	Advanced research	Decrease	Cheap	Multiple benefit, zero waste, quick decomposition, effective	Time and skill of farmers limited, CH_4 emissions can be measured

The upfront investment and O&M costs of composting are 10,000US$/tonne – 20,000US$/tonne and 20US$/tonne – 40US$/tonne respectively. The investment cost for anaerobic digestion lays between 900US$/$m^3$ – 1,000US$/$m^3$ of waste.

Table 2.38: Selected Technologies/ Measures - Waste Sector

Type and amount of waste	Estimated CH_4 emission	Existing Condition	Technology Input	Cost: Investment	Cost: O & M	CH_4 emissions reduction potential of input technology (2025)
	(t CH_4/year)			(US$/ t cap/day)	(US$/t)	
Type: Municipal Solid Waste (MSW) Amount: 48.8mio t/year	578,000 (Calculation covers only SWDS)	Urban Area: 40% disposed to SWDS, 7.5% illegally dumped, 1.6% composted/ recycled, 35.5% openly burned, 15.3% otherwise treated.	Low-tech composting	10,000 – 20,000	20 – 40	DOC is converted into CO_2 and small amounts of N_2O, CH_4. CH_4 emissions are 90% less than without treatment.
			High-tech composting	25,000 – 50,000	30 – 50	
			Low-tech MBT	10,000 – 20,000	20 – 40	DOC is converted into CO_2 and small amounts of N_2O, CH_4. CH_4 emissions are 90% less than without treatment.
			High-tech MBT	25,000 – 50,000	30 – 50	
			Incineration (MSW burning)	80,000 – 120,000	40 – 80	Waste is converted into CO_2, NO and small amounts of N_2O, CH_4. CH_4 emissions can be reduced by 90%.
			Landfill: - Co-mingled waste	300,000 – 400,000 USD$/ha	3 – 4	DOC is converted into CO_2 and small amounts of N_2O, CH_4. CH_4 emissions are 90% less than without treatment.
			Sanitary landfill - Methane gas flaring - Methane gas combusting for electricity generation			
Type: Domestic Wastewater Amount: 9,586mio m^3/year	488,000	On-site sanitation: 63% urban, 27% rural Off-site sanitation: 1.3% urban	Aerated Lagoon	800US$/$m^3$	-	CH_4 emissions 80% - 90% less than without treatment.
			UASB	900US$/$m^3$	-	
			RBC	925US$/$m^3$	-	
			Oxidation ditch	400US$/$m^3$	-	
			Stabilization ponds	300US$/$m^3$	-	

Type and amount of waste	Estimated CH_4 emission	Existing Condition	Technology Input	Cost		CH_4 emissions reduction potential of input technology (2025)
				Investment	O & M	
	(t CH_4/year)			(US$/ t cap/day)	(US$/t)	
Type: Agro-industrial waste - Palm oil residues Amount: 9,816,393t/year (2000-2005)	EFB = 27,000 Shell = 9,4000 Fiber = 14,000 Wastewater = 61,000	EFB: 85% disposed to plantation, 10% mulch, 5% burned Shell: 5-10% burned for steam and power generation for internal CPO consumption, low efficiency Fiber: Burned for steam and power generation for internal CPO consumption, low efficiency	Low-tech composting	10,000 – 20,000	20 – 40	DOC is converted into CO_2 and small amounts of N_2O, CH_4. CH_4 emissions are 90% less than without treatment.
			High-tech composting	25,000 – 50,000	30 – 50	
			Incineration/ Combustion with advanced, efficient, integrated power generation technology	80,000 – 120,000	40 – 80	Waste is converted into CO_2, NO and small amounts of N_2O, CH_4. CH_4 emissions can be reduced by 90%. Electricity generation potential is: 1MW from biogas, 2.3MW from EFB, 2.7 MW from shells, 4.6MW from fibers In Total: 10.6 MW (from mills with a capacity of 45t FFB/hour)
Type: Tapioca industry waste Amount: 15.2mio t /yr (solids) 100mio m^3/yr (liquid)	288,000	50% WWTP 25% Cattle feed 25% Others	Aerated Lagoon	800US$/$m^3$	-	CH_4 emissions 80% - 90% less for all anaerobic treatment systems
			Anaerob & aerob Filter	700US$/$m^3$	-	
			AFFR & lagoon	900US$/$m^3$	-	

Type and amount of waste	Estimated CH_4 emission	Existing Condition	Technology Input	Cost: Investment	Cost: O & M	CH_4 emissions reduction potential of input technology (2025)
	(t CH_4/year)			(US$/ t cap/day)	(US$/t)	
Type: Livestock waste	688,000	Disposed or dumped to become compost	Composting	10,000 – 20,000	20 – 40	CH_4 emissions can be reduced by 90%.
			Directly spread to land	-	-	Mostly converted to CO_2
			Anaerobic digestion	900US$/m³ - 1,000US$/m³	-	CH_4 emissions by utilization or flaring
Type: Sugar cane waste Amount: 8.5mio t/year	5,238	80% Water recycled 5 % SW Utilization 10% Others Bagasse for steam and electricity generation	Water Recycling/ Bagasse utilization using advanced, efficient, integrated power generation technology	5,000US$/m³		Generally 'Cleaner Production' approach in sugar cane factory/ Can reduce GHG emissions.
Type: Pulp & paper waste Amount: no data			Liquid waste: Aerated lagoon, Anaerob ferment., Activated sludge Solids:			

6. Barriers and Policy Needs for Technology Transfer

The most intensely discussed issues, when talking about technology transfer, are the patent problem, fees and access to information. Aspects regarding social structure, organizational and cultural issues and capacity development of local people get less attention. Condemnation of local communities happens in this context. The technological process research has not completely been finished yet for developing the best applicable technology, which is also inline with the condition, potential and needs of the local communities.

Beside that, the technology transfer process, specifically the Research & Development (R&D) activities, faces many problems. One example is the prohibition of activities in the R&D sector using a multi-year budget. Furthermore, the intra institution sector approach and inter institution approach are too rigid, a critical mass research could not been achieved yet.

In order to fasten the process of technology transfer, some supported policies are needed, for example:

- A communication forum between all technology users, R&D institutions and the technology provider needs to be formed.
- Multi-year financing policy is required for an effective technology transfer program.
- Cooperation and coordination between all development sectors has to be ensured.
- The incentives for science and technology equipment tax have to be discussed.

7. Implementation Plan for Technology Transfer

There are some preliminary actions in the municipal solid waste sub-sector, which could be introduced:

- Reduce as much as possible the waste that will be transported to the final disposal site, by implementing: reduce, reuse, and recycle (composting is included) technologies. Composting technology should be easy to implement, especially by the community and it should be low budget technology.
- In the metropolitan and big city, the implementation of 3R could also include private companies.
- The new final disposal site development should implement the sanitary landfill techniques with LFG recovery.

The GHG emission reduction potential is large in the domestic wastewater sub-sector. But the GHG emission source is dispersed due to the large number of individual septic tanks. GHG emissions could be reduced significantly, when controlling domestic wastewater via off-site systems (centralized treatment plants). Future options include:

- In big cities, due to the limited space available, communal treatment plant systems can be built for example by using bio-filters or UASB technology.
- In rural areas septic tanks shall be implemented, which meet the standards set by the Department of Public Work.
- Regarding industrial waste, the implemented technology should depend on the waste characteristics. In the future, biological based processes are expected to be developed, which will help to process the waste in such way, that the increasing energy price can be handled.
- For the agro-industry, especially palm oil production, it is suitable to implement waste-to-energy technology.

CHAPTER

3. IMPLEMENTATION ACTION AND MODALITY FOR TRANSFER OF TECHNOLOGY

3.1. Priority Sectors for Transfer of Technology

Seven sectors had been selected and assessed for technology needs for mitigation. Priorities for technology transfer were determined based on three major criteria:

1. GHG emissions reduction potential
2. Technology availability and maturity
3. Economic viability

The criteria mentioned above are meant to be a simplified method to produce a list of overall priorities. The individual selection of technologies has been done by each sector, as listed in Chapter 2 of this TNA report. However, the priority list given below is not meant to undermine the importance of each sector's individual, detailed technology prioritization, but merely to provide an indication of technology transfer needs to interested parties.

Table 3.1: Priorities for Technology Transfer

Sector	Sub-Sector	Key Technologies
Energy supply	Power generation technologies	Clean coal technology: Sub-critical fluidized bed coal, supercritical- and ultra-supercritical pulverized coal
		Geothermal power plant
		Biomass utilization technology and advanced bio-fuel processing technology
Industrial process	Pulp & paper	Drill type for paper press surface, Refinery improvement, steam traps treatment, condensate heat recovery
	Iron & steel	Slab/billets hot charging, thin slab mills (hot rolling), electric arc furnace, continuous casting, fuel substitution
	Cement	Variable speed drive, false air, material substitution, kiln sheet heat loss reduction
Transportation	Road-based transportation	Advance engines, alternative fuels to substitute gasoline, transport demand management and intelligent transport system
Forestry		Sink enhancement: silviculture, growth & yield, advance tree improvement, site species matching, pest disease and fire control, carbon related measurement and monitoring activities technology
		Carbon storage: reduced impact logging, forest fire prevention, monitoring carbon stocks and emission technology

Sector	Sub-Sector	Key Technologies
Waste	Solid waste	Intermediate treatment facility: composting, mechanical-biological treatment, waste-to-energy, anaerobic digestion Final treatment system: sanitary landfill with LFG recovery
	Wastewater	Domestic waste water: aerated lagoon, UASB, RBC, oxidation ditch
	Agro-industrial waste	POME: anaerobic filter, aerobic system, stabilization ponds, aerated lagoon, hydrogen from biological treatment
Agriculture	Rice fields	Soil and crop management: technology for developing no tillage equipment, intermittent irrigation system, appropriate fertilizer
Ocean		Seaweed cultivation, mangrove and coastal vegetation, coral reef conservation

3.2. Overcoming Barriers to Transfer of Technology

Barriers to transfer of technology were identified by seven sectors in the context of their technology needs assessment in Indonesia:

a. **Institutional set-up and policy -** insufficient long-term planning, lack of supporting policies and clear targets, poor inter-agency coordination of setting up and executing development planning, insufficient inter-agency's policies and measures, poor monitoring system of implementation stages of policy and projects, absence of institutional framework to support programs for transfer of technology.
b. **Economic concerns, investment and market -** poor investment climate, limited financial resources to carry out projects, policy and pricing distortions on the energy market, poor energy pricing system with regard to giving incentives for cleaner and new technology, lack of support from private sector, limited demand for new and advanced technology to mitigate GHG emissions.
c. **Human and technology resources -** lack of professional and skilled workers for new and advances technology, poor R&D for new and advanced technologies, lack of reference/ demonstration projects.
d. **Availability of information -** lack of credible data and information, poor information sharing and documentation.
e. **Social acceptance -** lack of acceptance and awareness from community and key stakeholders on the importance of climate change mitigation technology.

The discussion suggests that institutional, legal and policy barriers are considered as the most significant issues among all identified barriers. The lack of long-term planning, legal and regulatory frameworks, weak coordination among different stakeholders, limited institutional capacity, management and organizational experience were identified as the most important barriers to effective transfer of technology.

There is also a need for initiating and improving institutional support and training for assessing, developing and managing new technologies and pursuing collaborative networks among all stakeholders - government, private sectors and interested parties from different sectors, institutes, universities and NGOs. The government plays a key role in facilitating partnerships and an essential role in creating favorable conditions for the participation of these stakeholders. In particular, efficient cooperation among stakeholders can help to maximize synergies between various programs. For private sector participation it is essential to establish a stable institutional setting with a sound economic and regulatory framework and a transparent regulatory and judicial system.

Creating an enabling environment for technology transfer includes the establishment of adequate macroeconomic conditions, fair and transparent market mechanisms, human and institutional capacities for selecting and managing technologies, national legal institutions, which reduce risks and protect intellectual property rights, codes and standards, research and technology development, and the means for addressing equity issues and respecting existing property rights.

The enabling environment component of the framework focuses on government actions, such as fair trade policies, removal of technical, legal and administrative barriers to technology transfer, sound economic policy, clear and transparent regulatory frameworks, all of which create an environment conducive to private and public sector technology transfer. The purpose of the enabling environments component of the framework is to improve the effectiveness of the transfer of environmentally sound technologies by identifying and analyzing ways of facilitating the transfer of environmentally sound technologies, including the identification and removal of barriers at each stage of the process.

A lack of awareness and social acceptance, insufficient understanding of the advantage of new technologies, social biases and other social barriers create significant obstacles to technology transfer and pose a major challenge in assessing technology needs. The limited awareness of the benefits of new environmentally sound technologies is an important challenge to local communities as well as for policy makers. To overcome this barrier an information system should be established, which ensures full access to technological information. The initiation of awareness raising campaigns will contribute to information transfer among governmental agencies, private companies and the public.

The implementation of new technologies requires financial resources. Limited funding and the inability of national institutions to provide the necessary support make additional international support for mitigation transfer technologies necessary. Funding is a significant barrier, which can be overcome by grants or loans provided by domestic and international donors. Consequently, international assistance from multilateral, bilateral and other sources, including technical and financial assistance will be essential in this process.

3.3. Identification of Priority of Action

3.3.1. Process of Transfer of Technology

Technology transfer is a highly diverse process and the nature and contents of the transfer may vary widely. As shown in Table 3.2, the process of technology transfer can be divided in three main categories:

- Transfer of scientific and engineering material and equipments to improve existing technological capabilities of the recipient country/ parties;
- Transfer of the knowledge and competences, which are necessary to operate and maintain the technologies transferred; and
- Transfer of knowledge, competence and experience to simulate, create and lead technology change and development in the recipient country.

Technology transfer results from actions taken by various stakeholders. Key stakeholders include developers, owners, suppliers, buyers, recipients and users of technology (such as private firms, state enterprises, and individual consumers), financiers and donors, governments, international institutions, NGOs and community groups. Some technologies are transferred directly between government agencies or wholly between vertically integrated companies. But increasingly technology flows depend on the coordination between multiple organizations such as networks of information service providers, business consultants and financial firms.

Table 3.2: Technology Transfer Process

Technology Exporter (Suppliers/Developers)	Elements of Technology Transfer	Technology Importer (User)
Inventors, supplier firms, engineering, managerial and other technological capability	Capital goods, product design, engineering services, managerial services	Capacity to create new product and production capability
	Skill and know-how for operation & maintenance	
	Knowledge, expertise, and experience for generating and managing technical change	Accumulation of innovative technological capacity

Although stakeholders play different roles, there is a need for partnership among stakeholders to create successful technology transfer. The government can facilitate such partnerships. The three major pathways of technology transfer are government-, private sector-, and community-initiative. Pathways may be different for "close to market" technologies and for technology innovations, which are still in the development phase. Common pathways include government assistance programs, direct purchases, licensing, foreign direct investment, joint ventures, cooperative research agreements and co-production agreements, education and training, and government direct investment. Certain stages of the technology transfer process can be identified, including identification of needs, choice of technology and assessment of conditions of technology transfer, agreement and implementation.

The institutional capacity of different stakeholder needs to be developed. Enabling conditions need to be created by public and private institutions. Furthermore, coordination and planning of each respective sector is necessary and will ensure the effectiveness of mitigation technology use to support the country's climate change mitigation effort in the long-term.

3.3.2. Prioritized actions

In the short-term (1-3 years) the following priority actions need be carried out:

a. Development of National Transfer of Technology Action Plan (NTTAP)

The purpose of the NTTAP is to serve as a key policy document in stepping out from the initial TNA phase towards the concrete implementation of activities in a technology transfer framework. NTTAP should be integrated with the key planning documents of each sector in Indonesia, such as: Blue Print of National Energy Supply (PEN), National Electricity Plan, National Industrial Development Plan, Long-Term National Development Plan and Mid-Term National Development Plan (RPJPM) and other road maps of each sector.

From the perspective of the UNFCCC negotiation, the transfer of environmentally sound technologies will play a crucial role for developing countries' contribution to meet the UNFCCC's objectives. In that respect it is necessary that NTTAP defines all elements, which are important for this process in terms of objectives, actions, responsibilities, indicators of success and expected results. It is also important to effectively integrate the implementation of technology transfer activities into other relevant climate change programmes and stakeholder activities.

Provisional terms of reference for NTTAP may include:

- Objectives and targets, related to the implementation of each priority mitigation measure in form of specific, measurable, achievable and realistic goals;
- Scope of the actions, which will be undertaken to achieve goals; it is important to indicate the

dependency of these actions in order to minimize redundancy;
- Participants' responsibilities, which should be clearly defined as roles and responsibilities of each institution, which will be involved in technology transfer, taking into account their available resources;
- Feasibility assessment of priority technology, further techno-economic assessment and analysis of the priority technology identified in this TNA. Output of this assessment will be a feasibility study document for technology;
- Barriers, identified in this TNA report, should be further analyzed and solutions to overcome them have to be proposed;
- Duration of activities should be defined and a realistic timeframe of activities should be set up, which includes the completion dates as well as milestones for the activities' execution;
- Costs fpr actions' implementation have to be estimated and presented;
- Progress indicators, are monitoring tools, which will provide evidence that objectives and targets are achieved and/or accomplished;
- Awaited results, quantifiable outputs/deliverables of activities, are expected after activities have been finished.
- Options for pilot projects have to be discussed to initiate a concrete implementation of the action plan.

b. Development of a database on renewable energy resources
A database of renewable resources is highly important for developing energy policy and an energy development program. Lessons learned from the TNA exercise suggest, that credible and detailed information and data on renewable energy resources are important for technology selection. The TNA's team faced a set of data on renewable resources, which was incomplete, obsolete, too general and not specific. Updated, specific and reliable data on renewable energy resources is needed to open the opportunity for technology transfer and investment on renewable energy projects.

The development of a credible and updated renewable energy database needs the collaborative work of different ministries and agencies: Ministry of Energy and Mineral Resources, Ministry of Agriculture, Ministry of Forestry, Agency for Assessment and Application of Technology (BPPT), Indonesia Academy of Science and University.

c. Capacity building program
Capacity building should target national and local governments' planning units, ministries planning & research units, research & development centers, utility planning units, university research centers and NGOs. A capacity building program shall focus on enhancing scientific and technical skills and capabilities in Indonesia as a precondition for assessing, adapting, managing, and developing technologies. Moreover, there is a need for enhanced skills and capabilities referring to the areas of financing, marketing, maintenance, service, information dissemination, utility regulation, policy development, technology transfer, market intermediation, tax policies, macroeconomic policies and property rights.

Organizational capacity building will focus on developing firms for publishing and the provision of communication, access to and transfer of information; on encouraging industry associations, professional associations and user/ consumer organizations; on supporting participatory approaches to enable private actors, public agencies and NGO's to engage at all levels of environmental policy-making and project formulation; on advancing decentralization of governmental decision making and authority.

Informational capacity will focus on developing improved indicators and collecting data on the availability, quality and flows of environmentally sound technologies (EST); developing technology performance benchmarks for ESTs; improving information systems and linking them to international or regional networks.

d. Ensuring financial support

Finally, to ensure the continuation of activities related to the preparation and development of NNTAP, capacity building and other technology transfer activities, it is necessary to secure technical and financial support, both from foreign donor organizations and domestic institutions.

The institutional set up such as National System of Innovation (NSI) and National Technology Information System (NTIS) are required to support long-term and meaningful transfer of technology. The discussion of NSI and NTIS will be further elaborated in the section on Modalities for Transfer of Technology.

3.4. Modalities for Transfer of Technology

Modalities or means to acquire and implement new technologies are closely related to the flow of investment involving private and public sector activities. Transfer of technology can take place within a respective country or between countries; these are closely related to institutional and financial mechanisms. Modalities for enhancing transfer of technology of climate mitigation need to be linked with the development of institutional capacity on national level and financing modalities.

a. Development of a National System of Innovation

The literature reveals that a National System of Innovation (NSI), which integrates the elements of capacity building, access of information and an enabling environment into comprehensive approaches to EST transfer, adds up to more than the individual components and supports the creation of an innovation culture. Subsystems and the quality of interconnections within them can successfully influence technology transfer.

The concept of NSIs can be enhanced through partnerships with international consortia. Such partnerships would be system oriented, encompass all stages of the transfer process and ensure the participation of private and public stakeholders, including business, legal, financial and other service providers from developed and developing countries.

NSI activity may include:

- Targeted capacity building, information access, training for public and private stakeholders and support for project preparation;
- Strengthening scientific and technical educational institutions in the context of technology needs;
- Collection and assessment of specific technical, commercial, financial and legal information;
- Identification and development of solutions to technical, financial, legal, policy and other barriers to wide the deployment of ESTs;
- Technology assessment, promotion of prototypes, demonstration projects and extension services through linkages between manufactures, procedures and end users;
- Innovative financial mechanisms such as public/private sector partnerships and specialized credit facilities;
- Local and regional partnerships between different stakeholders for the transfer, evaluation and adjustment to local condition of ESTs; and
- Development of market intermediary organizations such as Energy Service Companies (ESCO).

In the Indonesian context, certain policies and regulations to support NSI are in place such as:

- Act No. 18/2002 on the National System of Science and Technology;
- Presidential Decree No. 4/2003; and
- Government Regulation No. 20/2005 on Transfer of Technology.

Despite the existing regulatory framework, the challenge is the implementation of the NSI on national and local level. Needs and opportunities for a transfer of technology program in the context of climate change should create larger commitment for establishing NSI on national level.

b. National Technology Information System

The technology transfer process requires a comprehensive and consistent set of information about different technologies. Therefore a technology information system, which defines the means, including hardware, software and networks, which facilitate the flow of information between the different stakeholders, is required to enhance the development and transfer of environmentally sound technologies. On national level a database/ information system on technology and case studies of technology application can be used by different parties to get information on the state of technology research and development and scale application. This system provides information on technical parameters, economic and environmental aspects of environmentally sound technologies and opportunities for technology transfer. It can be hosted by the respective ministry of technology and linked to various government research centers, university and industry research centers.

The National Technology Information System can be connected to the database compiled and stored in UNFCCC TT: CLEAR database, which includes Technology Transfer Projects (TT Projects), environmental sound technologies (ESTs) and technology needs and other technology information. The National Technology Information System can be an element of NIS.

c. Multilateral and bilateral mechanisms

Overseas Development Assistance

Overseas Development Assistance (ODA) is still significant for developing countries and successful transfer of ESTs. ODA can also assist the improvement of policy frameworks and take on long-term capacity building. ODA is still important for those parts of the world and sectors, where private sector investment is comparatively low, such as agriculture, forestry, human health and coastal zone management.

The recognition is increasing, that ODA helps with mobilizing and multiplying additional financial resources. Moreover, it can support the creation of enabling conditions, which may leverage a larger flow of private finance into ESTs in the context of overall sustainable development goals in recipient countries. National development plans and strategies should be able to link the technology transfer priorities of each sector to the ODA system to enhance development, transfer and deployment of technology for mitigating climate change.

Development cooperation agencies such as GTZ, USAID, JICA, NEDO, DFID and others can play positive roles in providing technical assistance and financial support for technology transfer projects. The Government of Indonesia needs to propose an initiative on the establishment of a development cooperation with focus on the transfer of climate change mitigation technologies, as well as capacity development and institutional set-up to host technology transfer activities.

Global Environmental Facility

The Global Environment Facility (GEF), an operating entity of the UNFCCC's financial mechanism, is a key multilateral institution for the transfer of ESTs. Compared to the magnitude of the technology transfer challenge, the efforts are of modest scale, even when added to the contributions from bilateral development assistance.

GEF targets incremental, one-time investment in mitigation projects and thus demonstrates a variety of financing and institutional models for the promotion of technology diffusion, which contributes to host countries' ability to understand, absorb and diffuse technologies. GEF also supports capacity building projects for adaptation with limitations currently imposed by UNFCCC guidance. Moreover, GEF backs leveraged financing through loans and other resources from governments, other donor agencies, the private sector, and the three GEF project-implementing agencies (UN Development Programme, UN Environment Programme and World Bank Group). In November 2008 GEF set up a program to create a funding window for supporting technology transfer activities.

d. Clean Development Mechanism (CDM)

The Kyoto protocol of 1997 created a new financial mechanism for North-South investment, which could be used for climate change mitigation called the clean development mechanism (CDM). The purpose of the CDM is to assist Parties not included in Annex I in achieving sustainable development, in contributing to the ultimate objective of the convention, and to assist Parties included in Annex I in achieving compliance with their quantified emission limitation and reduction commitments under Article 3 of the Kyoto Protocol. Although CDM is broadly similar to Joint Implementation (JI), because it is an international investment model used to offset national carbon abatement, CDM is different from JI in that it is for "sustainable development" projects in general. Furthermore, its description in Article 12 of the Kyoto protocol does not mention the words "sinks". Under the Kyoto protocol, JI is now restricted to countries within Annex I. Therefore it may mainly support investment by North America, the European Union in Russian, Eastern and Central Europe rather than in developing countries.

The CDM shall be subject to the authority and guidance of the Conference of the Parties (COP), which serves as the meeting of the Parties to this Protocol, and be supervised by an executive board of the CDM. It shall assist in arranging funding of certified project activities as necessary. At its first session the COP elaborated modalities and procedures for CDM with the objective of ensuring transparency, efficiency and accountability through an independent auditing and verification of project activities. Participation under the CDM and in the acquisition of certified emission reductions may involve private and/or public entities, and is subject to whatever guidance may be provided by the executive board of the CDM.

The CDM should facilitates the transfer of technology from Annex I Parties to non-Annex I host Parties. The transfer of environmentally safe and sound technology and know-how is one of the core objectives of the CDM, as stated by the Conference of the Parties.[4] Project participants are required to describe in their project design document (PDD), how technology will be transferred[5].

A lot of critiques are addressed to CDM due to its low impact regarding the promotion of sustainable development and meaningful transfer of technology required by developing countries to contribute to the objective of the climate convention. Furthermore, the poor economic impact to host countries and the complexity and high cost associated with setting up and monitoring CDM project are criticized. Despite these critiques, the mechanism can be used to promote technology transfer for private sector projects as long as institutional support is in place to strengthen the sustainable development benefit of CDM project.

During the latest discussion on the Kyoto Mechanism the "sectoral approach" was introduced. This new modality can be a meaningful instrument in the near future to enhance technology transfer for specific sectors.

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[4] COP Document: 17/CP.7, preamble: *The Conference of the Parties:*
Further emphasizing that clean development mechanism project activities should lead to the transfer of environmentally safe and sound technology and know-how in addition to that required under Article 3, paragraph 5 of the Convention and Article 10 of the Kyoto Protocol.

[5] A project activity shall be described in detail taking into account the provisions of the annex on modalities and procedures for a CDM, in particular, section G on validation and registration and section H on monitoring, in a project design document which shall include the following: A description of the project comprising the project purpose, a technical description of the project, including how technology will be transferred, if any, and a description and justification of the project boundary (4/CMP.1, Annex, Appendix B, paragraph 2).

3.5. Financing Modalities for Transfer of Technologie

Transfer of technology activity project needs strong financial support. Currently financial support from UNFCCC is very limited. However, outside the convention financing modalities are also available.

a. Multilateral Development Bank

Multilateral Development Banks (MDBs) (World Bank, Asian Development Bank) can help to mobilize financing from private capital. Furthermore, they can support developing countries' governments in meeting the needs and use of financial innovation to encourage the implementation of climate change mitigation technology programs or activities.

b. Private sector investment

Private sector investment can be carried out through Foreign Direct Investments (FDI) if the investors come from different countries or participate in project financing.

A further discussion of financing mechanisms for climate change projects is presented in chapter 4 of this report.

CHAPTER

4. FINANCING REQUIREMENT AND FUNDING SOURCES

4.1. Financing Needs

Financial support is required for research, development and deployment of prioritized technologies for GHG emissions mitigation and capacity building programs to enhance skills and capabilities, develop markets, marketing, utility regulation and processes for conducting technology transfer.

In addition, financing is required for comprehensive studies in each sector in order to develop technology road maps and for every stage of technology development:

1. Research & development
2. Demonstration project
3. Deployment
4. Diffusion
5. Commercialization of technologies

As an example, direct financing is needed for technology deployment in potential CDM projects targeting industrial processes, energy supply and transportation system. Activities in CDM can be linked to technology transfer activities

a. Financing required for energy supply

The Ministry of Energy and Mineral Resources (2007) estimated that the full fledged development of geothermal resources to produce geothermal power plants with a total capacity of 27GW in 2025 will require 161billion US$, while the development of CCS technology requires 158billion US$. More financing is needed to build decentralized energy systems in the remote areas of Indonesia.

According to the Electricity Supply Development Plan (RUPTL) of the state-owned electricity company PLN, new power plants with a total capacity of 57GW, including geothermal power plants with 5GW, hydropower plants with 4.74GW and mini hydropower plants with 0.19GW, will be built. The plan involves the construction of 35,811km^2 transmission, a more than 175million km^2 medium voltage distribution network and a more than 222million km^2 low voltage distribution network for the period 2009 – 2018. Total investment needed for building such a power system is estimated with 83.7billion US$ or more than 8billion US$/year.

Table 4.1: Investment required for the Development of the Power System, 2009-2018

Infrastructure	Investment Requirement (billion US$)
Power plants	56.87
Transmission network	14.44
Distribution network	12.38
Total Investment	**83.69**

Source: RUPTL PLN 2008-2018 (2009)

From these 57GW of new power generation capacity, PLN plans to build 35.3GW, while the private sector is expected to build 22GW through the IPP scheme over the next 10 years. Only the development of those power plants is covered by this investment plan, which will be connected into the interconnection/grid system (so called large unit power plant). The financing required to build the decentralized energy system based on renewable resources has not yet been integrated in the plan.

b. Financing requirements of the Industry sector

The assessment of required investment for energy conservation in the industry sector was carried out by the Ministry of Industry. The energy conservation program targets four energy intensive industry sub-sectors, cement, iron & steel, textile and pulp & paper, and will cost about 5.2billion US$.

Table 4.2: Investment for the Energy Conservation Program targeting Energy Intensive Industries, 2007

Industry	Total Activities	Technology	Total Investment (mio. US$)
Cement	9	Blended raw material Alternative fuel (palm kernel shell, rice husk)	114.3
Iron & steel	71	Utilization of coal gasification Changing of electric furnace technology Reheating fuel furnace	236.6
Pulp & paper	81	Recycling processes (product and waste)	3,240.0
Textile	2,726	Replacement of machinery	1,635.6
		Total Investment	**5,226.5**

c. Financing Requirement for Other Sectors

Financing required for implementing selected mitigation technologies varies for each sector. Most of the TNA sector reports have not yet identified the total financing volume required for developing and deploying technology due to a lack of data/information, which is the basis for estimating the total funding required in an accurate way. However, each report has identified costs per unit for priority technologies and measures. Selected investments needed for applying mitigation technology and measures in various sector is presented in Table 4.3.

Table 4.3: Investment required for Selected Mitigation Technologies and Measures

Sector	Technology/ Measure	Estimated Investm. (mio. US$)	Notes
Energy Supply	Geothermal Power Plant	161,000	Estimated cost to install 27GW until 2025
	Advance Coal PP	3,300	Estimated capital cost for 3 600MW units
	Carbon Capture & Storage	158,000	Lower estimation (capital cost)
	IGCC with sequestration	4,500	Estimated capital cost for 3 600MW units

Sector	Technology/ Measure	Estimated Investm. (mio. US$)	Notes
Transportation	Improvement of public transport system	435	Investment on building rail lines, trains and other infrastructure change. Transit scheduling and public awareness. Improvement of shelters in greater Jakarta.
	Intelligent transport system	978	Estimated cost for building ITS for $600km^2$
	Provision of public bikes in city centers and business district	1	10,000units of bikes a 100US$/ unit, additional costs for building a supporting infrastructure apply
Industry	Textile: Energy efficiency in spinning units	2	Estimated investment for energy efficiency improvement: low cost/ short-term and high cost/long-term option
	Textile: Composite mills	27,016	Estimated investment for energy efficiency improvement: low cost/ short-term and high cost/long-term option
	Cement Factory: Install VSD equipment	2,500 to 2,600	Installation of Variable Speed Drive (VSD) and peak cutting equipments
	Cement Factory: Install inlet cooler chamber	1,100	Installation of fixed grate inlet cooler chamber
Waste	Municipal solid waste: Composting	10 - 50	Estimated capital cost for installing composting technology for MSW with a solid waste capacity of 1,000ton/day
	Municipal solid waste: Landfills	300 - 400	Estimated investment cost for sanitary landfill technology, including gas flaring per hectares land
Forestry	Sink enhancement program	2	Estimated cost for activities in 1,000ha. Combination of several measures: plantation, pest, disease and fire control, monitoring for carbon sequestration.
Agriculture	Livestock: Biogas plant	8 - 9	Estimated cost for building 10,000units with a biogas plant size of $6m^2$
	Maintenance natural forest program	1	Estimated cost for maintaining 1,000ha natural forest. Different activities/ measures are applied.

4.2. Available Funding Resources

Several sources of funding for climate mitigation technology are available through bilateral and multilateral under UNFCCC and outside UNFCCC.

4.2.1. Funding Mechanism under UNFCCC

Under UNFCCC and its Kyoto Protocol, funding is available via the Global Environment Facility, which serves as the financial mechanism body for the Convention. In 2001 the UNFCCC decided to establish a Special Climate Change Fund (SCCF) and a Least Developed Country Fund (LDCF) to finance projects related to climate change adaptation, technology transfer, capacity building in various sectors including energy, transportation, industry, agriculture, forestry and waste management, and for economic diversification programs.

Via the GEF both the LDCF and SCCF are managed, after they became operational in 2002. The SCCF was funded from voluntary contributions beyond regular GEF replenishment from 13 contributing participants (Canada, Denmark, Finland, Germany, Ireland, Italy, the Netherlands, Norway, Portugal, Spain, Sweden, Switzerland and the United Kingdom). The plan for the initial five-year period of the SCCF was endorsed by the GEF Council in November 2004.

During the GEF Council meeting in November 2008 it was decided, that 50million US$ from the SCCF, Global Climate Fund and RAF account would be set aside to support a technology transfer program. The proposed program will consist of three funding windows to support technology transfer activities: (1) technology needs assessments; (2) piloting priority technology projects linked to TNAs; and (3) dissemination of GEF experience and successfully demonstrated ESTs (GEF 2008).

Another financial mechanism is the CDM, which helps to finance projects mostly by the private sector.

Table 4.4: Sources of Funding under UNFCCC and its Kyoto Protocol

Sources	Amount (mio US$)	Timeframe	Notes
Mitigation			
Funds			
Pilot phase	280.6	1991 - 1993	
GEF 1	507.0	1994 - 1998	
GEF 2	667.2	1998 - 2002	
GEF 3	881.8	2002 - 2006	
GEF 4	1,030.0	2006 - 2010	
Already committed under GEF 4	352.0		
SCCF (Technology)	16.2	As at 7-Nov-2008	Total, includes pledges
Special Programmes under GEF 4: Sustainable forest management/ LULUCF	154.0		
Investments			
CDM	8,400.0	During 2007	Market value of expected GHGe reductions by CDM projects in 2007

JI	400.0	During 2007	Market value of expected GHGe reductions by JI projects in 2007
Adaptation			
Funds			
SPA	50.0	GEF 3 - GEF 4	Resource: have been allocated
SCCF (Adaptation)	90.3	As at 7-Nov-2008	Total, includes pledges
LDCF	172.0	As at 7-Nov-2008	Total, includes pledges
Adaptation Fund	400 - 1,500	2008 - 2012	Estimated total
	91.3	As at 31-Oct-2008	Estimated current funding

Source: FCCC/CP/2006/3, FCCC/CP/2007/3, GEF. 2008, *GEF Resource Allocation Framework*. GEF-4 *Indicative Resource Allocation for the Biodiversity and Climate Focal Areas Eased on the Midterm Reallocation*, GEF. 2008. *Status Report on the Climate Change Funds*. GEF/LDCF/SCCF.5/Inf.2.

Abbreviations: CDM = clean development mechanism, GEF = Global Environment Facility, JI = joint implementation, LDCF = Least Development Countries Fund, LULUCF = land use, land-use change and forestry. SCCF = Special Climate Change Fund, SPA = Strategic Priority on Adaptation under the GEF Trust Fund.

Note: GEF 1 refers to the first replenishment period of the GEF Trust Fund, GEF 2 to the second replenishment period, and so on.

Source: Investment and Financial Flow to Address Climate Change: An Update (UNFCCC, 2008)

The Reducing Emissions from Deforestation and Forest Degradation (REDD) mechanism was accepted as a positive incentive for reducing deforestation in developing countries. Many Parties have proposed both, market- and fund-based mechanisms, to support REDD activities. Some Parties argue that funds supported by public finance would play a critical role for activities such as capacity building, institutional strengthening, conservation, sustainable management of forests and other means to increase forest carbon stock. Table 4.5 summarizes several dedicated funds and financing instruments, which are already operational to support capacity building and facilitate actions in developing countries to address REDD.

Table 4.5: National and Bilateral Public Funding Initiatives for REDD

Initiative	Estimated funding level	Period	Nominal funding level
s	(mio. US$)		(mio. US$/year)
International Forest Carbon Initiative (Australia)[a]	135	Uncertain	50 (pledged so far)
Climate and Forest Initiative (Norway)[b]	2,250	2008 - 2012	450
Forest Carbon Partnership Facility (World Bank)[c]	300	2008 - 2018	Uncertain
UN-REDD Programme[d]	35	2008 - 2012	Uncertain
Amazon fund[e]	1,000	2008 - 2015	100 (pledged so far)
Congo Basin Forest Fund[f]	200	Uncertain	Uncertain

[a]<http://www.climatechange.gov.au/international/publications/fs-ifci.html>

[b]<http://www.regjeringen.no/en/dep/md/Selected-topics/klima/why-a-climate-and-forest-initiative.html?id=526489>

[c]<http://www.carbonfinance.org/Router.cfm?Page=FCPF&ft=About>

[d]<http://www.undp.org/indtf/UN-REDD/assistance_strategy.shtml>

[e]<http://www.bndes.gov.br/english/news/not191_08.asp>

[f]<http://www.cbf-fund.org/>

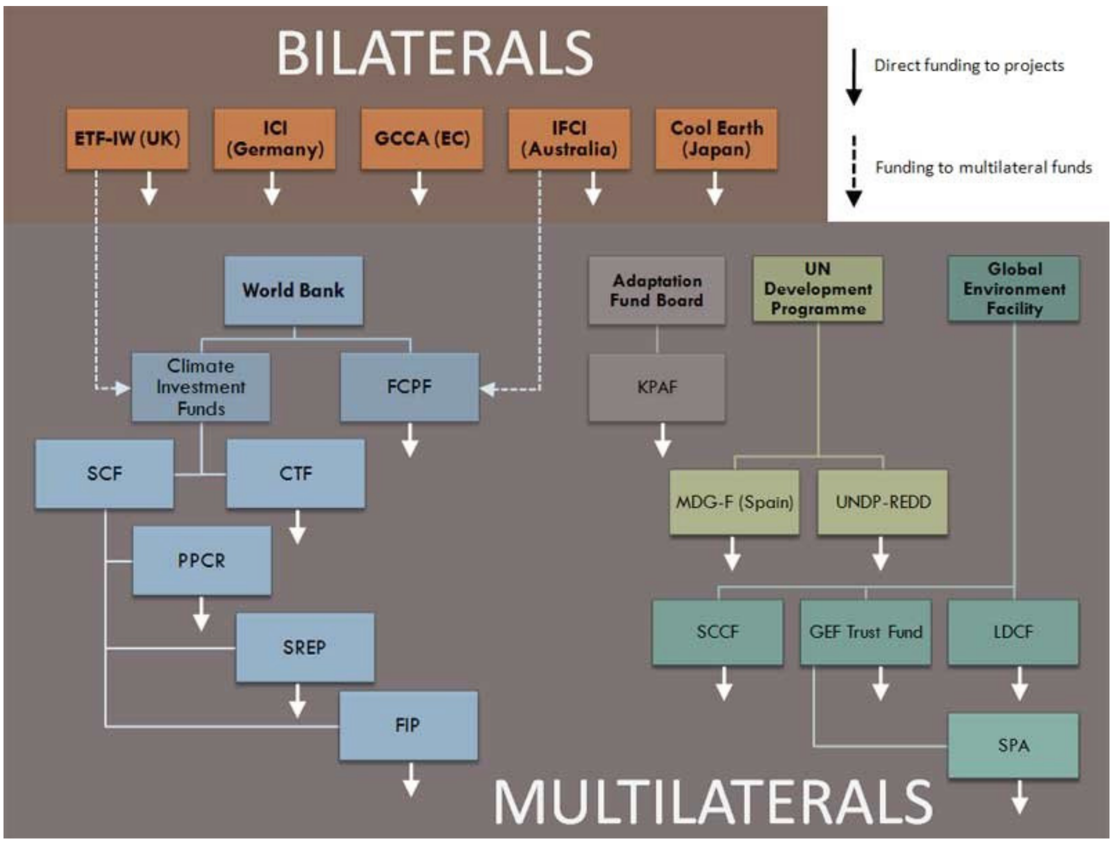
Source: Investment and Financial Flow to Address Climate Change: an Update (UNFCCC, 2008)

4.2.2. Bilateral and Multilateral Funding Initiatives

Funding initiative from developed countries

In addition to the financial mechanisms under UNFCCC, different bilateral and multilateral funding initiatives have been set up. Some developed countries such as the United Kingdom, the United States of America, Germany, Australia and Japan developed bilateral mechanisms to support climate change projects.

Japan introduced the Cool Earth Partnership, a 10billion US$ funding initiative to support climate change programs between 2008 and 2012. About 8billion US$ (1trillion Yen) of this funding are allocated for climate change mitigation projects in developing countries - 4billion US$ through the Japanese ODA loan and 4billion US$ through capital contribution and guarantee by JBIC, insurance by NEXI and government support projects by NEDO.



Source: climatefundsupdate.org (access 10 February 2009)

Figure 4.1: Emerging Architecture of International Climate Fund Administration

The International Climate Initiative (ICI) is a fund of the German Government. The German ICI will provide financial support to international projects supporting climate change mitigation, adaptation and biodiversity projects with climate relevance. It aims to ensure that such investments will trigger private investments of a greater magnitude and that financed projects will strategically support the post-2012 climate change negotiations. For this purpose, it will support multilateral activities and funds focusing on adaptation and forest management.

The ICI will mobilize resources from private companies (compliance buyers) under the framework of the European Union Emission Trading Scheme (EU ETS). In 2008 the German government auctioned 8.8% of its allowable emission permits to businesses. Approximately 30% of the revenue earned from this sale is intended to finance climate change related projects. This is expected to amount to 400million €/year for domestic and international use. 120million €/year is earmarked for developing countries and countries in transition - half of which is intended for sustainable energy projects and the other half for adaptation to climate change impacts and biodiversity projects. In 2008 the ICI supported approximately 100 projects in developing, newly industrializing and transition countries with a total of around 110million €.

Multilateral Development Banks

World Bank's Climate Investment Fund is a 6.3billion US$ climate change investment instrument. The fund consists of two trust funds. First, the Clean Technology Fund (CTF), through which the World Bank will provide new, large-scale financial resources to be invested in projects and programs in developing countries. These projects shall contribute to the demonstration, deployment and transfer of low-carbon technologies and must therefore offer a significant potential for long-term GHG emissions mitigation. The second fund, the Strategic Climate Fund, is set up with a broader and more flexible scope and serves as an overarching fund for various programs to test innovative approaches to climate change. The first program aims to increase climate resilience in developing countries.[6]

The Asian Development Bank (ADB) established two financing instruments, i.e. the Climate Change Fund (CCF) in May 2008 and the Clean Energy Financing Partnership Facility (CEFPF) in 2007. CCF was established with an allocation of 40million US$ from ADB ordinary capital resources - 25million US$ for clean energy development, 5million US$ for land use, REDD and improved land use management, and 10million US$ for adaptation.[7]

The CEFPF was set up to help improving energy security in developing member countries and decrease the rate of climate change. This aim is planned to be achieved via financing the deployment of new, more efficient and less polluting supply- and end-use technologies. ADB has set an initial target of 250million US$ by 2008. CEFPF resources are also used to finance policy-, regulatory- and institutional reforms, Which encourage clean energy development.

Table 4.6: Bilateral and Multilateral Funding Initiatives for Climate Change

	Estimated funding level			Purpose	Type	Period	Nominal funding level
		(mio.)	(mio. US$)				(mio. US$/year)
Bilateral initiatives							
Cool Earth Partnership (Japan)	USD	10,000	10,000	A, M	G, L	2008 - 2012	2,000.0
ETF-IW (United Kingdom)	GBP	800	1,182	A, M	G, L	2008 - 2010	394.0
Climate and Forest Initiative (Norway)[c]				M	G, L		< 600.0
UNDP-Spain MDG Achievement Fund	EUR	90	114	A, M	G	2007 - 2010	28.5
GCCA (European Commission)[d]	EUR	60	76	A, M	G	2008 - 2010	25.3
International Climate Initiative (Germany)[e]	EUR	600	764	A, M	G	2008 - 2012	153.0
IFCI (Australia)	AUD	200	132	M	G	2007 - 2011	26.4
Multilateral Initiatives							
UN-REDD[g]	USD	35	35	M	G	N.A.	N.A.

[6] World Bank CIF: www.worldbank.org/CIF

[7] Asia Development Bank CCF: www.adb.org/Clean-Energy/ccf.asp

	Estimated funding level			Purpose	Type	Period	Nominal funding level
		(mio.)	(mio. US$)				(mio. US$/year)
Forest Carbon Partnership Facility (World Bank)[h]	USD	300	300	M	G, L	2008 - 2020	23
Climate Investment Funds (World Bank):	USD	6,341	6,341			2009 - 2012	1,558
• Clean Technology Fund	USD	4334	4,334	M	G, L		
• Strategic Climate Fund, which includes	USD	2,006	2,006	M	G, L		
• Forest Investment Programme	USD	58	58	M	G, L		
Scaling up Renewable Energy	USD	70	70	M	G, L		
Pilot Programme for Climate Resilience	USD	240	240	A	G, L		

Source: Porter G, Bird N, Kaur N and Peskett L. 2008. *New Finance for Climate Change and the Environment*. The Heinrich Boll Foundation and WWF. World Bank, 2008. *Trustee Report Financial Status of the CIF*. CTF/TFC.1/Inf 2

Abbreviations: A = adaptation, ETF_IW = Environmental Transformation Fund - International Window, G = grants, GCCA = Global Climate Change Alliance, IFCI = International Forest Initiative, L = loans, M= mitigation, MDG = Millennium Development Goals, UN-REED = United Nation Collaborative Programme on Reduced Emissions from Deforestation and Degradation

[a]Valued at exchange rates available on 14 November 2008

[b]It is expected that most of the finance available under this initiative will be channeled through the Clean Investment Funds of the World Bank

[c]<http://unfcc.intl/files/meeting/ad_hoc_working_groups/lca/application/pdf/norway_accra.pdf>

[d]<http://ec.europa.eu/development/policies/9interventiomareas/environment/climate/climate_en.cfm>

[e]<http://www.oecd/org/datzoecd/38.61/40533487.pdf>

[f]During 2008-2012, funding for the initiative will be generated from auctioning 10% of allowances from the European Union emissions trading scheme. Larger amounts of funding can be expected from 2013 onwards, with up to 100% auctioning.

[g]<http://www.undp.org/indrf/un-redd/overview.shtml>

[h]<http://wbcarbonfinance/org/Router.cfm?Page=FCPF&ItemID=34267&FID=34267>

Source: Investment and Financial Flow to Address Climate Change: an Update (UNFCCC, 2008)

4.2.3. Other instrument: Public private partnerships for low carbon technologies

A promising instrument for the transfer and application of climate friendly technologies is the public private partnership (PPP). Its importance in terms of investment volume can be understood when looking into the share of foreign direct investment in relation to overseas development assistance, which was twice as high (approx. 50billion US$/year ODA and 170billion US$/year FDI in 2004).

Typically the *public partner* would provide technical assistance such as problem analysis, expertise, development of training modules, monitoring and evaluation, as well as financial contributions. The *private sector partner* would instead contribute with knowledge and technology, access to markets & networks and finance (typically 50 % of all costs, the other half borne by the public partner). Possible PPPs could include: improvement of energy-efficiency in industry, assistance to certain CDM projects, mini-hydro-power systems or support for GHG emissions mitigation management within enterprises and industrial clusters.

4.2.4. National Climate Change Trust Fund

The Indonesian government is currently preparing a financing mechanism as a source of funding for mitigation and adaptation projects, including the transfer of environmentally sound technology to achieve low carbon development.

The National Development Planning Agency (BAPPENAS) is preparing the Indonesian Climate Change Trust Fund (ICCTF), which will serve as a financing vehicle for mitigation and adaptation activities. The fund aims at promoting coordinated action to respond to climate change. Sources of funding of the ICCTF are the national budget and grants from donors/ODA. The first phase of the ICCTF is expected to start in 2009.

4.3. The Way Forward

Sources of funding under UNFCCC and its Kyoto Protocol, as well as under bilateral and multilateral funding initiatives are limited in terms of number and period. Hence government agencies responsible for the respective sectors need to develop several proposals for pilot projects for carrying out transfer of environmentally sound technology in cooperation with the private sector and/or state-owned enterprises. Proposals for pilot project can be developed for low/medium cost- and quick options.

As a long-term objective, a strategy to access funding from the above described sources needs to be included in the National Technology Transfer Action Plan. The government and the private sector should discuss various options, which help to enhance technology transfer and use mechanisms available under UNFCCC or market-mechanisms.

CHAPTER

5. CONCLUSION AND RECOMENDATION

5.1. Conclusion

The following overall conclusions from the TNA process are restricted to those that go beyond the sector specific conclusions, which can be found in the respective sector chapters.

1. TNA is a process to identify and analyze the technology needs of Indonesia. It was carried out through multi-stakeholder consultations, during which technologies for transfer were prioritized for seven sectors: energy, transportation, industry, forestry, agriculture, ocean and waste. The conduction of this TNA involved different stakeholders: ministries, government agencies, private sector, state-owned enterprises, academies/ university and NGOs. The coordination on national level and the participation of different sectors were necessary to acquire the real sector needs for GHG emissions mitigation options. During a subsequent stage possible technology needs, barriers to technology deployment and related policy gaps were identified. The strong involvement of the relevant sectors will ensure proper implementation of the technology needs at sector level. Although the chosen bottom up approach consumes more time than the consultative contract option, it will warrant the implementation at sector level in the long run.

2. Emissions scenario: Indonesia's GHG emissions are expected to increase dramatically until 2025 compared to 2006 level. The major emission sources will be fossil fuel consumption for electricity generation, transportation, industrial processes, waste and deforestation. In the light of these projections, the technology transfer of environmentally sound technologies can be a vital element to alter these trends in the long run.

3. Different scenarios show that the application of clean and advanced technology as well as the development of policies, which regulate GHG exposure from several economic activities, can reduce the production GHG emissions. These scenarios discuss the application of certain technologies/ measures for energy supply & -demand side, retrofit and fuel switching in industrial processes, application of advanced engines for vehicles, the development of a mass public transportation system, forest management and enhanced reforestation. The transfer of clean and advanced technology will play an important role in mitigating GHG emissions in Indonesia.

4. Transfer of technology in the short- and mid-term (1-10 years), both hard- and soft technology, should be prioritized according to the three main sources of GHG emissions, namely: electricity generation, industrial processes (iron & steel, pulp & paper, cement, petrochemical and textile) and transportation. Furthermore, taking into account the current and projected GHG emissions from deforestation and forest degradation, technology transfer and financial assistance are also required in the forestry sector to reduce the deforestation rate and improve the forest capacity to absorb and store carbon. One unique sector presented in this TNA is the ocean sector, which stands for the huge natural marine resources in Indonesia. This TNA describes some technology options for climate change mitigation, which apply to marine resources.

5. The modes of transfer of technology can be identified as follow: transfer of know-how, joint technology research & development, technology acquisition, technology implemented in embedded plants and turnkey projects and foreign direct investment. Capacity building programs are required for government agencies, public and private sector, academic institution and NGOs. Capacity building will enable to identify technologies, carry out technical assessment, evaluate technologies and prepare specific technology transfer proposals.

6. A technology transfer system will assure the participation of many stakeholders such as government agencies, academic institutions, state-owned enterprises, private sector and NGOs in the "long run". The government in collaboration with other stakeholders needs to prioritize the removal of identified barriers for technology transfer in Indonesia and to create an enabling environment to start and enhance technology transfer in the priority sectors.

7. The three major pathways of technology transfer are government, private sector and community-initiative. Pathways may be different for "close to market" technologies and for technology innovations, which are still in the development phase. Commonly they include government assistance programs, direct purchases, licensing, foreign direct investment, joint ventures, cooperative research- and co-production agreements, education and training, and government direct investment.

8. Large funding to develop and deploy cleaner, advanced and more efficient technology to mitigate GHG emissions is available under current UNFCCC mechanisms and through bilateral and multilateral initiatives. Meanwhile, the Indonesian government initiated activities to set up a national climate change trust fund (ICCTF), which may be a funding source for mitigation projects in the future.

5.2. Recommendation

1. UNFCCC needs to develop a framework, which helps to ensure a minimum level of technology transfer from developed to developing countries; including financial resources for technology implementation. In this regard, Indonesian delegates need to initiate the creation of such a framework in the upcoming negotiation process.

2. This TNA could be used as the solid basis of any technology transfer activity at the present stage in Indonesia. The document covers comprehensive ideas on technology transfer from seven sectors, which represent almost all sectors related to climate change mitigation in Indonesia. The technology transfer issue is handled by a working group underneath the newly established National Council on Climate Change (2008). The government of Indonesia is willing to accelerate any technology transfer process for the purpose of development priority as described in this TNA for general and specific sector criteria. Nonetheless several sectors require more accurate GHG emission inventories and emission projections, which need to be processed in parallel in the context of a climate study. Further scientific collaboration to encourage and support more studies on climate change related issues are needed, especially regarding methodological aspects such as acceptable estimation techniques of emission reduction cost.

3. The government of Indonesia is currently mainstreaming climate change into the national development plans, especially into the next mid-term development plan (5-10 years ahead). Furthermore, the National Standardization and Accreditation Agency has started to establish new eco-friendly standards. The government can impose more general environmental policies by adopting international standards, systems and procedures based on "best available technologies" to create conducive conditions for the transfer of ESTs.

4. Fostering the transfer of technologies needs coherent and institutional response. In the short-term (1-3 years), a follow up exercise of this TNA needs to take place, including:
   - Development of National Transfer of Technology Action Plan (NTTAP). Provisional terms of reference were described in chapter 3.
   - Creation of a database for renewable energy resources, which includes information on agricultural waste, hydro, solar, wind, renewable energy potential from ocean (tidal and waves) on district level. All government institutions, public and private sectors and universities must be able to access the database. It should be updated regularly on a 3-5 year basis to keep information sufficient.
   - Identification and set up of a capacity building program for each priority sector.
   - Recognition of funding requirements and sources. Set up of a regulatory and institutional framework to boost opportunities for accessing available funding.

Completion of NTTAP may require financial assistance and technical expertise.

5. Lastly, the government shall encourage more pilot projects for technology transfer in business/ private sector, especially for energy supply, use of biomass and industrial processes, and disseminate success stories of enterprises/ industries, which benefited from technology transfer to motivate other actors. Experiences gained from these activities might be used to improve future planning and broaden the institutional set up for a technology transfer program in the near future, in particular as identified in the agriculture, waste and energy supply sector reports. Further technical assessment and preparation are required, in particular the coordination of respective government institutions in determining technical feasibility.

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CHAPTER - I

ENERGY - SECTOR

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CHAPTER I - ENERGY SECTOR

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1. BACKGROUND

1.1. Aims

Indonesia ratified the United Nations Framework of Climate Change Convention (UNFCCC) through Act No. 6, in 1994 and the Kyoto Protocol through Act No. 17, in 2004. "*...Article 4.5 of the Convention defines technology needs assessments (TNAs) as, a set of country-driven activities that identify and determine the mitigation and adaptation technology priorities of Parties. They involve different stakeholders in a consultative process to identify the barriers to technology transfer and measures to address these barriers through sectoral analyses. These activities may address soft and hard technologies, such as mitigation and adaptation technologies, identify regulatory options and develop fiscal and financial incentives and capacity-building."* [UNFCCC: Technology Transfer Framework] Stakeholders are governments, private sector entities, financial institutions, NGOs and research/education institutions. The aims of Indonesia's TNA can be itemized as follows:

- Contribute to the global effort towards sustainable development and, in particular, the protection of the climate system
- Communicate Indonesia's needs for environmentally sound technologies (ESTs) to the UNFCCC Conference of the Parties (COP) and the global community
- Resource documents to identify and prioritize ESTs needed by Indonesia and mark those, which require support and co-operation from developed countries
- Set the foundation for a database for ESTs

1.2. Objectives

- Identify, analyze and prioritize technologies, which could form the basis for a portfolio of Technology Transfer programmes aiming GHG emissions mitigation
- Identify human and institutional capacity needs that ensure the smooth development, transfer and acquisition of environmentally sound technologies
- Enlist interest and commitments from key stakeholders and partnerships to support investment or barrier removal actions for enhancing the commercialization and diffusion of high priority technologies

1.3. Scope

This report addresses the energy supply and demand side and analyses the technologies that are available, the cost and potential of greenhouse gas (GHG) mitigation from deployment of those technologies over the next two decades. This TNA reviews current stage of the country's energy supply and demand situation, their trends, GHG emissions from the energy sector, technology options and priorities to Indonesia, based on policies, planning and technological capacity.

1.4. Stakeholders Participation Process

In making this report, the authors carried out several meetings, workshops and seminars with various stakeholders such as: different government institutions, mainly from directorates, research units and agencies within the Ministry of Energy and Mineral Resources, State-owned enterprises, Private Sector, Business Associations and NGOs.

Along with this process, a number of meetings and discussions were held, a seminar was attended by a large number of multi-stakeholders in the energy supply sector, a seminar to present the final draft and two workshops, attended by representative of the sectors.

The primary and final drafts of this report were presented to the prominent stakeholders and were open for comments and suggestions. In this process, most of the invited participants and stakeholders involved were from the energy supply sector. Representative from other end-user sectors, such as transportation and industry, were involved in the separate stakeholder consultations organized by industry and transportation teams. Inside the core group meeting, the results and findings of the workshop and conclusions made for each TNA report, were discussed.

2. EXISTING CONDITIONS IN INDONESIA

2.1. Introduction

The energy sector of Indonesia is currently facing a transitional period, due to the energy supply crisis and the fuel price increase. These situations have posed great challenges to the country in provision of energy sources and delivery of energy services to the people. Current administration has been trying to implement a new paradigm and approach, to confront these new challenges. In general, the priorities of policies and regulations of the energy sector have shifted from the supply side development to the implementation of demand side management while, at the same time, developing alternative energy resources to meet increasing energy demand.

Table 2.1: Profile of Energy and Economic Performance

	Unit	2004	2005	2006
GDP at Constant Price 2000	Billion Rupiah	1,657	1,750	1,847
	Million US$	227,229	247,642	318,910
GDP Nominal	Billion Rupiah	2,303	2,730	3,338
	Million US$	247,904	277,691	370,088
GDP Nominal per capita	Million Rupiah	10,571	12,414	15,024
	US$	1,138	1,263	1,666
Population	Thousands	217,854	219,893	222,192
Number of Households	Thousands	58,253	59,927	60,554
Primary Energy Supply	Thousands BOE[1]	915,091	961,338	927,413
Primary Energy Supply per Capita	BOE/Capita	4.20	4.37	4.17
Final Energy Supply	Thousand BOE	569,962	568,472	577,533
Final Energy Supply per Capita	BOE/Capita	2,62	2,59	2,60

Source: Handbook of Energy and Economics Statistics of Indonesia 2007

The energy sector is important for the growth of Indonesia's economy, not only as input to economic sector activities but also as sources of revenue from the export of raw energy commodities, in particular coal, natural gas and oil. Increasing demands for energy commodities abroad have boosted production of coal, natural gas and such agricultural products as palm oil for feedstock to produce biofuel to supply the international market.

As the country's population increases and the domestic economy grows, the amount of energy resources and energy services required to supply the demand increase. During the last three decades, total primary energy consumption has increased more than ten times. Nevertheless, dependency and more consumption of conventional energy resources have environmental and social consequences. One of them is the higher amount of greenhouse gasses released into the atmosphere, contributing to the global warming. As climate change becomes a real threat, reducing emission from the energy supply sector is an immediate priority for the country. Given the enormous challenge of mitigating emissions, while satisfying energy needs, the so-called soft and hard technology can play important roles in both utilizing and managing energy resources, as well as reducing environmental impact of the resource exploration and exploitation.

2.2. Energy Resources

Indonesia has a wide variety of and huge energy resources, both fossil and non-fossil based energy.

[1] BOE: Barrel of oil equivalent

The most abundant fossil energy resource is coal, about 0.5% of the world's proven reserves, followed by natural gas about 1.7% of world's reserves (BP, 2008). Oil has been exploited commercially for almost 100 years and mot of the conventional wells have now matured, depleting their production. . Oil resources of Indonesia account for 0.4 % of total world's reserve (BP, 2008). Although new oil sources and fields have been discovered, production activity of those fields has not started or is relatively stagnant, due to the poor investment in this sector for almost a decade, after the economic crisis in the late 1990s.

The Government of Indonesia (GoI) has considered the potential of coal bed methane (CBM) to be an energy source in the near future and has registered it in the national energy resource inventory. Currently, the CBM potential is estimated at about 453 TSCF, but further investigation is needed to realize the potential technical resources available. At present, there is no single commercial project that has been implemented. However, the road map of the Blueprint of National Energy Management (2005) suggests that the CBM pilot project might be started in the next 2 to 3 years. Table 2.2 presents the fossil energy resources of Indonesia.

Table 2.2: Fossil Energy Resources, 2007

Energy Resources	Unit	Potential Resources	Proven Reserve	Production
Crude oil	billion barrels	56.6	8.4	348.0
Natural gas	TSCF[2]	334.5	165.0	2.79
Coal	billion tonnes	90.5	18.7	250.0
Coal Bed Methane	TSCF	453.0	-	-

Source: Ministry of Energy and Mineral Resources (2008)

Indonesia also has a huge potential of renewable energy resources such as: biomass, solar, wind, geothermal, hydro, wave and ocean. Despite its vast potential, utilization of this renewable energy remains relatively poor in supplying the country's energy needs. Renewable sources are scattered all over the region, located in remote area and most of them are in small scale. These conditions give enormous challenge to utilize renewable energy resources to provide energy services. More discussions on renewable energy resources are presented in section 2.2.2 of this report.

Table 2.3: Primary Energy Supply by Source, 2000-2006

(thousand BOE)

Year	Coal	Oil export/ import (Crude)	Natural gas export/ import (LNG, LPG)	Hydro power	Geothermal	Biomass	Total
2000	93,832	463,607	205,087	25,249	9,596	269,042	1,066,413
2001	115,029	454,006	233,101	29,381	9,961	268,953	1,110,431
2002	112,879	448,138	251,864	25,038	10,248	270,207	1,128,375
2003	128,763	456,890	246,753	22,938	10,375	271,974	1,137,683
2004	151,525	492,552	235,552	24,386	11,077	271,765	1,186,856
2005	173,673	536,843	212,790	27,121	10,910	271,094	1,232,432
2006	205,779	487,883	198,311	24,257	11,183	276,271	1,203,689

Source: Handbook of Energy and Economics Statistic of Indonesia 2007

[2] TSCF: trillion standard cubic feet

Table 2.4: Final Energy Consumption by Type, 2000 - 2006

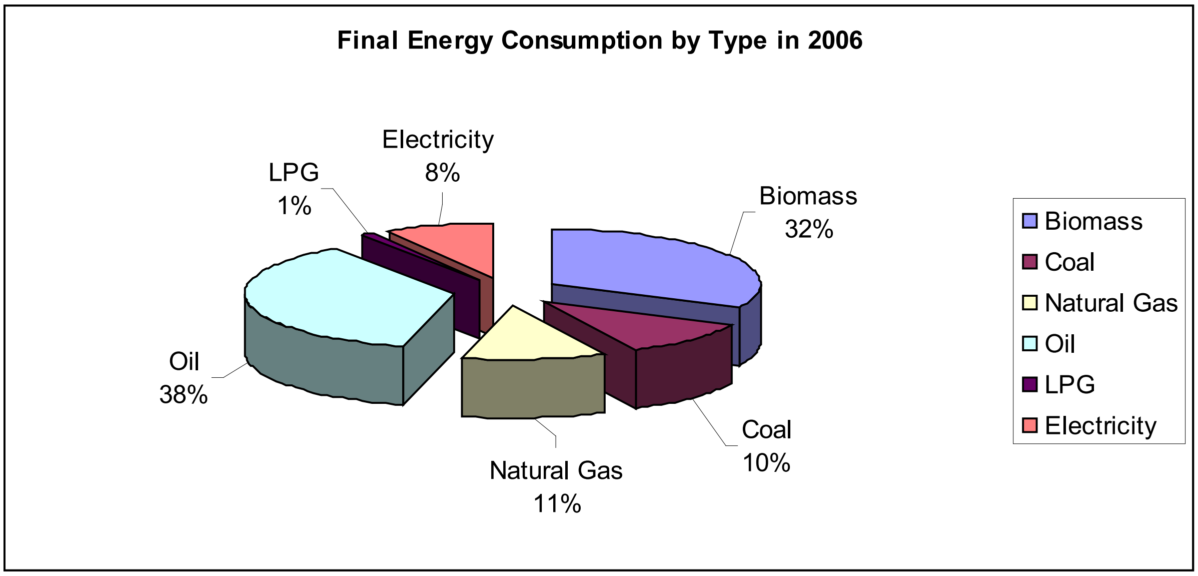
(thousand BOE)

Year	Biomass	Coal	Natural Gas	Petroleum (Oil Fuels)	LPG	Electricity*	Total
2000	269,042	36,135	87,499	316,138	8,261	48,555	765,632
2001	268,935	37,098	84,541	327,695	8,280	51,841	779.409
2002	270,207	38,778	65,971	325,202	8,744	53,418	762,320
2003	271,974	32,159	91,700	321,384	8,766	55,473	781,456
2004	271,765	55,428	89,637	354,317	9,187	61,393	841,727
2005	271,094	65,862	90,537	337,976	8,453	65,644	839,567
2006	276,271	89,194	94,210	314,046	9,414	70,670	853,804

*: Electricity is presented here as the final energy and it is not converted to primary energy. The conversion factor used to convert final electricity consumption is 1MWh = 0.589BOE.

Source: Handbook of Energy and Economics Statistic of Indonesia 2007

As presented in Table 2.4 and Figure 2.1, more than 80% of energy consumption is supplied by fossil fuel. Biomass supplies about 20%, but most of the biomass energy is used for cooking, particularly in rural households. However, due to difficulties in getting real data and analyses of supply and consumption of biomass energy, information presented in the table should be treated as indicative only, not exact figures. Further discussions of biomass sources are presented in section 2.2.2 of this report.



Source: Handbook of Energy and Economics Statistic of Indonesia 2007

Figure 2.1: Final Energy Consumption by Type, 2006

2.2.1. Fossil Fuel

Oil

Oil has dominated energy supplies to fuel Indonesia's economy for several decades and it is likely to do so for the next few decades. Nevertheless, decreasing domestic production, increasing domestic consumption, and global price hikes over the past few years have reduced slightly the growth of oil consumption and prompted efforts to develop other domestic energy resources. During the 1980s, the share of oil in the national energy mix was about 70% but it continued to decrease to about 53% in 2006.

Recently, Indonesia faced a mini-crisis caused by rising oil prices and the need to import oil products due, to declining production and the lack of refinery capacity to meet the demand. Indonesia has become a net importer of oil since 2004. Demand - Supply of oil, generated by Ministry of Energy and Mineral Resources (MEMR), suggests that the volume of imported oil will likely increase in the coming years, given the demand. The quantity of oil could increase from 1.4 million barrels per day (MBPD) in 2008 to 1.6 MBPD in 2015 and 1.7 MBPD in 2025 (MEMR, 2008).

According to the official data, oil reserves have slightly increased in 2007 from lower figures in the past few years, due to the discoveries of new potential oil reserve areas. However, the overall crude oil reserved (proven and potential), declined about 12.59% from 9.61 billion barrels in 2000 to 8.4 billion barrels in 2007 (CDI-MEMR, 2007). The resource per production ratio (R/P) suggested that with current extraction levels, crude oil production will last for 20 years. Since 2004, oil wells produce less than 1 million barrels per day (MBPD) of crude oil. This is because most of the oil fields have matured and face declining production. Investments in exploration and production of new oil fields have been stagnant for the last decade. Nevertheless, despite an increase of working areas (new fields) in the last few years It will take few more years to make these fields productive.

The production scenario developed by the Ministry of Energy and Mineral Resources (MEMR) suggests that, under optimistic scenarios, Indonesia crude oil production will slightly increase to 1 MBPD in 2010 and reach the peak production in 2014, followed then by a steady decline until 2030. Under the pessimistic prognosis, crude oil production will slightly revive to reach 1 MBPD in 2009 and reach the steady production with 1.05 MBPD from 2010 to 2012, before steadily declining until 2030.

The petroleum products had about 54.45% share in the final energy consumption in 2006. Petroleum fuels are mainly used for transportation, industry and households. The high oil fuel consumption is due to limited non-oil fuel energy supplies and high subsidy of some petroleum fuel types, such as gasoline, kerosene and diesel oil. The government determines quotas for subsidized fuels every year through estimation of petroleum fuel demand and thus the amount of quotas are planned to be reduced every year, as part of diversification and conservation program.

Table 2.5: Crude Oil Supply, 2000 – 2006

Year	Production (thousand bbl[3])	Export (thousand bbl)	Import (thousand bbl)
2000	517,489	223,500	78,165
2001	489,306	241,612	117,168
2002	456,026	218,115	124,148
2003	419,255	189,095	137,127
2004	400,554	178,869	148,490
2005	386,483	159,703	164,007
2006	367,049	134,960	116,232

Source: DGOG-MEMR (2007)

The enhanced oil recovery (EOR) technology is being used for capacity expansion of the oil resources. Currently, there are three fields applying EOR, using steam injection methods to increase the oil production and some 19 oil fields are using water injection (DGOG, 2008). Since steam production uses crude oil as fuel, increases in efficient steam generation, will directly reduce the GHG emissions.

[3] bbl: barrel

Natural Gas

Indonesia has about 165 trillion cubic feet of natural gas reserves and 334 trillion standard cubic feet (TSCF) as potential resources and has estimated having 60 tertiary sedimentary basins but only 15 basins were producing in 2006. About 60% of Indonesia's gas fields are located off-shore where most of the country's natural gas reserves are located near the Arun field in Aceh, around the Badak field in East Kalimantan, in smaller fields offshore Java, the Kangean Block in offshore East Java, several blocks in Irian Jaya (West Papua), and the Natuna D-Alpha field, the largest in Southeast Asia.

In 2007, the country produced 2.79 TSCF of natural gas, lower than the 2.95 TSCF produced in 2006. In the last few years, although demand increased, production declined after 2003. Natural gas consumption in 2006 was estimated at 13 TSCF for power generation, LNG and several industrial uses, such as the petrochemical and ceramics industries, city gas, and a small amount for transportation.

Table 2.6: Natural Gas Production, 2000 – 2006

(MMSCF)

Year	Pertamina 4	Production Sharing Contractors	Total
2000	346,483	2,554,896	2,901,379
2001	346,710	2,460,440	2,807,150
2002	334,745	2,707,130	3,041,875
2003	336,966	2,818,277	3,155,243
2004	383,870	2,646,262	3,030,132
2005	379,612	2,605,729	2,985,341
2006	306,482	2,647,617	2,954,099

Source: DGOG-MEMR (2007)

Natural gas production is carried out by the state-owned Oil and Gas company, Pertamina, and private contractors under production, sharing contracts (PSC), while natural gas transmissions and distribution are carried out by Perusahaan Gas Negara (PGN). More than 85 % of natural gas is produced by PSC contractors (Table 2.6).

Coal

Coal reserve is considered abundant compared to other types of fossil fuels. In 2007, the potential resource of coal was estimated at 90 billion tonnes and reserves were estimated 18.7 billion tonnes. In 2007, the country produced 250 million tonnes of coal. Indonesian coal is mostly dominated by medium rank calorie or sub-bituminous (63%), followed by low rank calorie or lignite (23%), high rank calorie or bituminous (13%) and very high rank calorie or anthracite (1%). Sumatra contains roughly two-thirds of Indonesia's total coal reserves, with the balance located in Kalimantan, West Java, and Sulawesi.

In 2006, domestic coal consumption was 45.5 tonnes and coal had 10.5% share of the final energy consumption. Currently, coal is used mostly for electricity generation (68%) and industrial uses, cement (12%), pulp & paper, iron & steel and home industries[5] (20 %).

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[4] Pertamina is an Indonesia Govermen-Owned Corporation which exstracts and refines the country's oil and gas reserves

[5] Home Industry is a small and medium scale industry or enterprises (SME) usually carried out at household or community level and run by family, number of families and communities. The industry ranges from food production, small and light manufacturing , handicrafts, etc.

In the near future, it is very likely that consumption of coal will increase significantly, due to the acceleration program of new coal fired power plant development initiated by the Government and the state-owned electricity company, PLN in 2006.

According to the acceleration program, PLN will build 10 thousand MW coal fired power plants from 2006 until 2012, in addition to the IPP projects, indicated by capacity expansion plans of the company. The PLN best-scenario estimated that an additional 12.7 GW newly installed capacity of coal fired power plant will come into operation in 2011/2012 and will require 44 million tonnes of coal annually. The new coal fired power plants, built under crash programmes, will use low-rank coal (lignite) as fuel.

The Ministry of Energy and Mineral Resources is developing various low rank coal utilization programmes, namely coal liquefaction for alternative fuel, to oil based-fuel; coal gasification, upgrading brown coal and mine-mouth power plants. According to the road map of coal liquefaction programmes, three coal liquefaction plants will be built from 2015 to 2023. Each plant is expected to produce equal to 8.1 million barrels of oil per year. Joint research and development activities of coal liquefaction, using BCL technologies, ,has been conducted from 1992 – 2004 by MEMR, the Technology Assessment and Application Agency (BPPT), NEDO and JCOAL of Japan.

In 2002, the GoI and Government of Japan had initiated building a pilot plant of upgrading brown coal (UBC) with a capacity of 3 - 5 tonne production of cleaner coal per day. The plant located in Palimanan, Cirebon, West Java where operations of the plant started in 2003. Raw materials for the UBC pilot plant have calorific value of 3,500 – 4,500 kcal/kg or known as low-rank coal. The plant is specifically designed to yield a bituminous coal type that retains calorific values of 6,000 – 6,500 kcal per kg by minimizing water content from 25 – 45% to somewhat less than 5%. To commercially process 5,000 tonnes a day of low-rank coal, it needs investment of 100 million US$ and the estimated operational cost is 5 – 7 US$/tonne product.[6]

Given the resources and current developments in technology and policy, coal will likely play a more significant role in Indonesia's energy scene as alternative transport's fuel to petroleum and fuel for power generation in the near future.

2.2.2. Renewable Energy

Table 2.7: Renewable Energy Resources, 2007

Energy Sources	Potential Resources	Installed Capacity
Hydro Power	75,670 MW	4,200 MW
Micro and Mini Hydro	450 MW	84 MW
Geothermal	27,150 MW	1,042 MW
Biomass	49,810 MW	300 MW
Solar Power	4.8 kWh/m²/day (0.0006 MW/m2)[7]	8 MW
Wind Power	9,280 MW	0.5 MW

Source: MEMR (2008)

[6] Further information of UBC plant can be read from Indonesia's Research and Development Center for Mineral and Technology (TEKMIRA) website: http://www.tekmira.esdm.go.id/en/aset/UBC/index.asp
[7] With assumption the average duration of sunshine of 8 hours per day

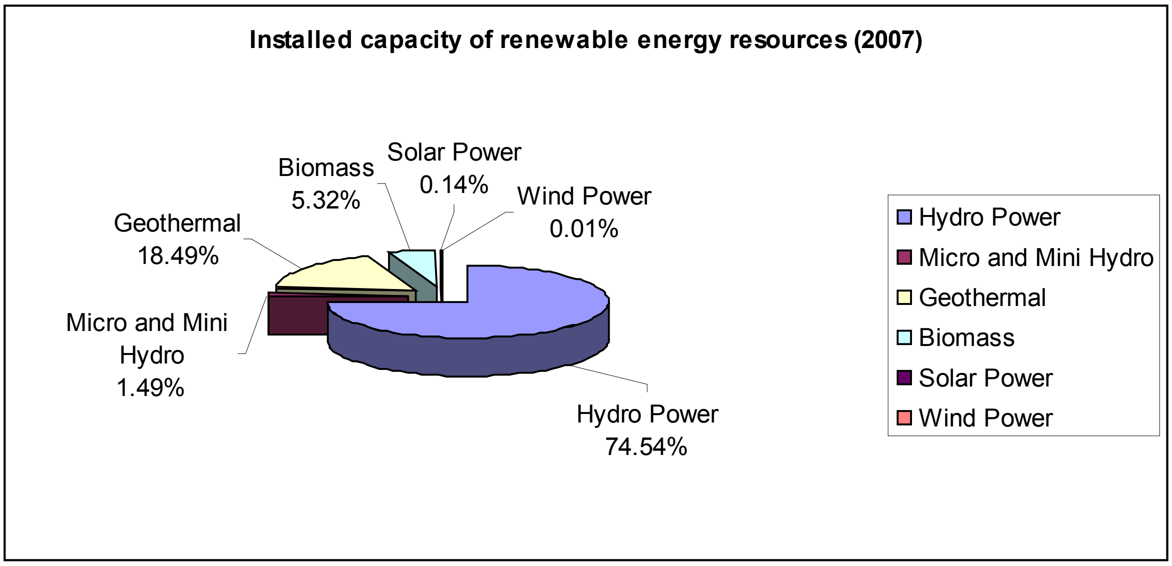


Figure 2.2: Installed Capacity of Renewable Energy, 2007

Biomass

The second most important fuel source for Indonesia's population is (traditional) biomass. Biomass resources, such as firewood, are mainly for cooking and heating in households and small industries. Other biomass resources such as agricultural waste are plentiful but this resource has not been well utilized. Nevertheless,biomass had a 32% share in the final energy consumption which was second after consumption of oil in 2006. However, growth rate of the use of traditional biomass is considered low compared to the growth rate of fossil fuels.

Indonesia has a major theoretical potential for generating energy from biomass, totaling about 50,000 MW. This is based on the energy content of more than 200 million tonnes of agricultural biomass, forestry and plantation residue and urban waste produced every year. According to official estimates, 35% of all energy consumed in Indonesia, particularly in rural areas, stems from biomass – mainly unsustainably managed firewood. At the end of 2005, total installed capacity for power generation based on biomass, had reached 445 MW. The construction of additional biomass-fuelled power generating installations is planned in several provinces (GTZ, 2007).

Vast biomass resources are found mainly in Sumatera, Kalimantan and Java. Limited biomass potential can be found in Sulawesi, Nusa Tenggara, and West Papua/Irian (Table 2.8). The potential sources of fuel wood are rubber wood or palm tree wood from plantations that are cleared or renewed, as well as logging residues, cuttings, trimmings and saw dust from wood processing and plywood industries. The major crop residues, to be considered for power generation in Indonesia, are palm oil residues, generated throughout the year and sugar processing, as well as rice processing residues

Survey on biomass potential in 2000 suggested that Indonesia produces around 146.7 million tonnes of biomass per year, equivalent to about 470 GJ/year. The main source of biomass energy in Indonesia is from rice residues which give the largest technical energy potential of 150 GJ/year, rubber wood with 120 GJ/year, sugar residues with 78 GJ/year, palm oil residues, 67 GJ/year. The rest, with less than 20 GJ/year are from plywood and veneer residues, logging, sawn timber and coconut residues, plus agricultural wastes (ZREU, 2000).

As the largest palm oil producer in the world, Indonesia's residue from palm oil and palm oil mill (POM) are one of the biomass potentials. Production of crude palm oil (CPO) was 13.8 million tonnes in 2005, resulting from 5.4 million ha of oil palm plantation processed by 340 POM, with a total capacity of 14,600 tonnes of fresh fruit bunch (FFB) per hour. Sumatera has become the major production area for

CPO with 77 % of the total oil palm plantation covering and producing about 84 % of the country's CPO.

Table 2.8: Major Biomass Potential in Indonesia, 2000

Biomass Source	Main Region	Production	Technical Energy Potential	Remarks
		(mio. t/year)	(mio. GJ/year)	
Rubber Wood	Sumatera, Kalimantan, Java	41 (replanting)	120	Small logs diameter <10 cm Big and medium logs are used as fire wood in brick and roof tile industry
Logging residues	Sumatera, Kalimantan	4.5	19	
Sawn timber residues	Sumatera, Kalimantan	1.3	13	Residues of the factories are often used as firewood by local communities and available for free
Plywood and veneer production residues	Kalimantan, Sumatera, Java, Irian Jaya, Maluku	1.5	16	Residues are generally used in production facilities.
Sugar residues	Java, Sumatera, South Kalimantan	Bagasse: 10 Cane tops: 4 Cane leaves: 9.6	78	Bagasse is generally used in sugar factories (90 %). The use of cane tops and leaves needs to be investigated.
Rice residues	Java, Sumatera, Sulawesi, Kalimantan, Bali/Nusa Tenggara	Husk: 12 Bran: 2.5 Stalk: 2 Straw: 49	150	Stalk and straw are generated at the field and generally burnt. In some areas they are used for feeding or raw material for paper industry. Husks often burnt uncontrolled.
Coconut residues	Sumatera, Java, Sulawesi	Shell: 0.4 Husk: 0.7	7	Residues are generated decentralized and usually left on the plantation field. Largely used as fire wood and for the production of charcoal.
Palm oil residues	Sumatera, Kalimantan, Sulawesi, Irian (West Papua)	Empty fruit bunches: 3.4 Fibres: 3.6 Palm shells: 1.2	67	Palm shells and fibers are common fuel sources. EFB are generally incinerated

Source: ZREU (2000)

The area with the largest capacity is in Riau province, where 122 palm oil mills are built with a total capacity of 5,210 tonnes of s Fresh Fruit Bunch (FFB)/hr. The second largest palm oil producer is North Sumatra, with a total installed capacity of 3,446 tonnes of FFB/hr (in 2004) produced from 94 POM. In total, there are about 350 POM in 19 provinces with a total capacity of 14,600 tonnes FFB/hr. The output of mills ranges from 5 tonnes of FFB/hr to 120 tonnes of FFB/hr. Sumatra has 287 POM, having a total installed capacity of 11,730 tonnes of FFB/hr. The second largest POMs are located in Kalimantan with 51 POMs, having a total installed capacity of 2,356 tonnes of FFB/hr. The average CPO yield is 20-22 % of the FFB weights, while the Palm Kernel Oil (PKO) is 5%. Therefore, based on these figures, 13.8 millions CPO would require about 69 million tonnes of FFB per annum.

Latest studies carried out by ADB and Golder Associate (2006) estimate biomass energy potential comes from waste products from all POMs in Indonesia, equivalent to about 230,530 TJ per year.

The potential of electricity production is 4,243,500 MWh per annum.[8]

Table 2.9: Energy Conservation Potential and Estimated Investment in Palm Oil Mills, 2006

Technology Intervention	Potential of Electricity Production	Potential of Diesel Consumption Reduction	Potential of GHG Emission Reduction	Estimated Investment
	(MWh/year)	(t/year)	(tCO_2e/year)	(US$)
Interconnection: POM to PLN grid	463,500	71,400	590,000	48,000,000
Gasifier system for rural electricity	115,000	32,583	92,000	39,000,000
Remnant oil extraction system	0	0	0	38,000,000
Bio-diesel plant	0	131,100	317,262	46,000,000
Biogas	485,000	123,675	3,308,099	114,600,000
Biomass (EFB) power plant	3,180,000	810,000	2,230,000	695,625,000
Total	**4243,500**	**1,168,758**	**6,538,361**	**981,225,000**

Source: ADB and Golder Associates (2006)

A small amount of saw dust from saw mills is found in the northern part of Central Java. For example, a feasibility study for a Wood Waste Biomass Power Generation Project near Semarang/ Central Java, carried out by Sumitomo Forestry Co. Ltd in 2006, concludes that, from a survey of 431 saw mills located within 200 km of the project location, the amount of off-cuts and sawdust generated came to about 46,148 tonnes/month.[9]

Biomass-based CDM projects have about a 20 % share of total CDM projects approved by Indonesian DNA. Appendix 1 shows various Biomass CDM projects in Indonesia (until September 2008). Biomass CDM projects typically are CHP which utilize waste from production processes to generate heat/steam and electric power to replace electricity from diesel generators and partial fuel substitution of coal. Most of the projects are located in palm oil mills (POM) in Sumatra and Kalimantan. Typical feedstock for fuel is empty fruit bunch, palm kernel shell and fiber, while some projects utilize saw dust and rice husk. There is one project to use methane capture technology from wastewater to produce heat and electric power. The steam is mostly being used on-site but the electricity generated is both used on-site and sold to the grid. List of Biomass CDM project is listed in Annex 1 of this report.

Biofuel

In 2005, the government of Indonesia initiated a plan to develop utilization of biofuel, to substitute petroleum fuel used for motorized vehicles and diesel power plants. The government set up targets to utilize biofuel, amounting to 5% of the total national primary energy mix - or equal to 22.26 billion liters, to be planted on 5.25 million hectares of land by 2025. The detailed planning of biofuel production and fuel substitution is listed in Table 2.10.

The biofuel programme consists of development and utilization of three types of biofuel: biodiesel, bioethanol and bio-oil/pure plant oil. The feedstock options for biofuel are mainly coming from palm oil and jatropha for biodiesel; cassava and molasses for ethanol. During the introduction of biofuel in 2006, the state-owned Oil and Gas Company blended 5% of fatty acid methyl ester (FAME) with diesel oil and 5 % ethanol with gasoline.

[8] Assumption for Biomass power plant: a) Potential of EFB is 15.18 million ton/y, 70% EFB for electricity generation, operating time 8000 hr/year, electricity production of 5 MW power plant is 40,000
MWh/year.

[9] Sumitomo Forestry Co. Ltd (2007): Wood Biomass Power Generation Project Investigation http://gec.jp/gec/gec.nsf/3d2318747561e5f549256b470023347f/6d92ffe8dc06620c4925730d002ebbf2/$FILE/Summary_SumitomoForest.pdf (Download 30 September 2008)

After running for less than a year, Pertamina reduced the blending ratio to 3% and finally 1%.

The government has published national biofuel standards, which serve as guidance for biofuel production and quality. The government is also preparing a regulation that mandates fuel retailers to blend 2.5% of biofuel in their products. The regulation was expected to be effective at the end of year 2008 and will require fuel retailers to ensure biodiesel accounts for at least 1 % of their national fuel sales, and 3% for bioethanol

Table 2.10: Planned Biofuel Production and Fuel Substitution in, 2005 – 2025

	2005 - 2010	2011 - 2015	2016 - 2025
Biodiesel	10% substitution of diesel fuel consumption: 2.41 billion liter	15% substitution of diesel fuel consumption: 4.52 billion liter	20% substitution of diesel fuel consumption: 10.22 billion liter
Bioethanol	5% substitution of gasoline consumption: 1.48 billion liter	10% substitution of gasoline consumption: 2.78 billion liter	15% substitution of gasoline consumption: 6.28 billion liter
Bio Oil: Bio kerosene	Utilization of bio kerosene: 1 billion liter	Utilization of bio kerosene: 1.8 billion liter	Utilization of bio kerosene: 4.07 billion liter
Bio-Oil: Pure Plant Oil (PPO)	Substitution of diesel oil in power plant by PPO: 0.4 billion liter	Substitution of diesel oil in power plant by PPO: 0.4 billion liter 0.74 billion liter	Substitution of diesel oil in power plant by PPO: 0.4 billion liter 1.69 billion liter
Biofuel (total)	Utilization of biofuel as 2% of total primary energy mix by 2010: 5.29 billion liter.	Utilization of biofuel as 3% of total primary energy mix by 2015: 9.84 billion liter	Utilization of biofuel as 5% of total primary energy mix by 2025: 22.26 billion liter

Source: Blueprint National Team of Biofuel (2007)

Geothermal

Indonesia has the world's largest geothermal resources potential, estimated to be about 27,000 MWe or about 40 % of world's geothermal potential. The "Ring of Fire," the world's most active volcanic zone, stretches along the southern coast of the islands of Sumatra and Java, which accounts for about 37 and 51 % of the national total geothermal resources, respectively (Table 2.11). Nowadays, the Ministry of Mines and Energy ESDM has mapped about 256 locations with geothermal manifestations (geothermal working areas or WKP), where geothermal resources of an estimated capacity about 28,000 MW can be developed for direct or indirect use.

Approximately 80 % of the known and mapped geothermal working areas (WKP) represent high temperature geothermal resources, which are suitable for easy electricity generation in flash power plants. As a matter of priority, the focus has been set on geothermal resources, which can be used for electricity generation in flash power plants.

Additionally, there is a huge potential for further geothermal resources with low and medium temperature profiles, which can be either developed for direct use or for indirect use with binary power plants. This additional potential of medium and low temperature resources is estimated to be an addition of more than 100,000 MW, but has not been investigated yet diligently.

In the Master Plan for the further geothermal power development of Indonesia, 50 geothermal working areas have been defined, representing an estimated potential of more than 9,000 MW for priority electricity production. In 2008, there are about 1,052 MW of installed capacity that accounts for less than 4% of the identified potential. The installed capacity, operated jointly or independently by five companies, including a subsidiary of the state-owned oil and gas enterprises (Table 2.12).

Table 2.11: Geothermal Resource Potential

Location (Island)	Resources (MW)		Reserves (MW)			Installed Capacity (MW)
	Speculative	Hypothetical	Probable	Possible	Proven	
Sumatera	5,275	2,194	5,555	15	380	2
Java	2,235	1,446	3,175	885	1,815	1,000
Bali/ Nusa Tenggara	360	359	943	-	14	-
Kalimantan	45	-	-	-	-	-
Sulawesi	925	12	865	150	78	40
Maluku	400	37	297	-	-	-
Papua	50	-	-	-	-	-
Total (256 location)	**9,290**	**4,048**	**10,835**	**1,050**	**2,287**	**1,042**

Source: MEMR (2008)

The Ministry of Energy and Mineral Resources (MEMR), issued the Blueprint for Geothermal Development in Indonesia, which was intended as a roadmap to develop a total of 6,000 MW of geothermal power capacity by 2020. The updated plan of geothermal power development of MEMR indicates a development of 6.8 GW in 2009-2018. Now, there are nearly 1,000 MW of unexploited geothermal power potential under private control and over 3,000 MW with state-owned enterprises. About half of these resources are in geothermal fields, which are currently producing electricity or with confirmed reserves and are well placed for further expansion.

Table 2.12: Installed Geothermal Plant in Indonesia (up to September 2008)

No	Power Plant	Location	Unit	Installed Capacity	Power Plant Owner
1	Kamojang	Java-West	1 x 30 MW		PLN
			2 x 55 MW		PLN
			1 x 60 MW	200 MW	Pertamina
			1 x 60 MW		Pertamina – 2009
2	Lahendong	Sulawesi	2 x 20 MW	40 MW	PLN
			1 x 20 MW		PLN - 2009
3	Sibayak	Sumatra	1 x 2 MW		Pertamina
			2 x 5 MW	12 MW	Pertamina
4	Gunung Salak	Java-West	3 x 60 MW		PLN
			3 x 55 MW	375 MW	Chevron - GS
5	Darajat	Java-West	1 x 55 MW		PLN
			1 x 90 MW	255 MW	Chevron - GI
			1 x 110 MW		Chevron – GI - 2009
6	Wayang Windu	Java-West	1 x 110 MW	110 MW	Star Energy
			1 x 110 MW		Star Energy
7	Dieng	Java – Ctrl	1 x 60 MW	60 MW	Geo Dipa Energy
			1 x 60 MW		Geo Dipa Energy -2009
			Total	**1,052 MW**	

Source: Meyerholz (2008)

Large and Small Hydropower

Indonesia has abundant hydropower resources and has been successful in developing micro, mini, small and large hydropower plants over the past decades. In the 1990s, official data estimated that the national hydropower potential is about 75,000 MW distributed in 1,315 locations[10]. Recent official data estimated that hydropower potential is about 41,436 MW[11] with small (mini and micro) hydro potential accounting for only 450 MW. Because of the processes used for these estimates, the small hydropower potential is likely be larger than 450 MW, although it still remains as a small percentage of total potential.

Most of mini and micro hydro potential are located in outer islands and very suitable to substitute diesel-engine for power generation. The current installed capacity for all hydropower plants is about 4,260 MW, of which small hydropower comprises about 64 MW. In 2003, there were 2,493 MW large hydropower projects under design stage, located in nine provinces, but 1,300 MW capacity alone located in West Java provinces. About 2,000 MW projects are under feasibility study in 14 provinces.[12] There are several small hydropower plants under construction and planned over the next few years. Hydropower contributed 12.9 TWh to the total electricity supply in 2005.

Solar Energy System

The potential of solar energy in Indonesia is relatively abundant with an average intensity of 4.5 to 5 kWh/m^2 per day. There are two technologies, which have been commonly installed in Indonesia: solar thermal and solar photovoltaic. Solar thermal energy is mainly for cooking, drying agricultural products, and for water heating systems in most urban residential areas. Solar photovoltaic is mainly for rural electrification, water pumping, telecommunication systems in remote areas and refrigerators in Peoples Health Centers in rural and remote sites. Solar photovoltaic application in Indonesia dominates the solar home system, comprising solar modules of 40 Wp to 75 Wp, battery systems, charge/discharge controllers and inverters to supply small loads comprising 3 to 5 low wattage FT or CFL lamp, radio and black and white television.

Recently, the government is promoting solar photovoltaic for urban household and for rural electrification using a hybrid system type with diesel engine and/or wind power generator. This system usually is built to supply power for small villages and communities. The installed capacity of this solar system is about 1.25 kWp to 1.5 kWp, plus additional diesel engine or wind power as back-up.

Larger systems, such as large solar home systems on the rooftops of houses or buildings (> 1 kWp) are not common and rarely seen. Moreover, new technology such as Building Integrated Photovoltaic (BIPV) has not yet been developed in Indonesia. However, solar home systems or solar PV manufacturer has been established in Indonesia since 1990s. Some of these companies have already been exporting their products to markets in Africa and other regions of Asia.

Since the 1980s, about 50,000 solar home systems have been installed, as well as relatively large hybrid plants, in combination with diesel or wind generators or both. In late 2005, the installed capacity of Solar Photovoltaic was estimated at about 8 MW, over 1 MW of which was feeding into the power grid. The official road map for photovoltaic development has indicated the plan to install of 870 MWp of solar photovoltaic by 2025.

[10] Ketentuan Umum Bidang Energi (Energy Sector Directive) 1990, Ministry of Mining and Energy.

[11] Rencana Umum Ketenagalistrikan Nasional (National Electric Power Plan) 2006, Ministry of Energy and Mineral Resources (MEMR).

[12] Rencana Umum Ketenagalistrikan Nasional (National Electric Power Plan) 2006, Ministry of Energy and Mineral Resources (MEMR).

Wind Energy

Due to the minor influence of trade winds in Indonesia, the country has relatively little wind energy potential – amounting to only 9,290 MW. The average wind speed is 3-5 m/s. In the eastern regions, however, it exceeds 5 m/s. Hence, the Indonesian wind regime is mainly suitable for small and medium-size wind power plants requiring wind speeds of 2.5 – 4 m/s and 4 – 5 m/s, respectively, for corresponding outputs of < 10 kW and 10-100 kW. At only a few locations is the wind potential sufficient to power large wind energy conversion systems (> 100 kW) that require wind speeds more than 5 m/s. Recorded and measured wind data by the National Institute for Aeronautics and Space of Indonesia (LAPAN) in some eastern parts of Indonesia are as follows:

- Region of Nusa Tenggara Barat: wind speeds ranging 3.4 – 5.3 m/s (10 locations);
- Region of Nusa Tenggara Timur: wind speeds ranging 3.2 – 6.5 m/s (10 locations);
- Region of Sulawesi and other: wind speeds ranging 2.6 – 4.9 m/s (10 locations).

Given the total installed generating capacity of 5 MW, only a small fraction of Indonesia's overall wind power potential is being utilized. Small aerogenerators are used for rural and/or decentralized electrification, for driving water pumps, for charging batteries, and for such mechanical purposes as aerating fish-farm ponds.

The official road map for wind energy development indicated the installation of 800 MW of wind power connected to the grid system and off-grid in 2025. Currently, LAPAN and several other government and academic institutions have been developing wind turbine called Wind Power Conversion System or Sistem Konversi Energi Angin (SKEA) based on Savonius and Windside rotor. The SKEA system has reached the size of 50 kW and the ongoing research is to build 300 kW wind turbines. Several other small scales SKEA for different direct applications have been developed and are available in the market. Several pilot sites for evaluating the performance of SKEA have been conducted by LAPAN and the Bandung Institute of Technology (ITB).[13]

2.2.3. Nuclear Power

According to the Indonesia Atomic Agency (BATAN) the first Nuclear Power plant will commence building in 2011/2012 and this unit is expected to operate in 2016/2017. According to the official document, Indonesia plans to build four units of nuclear reactors of light water reactor type, with 4.2 GW installed capacity, by 2025. If these plants operate by 2025, electricity from nuclear power plant will contribute less than 2% of final energy mix. Although a number of studies regarding nuclear power feasibility, sites, and infrastructures have begun since 1970s, no single NPP has been built yet. In recent years, the ministry of energy, ministry of research and technology and BATAN are working on preparing nuclear power infrastructures, selecting nuclear power technology, promoting public awareness and information dissemination. However, the political decision has not yet made by current administration, creating uncertainty as to how the plan will be carried out in the near future.

2.2.4. Electricity

In 2006, Indonesia had 30 Gigawatts (GW) of installed electricity generating capacity. Indonesia's power generation sector is dominated by the state-owned electric utility PT PLN (Persero), formerly known as Perusahaan Listrik Negara. PLN operates more than 50 power plants, with total installed capacity of about 25,000 MW, or roughly 85% the country's generating capacity.

[13] More information on wind power potential in Indonesia can be found at Directorate General of Electricity and Energy Utilization of Ministry of Energy and Mineral Resources in the following link: http://www.energiterbarukan.net/index.php?Itemid=59&id=37&option=com_content&task=view

The remainder, owned by private utilities or IPP power, (13%), while integrated power plants service factories or manufacturing facilities (2%).

Table 2.13: Operating Power Plants Capacity, 2000 – 2006 [14]

(MW)

Year	Hydro	Steam	Gas	Combined Gas-Steam & Oil	Geothermal	Diesel	Total
2000	4,199	11,116	3,804	6,863	525	11,223*	37,733
2001	3,112	7,946	1,973	6,998	785	3,016	23,830
2002	3,155	6,900	1,224	6,863	785	2,589	21,517
2003	3,169	9,574	1,224	7,148	785	2,879	24,781
2004	3,199	10,865	2,340	6,858	800	3,277	27,327
2005	3,220	10,865	2,724	6,728	800	3,325	27,663
2006	3,532	12,990	2,727	7,907	800	3,001	30,958

Source: Handbook of Energy and Economics Statistic of Indonesia 2007

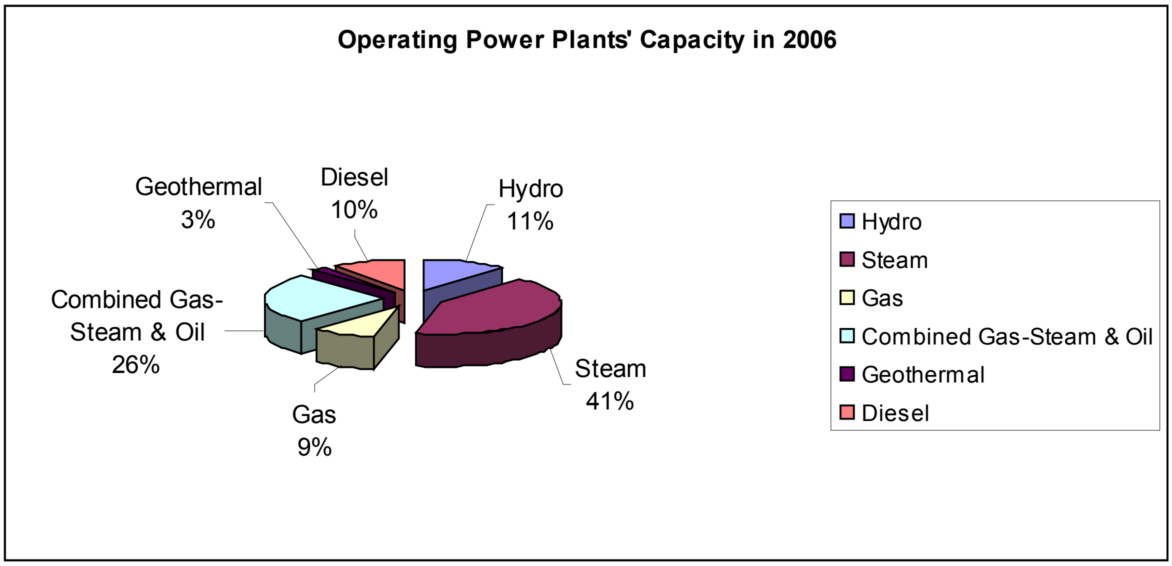


Figure 2.3: Electricity Generation Capacity by Fuel Type, 2006

In 2006, PLN generated 133 Gigawatt-hours (GWh) of electricity, of which 86% came from conventional thermal sources (oil, natural gas, and coal), 8% from hydroelectric sources, and 5% from geothermal and other renewable sources. PLN's power plants generated 85% of electricity with 15% generated from IPP and rented diesel engines. In 2006, Indonesia consumed 115 GWh of electric power.

During 2000 to 2007, electricity demand grew by 5.3% annually, compared to double digit growth in the last decade. This low growth was exacerbated by suppressed demands as the result of limited number of additional generation capacity plants operating during this period and the limitation of new connections to the PLN. During the economic crisis in 1997-1998, electricity demand grew 5.3 %, with the exception of the commercial sector that grew by 13.5%, but industry grew by -0.9%. Before 1997, the electricity demand increased by 12 – 14 % annually. Currently, about 60 % of Indonesian households are connected to electricity, mainly in the most densely populated Java and Bali islands.

[14] The number of diesel power plant in 2000 includes captive power from industry/factory. After Year 2000, the captive power does not longer include in the figure.

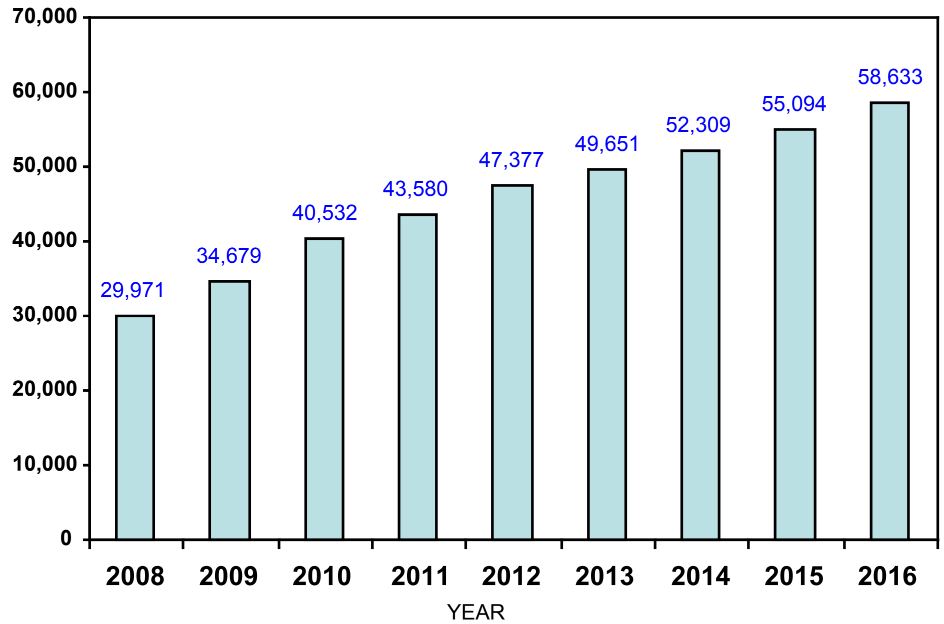
PLN estimates that electricity demand will grow higher after 2009/2010. Elasticity [15] is predicted to reach 1.5 for 2008 – 2018 then expected to decrease to 1.3 – 1.4 after 2018. Therefore, after 2009, electricity demand is predicted to grow by 9 % annually. To meet demand, PLN needs to develop and build power plants for base-load, medium and peak-load. Coal and renewable energy from geothermal and hydro power plants are able to meet demand for electricity in the base-load.

Table 2.14: Fuel Consumption of PLN Power Plants, 2000 – 2006

Year	Coal	High Speed Diesel	Light Diesel Oil	Fuel Oil	Natural Gas
	(Tonne)	(10^3 Liter)	(10^3 Liter)	(10^3 Liter)	MMSCF
2000	13,135,584.0	3,141,917.0	23,146.0	1,858,568.0	228,838.0
2001	14,027,712.7	3,575,348.2	30,457.4	1,793,282.5	222,420.8
2002	14,054,377.5	4,625,521.3	40,681.7	2,300,603.5	192,926.7
2003	15,260,304.8	5,024,361.5	31,573.0	2,557,546.2	184,304.5
2004	15,412,738.3	6,299,706.3	36,934.9	2,502,597.5	176,436.1
2005	16,900,972.4	7,626,201.2	27,580.6	2,258,775.9	143,050.1
2006	19,084,438.0	7,586,916.0	23,977.0	2,387,622.0	157,894.0

Source: PLN (2007)

Java and Bali have the most advanced power systems. Load centrals in Java are connected by 150 and 500 kV transmission lines, laid up from west to east Java, with interconnecting systems to Bali Island. Sumatra has transmission systems but consumers in several sub-regions are connected through local grid. On other islands, local and regional grids dominate the power system. System losses vary for each region and systems. In the last 10 years, average T&D losses for the PLN system were 10% - 15% per year.



Source: PLN (2008)

Figure 2.4: Projected Electricity Generation Capacity, 2008 – 2012

[15]Elasticity is the total energy consumption growth rate/GDP growth rate

2.3. Energy Losses

PLN experiences two digit electricity losses in transmitting and distributing electricity. The electricity use of power plants and sub-stations accounts, on the average, for about 4% of total electricity produced by PLN. Java-Bali and Sumatra have the most advanced grid systems. Java-Bali grid systems are connected with 500 kV and 150 KV transmission lines, while the Sumatran grid is connected with 225 kV transmission lines. The average losses over the last decade of transmission were 2.2 – 2.8%, and for distribution were 8.9 to 14.4%. Energy losses reduced significantly in 2004 due to the changing methodology of calculating energy losses of PLN and increasing efforts to reduce power theft.

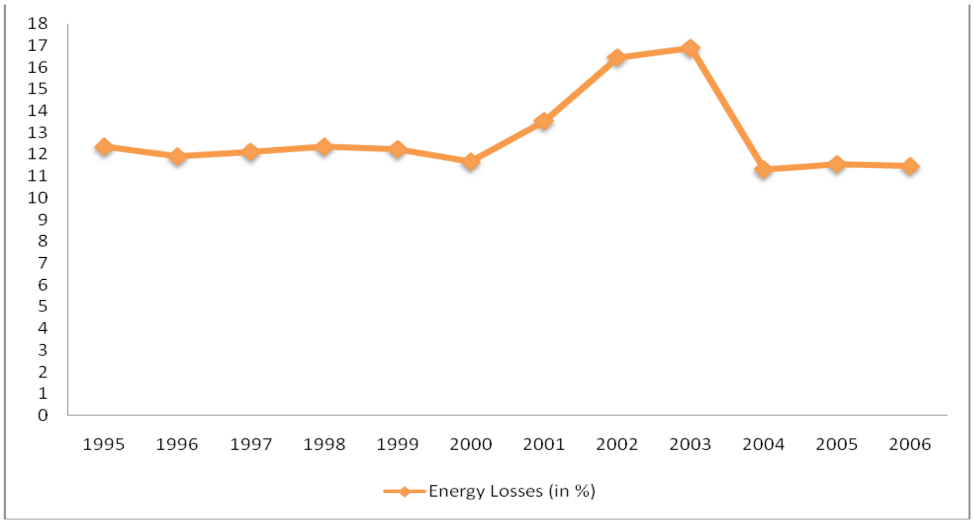
Table 2.15: Internal Use of Electricity and Energy Losses of PLN, 1995 – 2006

Year	Internal Use (for power plant and sub-station)		Energy Losses					
			Transmission		Distribution		Total	
	(GWh)	(%)	(GWh)	(%)	(GWh)	(%)	(GWh)	(%)
1995	2,260.91	3.81	1,698.58	2.86	5,626.12	9.47	7,324.69	12,33
1996	2,588.33	3.93	1,825.40	2.82	5,882.49	9.07	7,707.89	11,89
1997	3,230.30	4.32	1,818.68	2.47	7,069.91	9.62	8,888.59	12,10
1998	3,218.68	4.29	1,755.24	2.35	7,462.54	9.99	9,217.78	12,34
1999	3,224.35	4.00	2,116.56	2.59	7,862.40	9.63	9,978.97	12,22
2000	3,416.13	4.05	2,307.77	2.56	8,175.10	9.08	10,482.87	11,65
2001	3,709.87	419	2,336.56	2.38	10,942.80	11.14	13,261.36	13,52
2002	3.767.51	4.20	2,706.61	2.59	14,521.74	13.87	17,228.35	16,45
2003	4,039.82	4.35	2,686.10	2.46	15,715.54	14.41	18,401.64	16,88
2004	5,824.43	5.72	2,711.49	2.33	10,420.45	8.96	13,131.94	11,29
2005	5,302.43	5.01	2,794.43	2.27	11,442.77	9.28	14,237.21	11.54
2006	4,273.73	4.09	2,905.23	2.26	11,803.66	9.18	14,735.89	11.45

Source: PLN Statistics (various years)

In the dense areas like Java, Bali and Sumatra, higher energy losses in distribution lines occurred due to the increase of load on the distribution side and poor investment on the distribution side, to meet the increasing new connections. In cases outside the Java-Bali system (outer islands), the density of consumers is relatively low and load is scattered which requires long distribution lines to bring electricity.

Given the situation of the availability of local energy resources, low density of consumers, and widely scattered loads, it makes decentralizing the energy system a good option to utilize local energy resources and local grids to supply electricity for most populations in the outer islands (Kalimantan, Sulawesi, Nusa Tenggara islands, Maluku islands and West Papua).



Source: PLN Statistic (various years)

Figure 2.5: Energy Losses in Transmission and Distribution, 1995 – 2006

2.4. Energy Trading

Indonesia has been a net energy exporter for many years, in particularly of fossil fuels. After the declining of oil production in mid 1990s, natural gas and coal replaced oil as a main export commodity. However in the market, revenue from oil contributes the largest share of government revenue from the extractive industry sector.

Oil

Crude oil export are currently about 35% of the total oil production and has been continuously decreasing due to an ever less oil production and increasing domestic use of oil. In 2006, crude oil exports accounted for 130 million BOE. As comparison, in 2001 export of crude oil accounted for 240 million BOE.

Oil imports are needed, due to the limited domestic production and the fact that some refineries were designed to process crude oil imported from abroad, especially from the Middle East, and to secure long-term energy supplies. Crude oil imports in 2006 were about 116 million barrel – a decrease of around 4% compared to 2005. The decrease was caused by, among other things, the increased use of non-oil fuels for electricity generation.

Natural Gas

In 2006, more than 4.5 million standard cubic feet per day (MMSCFD) or 55% of natural gas production was for export and the remaining 2.8 MMSCFD was used for the domestic market (MEMR, 2008). Currently, Indonesia exports most of its gas as LNG. During 2005, Indonesia exported 23 million tonnes (MMt or 1,123 BSCF) of LNG, or about 16% of the world total. Natural gas produced in the Natuna field was sent by pipeline to Singapore and Malaysia.

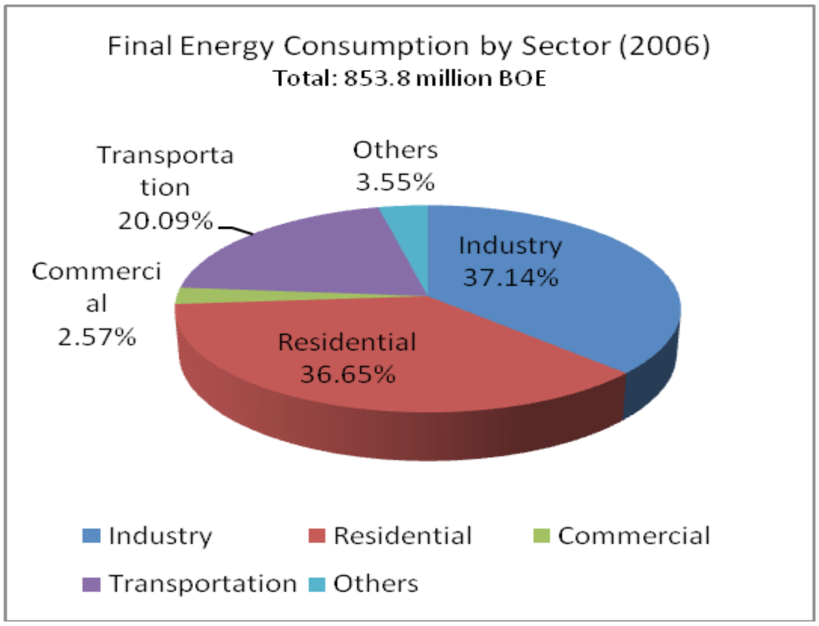
Indonesia is facing a declining share of global LNG markets, despite its past status as the world's leading LNG exporter. The decline can be attributed partly to questions over the reliability of the Indonesian supply and lower investments in the Indonesian energy sector. Uncertainties over political support for the sanctity of contracts, regulatory transparency, and relatively unfavorable Production Sharing Contract (PSC) terms, have undermined investment support. As a result, Indonesian LNG exports have been partially replaced in the world market, by exports from Oman, Qatar, Russia, and Australia. . Since early 2005, exports from the export terminal at Arun in Aceh have been cut back to below the level of contractual commitments, due to continuing production problems in the area, despite the end of the insurgency there.

Coal

In 2007, more than 166 million tonnes or 77% of 215 million tonnes of total coal production delivered for export and 49 million tonnes or 33% was for the domestic market. Main destinations for coal exports were Japan, Taiwan, South Korea, Europe and several other Asian Pacific countries. Coal companies in Indonesia projected that coal exports will grow 1.81 million tonnes/year as demand in domestic market increases.

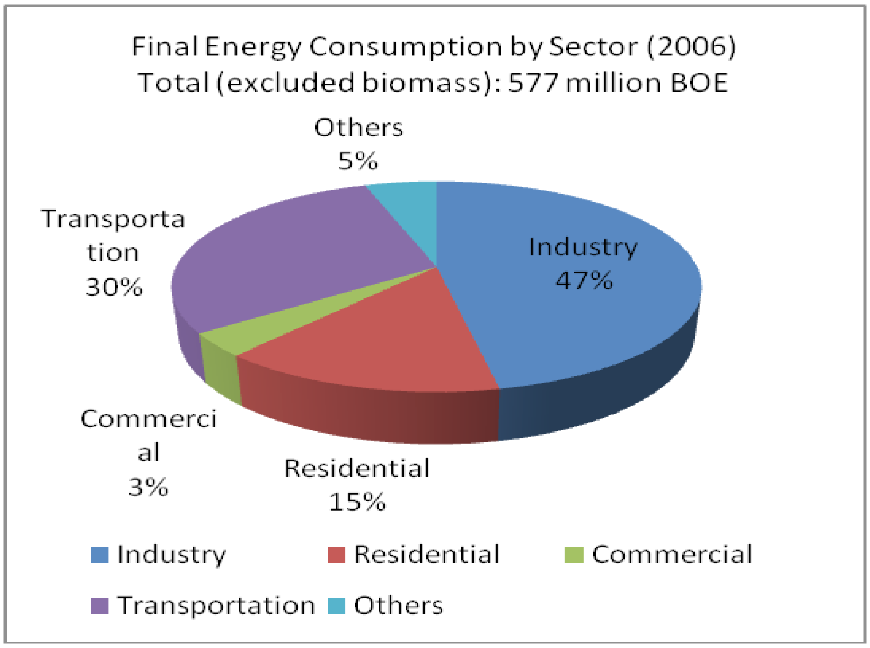
2.5. Energy Demand Side and Energy Conservation Potential

Energy consumption in the end use sector is dominated by petroleum fuels and electricity. Petroleum fuels are mainly distributed to consumers in Java, Bali and Nusa Tenggara (59%), Sumatra (23%) and regions in central and eastern Indonesia (18%). In 2006, final energy consumption was 853.8 million BOE. The main users of energy were industry (37%), residential (36%) and transportation (20%). Figure 2.6 and Figure 2.7 show the percentage of final energy consumption, by sector.



Source: Handbook of Energy & Economic Statistics of Indonesia (2006)

Figure 2.6: Final Energy Consumption by Sector (including biomass), 2006



Source: Handbook of Energy & Economic Statistics of Indonesia (2006)

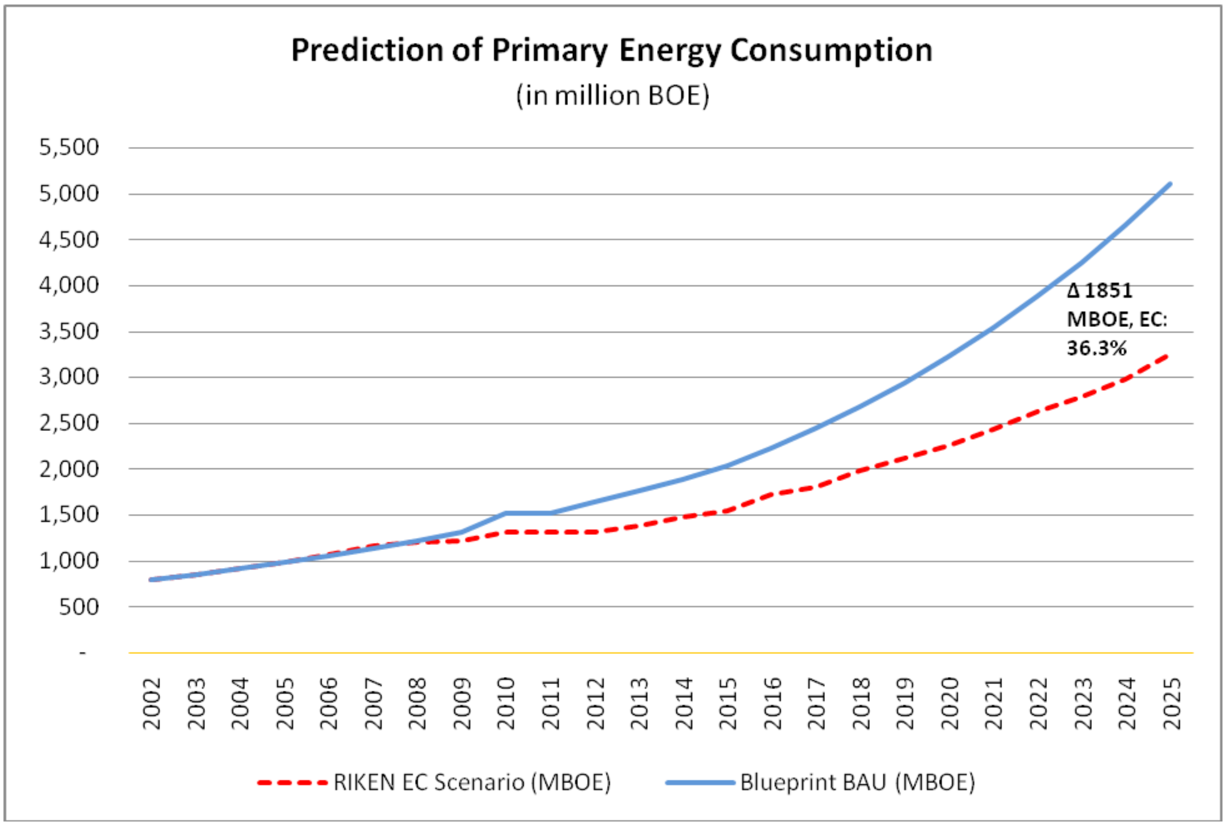
Figure 2.7: Final Energy Consumption by Sector (excluding biomass), 2006

Energy consumption, in the end use sectors, can well be reduced. The Directorate General of Energy and Electricity Utilization (2007) estimated, that in 2002 the potential for energy efficiency in industry, residential, commercial building and industry was in the range of 10 – 30%. The energy conservation potential in 2002 is listed in Table 2.16.

Table 2.16: Energy Conservation Potential, 2002

Sector	Consumption	Energy Conservation Potential	
	(10^3 BOE)	(10^3 BOE)	(%)
Industry	194,356	29,153 – 58,307	15 – 30
Transportation	169,730	42,432	25
Residential and household	134,630	13,463 – 40,389	10 – 30

Source: DGEEU (2007)



Source: MEMR (2007)

Figure 2.8: Projection of Primary Energy Consumption

The Master Plan for National Energy Conservation (RIKEN) in 2002, estimated that primary energy consumption will reach 5,103 MBOE in 2025, if no energy conservation (EC) measures are taken. However, implementation of these measures will able to reduce final energy consumption to the level of 3,252 MBOE or 36% lower, when compared to the business-as-usual scenario (Fig. 2.8). Cumulative CO_2 emission reductions from 2005 – 2025 through EC, will be 6.456 million tonnes or 34.8% of BAU.

Moreover, the Blueprint for Electricity Conservation, issued by MEMR in 2008, predicted that electricity consumption will reach 414,291 GWh in 2025. If energy conservation applies, by 2025, electricity consumption will reach 233,111 GWh. As a result, potential electricity conservation in the year 2025 will be 181,180 GWh (338 MBOE) or about 43.7% compared to BAU. Cumulative CO_2 emission reductions from 2005 – 2025 could be 1,144 million tonnes or 31% of BAU. Recent studies by JICA (2008) suggest the technical potential for energy conservation from electricity savings to be in the range of 20 – 26%. (Table 2.17).

Table 2.17: Comparison of Energy Conservation and CO_2 reduction Potential RIKEN and JICA Study, 2008

Item	Blueprint for Electricity Conservation (Jan 2008)		JICA Approach 1 (Electric Product)		RIKEN		JICA Approach 2 (sector & facilities)	
	BAU Case	EC Case	BAU Case	EC Case	BAU Case	EC Case	BAU Case	EC Case
Economic Growth	6.27% (2000 – 2025)	6.27% (2005 – 2025)	6.27% (2005 – 2025)	6.27% (2005 – 2025)	2005 4.92% 2010 5.13% 2015 5.13% 2020 6.51% 2025 6.52%			6.50%
Primary Energy Consumption\ Growth					8.40% (2006 – 2025)	6.30% (2002 – 2025)	8.40% (2005 – 2025)	
Electricity Consumption/ Growth	6.80% (2000 – 2025)	4.40% (2000 – 2025)	7.05% (2006 – 2025)	5.80% (2006 – 2025)				
Energy Elasticity					1.48% (2005 – 2025)	2005 1.09% 2010 1.80% 2015 1.38% 2020 1.13% 2025 0.94%	1.48% (2005 – 2025)	
Energy Conservation in 2025		43.70% or 338MBOE (181,180GWh)		20.00 – 26.00% or 157 – 203MBOE (83,811 – 108,954GWh) (electricity only)		36.30% or 1,851MBOE		21.00% or 1,069MBOE
CO_2 Reduction in 2025		43.70% or 138Mt CO_2		20.00 – 26.00% (electricity only)		47.70% or 904Mt CO_2		14.20% or 160Mt CO_2

Item	Blueprint for Electricity Conservation (Jan 2008)		JICA Approach 1 (Electric Product)		RIKEN		JICA Approach 2 (sector & facilities)	
	BAU Case	EC Case	BAU Case	EC Case	BAU Case	EC Case	BAU Case	EC Case
Cumulative CO_2 Reduction between 2000 – 2025		31.00% or 1,144Mt CO_2		19.60 – 21.10% 674 – 727Mt CO_2 (electricity only) (2008 – 2025)		34.79% or 6,456Mt CO_2		7.70% or 912Mt CO_2

2.6. Policy and Regulation

Energy Act

The Government issued a new Energy Act (Act No. 30,2007) , which is expected to serve as a guiding principle for the entire energy sector. The Act is aimed at securing sustainable energy supplies and promoting energy conservation and the use of renewable energy resources. It sets out broad policies for the development of the energy sector. The Act sets our four elements of national energy policy, consisting of:

1. Securing energy supplies to meet national energy demands;
2. Priorities for developing energy resources;
3. Optimal utilization of national energy resources;
4. Implement national energy reserve strategies.

The Act mandates the establishment of a National Energy Board (NEB), chaired by the President, which will draft a national energy policy and oversee developments in the energy sector. The NEB will play a coordination role in policy making and implementation of different respective ministries and agencies, concerning energy production, supply and use. The Act mandates the government to make National Energy General Planning, which will be the basis for the implementation of energy policy.

The Energy Act will complement existing energy-related laws including the 2003 Geothermal Act, the 2001 Oil and Gas Act, the 1997 Nuclear Energy Act and the 1985 Electricity Act.

Presidential Decree on National Energy Policy

The Presidential Decree on National Energy Policy, released in January 2006 outlines the goal of ensuring energy supply security for the country. In the decree, the government has implemented a primary energy mix target that mandates reduction of oil fuels and an increase of the share of coal and renewable energy by 2025.

According to the decree, the share of oil fuels in the energy mix shall be decreased from 51% at current level to 20% in 2025 but the coal share shall be increased by up to 33%. This target is the optimization to the previous primary energy mix, set up in the National Energy Blueprint document in 2005. The detailed targets are as follows:

1. Energy Mix scenario (based on year 2005):
   - Oil less than 20%,
   - Gas more than 30%,
   - Coal more than 33%,
   - Geothermal more than 5%,
   - Biofuels more than 5%,
   - Other renewable energy sources, including nuclear power, more than 5%, and
   - Coal liquefaction more than 2%.
2. Energy conservation: reducing energy elasticity below 1.0, which accounts for about 1% reduction in energy intensity per year.
3. Energy pricing: adjustment of domestic energy pricing to reflect the economics of supply, reduction of oil subsidies and reform of the subsidy mechanisms.

Ministerial Regulation of MEM No. 002/2006, on Medium Scale Power Plant Utilizing Renewable Energy; and Ministerial Decree of MEM No. 1122K/30/MEM/2002, on Small Scale Distributed Generation

The regulation requires the state-owned electricity enterprise, to purchase electricity from medium scale power plants (up to 10 MW), utilizing renewable energy.

If it is connected to a medium voltage distribution grid, the purchasing price would be 80% of the total system production cost of medium voltage grid,; if it connected to a low voltage distribution grid, the purchasing price would be 60% of the total system production cost of a low voltage distribution grid.

The Ministerial Decree set the requirements of distributed generation and mandated the state owned Electricity Company to purchase electricity from distributed generation (up to 1 MW),with a determined price of 80% of the total system cost at medium voltage grid, if connected thereto , and 60% of total system cost at low voltage grid if it connected to that grid.

Ministerial Regulation No. 0002/2004, on Policy of Renewable Energy Development and Energy Conservation

The Decree released in January 2004, has the objective of ensuring the development and utilization of renewable energy resources, to meet the sustainable development goal. The specific goal of the decree is to ensure the security of energy supply, enhance the utilization of renewable energy and create a more efficient, reliable, diversified and environmentally friendly energy use.

2.7. Energy Diversification and Conservation Programmes

Current government administration is endorsed by several progra
mmes and activities with the objectives of enhancing energy security and reducing oil consumption. Fuel substitution is one of the main programmes to be implemented in the next decade, in anticipation of meager oil supplies, high prices costly fuel distribution throughout the country and reduction of oil subsidies, as well as climate change. Fuel substitution programmes aim at reducing the incidence of several petroleum products namely gasoline and diesel oil for transport, kerosene for cooking and high diesel oil and marine fuel oil for power generation. The substitution of the fuel program has been planned to utilize cleaner fossil fuels such as natural gas, renewable energy such as biofuels (bioethanol, bio-kerosene, biodiesel) and geothermal fuels. Table 2.18 gives more detailed information on targets and plans of the fuel substitution programmes.

Table 2.18: Fuel Substitution Programme, 2007 – 2020

(thousand liters)

Fuel Type & Fuel Substitution	2007	2010	2015	2020
Gasoline (Premium)	**17,645,000**	**17,609,014**	**15,891,145**	**16,377,581**
Bioethanol	3,460	2,553,600	6,354,174	8,159,151
CNG	7,532	21,780	35,077	56,492
LGV	0	27,908	35,618	45,459
Kerosene	**10,526,508**	**2,833,375**	**2,977,906**	**3,129,809**
LPG (3kg)	145,004	7,066,625	7,066,625	7,066,625
LPG (for households)	1,473,951	1,755,500	2,349,254	3,143,832
City gas	632	50,503	72,504	104,089

Fuel Type & Fuel Substitution	2007	2010	2015	2020
Biokerosene	0	100,000	180,000	200,000
Briquette	9,000	30,000	60,000	65,000
Diesel oil	**11,000,000**	**11,444,400**	**12.635.542**	**13.950.660**
Biodiesel	508,000	1,188,720	1,914,445	3,083,234
CNG	7,286	24,589	39,601	63,777
Diesel oil (for power plants)				
Coal	4,002,825	31,116,300	49,015,725	55,208,775
Geothermal	170,000	2,050,000	2,550,000	6,880,000
Renewable energy	398,054	923,304	1,536,504	2,054,220

Source: MEMR (2008)

Furthermore, current government administration has planned a comprehensive strategy and measures to ensure the security of energy supplies.

1. Enhancing Diversification of Fuel Supplies:
    1. Increasing oil and gas production by about 30% in 2009, to supply domestic demand:
        a. Optimization of existing (mature) fields, implementing the application of the "Enhance Oil Recovery "(EOR) technology, and offering new locations to investors, for oil exploration.
        b. Accelerate the production of some new oil fields.
    2. Implement national biofuel development programmes. Biofuel programmes started in 2006, aiming to increase biofuel (FAME, ethanol) production from different crops: palm oil, jathropa curcas, cassava, and sugarcane, and its utilization to reduce fossil fuels consumption. The government, through Pertamina, has introduced blending of gasoline and diesel oil with biofuel up to 5% in 2007. Later, the volume of biofuel blending was reduced to 1% in 2008, due to supply constraints of FAME and pricing policies. . However, MEMR is planning to increase the volume of biofuel blending up to 2.5%, by the end of 2008.

1. Reduction of volume of subsidized fuel:
    1. Kerosene conversion to LPG for households. The government has a target of supplying six million poor families and small households with 3 kg LPG tanks in 2007, 10 million families in 2008, 13,251 thousand families in 2009 and 12,768 thousand families in 2010. The first tanks and stoves will be distributed free of charge, in order to reduce the kerosene consumption level and the refill tank will be subsidized. By 2010, the government expects to remove the subsidy for kerosene.
    2. Developing 1000 Self Sufficient Energy Villages up to 2009, based on local energy resources potential to substitute consumption of oil.
    3. Limit the consumption of subsidized fuels, by introducing *smart card* (for gasoline and Automotive Diesel Oil (ADO)) and *control card* (for kerosene).

2. Enhancing coal utilization and renewable energy for electricity generation:
    1. Accelerated coal fired power plant development programmes. The target is to build 10 GW coal fired power plants by 2009, revised by 2010/2011, in addition to the ongoing projects of

PLN and IPP.

2. Enhancing the use of renewable energy, in particular geothermal, for electricity generation. It is consistent with the blueprint on energy development that proposed a target to build an additional 6,000 MW of capacity geothermal power plants by 2020.

3. Energy Conservation Programme:

1. Demand Side Management (DSM) activities: replacing the inefficient light bulb (incandescent bulb) with high efficient compact fluorescent lamps (CFL) for households. The DSM Programme, undertaken by the Ministry of Energy and Mineral Resources (MEMR) and PLN, the state-owned electricity company conducts several activities: dissemination of energy efficiency lamps, energy labeling for household appliances and some financial incentive schemes for customers to encourage them to shift their peak demand and/or improve their energy efficiency. It also includes energy audit services. PLN estimates (2005), the use of CFL to replace Incandescent lamp can cut the electricity demand up to 200 MW in the Java-Bali region only. Given the huge market of CFL and Fluorescent Tube Lamp (FTL) in Indonesia, potential energy saving through DSM programmes is still large. DSM programmes were started in 2002.
   a. DSM Terang: Introduced by PLN, together with MEMR and five CFL producers in 2002, has t main objective of cutting the peak load, through replacement of incandescent lamps with 8 W CFL for household customers with connection capacities below 900 VA. PLN sold almost one million CFL at 50 % of market price to its customers.
   b. DSM PJU: DSM for Public Street Lighting, launched by MEMR, in cooperation with local government. The objective was to cut the peak load through replacing and increasing the efficiency of street lamps.
   c. DSM Peduli: Introduced by PLN in 2004 to reach lower income households having connection capacities up to 900 VA. The programme is similar to DSM Terang which is replacement of incandescent lamps with CFL. In this programme, PLN provides direct subsidy to the lower income customers for purchasing 3 CFL lamps. PLN and MEMR expected that this can reach 5 million customers of PLN.
2. Partnership on energy conservation: different initiatives, to improve energy efficiency in the building, industry, and transport sectors. The government offered free energy audits to energy intensive industries (textile, steel, pulp and paper, etc.) and commercial buildings.
3. Energy efficiency standards and labeling for electronic appliances.
4. Information dissemination of energy conservation measures.

Table 2.19: Estimated CFL and Fluorescent Tubes Lamps (FTL) Market Assessment

Areas	Electrified Customer (2005)	CFL Market	FTL Market
Residential 450VA	19,052,817	21,300,000	4,260,000
Residential > 450VA	12,860,722	41,200,000	8,240,000
Commercial	1,435,989	10,100,000	2,020,000
Public	821,624	24,600,000	4,920,000
Industrial	52,020	9,900,000	1,980,000
Total market	34,223,171	107,100,000	21,420,000
Annual replacement (after 5,000hours)		40,400,000	8,100,000
Total import		48,000	
Ratio: Total import/Market		32.5%	

Source: Econoler-World Bank (2006)

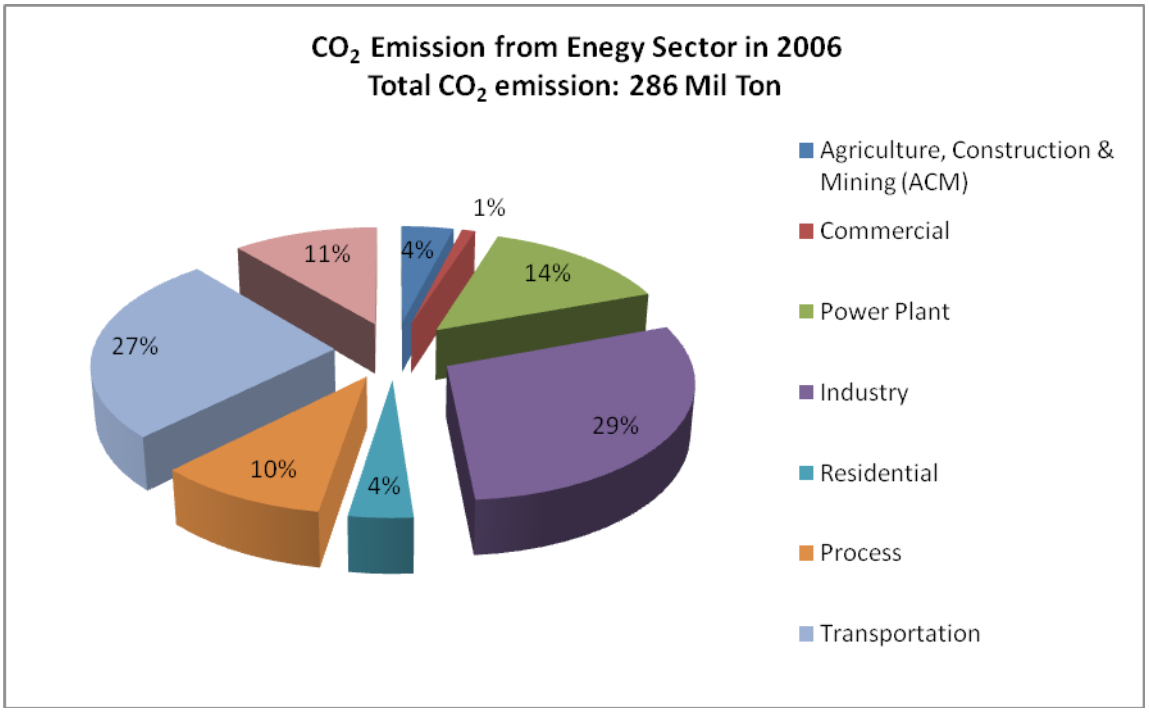
2.8. Greenhouse Gas Emissions and Mitigation Scenario

2.8.1. Current and Projected Greenhouse Gas Emissions

In 1994, total GHG emissions of Indonesia (without Land-use Change and Forestry) were 323,262 Gigagram (Gg) and 487,380 Gg, with the inclusion of emissions from Land-use Change and Forestry (LUCF). The energy sector accounted for 222,102 Gg or 68.7% of the total emissions, without LUCF, or 46% of the total emissions with LUCF. As a result of an increasing energy demand, the increase in CO_2 emissions from the energy sector between 2000 and 2010 is estimated to average 6.5% per year, greater than the primary energy growth rate of 6% per year. CO_2 emissions in 2010 are expected to double that of 2000[16].

This estimation is made without taking into account the emissions from new coal fired power plans, which are accelerating the development started in 2006 and expected to be commissioned in 2010 – 2012.

In 2003, CO_2 emissions from the energy consumption were estimated to be about 275 $MtCO_2e$[17]. Calculations made by BPPT and MEMR in 2008, noted that CO_2 emissions from energy use in 2006 were 287 $MtCO_2$ (Figure 2.9). The emissions from the industry, power generation, and transport sectors are increasing very rapidly in the wake of industrialization and economic growth. It is expected that, with massive expansion of coal fired power plants and high barriers to wide-spread deployment of clean and renewable energy technology, the emissions from the energy sector will continue to demonstrate a strong increase.



Source: Output MARKAL by BPPT (September 2008)

Figure 2.9: GHG Emissions from Fuel Consumption, 2006

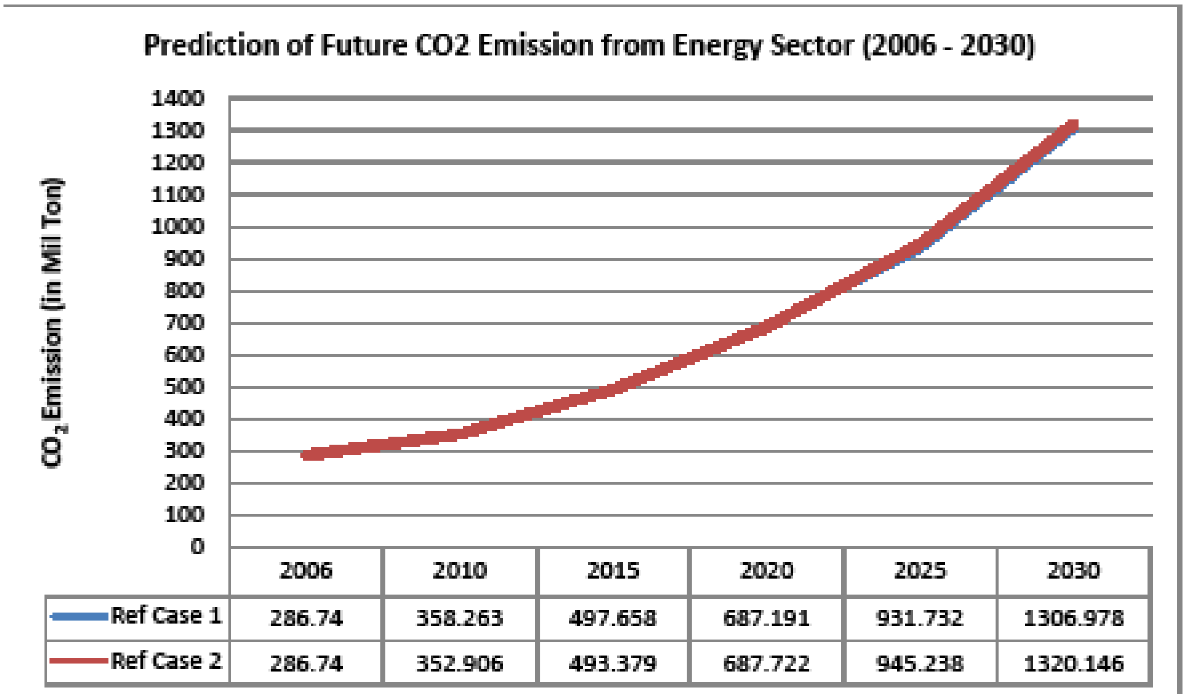
Emission projections in this report are generated, using MARKAL models and coefficients determined by IPCC tier 2 methodologies, with data inputs of estimation of fuel consumption of each sector in particular years. Due to the limitations of data and information available, calculations were limited to CO_2 emissions only, and not all the GHG emissions are dealt with. Two reference cases were utilized:

[16] (Ministry of Energy and Mineral Resources (MEMR) and Center Energy Information (CEI) 2002)

[17] million tonnes of CO_2 equivalent

The first refers to an oil price of 60 US$/barrel and the second to an oil price of 120 US$/barrel. Under BAU, the first case gives a result that CO_2 emissions will increase five times in the next 25 years from about 287 $MtCO_2$ in 2006 to about 1,306 $MtCO_2$ in 2025. While the second instance gives a result of 1,320 $MtCO_2$ (Figure 2.10).

In the absence of carbon value and the high capital cost of renewable energy technology, as oil price increases the MARKAL model selects non-oil fossil fuel technology, such as coal power plant and natural gas, to form optimal solutions in terms of the lowest cost for the energy system. Coal power technology and natural gas generators will substitute diesel generators. In time, coal will be the predominant technology to supply electricity to the country. As the result, GHG emissions are higher than first reference case.



Source: Calculation by BPPT and MEMR (2008)

Figure 2.10: Projected GHG Emissions BAU (Reference Case 1 & 2)

2.8.2. Greenhouse Gas Emissions Mitigation Scenario

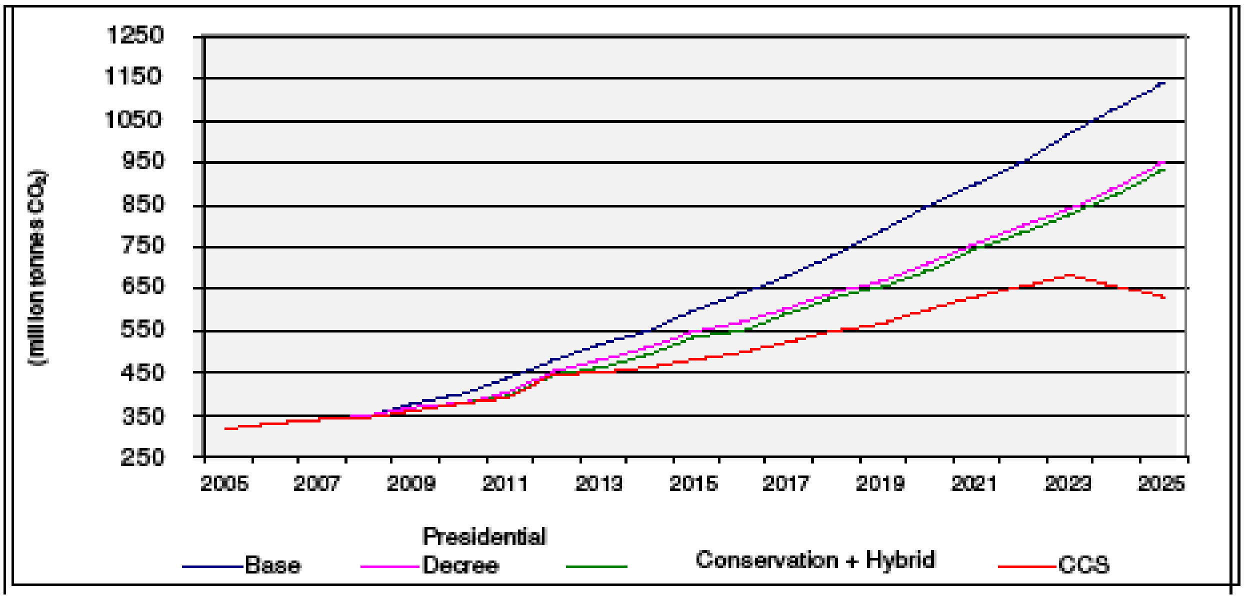
2.8.2.1. Initial Projected Greenhouse Gas Emissions and Mitigation Scenario

Emission projections, made by the Indonesian Working Group on Energy in 2007, which were published in the National Action Plan in Addressing Climate Change (RAN-MAPI), projected that GHG emissions from the energy sector might reach 1,200 million tonnes of CO_2 in 2025 under BAU. The emission reduction scenario from the energy sector is assessed under four cases:

1. The BAU case is based on the energy supply target indicated in the Blue Print of National Energy Management that was published in 2005 by MEMR. This scenario has considered the energy conservation programme. The total CO_2 emissions generated from 2006 to 2025 are 13.4 billion tonnes.
2. The optimization scenario is based on the Presidential Decree No. 5/2006, which sets target to reduce oil and increase the utilization of coal, natural gas, renewable energy and nuclear power for the primary energy mix in 2025. The total CO_2 emissions generated from 2006 to 2025 would be 11.74 billion tonnes or about 1.7 billion tonnes (13%) of emission reductions

from the BAU scenario.

3. The conservation scenario is an enhancement of the optimization scenario, with the addition of the deployment of hybrid cars, started by 2% in 2020 up to 5 % of total cars in 2025 and the enormous use of energy-efficient home appliances that contribute 5% reduction in electricity in 2025, energy saving lamps that could contribute to 10% reduction in electricity in 2025, and the reduction of electricity consumption up to 10% in the commercial sector through 2025. The total emissions generated from 2006-2026 are 11.5 billion tonnes or about a 1.9 billion tonnes (19%) reduction from BAU extrapolations.
4. The Carbon Capture and Storage (CCS) scenario assumes the use of CCS technology in coal-fired power plants, started in 2012, in addition to the conservation scenario. The application of CCS technology will start in 2012, with 10% of the number of power plants and continuously increase up to 100% in 2025. The total CO_2 emissions generated from 2005-2025 could be 10.05 billion tonnes, with 3.3 billion tonnes (25%) emissions reduction from the BAU scenario.



Source: Analysis of Working Group on Energy (2007)

Figure 2.11: GHG Emissions Projection and Reduction Scenario

2.8.2.2. Projected Emission and Mitigation Scenario

Further assessments using a MARKAL model,[18] are undertaken, to give a more realistic emissions reduction scenario and the impact of several technology deployments in current and future energy systems of Indonesia. The baseline of this model is a long-term crude oil price set at 60US$/barrel (reference case 1) and 120 US$/barrel (reference case 2). Based on two cases of oil price, four scenarios have been applied, to assess the impact of technology in the CO_2 emissions reduction.

1. BASE case scenario is BAU; it assumes that there are no energy conservation and energy

[18] MARKAL is a generic model tailored by the input data to represent the evolution over a period of usually 40 to 50 years of a specific energy system at the national, regional, state or province, or community level. The basic components in a MARKAL model are specific types of energy or emission control technology. Each is represented quantitatively by a set of performance and cost characteristics. A menu of both existing and future technologies is input to the model. Both the supply and demand sides are integrated, so that one side responds automatically to changes in the other. The model selects that combination of technologies that minimizes total energy system cost. Thus, unlike some "bottom-up" technical-economic models, MARKAL does not require -- or permit -- an a priori ranking of greenhouse gas abatement measures as an input to the model. The model chooses the preferred technologies and provides the ranking as a result. Indeed, the choice of abatement measures often depends upon the degree of future abatement that is required. For more information: http://www.etsap.org/markal/main.html

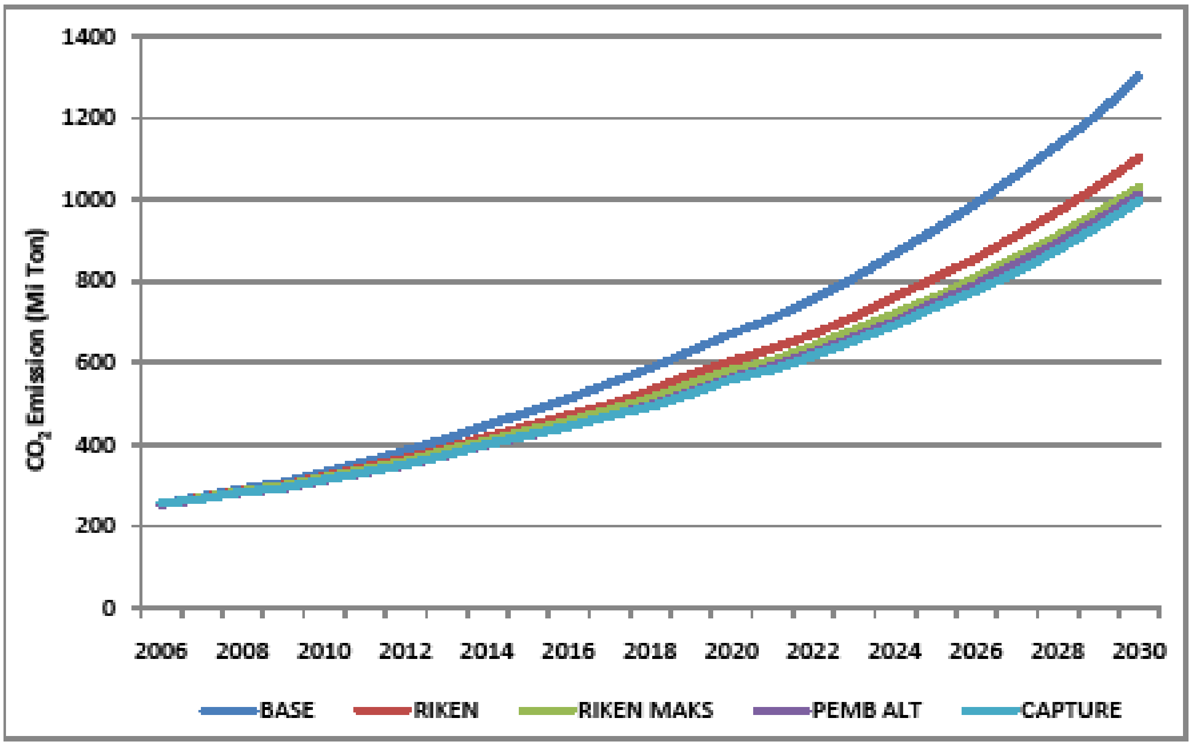
efficiency measures that electricity generation is fully based on a coal fired power plant. The results show that CO_2 emissions will increase up to 1,300 million tonnes in 2030.

2. The energy Efficiency (RIKEN) scenario is assessed from the impact of a national energy conservation programme target set in 2005, an assumed energy efficiency improvement of 15%. The emissions can be reduced to 1,100 million tonnes of CO_2 in 2030 or 200 million tonnes lower than BAU.
3. The maximum Energy Efficiency (RIKEN MAX) scenario, assumes that energy efficiency improvement reaches 30% (maximum). This scenario will give 100 million tonnes of CO_2 reductions, in addition to the Riken scenario, 300 million tonnes of CO_2 reduction under BAU in 2025.

4. The alternative Power Plant (PEMBALT) scenario is based on the application of advanced thermal power plant, nuclear and renewable technology. Advanced clean coal technology is set to six units (3 x 600 MW for IGCC and 3 x 600 MW advanced coal power plants). This will give similar results with the RIKEN max scenario in terms of emission reductions.

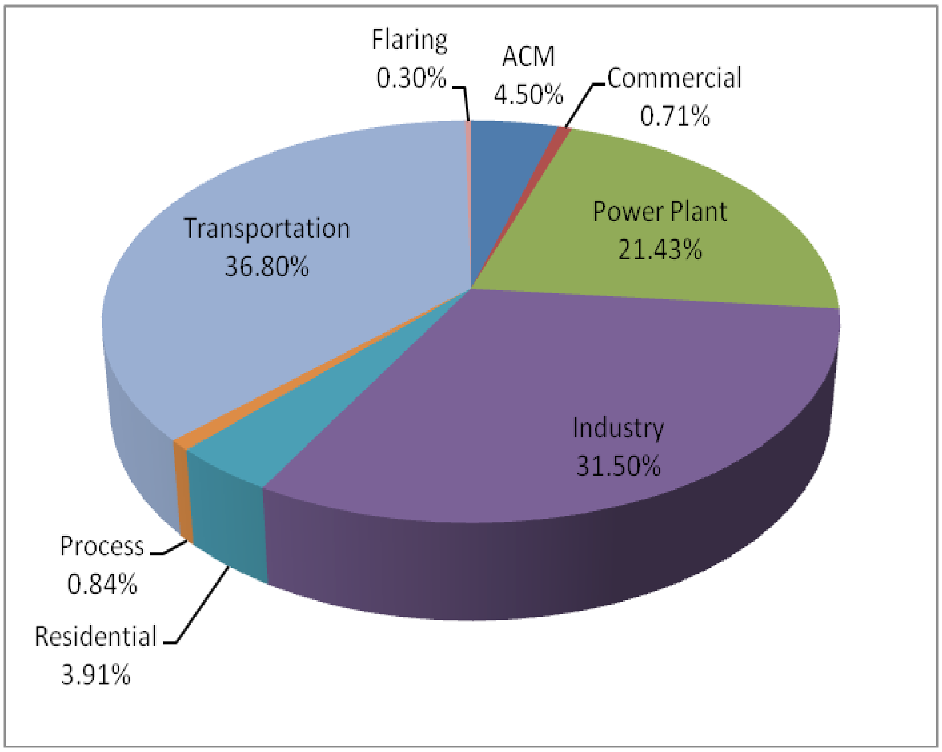
5. The Carbon Capture and Storage (CAPTURE) scenario is based on the application of advanced thermal power plants with Carbon Capture Technology and gives similar results as scenario 4 (PEMBALT).

Under the reference case-1, energy efficiency measures gave a significant reduction of emissions. As can be seen in Figure 2.12, energy efficiency measures (RIKEN and RIKEN MAX) might reduce emissions up to 200 to 300 million tonnes or about 15% to 25% of emissions in 2030.
As shown in Figure 2.13 and Figure 2.14, under CAPTURE scenario, although total emissions decrease compared to the BAU scenario, share of emissions from industry is the highest among others while share of emissions from power plants is reduced by about 5% from BAU. This indication suggested that if new and advanced technology for specific energy intensive industries, such as cement, pulp and paper, steel, chemical and textile are deployed, it will reduce the emissions further. However, the exercise of the impact of such new technology is not the subject of this report, but is done in TNA Industry report.
Under the case of an oil price of 60US$/barrel, enforcement of advanced CCS technologies and renewable technologies will increase costs of systems, since those technologies are not economically feasible (cost-effective).



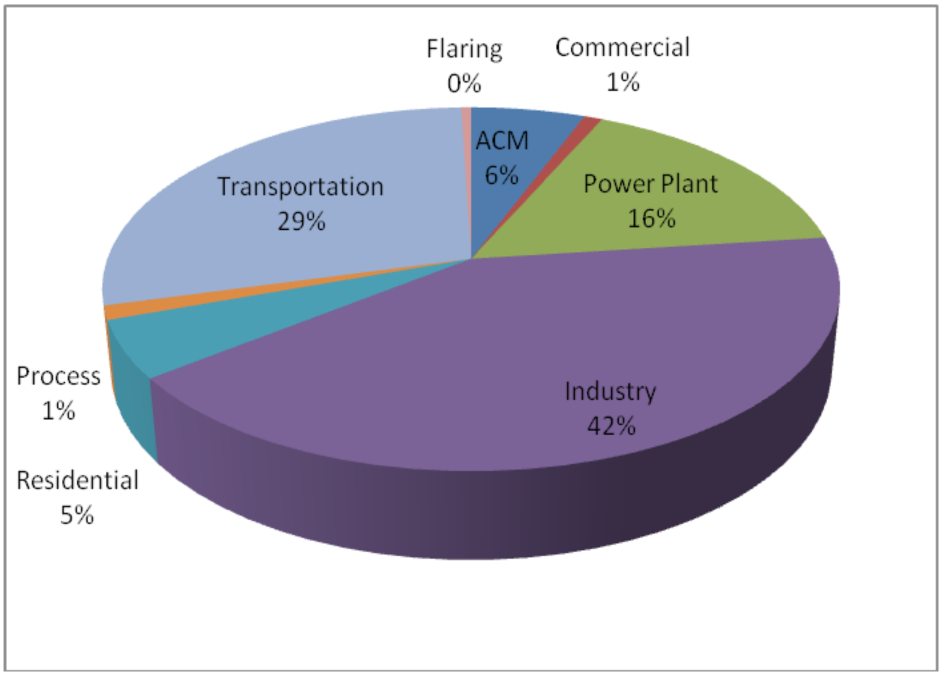
(Baseline crude oil price of 60US$/bbl)

Figure 2.12: Projection of GHG Emissions from Energy Consumption (Reference Case 1/ Reduction Scenarios)



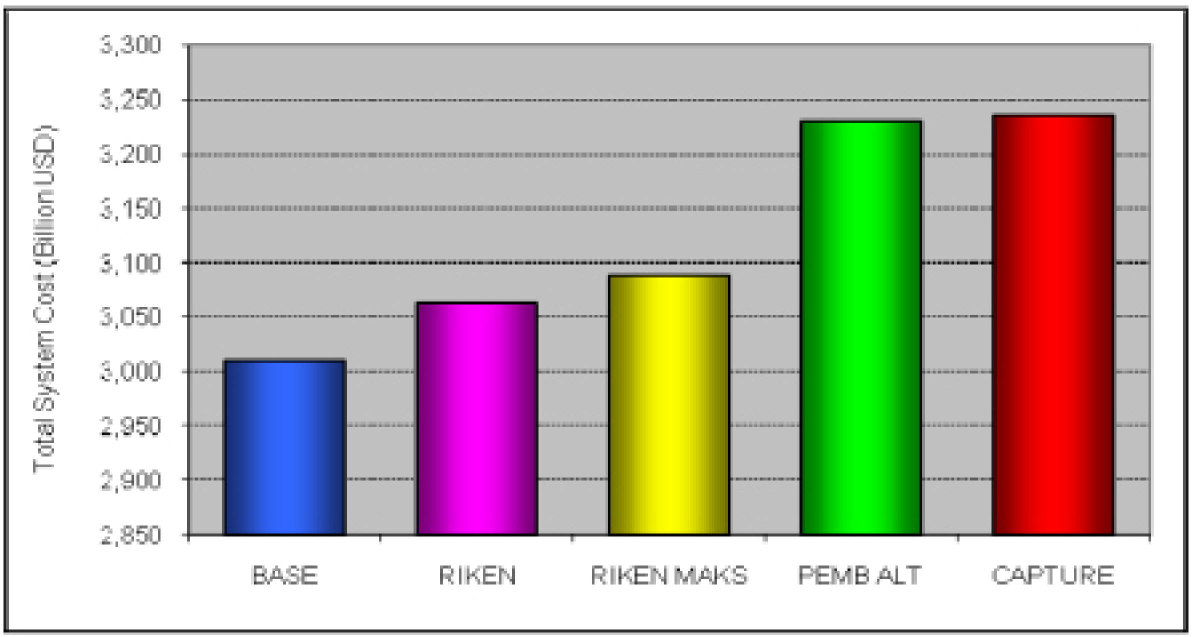
(Baseline crude oil price of 60US$/bbl)

Figure 2.13: Projected CO_2 Emissions from Energy Consumption (Reference Case 1/ BAU scenario), 2030



(Baseline crude oil price of 60US$/bbl)

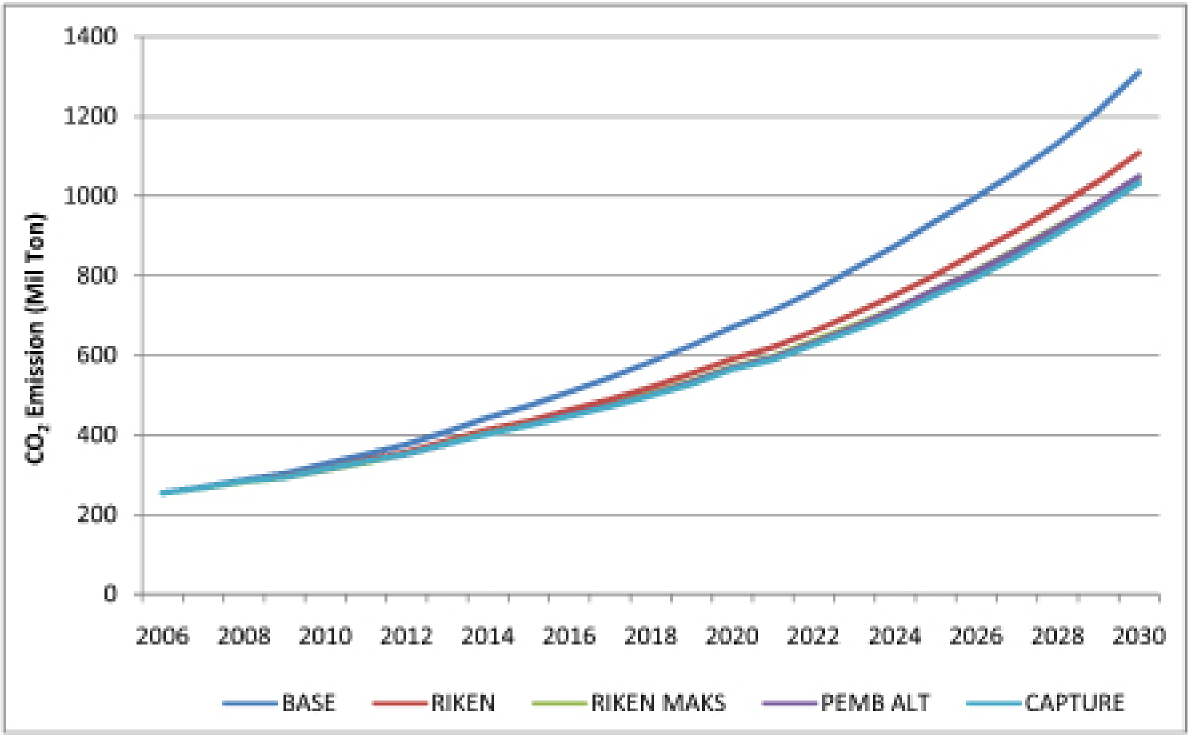
Figure 2.14: Projected CO_2 Emissions from Energy Consumption (Reference Case 1/ CAPTURE scenario), 2030



(Baseline crude oil price of 60US$/bbl)

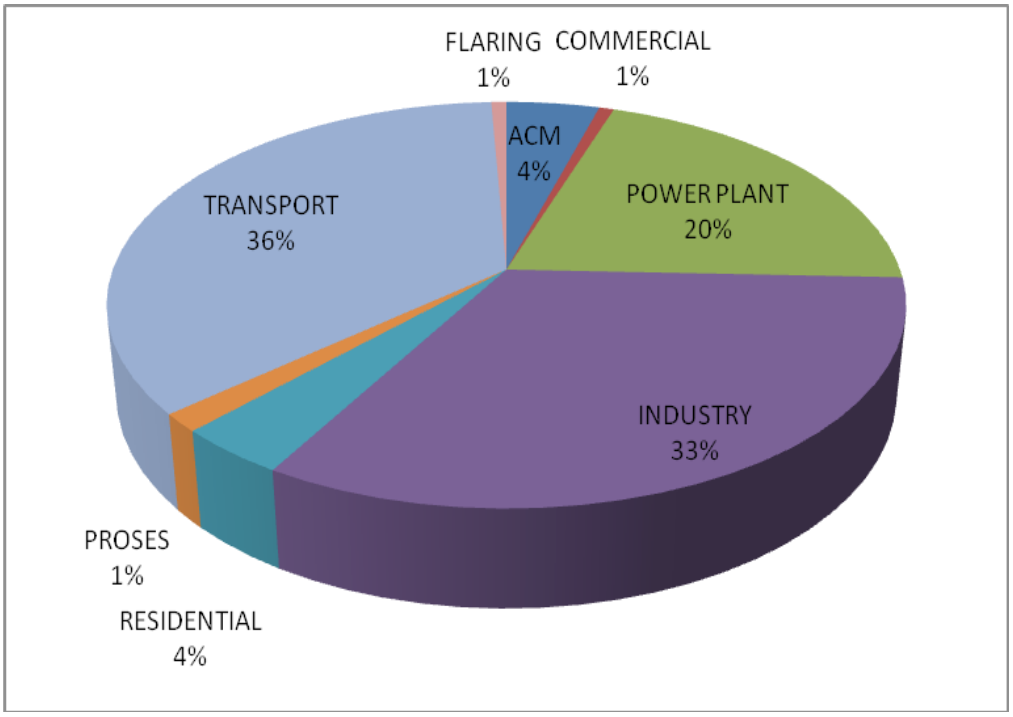
Figure 2.15: Total System Cost (Reference Case 1/ Reduction Scenarios)

In the case of oil prices of 120 US$/barrel, most technologies are feasible, therefore application of advanced CCS, nuclear and other renewable technologies will give lower system costs compare to BAU (Figure 2.16).



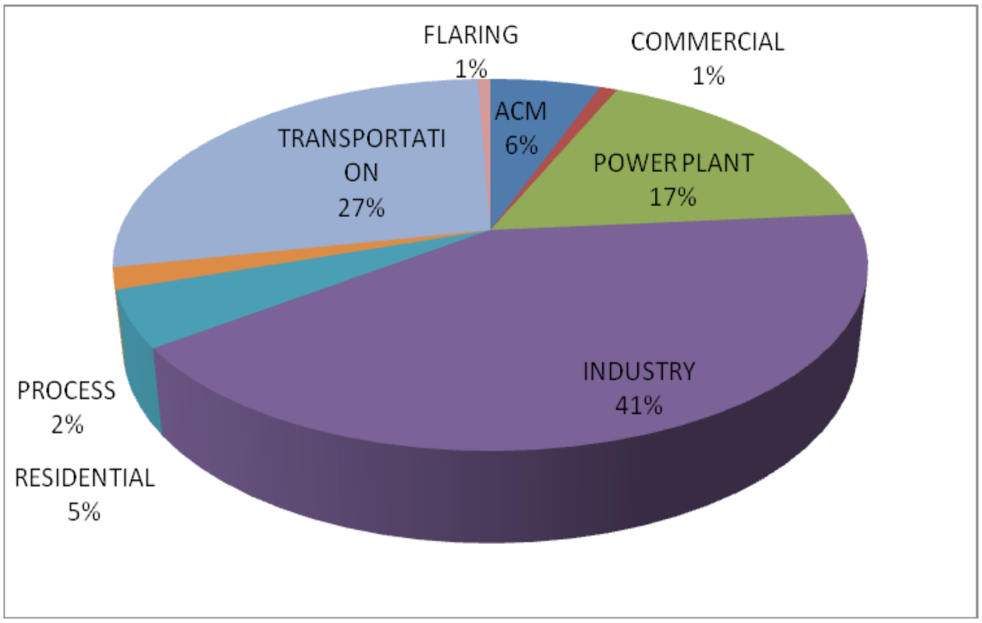
(Baseline crude oil price of 120US$/bbl)

Figure 2.16: Projection of GHG Emissions from Energy Consumption (Reference Case2/ Reduction Scenarios)



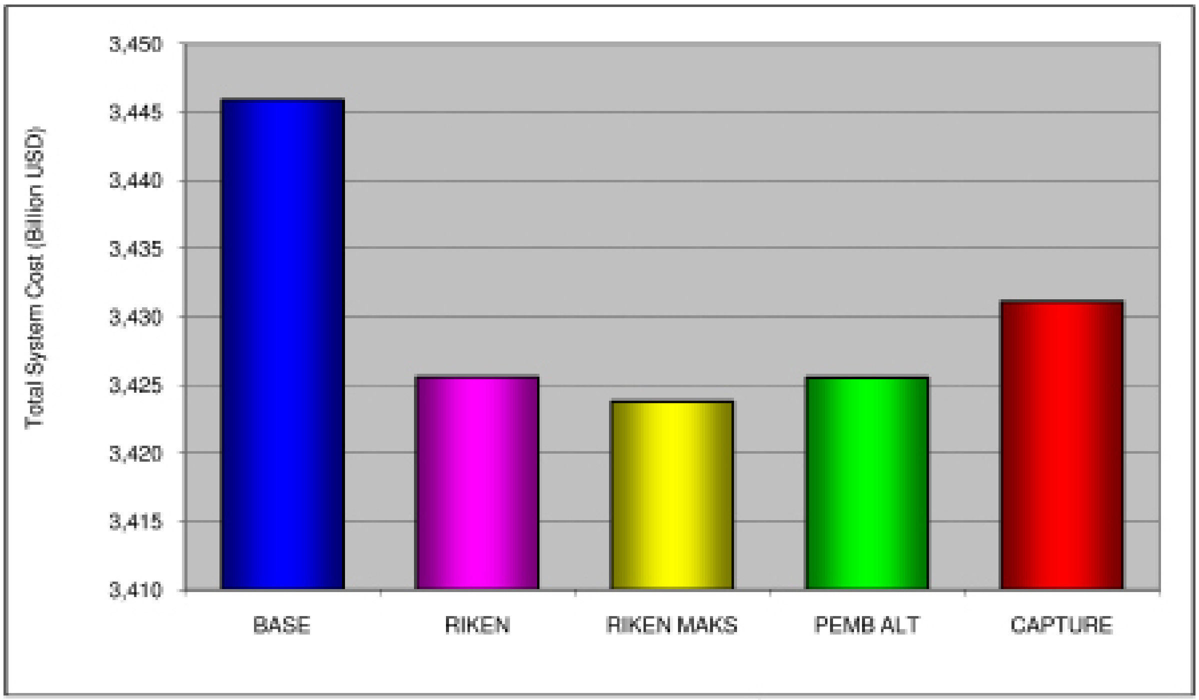
(Baseline crude oil price of 120US$/bbl)

Figure 2.17: Projected CO_2 Emissions from Energy Consumption (Reference Case 2/ BAU scenario), 2030



(Baseline crude oil price of 120US$/bbl)

Figure 2.18: Projected CO_2 Emissions from Energy Consumption (Reference Case 2/ CAPTURE scenario), 2030



(Baseline crude oil price of 120US$/bbl)

Figure 2.19: Total System Cost (Reference Case 2/ Reduction Scenarios)

3. TECHNOLOGY CRITERIA AND OPTIONS

3.1. Selection Criteria of Technology Assessment

Technology transfer priorities are selected using determined general and specific criteria. The general criteria are based on national-wide interest and priorities, while specific criteria are reflecting the priorities, current policies, objectives and situation of the energy sector.

The selection of general criteria is made through a broad consensus of the Energy Working Group on Technology Transfer (EGTT) member of which comprise representatives from the different stakeholder of the TNA. Specific criteria are determined and selected by energy sub-group.

3.1.1. General Criteria

In accordance with national interests and policies, four general criteria and 11 sub-criteria are set for national technology transfer priorities. The general criteria are as follow:

Table 3.1: General Criteria for Technology Selection

General criteria	Sub-Criteria
a. Conformity with national regulation and policy	• Food security (FS) • Natural resource security (NR) • Energy security (ES) • Incentive for participation (IP)
b. Institutional and human development	• Capacity building (production & know how) (CB)
c. Technology effectiveness	• Reliability of technology (RT) • Easiness of wider use of technology, including local contribution support of technology application (ET)
d. Environmental effectiveness	• Greenhouse gas emissions reduction (GR) • Improvement of local environmental quality (LE)
e. Economic efficiency and cost effectiveness	• Capital and operational costs relative to alternatives (COC) • Commercial availability (market) (CA)

3.1.2. Specific Criteria

The four specific criteria and nine sub-criteria for technology transfer in the energy sector are as follows:

Table 3.2: Specific Criteria for Technology Selection

Specific Criteria	Sub-Criteria
a. Consistency with national policy & target and specific local situation	• Relevant to existing energy policy & target (EP) • Utilization of local energy resources (LER)
b. Economics and cost-effectives of technology	• Total capital cost (TC) • Internal Rate of Return (IRR) • Payback period (PR) • Abatement cost (AC)
c. Technology development	• Advance but proven technology (AD) • Possibility for local manufacturing & production (PLB)
d. Social acceptability	• Good impact for socio-economic development (LED)

3.2. Technology Options

The main source of GHG emissions from the energy sector is generated by the activities in mining, processing, transporting, combusting of fossil fuels; combustion of fossil fuels to produce electricity and heat and transmission and distribution of those energies. Energy is produced to supply demand; in normal circumstances, more demand will lead to more supply unless there is supply disruption.

To have effective GHG emissions mitigation measures, technology and policies should be able to address both the demand and supply side.

3.2.1. Energy Supply Side Technology

Given the situation of energy supply and demand, national targets, policy objectives and current programs in Indonesia, GHG emissions mitigation measures on the supply side can be achieved through several approaches:

a. Deploying advanced thermal power technologies/clean coal technology to generate electricity.
b. Reducing carbon based fuel combustion through three activities:
    a. Switching from conventional fuels to alternative, non-carbon or fuel with less carbon content,
    b. Increasing combustion efficiency,
    c. De-carbonization of fuels and flue-gas.
c. Utilizing carbon storage and sequestration technology to reduce carbon dioxide produced by power generation, oil and gas operations (e.g.: Carbon Capture and Storage).
d. Improving efficiency and reducing leakage in extracting, processing and transporting of fossil fuels and energy.

Four areas of potential for GHG emissions mitigation on the supply side are herewith listed: oil and gas operations, power generation, renewable energy systems, and nuclear power.

3.2.1.1. Oil and Gas Operations

There are two main potentials for greenhouse gas emissions in oil and gas exploration activities: gas flaring that is generated due to exploration, exploitation and refining; and CO_2 leakage during production processes (wellhead, pipeline, refinery, LPG/LNG plant).

An estimated average of 50% or more of natural-gas production is emitted into the atmosphere from upstream oil and gas operations. In some areas, emissions are assumed to be as high as 15%, of which 6% is emitted from natural-gas usage. Such high levels of emission could probably be decreased by 20 – 50%. Gas flaring also occurred in many oil production facilities that produce just a small amount of gas or are located in remote areas (far from gas collecting system). Besides losses through flaring, gas from the oil production facilities can also be utilized as fuel for power generation, cogeneration, and transport. These options could reduce CH_4 emissions by 50 – 99%, and their implementation would be more successful, if they are economically attractive.

The CO_2 emissions potential from gas flaring are estimated at 5.7 million tonnes/year. The reduction of CO_2 released from oil and gas production processes, can be achieved by utilizing the flaring. There are three technologies available: Flare Gas Recovery Unit (FGRU) and Mini LNG Plant with CO_2 removal unit; and CCS-Enhanced Oil Recovery (EOR) for CO_2 storage.

1. A Flare Gas Recovery Unit with 1 MMSCFD[19] capacity can remove 600 thousand tonnes CO_2/year. The investment cost is about 7 million US$ per unit and CO_2 abatement cost is about 12 US$/tonne CO_2, assuming the plant works at full capacity.
2. A Mini LNG Plant with a CO_2 removal unit of 10 MMSCFD capacities can remove 237,000 tonnes CO_2/year. The investment cost is about 18 million US$ per unit and CO_2 abatement cost is about 76 US$/tonne CO_2.
3. Carbon Capture and Storage – EOR technology: Experience in Indonesia, with this technology, shows that incremental oil recovery is 8 – 16 %, and gross CO_2 utilization is 5 - 10 Mcf/Bbl. It is estimated that 38 – 152 million tonnes CO_2 can be stored in depleted oil reservoirs in Kalimantan and a potential oil recovery as large as 265 – 531 million barrels can be obtained. In the South Sumatra region, CO_2 volume of 18 – 36 million tonnes could be stored in the depleted oil reservoirs with potential oil recoveries of 84 – 167 million barrels. The investment cost is varied and depends on many factors, but abatement cost is estimated about 50 – 70 US$/tonne CO_2.

3.2.1.2. Electric Power Generation

The GHG mitigation options in the power generation are the use of more efficient power generation technologies for fossil fuels and the use of non-fossil fuels with lesser or no carbon content (nuclear and renewable, such as geothermal, hydro, mini hydro, pump storage, photovoltaic, wind, and waste derived fuels).

The application of clean coal technologies (CCTs) in energy systems is one of GHG emissions mitigation options. The IEA (2008) has identified groups of CCTs, as listed below, which have the capability to reduce CO_2 emissions from coal-fired power plants:

a. Coal upgrading technology: Upgrading technologies remove moisture from low-rank coals using various methods such as: direct heat (e.g. saturated steam drying), indirect heat (waste heat utilization or exhaust gas re-circulation) and electromagnetic energy. The dried coal is then briquetted as fuel for the power plant. The environmental effects of using upgraded coal are to reduce sulfur and mercury associated with water removal, increase heat content of coal, resulting in lower NO_x per energy generated and increasing fuel and boiler efficiency leading to lower CO_2 per energy generated. It is estimated that coal washing/drying and briquetting could reduce CO_2 emissions by as much as 5%. This involves the application of established commercial technologies which are in use in the USA, Europe, Japan and Australia, but not yet widely deployed in the developing world or the former Soviet Union (IEA, 2008)
b. Efficiency improvements in existing plants: Conventional sub-critical plants can achieve thermal

[19] Million Standard Cubic Feet per Day

efficiencies of up to 40%. Improving less efficient plants will reduce emissions. Improved efficiency sub-critical plants are operating throughout the world. Supercritical and ultra supercritical plants can achieve efficiencies of up to 45%, and are operating in Japan, USA, Europe, Russia, China and Australia. That level of efficiency can reduce CO_2 emissions by as much as 22 %.

c. The advanced power generations technologies such as subcritical pulverized coal (SubPC), supercritical pulverized coal (SPC) and ultra supercritical pulverized coal (USPC), IGCC (Integrated Gas Combined Cycle) fuel cells, cogeneration will increase efficiency, reduce fuel consumption and associated environmental pollution, and increase fuel diversity.
   - Subcritical Pulverized Coal (SubPC) technology has power generation efficiency of 33% to 37%, depending on coal quality, operation and design parameters. A 500 MW SubPC requires 208,000 kg coal per hour and emits 931 gCO_2 per kWh. Total plant costs 1,280US$/$KW_e$ (2007).
   - The supercritical Pulverized Coal (SPC) power plant has higher thermal efficiency compared to the conventional pulverized coal power plant. This type of plant's power generation efficiency ranges from 37% to 40%, depending on coal quality, operations and design parameters. A 500 MW SPC requires 185,000 kg coal per hour and emits 830 gCO_2 per kWh. Total plant costs 1,330US$/KWe (2007).
   - Ultra Supercritical Pulverized Coal (USPC) power plant's efficiency ranges from 44% to 46% with bituminous coal. A 500 MW USPC requires 164,000 kg coal per hour and emits 738 gCO_2 per kWh. Total plant costs 1,360US$/KWe (2007).
   - Subcritical Fluid Bed Combustion (SFBC) is the technology suited to low cost waste fuels and low quality or low heating coal. A 500 MW SFBC power plant efficiency ranges from 34 to 35 % with lignite. A 500 MW USPC requires 297,000 kg coal per hour and emits 1030 gCO_2 per kWh. Total plant costs 1,330US$/kWe (2007).
   - Integrated Gasification Combined Cycles (IGCC) technology produces electricity by first gasifying coal to produce syngas which, after clean-up, is burned in gas turbines which drive generators IGCC for coal and gas and cogeneration power generation has the potential for reducing CO_2 released less abatement cost. The potential for implementing this technology is very high. The overall generation efficiency of IGCC is about 36 to 40.5 %, but the type of coal and gasifier will affect this number. IGCC emits 102 g CO_2 per kWh. The investment cost for IGCC plant without CO_2 capture vary from 1,111 – 1,350 US$/kWe and 1,600 - 1,800 US$/kWe for IGCC with CO_2 capture.
   - The fuel cell power systems are characterized by high thermodynamic efficiency and low levels of pollutant emissions. Almost all the fuel cell technologies currently are developed for commercialization, by using pure hydrogen as the fuel, but they are not recommended for GHG mitigation option because the abatement cost is very high - similar to photovoltaic and wind power plants.

3.2.1.3. Renewable Energy Technologies

Hydro and geothermal power have big potential in terms of available resources, therefore, giving the country a wide range of options for GHG emissions mitigation from the power sector, if those resources are developed extensively in the near future.

Several types of new renewable energy technologies are still relatively expensive and cannot compete yet with current conventional energy technologies, dominated by fossil fuel technology, because although renewable energy releases less CO_2, it is still on a small scale, the investment cost is still relatively high and the utilization may not be cost-effective. Currently new renewable energy technologies are mostly used to generate electricity. Available renewable technologies for GHG emissions mitigation as follows:

1. Biopower or biomass power is the generation of electric power from biomass resources. Biopower

reduces most emissions (including GHG emissions) compared with fossil fuel-based electricity generation. Because biomass absorbs CO_2 as it grows, the entire biopower cycle of growing, converting to electricity, and re-growing biomass can result in very low CO_2 emissions, compared to power generation from fossil fuels without carbon sequestration, such as coal, oil or natural gas. Through the use of residues, biopower systems can even represent a net sink for GHG emissions, by avoiding methane emissions that would result from landfill of the unused biomass. Recent technologies for power generation from biomass are:

a. Direct combustion of biomass (wood, bagasse) in a boiler and use of the heat of combustion to produce steam in a waste heat boiler. The steam is then used to drive a steam turbine connected to a generator. Biomass utilization, to produce heat and power, can avoid the use of fossil fuels. Plant efficiency is around 20% – 40%. Avoided emissions are based on the baseline. Typical capital cost is 1,975 – 3,085US$/kW.
b. Co-firing: substitution of biomass with coal or other fossil fuels in existing boilers. Plant efficiency is about 35%, and co-firing of 15% biomass to substitute coal will give 23% GHG emission reductions. Typical capital cost for biomass/coal co-fired power plant is 123 – 235 US$/kW + power station cost.
c. Biomass gasifier: Biomass integrated gasification gas turbines (BIG/GT) are not yet in commercial use, but their economies are expected to improve. Recent technology has 30 – 40 % plant efficiency. Integrated Gasification Combine Cycles (IGCC) is already economically competitive in the CHP mode, using black liquor from pulp and paper industry as feedstock. The efficiency is 30 – 40 % with total capital cost 2500 – 5000 per kW.

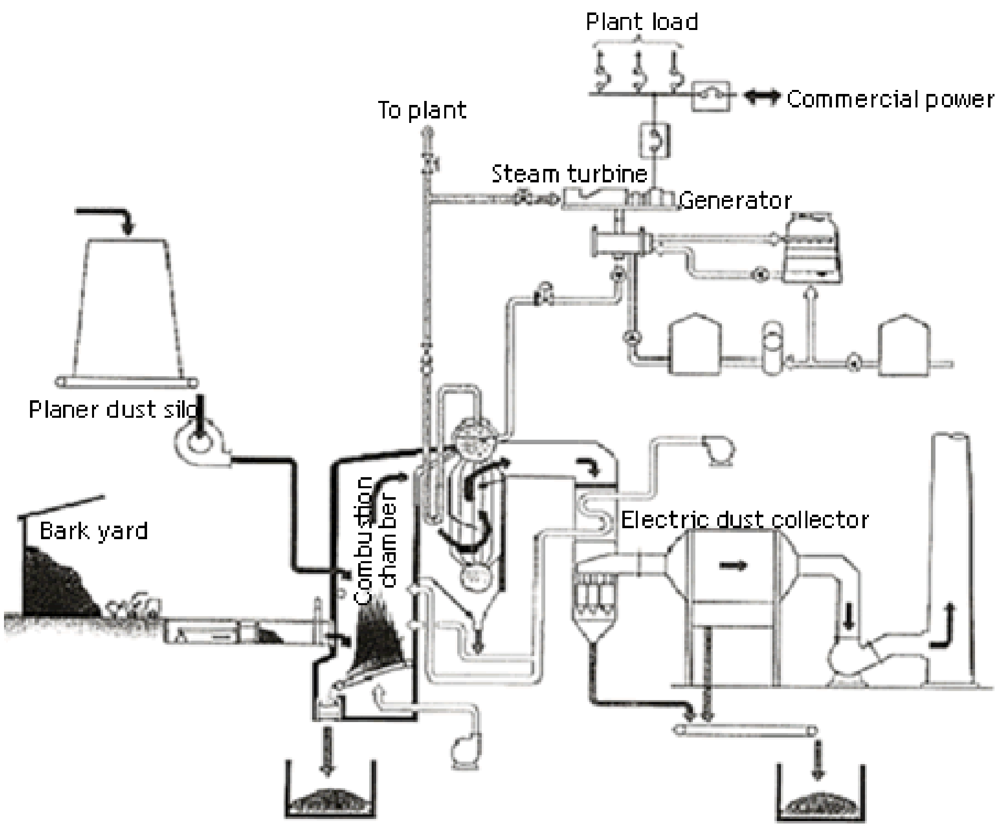
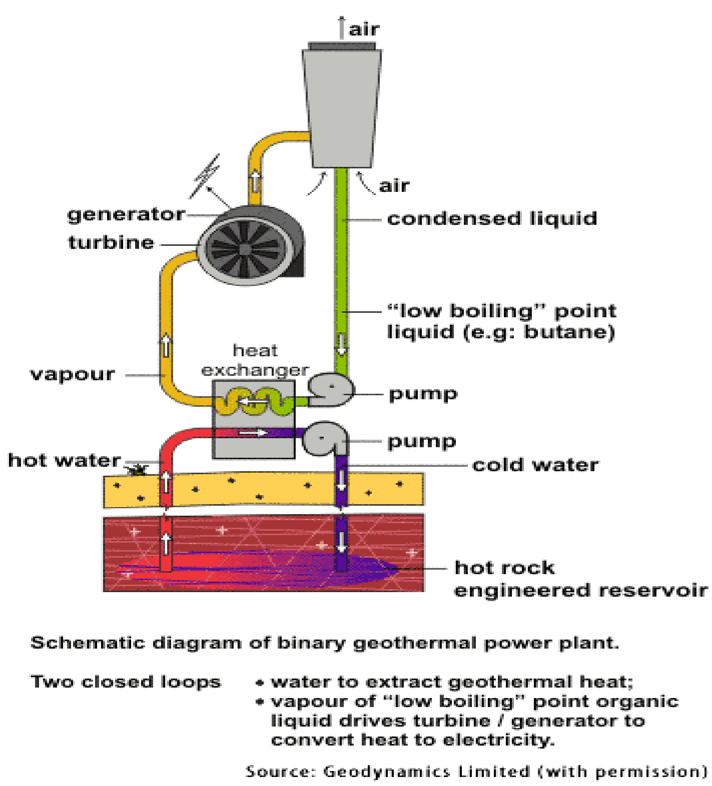


Figure 3.1: Direct Combustion and Electricity Generation Flow

2. Geothermal energy is heat from inside the Earth. Hot water or steam is used to produce electricity or applied directly for space heating and industrial processes. This energy can offset the emissions of carbon dioxide from conventional fossil-powered electricity generation (usually coal fired power plant), industrial processes, building thermal systems, and other applications. Beside direct

use of heat without converting to electricity, geothermal is being used to produce electricity. There are three technologies for electricity generation from geothermal energy sources:

a. Binary Cycle technology: It is used for hydrothermal sources containing fluids with moderate temperatures (below 200°C). Binary Cycle system is used to extract their heat. The hot water and a secondary (hence, "binary") fluid, with a much lower boiling point than water passing through a heat exchanger. Heat from the geothermal fluid causes the secondary fluid to flash to steam, which then drives the turbines. Because this is a closed-loop system, virtually nothing is emitted to the ground or the atmosphere. Binary Cycle has 93% capacity factor, with total capital cost 1,600 – 1,700 US$/kWe for high quality resource.
b. Flash Steam power plant: It uses hydrothermal fluids with temperatures above 200°C (400°F). The fluid is sprayed into a tank held at a lower pressure than the fluid, causing some of it to rapidly vaporize, or "flash" into steam. The steam drives a turbine, which then drives a generator. It has 93 % capacity factor, with total capital cost 1,250 – 1,300 US$/kWe for high quality resource
c. Hot Dry Rock (HDR) technology: The heat from the earth, which uses the natural geothermal systems, is used in places where cracks or pore spaces are present. The major aspect of the successful heat mining is to form an engineered geothermal reservoir in a hot body that is an impervious rock. The surface in a hot rock body where an HDR reservoir is developed is determined by selecting a location on the surface where the injection well is drilled. It is also determined by the deepness within the well bore at which the water is pumped into the hot rock and converted into steam to generate carbon-free electricity, by the use of a conventional steam turbine technology. The capacity factor of HDR plant is about 86 %, and the total capital cost is around 4,600 – 4,700 US$/kWe (2005).



Source: lgc.org (accessed September 2008)

Figure 3.2: Schematic Diagram of Binary Geothermal Power Plant

3. Solar Energy: Solar thermal and solar photovoltaic are two types of solar energy technologies that are available in the market. For solar photovoltaic the various systems are as below:
    a. Photovoltaic cells from thin film semiconductor (amorphous silicon), copper indium diselenide, cadmium telluride, dye-sensitized cell, with commercial module rated efficiency of 6-10%. Total cost for PV systems, with thin film technology is about 4.5 – 5 US$/Watt peak (Wp) or about 4,500 – 5,000 US$/kWp.
    b. Photovoltaic cells from single crystalline and multi-crystalline silicon wafer, with commercial module rated efficiency of 12 – 14%. Total cost for PV systems is about 5.5 – 6.5 US$/Watt peak (Wp) capacity or about 5,500 – 6,500 US$/kWp.
    c. High efficiency Photovoltaic cells, single crystal silicon and multi-junction gallium arsenide alloy cells for concentrator with 27 – 39% efficiency. Pre-commercial module has 15 – 24% efficiency. Since this technology is not yet commercial, the capital cost for this technology is unknown.
4. Wind Power Turbine
    a. Small and medium size horizontal axis wind turbines (less than 1 MWe capacity). Economic analysis of installation of a 10 MW wind farm, using SKEA's technology assuming that wind speed is above 7 m/s, the capacity factor is about 20 % and estimated capital cost is 1,500US$/kWe. Electricity generation cost is about 1,053Rp. (0.10 – 0.11 US$) per kWh[20].
    b. Small and medium size vertical axis wind turbines for low wind speed (below 7 m per second). Capacity factor is less than 30 % and estimated capital cost is about 2500 – 3200/kWe.

5. Micro and mini hydro power plant. Hydropower is a power generating technology, which converts the kinetic energy of flowing river water into electric power. Because no fuel is required, power can be obtained without emissions of greenhouse gases (GHG). Plant outputs are from several kW to 20 MW scale and output is affected by the efficiency of the water turbine. Various types of water turbines have been devised, the most suitable, differs, depending on conditions, for example, with high head/low flow and low head/high flow conditions. Typical capital investment for micro or mini hydro plant varies from 2,000 – 3,000 US$/kWe and cost of electricity generation is 0.03 – 0.04 US$/kWh.

6. Advanced Large Hydro Power: New turbine designs that improve survivability of fish that pass through the power plant.
    a. Auto venting turbines to increase dissolved oxygen in discharges downstream of dams.
    b. Re-regulating and aerating weirs used to stabilize tailwater discharges and improve water quality.
    c. Adjustable-speed generators producing hydroelectricity over a wider range of heads and providing more uniform instream-flow releases without sacrificing generation opportunities.
    d. New assessment methods to balance instream-flow needs of fish with water for energy production and to optimize operation of reservoir systems.
    e. Advanced instrumentation and control systems that modify turbine operation to maximize environmental benefits and energy production.

Typical capital cost for large hydro plant ranges between 1,500 – 4,500 per kW, depending on various factors.

[20] This range of cost is valid for the case of installation of more than 10 MW of wind turbine using SKEA's technology in the eastern part of Indonesia which has wind speed more than 7 m/s, and the capacity factor is about 20%.

3.2.1.4. Combined Heat and Power

Combined heat and power production technology (CHP) offers a significant increase in fuel efficiency, which can reduce the GHG emissions. Therefore, it is of interest in relation to GHG emissions mitigations. CHP has been applied in the industrial, residential, and commercial sectors and this technology has been installed in the pulp & paper and food industries. It has high potential for implementation. Combined production of heat and electricity is possible with all heat exchangers and fuels (including biomass and solar thermal) from a low kW rating to large steam-condensing power plants. Heat-plus-power (first-law) efficiencies are typically 80 – 90%. CHP plants may have an added heat storage that allows the production plant to operate at optimum economy, while fulfilling the heat needs.

Table 3.1 shows four typical examples of CHP installations in various sizes, differentiated by their power and heat production, reduction in fuel use, and CO_2 emissions, relative to appropriate alternatives for separate supply of heat and power. Combined-cycle power and heat production provide better thermodynamic performance than that of single cycles, even if first-law efficiencies are lower, as more electricity is produced. In principle, this electricity may be used with heat pumps to generate more heat at higher temperatures.

Table 3.1: CHP Installation, Fuel and Potential CO_2 Reduction

Power Plant and Heat Technology	Energy Balance (GJ)			CO_2 Emission	
	Fuel Input [1]	Power/ Heat Output	Fuel Reduction	Volume (tC)	Reduction (%)
Large Coal Fired CHP Plan	100	36/56	28%	2.4	11
Large Coal Fired Power Plant plus Residential Gas Burner	80/59	36/56	48%	2.7	13
Large Coal Fired Power Plant plus Residential Coal Burner	80/112	36/56		3.5	
Small Biomass-Fueled CHP Plant	100	22/56	7%	0.0	
Large Coal-Fired Power Plant plus Residential Gas Burner	45/59	22/56		2.0	100
Small Gas Turbine CHP Plant	100	30/55	15%	1.4	
Large Coal Fired Power Plant plus Residential Gas Burner	60/58	30/55		2.2	37
Medium Sized Gas Engine CHP Plant	100	39/46	21%	1.4	
Large Coal Fired Power Plant plus Residential Gas Burner	78/48	39/46		2.5	45

[1] Arbitrarily fixed reference level

3.2.1.5. Nuclear Power Technology

Commercial nuclear power is dominated by Light Water Reactors (LWR)-type technology. LWR generate power through steam turbines. Similar to those used for power generation by coal or fuel oil. Two models of LWR technology are Pressurized Water Reactor (PWR) and Boiling Water Reactor (BWR). Other reactor types are Pressurized Heavy Water Reactor (PHWR), Water Energetic Reactor (WWER/VVER), Reactor Bolshoy Moshchnosti Kanalniy (High Power Channel Reactor) (RBMK), Gas Cooled Reactor (GCR) and Liquid Metal Fast Breeder Reactor (LMFBR). LWR reactors are commonly built and operated in Europe, US and several developing countries.

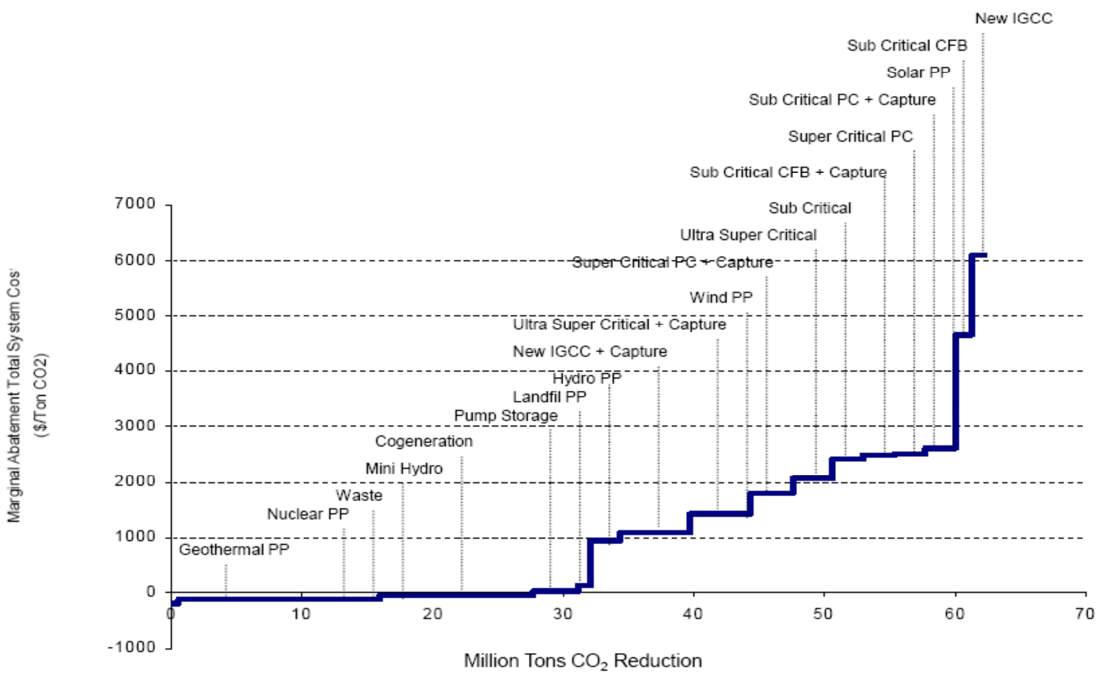
Advanced nuclear power plant technologies, categorized as III/III+ generation, are now available in the market. Those plants are based on PWR, BWR and PHWR types with evolutionary design. Generation III nuclear reactor are: Advanced Boiling Water Reactor (ABWR), Economic and Simplified Boiling Water Reactor (ESBWR), Advanced Pressurized Water Reactor (APWR), European Pressurized Water Reactor (EPR), AP-1000, System 80+/APR 1400, AES-91 and AES-92 WWER -1000, Advanced Candu Reactor (ACR) and High Temperature Gas Reactor (HTGR).

There are different specific capital costs for current nuclear power plant technologies. IEA/OECD report (2005) reviewed 130 costs for a range of power plants and included a new build of 13 nuclear power plants. Costs, with one of a completed plant, suggested the range for specific overnight costs of 1,133 – 2,555 US$/kWe. Costs for advanced nuclear power plant are higher than for the former generations. A number of new proposals from US utilities to build advanced nuclear power generators indicated total plant cost varies from 5,500 – 8,100 US$/kWe.

Nuclear reactors are assumed to be developed for mitigation options, but are often more costly compared with the older ones. Nevertheless, other aspects of technology performance for nuclear reactors are usually improved and CO_2 emissions are reduced, compared to older technology.

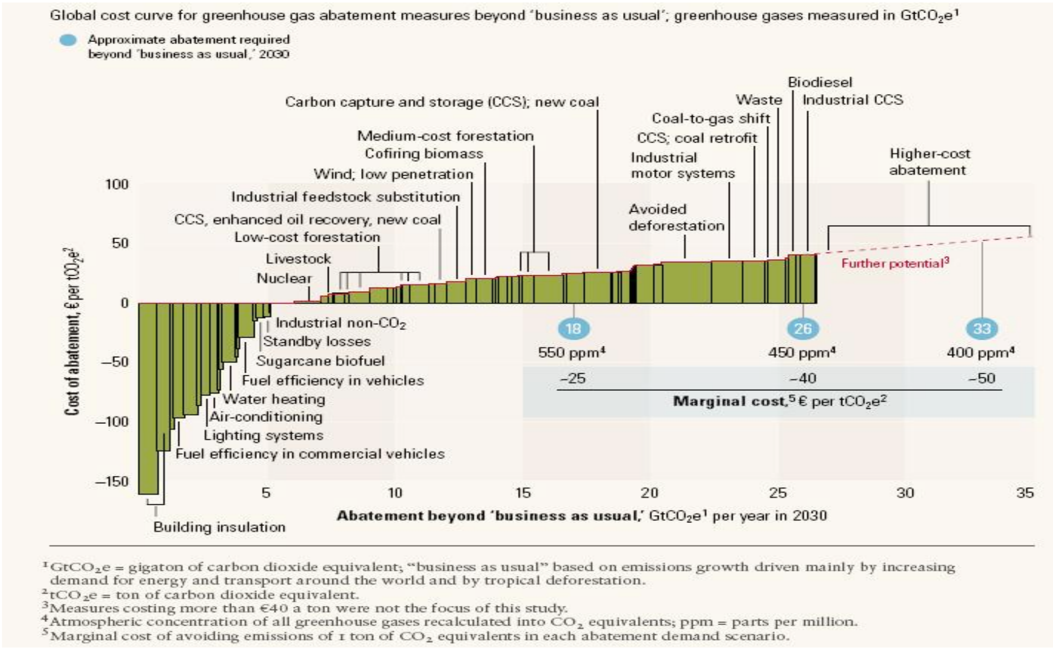
3.2.1.6. Abatement Costs for Supply Side Technologies

Figure 3.3 shows the GHG emissions abatement cost curve for power plant in 2030, with oil price 120 US$/barrel.



(Baseline crude oil price of 120US$/bbl)

Figure 3.3: Marginal Total System Cost for Various Electricity Generation Technologies (Case 2), 2030



Source: McKinsey (2007)

Figure 3.4: GHG Emissions Abatement Cost of Mitigation Technologies, 2030

Table 3.2: Summary of Electricity Generation Technologies for GHG Emissions Mitigation

Energy Type	Available Technology	Mitigation Measures
Fossil Fuel	a. Combine Heat and Power (CHP), b. Clean Coal Technology (CCT): Supercritical Pulverized Coal, Ultra Supercritical Pulverized Coal; Pressurized Fluidized Bed Combustion (PFBC) c. IGCC	• Regulation controlling emissions, prices • Tax incentives • Research and Development • Technology demonstrations • Information dissemination
Biomass	a. Direct combustion for power generation b. Combine Heat and Power (CHP) c. Co-firing with coal d. Gasification (IGCC) e. Biofuels	
Wind	a. Wind turbine generators for low wind speed	
Solar Energy	a. PV Crystalline Silicone b. PV Thin Film c. PV Advance Cell (high efficiency)	
Geothermal Technology	a. Direct use (heat) b. Dry steam c. Flash steam d. Binary cycle	
Hydroelectric	a. Conventional Hydro b. Pump storage c. Advance hydro power technologies d. Micro-hydro and Pico-Hydro	
Nuclear Power	a. PWR, BWR b. Advance PWR, Advance BWR,	
Transmission and Distribution	a. Higher efficiency transformer b. Higher efficiency transmission cable c. Distributed generation and local grid	

3.2.2. Energy Demand Side Technology

Demand Side is comprised of energy use in residential, industry, transportation, and commercial buildings. This part discusses technology to save or reduce energy use in residential, commercial buildings and industry. Technology for the transportation se
is discussed separately in TNA transportation report.

GHG emissions from industry accounted for about one-third of the total emissions of Indonesia, followed by emissions from transportation. Industry, transportation and residential sectors are the largest consumers of energy. BPPT and MEMR MARKAL model of the future emissions suggested that industrial and transportation activities will contribute as the largest GHG emitters, compared to other end-user sectors.

3.2.2.1. Industry

Improving energy efficiency in the industrial sector is important for reducing industrial emissions. In energy intensive industries such as steel, chemical, pulp and paper, and cement manufacturing, cost-effective efficiency gains in the range of 10 – 20% are already possible using commercially available technology. Higher efficiency is theoretically possible though. Crosscutting technologies for motor and steam systems would improve efficiency in all industries, with typical energy savings in the range of 15 – 30%.

A wide range of measures and technologies have the potential to reduce GHG emissions. These technologies can be grouped into the categories: energy efficiency, fuel switching, power recovery, renewable, feedstock change, product change and material efficiency. Within each category, some technologies, such as the use of more efficient electric motors, are broadly applicable across all industries (IPCC, 2007).
Technologies for industrial processes such as more highly efficient boilers, compact heat exchangers and indirect and direct heat technologies, are widely available.

Moreover, many relatively new technologies, related to the industrial processes of several industries such as smelting reduction, near reduction, near net-shape casting of steel, new separation membranes, black liquor gasification and advanced cogeneration are currently being developed, demonstrated and adopted in the industrial sector (IEA, 2008).

Soft technology measures, such as energy audit, energy management and the improvement of maintenance systems can be effective tools to reduce energy consumption and GHG emissions, without -or with minimum capital investment or increased operational costs.

3.2.2.2. Residential and Commercial Buildings

In Indonesia, residential refrigerating, lightning, electric appliances and water heating in some middle and most of the high-income households dominate the extent of final energy consumption. For commercial and public buildings, air conditioning/space conditioning and lightning dominate the total of final energy consumption.

Lightning
The amount of energy required to produce light depends on the type of lighting and the behavior of the energy users. As lighting is considered an energy-consuming sector, it has the potential to be a mitigation option. Substitution of incandescent lamps by compact fluorescent lamps (CFL), will increase the illumination efficiency of the lamp by up to 75 – 80%, which leads to a reduction of the electricity consumption. However, investment on CFL is much higher than that of the incandescent lamp. The price of CFL lamps is about 5 to 6 times higher than conventional incandescent lamp. A typical 15 Watt CFL

equal to 75 – 80 Watt incandescent lamp cost about 2 – 3 US$ per unit.

Another mitigation option is the substitution of magnetic ballast with electronic ballast for fluorescent lamps and the installation of intelligent switches. A set of 20 Watt fluorescent lamps is about 2.0 – 2.5 US$ per unit. The Light Emitting Diode (LED) lamp is already entering commercial stages and thus, a steady penetration of the market. As efficacy increase, LED will be more competitive with the CFL and FL technology.

The potential of implementation for this option is widely open in Indonesia as the number residential and commercial buildings increases, giving a potential of an additional 20 – 25 million new household, connecting to the grid, in the next 20 years.

Cooking

Most of the energy demand for cooking in Indonesia is fulfilled by biomass fuel and kerosene. The high-energy consumption for cooking is mostly caused by low efficiency of the cooking stoves, especially biomass stoves. The efficiency of the biomass stove is on the average 12.5% while the efficiency of kerosene stove is 30% (BPPT-MARKAL 1988). Therefore, improvement of the efficiency of biomass stoves offers a great opportunity for the reduction of GHG emissions from cooking. In the last 10 years, the efficiency biomass stove technology has been increased by 10 – 20%. Another GHG emissions mitigation option is fuel switching, i.e. utilization of kerosene to replace biomass fuel and of LPG or natural gas to replace kerosene.

Improvement of the efficiency of stove will reduce the consumption of fuel. It offers 30 – 40% GHG emissions reduction. A higher efficiency kerosene or biomass stove for household cooking costs about 5 – 10 US$ per unit.

Refrigeration

Refrigerant in residential and commercial buildings employs large quantities of HFC refrigerant. Two basic mitigation options are: to reduce leaks and alternative system designs. Refrigerant leakage rates are estimated to be around 30% of banked system charge. Leakage rates can be reduced by system design for tightness, maintenance procedures for early detection and repairs of leakage, personnel training, system leakage record keeping and end-of-life recovery of refrigerant. Alternative system design involves, for example, applying direct systems using alternative refrigerants, better containment, distributed systems and indirect systems or cascade systems. Best available technology for refrigerant system can save 20 – 30% in energy consumption.

Room Air Conditioning

Room air conditioning in Indonesia is merely for cooling purposes and the energy consumption is relatively low. The reduction of energy consumption can be achieved through increased efficiency of the room air conditioning equipment and through the improvement of control systems Newest technology for Air Conditioner (AC) equipment is more energy efficient than previous model. Rated power for a 1 hp capacity AC can run with electric power of 320 – 350 VA or about 50 – 60% lower than previous model.

The other factor that has impact on energy consumption for this utilization is human behavior, such as timing and level of the temperature setting. Setting AC temperature close to room temperature (about 22 – 25°C) can reduce the work of the compressor, therefore reducing electric power input. Moreover, better insulation of room will maintain the cool air inside the room and reduce the work of AC. A study in Thailand found that installing 7.5 cm of insulation in the attic of a typical single-family house would reduce 30% of the air conditioning requirement (Parker, 1991).

Table 3.3 shows key energy efficient technologies for residential, commercial buildings and industry and supporting policies and regulation measures to enhance the application of technologies.

Table 3.3: Energy Efficient Technology for End User

End-use Sub-sectors	Technologies	Supporting Policy and Regulation Measures
Residential and Commercial		
Lighting	• Compact fluorescent lamps, • Fluorescent lamps with electronic ballast	• Public awareness • Energy labeling program • Energy pricing • Price incentives/discount • Manufacturer tax rebates
Refrigeration	• Efficient compressor/ motor • Better insulation/Leak reduction	• Energy labeling program • Energy pricing
Cooking	• Efficient Cook Stove • Switching to Lower Carbon Fuels • Solar Oven	• Public awareness • Manufacturer tax Rebates
Water Heating	• Electronic ignition • Gas Fuelled water heater • Solar Water Heater	• Energy pricing • Energy labeling program • Manufacturer tax Rebates
Room Conditioning	• Improved insulation system • Higher efficiency Air Conditioner (AC) • Improved Temperature Control • Heating, Ventilation and Air Conditioning (HVAC) System • Passive cooling design	• Energy pricing • Energy Audit • Building Code • Public awareness
Industrial		
Industrial Boiler	• Higher efficiency of boiler • Efficient-high pressure boiler • Upgrade to cogeneration system	• Mandatory energy audit • Energy pricing
Industrial Motor	• Higher efficiency motor • Variable speed drive • Redesign of process system (efficient motor-driven systems) • Operation and Maintenance • Installation of inverter in motor	• Energy Labeling program • Capacity building • Mandatory energy audit • Improving electricity quality (voltage stability)
Transformer	• High efficient transformer (cooper)	• Energy audit • Energy pricing
Industrial heat	• Compact Heat Exchanger (CHE) • Higher Efficient technology for fossil fuels combustion • Energy efficient insulation	• Mandatory energy audit • Economic Incentives • Energy pricing

Mitigation measures on the demand side can be implemented in several areas such as, lighting, cooking, refrigeration, space conditioning, water heater and electronic appliances that use electric motors in the household, commercial, and industry sectors. Potential mitigation measures through DSM in Indonesia are:

1. Improvement of the lightning system:
   a. Replacement of conventional incandescent bulb with compact fluorescent lamp (CFL) and/or tube fluorescent lamp (TFL). This measure can save electricity up to 80% per lamp. Typical cost for a 25 Watt CFL is 3 – 4 US$ per unit and cost for typical 20 Watt TFL is about 2.0 – 2.5 US$ per unit.
   b. Replacement of magnetic ballast with electronic ballast. The electricity saving is about 20 – 40 %.

2. Installing intelligent energy efficient systems:
   a. Install Building Automatic Systems (BAS). Energy saving can be obtained by installed BAS, particularly in lightning.
   b. Variable Speed Drive (VSD). Energy saving can be obtained by installing VSD technology on industrial fans and pumps.

3. Switching to more energy efficient technologies:
   a. Using hydrocarbon refrigerant. Energy efficiency can be achieved by replacing the CFC with hydrocarbon refrigerant.
   b. Install high efficiency and energy saving Air Conditioners (AC): Energy saving can be obtained by changing the standard AC with more energy efficient AC. The saving can be obtained by the improvement of the coefficient of performance by 50%.
   c. Using high efficiency chillers: Installing new high efficiency chillers or recovery systems on centralized chillers for pre-heating water or any other heating usage. The centralized chillers lose their efficiency as the condensers become dirty and old. Installing a heat exchanger before the condensers (refrigerant at the chiller level), to preheat fresh water going into the boiler room, can increase the efficiency of the chiller. A double skin tube exchanger is normally recommended. The impact is at two levels: improvement of the chiller efficiency and recovery of energy to replace the heat requirements for fresh water feeding into the condensate water tank.
   d. Using high efficiency electric motors: Energy saving can be obtained by installing high efficiency electric motor to replace low efficient ones in industry.
   e. Using higher efficiency transformers to reduce energy loss.

4. Install DSM Peak Shaving Technologies:
   Peak shaving technologies mainly consist of two options:
   a. Alternative energy for heating process, such as using solar thermal as substitution for electricity for heating or use CHP/cogeneration.
   b. Load management systems (in industries, etc).

5. Install DSM Peak Shifting Technologies:
   Energy Efficiency (EE) technologies, which can contribute to peak shifting in Indonesia, primarily concern air conditioning technological options. Efficient technologies may be a combination of one or more among the following options:
   a. Splitting the HVAC system into zones adjusted to solar and other variable loads.
   b. Usage of primary, secondary and tertiary pump systems with plate type heat exchangers.
   c. Usage of pre-insulated material rather than conventional ducting.
   d. Usage of high efficiency recovery wheels in the air handling units for electricity recovery from outlet air.
   e. Installation of dehumidifier, as required.
   f. Installation and adjustment of oxygen (new fresh air) in places such as crowded rooms or those containing high levels of carbon dioxide.

g. New high-tech equipment for air conditioning including a new ionizing filter, a new design for its coils in window and mini-split systems, as well as a new scroll technology for its medium-sized refrigeration plants.
h. Use of lighting lamps with minimum electricity dissipation in the air.
i. Ice storage systems to shift the air conditioning use from peak to off-peak period

4. TECHNOLOGY SELECTION

Technology selection is determined by applying general and specific criteria as listed in the next section spanning all technology available. As a result a matrix of technology available vis-a-vis selection criteria was formed, both for supply and demand side. We used experts' judgment methodology to give weight and score for each individual criterion.

4.1. Selection Process

Multi-criteria analyses were employed to select the technology. First we applied general criteria for listed technology and indicator in the matrix. Then a weight is assigned to each indicator, based on expert judgment and additional information from literature and project reports.

The selection of technology can be read in Table 4.1. The numeric values are determined for each indicator, as follow:

- H: High value/high relevance/high impact, score: 5
- M: Medium value/relevant/moderate impact, score: 3
- L: Low value/less relevant/low impact, score: 1
- NR: not relevant, not applicable

Table 4.1: Supply Side Technology Options vs. General Selection Criteria

Supply Side Technology	General Criteria											TP
	FS	NR	ES	IP	CB	RT	ET	GR	LE	CoC	CA	
Oil & gas												
Flare Gas Recovery Unit	NR	L	M	NR	M	M	M	H	M	M	M	22
Mini LNG Plant	NR	L	M	NR	M	M	L	M	L	L	M	19
CCS-EOR	NR	H	H	NR	L	M	L	M	L	L	L	21
Fossil fuel power generation												
Coal upgrading – UBC	NR	M	M	NR	M	M	L	L	M	L	L	19
Improvement of plant efficiency	NR	M	M	NR	H	L	M	M	M	M	H	29
Advanced coal power plant: Sub PC	NR	M	H	NR	M	M	L	M	M	M	L	25
Advanced coal power plant: SPC	NR	M	H	NR	M	M	L	M	M	M	L	25
Advanced coal power plant: USC	NR	M	H	NR	M	M	L	M	M	M	L	25
Advanced coal power plant: SFBC	NR	M	H	NR	M	M	L	L	M	M	L	22
Advanced coal power plant: IGCC	NR	M	H	NR	M	L	L	M	M	M	L	25
Advanced power plant: Fuel Cell	NR	M	H	NR	M	L	L	H	M	L	L	18
Renewable energy technology												
Biomass power-direct combustion	NR	H	H	NR	M	H	H	H	M	M	H	39
Biomass power – co-firing	NR	H	H	NR	M	H	H	M	M	H	H	39
Biomass power – gasification	NR	H	H	NR	M	H	M	H	M	M	M	35
Geothermal – Flash Steam	NR	L	H	NR	M	H	H	H	L	M	H	33
Geothermal – Binary Cycle	NR	L	H	NR	M	H	M	H	L	M	M	26
Geothermal – Hot Dry Rock	NR	L	H	NR	M	L	L	H	M	L	L	21
PV crystalline silicone	NR	L	M	NR	M	H	H	H	H	NR	H	32
PV thin film	NR	L	L	NR	M	H	H	M	H	L	H	29

Supply Side Technology	General Criteria											TP
	FS	NR	ES	IP	CB	RT	ET	GR	LE	CoC	CA	
PV high efficiencies cells	NR	L	M	NR	M	H	M	H	H	NR	L	26
PV grid connected system (control, etc)	NR	L	M	NR	M	M	M	H	H	L	L	25
PV and building material integration	NR	L	L	NR	M	M	H	H	H	L	L	26
Wind – low speed horizontal axis turbine	NR	L	M	NR	M	M	H	M	H	L	M	27
Wind – low speed vertical axis turbine	NR	L	L	NR	M	M	H	M	H	L	L	23
Micro & mini hydro	NR	M	H	NR	M	H	H	H	H	L	H	34
Advanced hydro power	NR	M	M	NR	M	M	M	M	M	L	L	23
Nuclear power	NR	L	H	NR	M	M	L	H	H	M	L	25

Note: H: High value, high relevance/impact (5), M: Medium value/relevant/med impact (3); L: Low value/less relevant/less impact (1); NR: nil – not relevant/no impact (0), TP: Total point

Selection of technology using general criteria indicated that, compared to other mitigation technologies on the supply side, oil and gas technologies are less relevant. This is due to the cost of technologies and its commercial availability/market. In fossil fuel-based power generation technology, improving existing PC plants is the more favorable, due to the lower cost factor and ease of application. In renewable energy, biomass power, as well as geothermal. Other renewable technologies are limited by the high capital cost compared to conventional ones.

Table 4.2: Demand Side Technology Options vs. General Selection Criteria

Demand Side Technology	General Criteria											TP
	FS	NR	ES	IP	CB	RT	ET	GR	LE	CoC	CA	
Industry												
Boiler	NR	L	M	L	M	H	M	M	M	M	H	30
Process heating (important for energy intensive sectors like cement)	NR	M	M	L	M	H	M	M	L	M	M	28
Air compressor	NR	L	M	L	M	H	H	M	L	H	H	32
Electric Motors	NR	L	M	L	M	H	H	M	L	H	H	32
Pump and Fan System	NR	L	M	L	M	H	H	M	L	H	H	32
Motor-driven system	NR	L	M	L	M	H	H	M	L	H	H	32
Lightning system	NR	L	M	L	M	H	H	M	L	H	H	32
Energy management System	NR	L	M	L	H	H	H	M	L	H	M	32
HVAC	NR	L	M	L	M	M	M	M	L	H	M	26
Energy audit	NR	L	M	M	H	H	H	M	NR	H	H	35
Energy labeling	NR	L	M	L	H	H	H	M	NR	H	H	33
Cogeneration	NR	L	M	L	M	H	H	H	M	M	H	34
Compact Heat Exchanger (CHE)	NR	L	M	L	M	M	H	M	L	M	M	26
Residential/ Commercial												
CFL	NR	L	M	M	M	H	H	H	L	H	H	36
Electronic ballast	NR	L	M	L	M	H	H	M	L	H	H	32
Air Conditioner	NR	L	M	L	M	H	H	H	L	M	H	32
Building Insulation	NR	L	M	L	M	M	M	M	L	L	L	20
Electrical appliances	NR	L	M	L	M	H	H	M	L	M	M	28

Demand Side Technology	General Criteria											TP
	FS	NR	ES	IP	CB	RT	ET	GR	LE	CoC	CA	
Building Automatic System	NR	L	M	L	M	M	M	M	L	M	L	22
Chiller	NR	L	M	M	M	H	H	M	L	L	M	28
Energy Audit	NR	L	M	M	H	H	H	M	L	H	H	36

Note: H: High value, high relevance/impact (5), M: Medium value/relevant/ impact (3); L: Low value/less relevant/less impact (1); NR: nil – not relevant/no impact (0), TP: Total point

After selecting the technology based on general criteria, specific criteria are used for selecting technologies.

Table 4.3: Supply Side Technology Options vs. Specific Selection Criteria

Supply Side Technology	Specific Criteria									TP
	EPT	LER	AC	TC	IRR	PB	AD	LMP	LED	
Oil & gas										
Flare Gas Recovery Unit	L	L	M	L	L	L	M	L	L	13
Mini LNG Plant	L	L	L	L	L	L	M	L	L	11
CCS-EOR	M	M	L	NR	L	L	H	L	L	16
Fossil fuel power generation										
Coal upgrading (UBC)	M	M	M	M	L	M	H	M	M	27
Improvement of plant efficiency	H	L	H	M	M	H	M	M	L	29
Advanced coal power plant: Sub PC	H	M	M	M	M	M	H	L	L	27
Advanced coal power plant: SPC	H	M	M	M	M	M	H	L	L	27
Advanced coal power plant: USC	H	M	M	M	M	M	H	L	L	27
Advanced coal power plant: SFBC	H	M	M	M	M	M	H	L	L	27
Advanced coal power plant: IGCC	M	M	L	L	M	L	H	L	L	19
Advanced power plant: Fuel Cell	L	L	L	L	M	L	H	L	L	15
Renewable energy technology										
Biomass power-direct combustion	M	M	M	M	M	M	M	M	L	25
Biomass power – co-firing	M	M	H	H	H	L	L	M	L	27
Biomass power – gasification	M	L	M	M	M	M	M	M	L	23
Geothermal – Flash Steam	H	H	M	H	M	M	M	M	L	31
Geothermal – Binary Cycle	M	M	M	H	M	M	M	M	L	27
Geothermal – Hot Dry Rock	L	L	L	L	L	L	H	L	L	13
PV crystalline silicone	M	H	L	L	L	L	L	M	M	19
PV thin film	L	H	M	M	L	L	L	M	M	21
PV high efficiencies cells	L	H	L	L	L	L	H	L	L	17
PV grid connected system (control etc.)	L	L	L	L	M	M	M	M	L	19
PV and building material integration	L	L	L	L	L	M	H	L	L	15
Wind – low speed horizontal axis turbine	M	M	L	M	M	M	M	H	L	25
Wind – low speed vertical axis turbine	M	L	M	L	M	L	M	H	M	23
Micro & mini hydro	H	M	M	L	M	L	M	H	M	27
Advanced hydro power	L	M	L	L	L	L	H	L	M	17
Nuclear power	M	L	L	L	L	L	H	L	L	15

Note: H: High value, high relevant/high impact (5), M: Medium value/relevant/med impact (3); L: Low value/less relevant/

less impact (1); NR: nil – not relevant/no impact (0), TP: Total point

Table 4.4: Demand Side Technology Options vs. Specific Selection Criteria

Demand Side Technology	Specific Criteria									TP
	EPT	LER	AC	TC	IRR	PB	AD	LMP	LED	
Industry										
Boiler	H	L	M	M	M	M	H	H	M	26
Process heating (important for energy intensive sectors like cement)	H	L	M	L	M	M	H	L	M	25
Air compressor	H	L	M	M	M	H	M	M	M	29
Electric motors	H	L	H	H	H	H	M	M	M	33
Pump and Fan	H	L	H	H	M	H	M	H	M	35
Motor-driven system	H	L	L	H	M	M	M	H	M	29
Lighting system	H	M	H	H	H	H	M	H	M	39
HVAC	H	L	M	M	M	M	H	L	L	25
Energy management system	H	L	H	H	H	H	M	NR	NR	29
Energy audit	H	L	H	H	H	H	M	NR	NR	28
Energy labeling	H	L	H	H	H	H	M	NR	NR	28
Cogeneration (CHP)	H	H	M	M	M	M	H	L	L	29
Residential/ Commercial										
CFL	H	L	H	H	H	H	M	H	L	35
Electronic ballast	H	L	H	H	H	H	M	H	L	35
Air conditioner	H	L	L	M	M	M	M	H	L	24
Building Insulation	H	L	L	L	H	L	M	L	L	19
Electrical appliances	H	L	M	M	M	M	M	M	L	25
Building Automatic System	H	L	M	M	M	M	M	L	L	23
Chiller	H	L	L	L	L	M	H	L	L	19
Energy Audit	H	L	H	L	H	H	M	NR	NR	25

Note: H: High value, high relevant/high impact (5), M: Medium value/relevant/med impact (3); L: Low value/less relevant/ less impact (1); NR: nil – not relevant/no impact (0), TP: Total point

4.2. Technologies Selected

4.2.1. Energy Supply Side Technology

Selection of technology, using specific criteria, suggested that for the supply side technology, high priority for technology transfer is given to:

1. Advanced coal technology/Clean coal technology
2. Geothermal
3. Biomass technology, in particular for direct combustion technology and co-firing technology

Those technologies are selected, due to their strong relation to the current government policies and targets, which are enhancing the utilization of coal in power generation to replace diesel and marine fuel oil, up to 2025, and diversification of energy supplies by enhanced development and utilization of renewable energy resources to generate electric power. Moreover, burning more coal will create large emissions. Therefore, reducing emissions and/or offsetting emissions from energy generating activities, should become main considerations while, at the same time, considering the energy system cost and

economic effectiveness of adopting the technology.
Clean Coal Technologies, such as coal upgrading technology and Subcritical Fluid Bed Combustion (Sub FBC) technology, will match low rank coal resources, which comprise 60% total coal resources in Indonesia. Adding the CO2 sequestration technology (Carbon Capture and Storage) in the near future may reduce the large quantity of coal emissions from these types of power plants. Other CCT's types, like Supercritical Pulverized Coal and Ultra Supercritical Pulverized Coal are also important to anticipate more utilization of medium rank coal and can be a substitution for the decommissioned old coal power plants in the Java-Bali system. Advanced coal technology can reduce environmental impact and emissions compared to conventional Pulverized Coal technology recently installed widely in Indonesia. However, since coal power plant technology keeps releasing large emissions, thus increasing the level of GHG emissions in the atmosphere, this technology should be considered only as an interim solution, before cleaner and more effective GHG emissions abatement technologies for power generation become available in the market. IGCC technology is still less competitive compared to other CCTs, due to the high cost of investment and the state of the technology itself. IGCC technology might be more competitive in the coming decades.

As non-Annex-1 country, Indonesia has no obligation to reduce GHG emissions, however there are discussions to involve developing countries in the global effort to mitigate GHG emissions, within the framework of principles of common, but differentiated responsibilities. Advanced coal could be an effective technology, to serve national objectives in securing energy supplies and contributing to global efforts in reducing GHG emissions, through voluntary mechanisms.

Geothermal technology is selected, due to the abundant resources of geothermal in Indonesia, but low utilization levels - and consistent with policy and planning, to enhance geothermal development in the range of 6,000 – 8,000 MW. Deployment of advanced geothermal technology, such as a binary cycle, might be suitable for some area in different islands of Indonesia, which have medium temperatures. Deployment of binary technology will add the potential resources of geothermal, up to 100 thousand MW.

There are abundant biomass resources from agricultural l waste, waste biomass and plants in Indonesia, which, so far, so far have not been fully utilized. Several biomass technologies, such as direct combustion and co-firing, can help utilization of the potential resources. In the last fifteen years, several biomass plant projects such as biomass power generation, using rice husk or straw have been introduced, but gave poor results, mostly unsustainable. The main problem lies in the ability of a plant's owners to have continuous feedstock from the area nearby to the plant. Therefore, in addition to the deployment of biomass technology, there is a strong need on developing a database on the technical potential of biomass resources in Indonesia which can be updated regularly. Other important policies, such as feed-in-tariff, will be an attractive factor for any biomass plant's developer.

Figure 4.1: Utilization of Biomass as Energy Resources

Beside the main priority, a second priority can be given to other renewable energy technologies such as wind power technology, micro and mini hydro and PV technology. For wind power, technology to improve efficiency and reliability of low-speed wind turbines, materials for blades and other vital parts are important. For PV, technology transfer can be given to manufacturing of PV modules, both silicon based and advanced thin film technology. Technical capacity on large scale PV installations, connecting to the grid, need to be developed. Large scale and grid-integrated PV systems have been well installed in some developed countries, such as Germany, Spain, Japan, and US. Another important technology transfer for a PV system is building integrated PV, which can transform buildings into power generator.

The main barriers for renewable energy development are their technical limitations, high capital costs and a long payback period, which make them not favorable and not economically competitive, compared to other conventional fossil fuel based technologies. . However, these renewable energy technologies are very suitable to supply energy for remote sites and distributed generation systems. Technology transfers, in this area, should be focused on industrial based manufacturing of the technology locally for mass production.

Transfer of technology for advanced coal power plants and geothermal plants can be done through market-based mechanisms, such as development of turnkey plants, direct investments and technical licensing agreements; and through non-market mechanisms such as pilot projects between the state-owned electricity company with technology vendors, and technical assistance from foreign vendors. To enhance the transfer of technology, public- private partnership (PPP) can be used to facilitate investment of advanced and clean technology into the country.

4.2.2. Energy Demand Side Technology

For demand side, priority of technology transfer should be given to:

1. Energy efficiency technologies for industry such as:
    a. Lighting systems
    b. Pump and Fan
    c. Industrial Motor
    d. Cogeneration
2. Energy efficiency technology for residential and commercial buildings:
    a. Lighting equipment (CFL and electronic ballast)
    b. Cooling systems
3. Soft technology:
    a. Energy Audit
    b. Energy Rating and Labeling
    c. Energy Management

Given that most of the energy efficient appliances and equipment to reduce energy consumption in industrial, residential and commercial buildings are widely available in the market and can be easily purchase and installed; therefore the technology transfer in the form of hard technology is not a high priority for the range of these technologies mentioned above. However, transfer of technology in the form of soft technology, is required in order to improve knowledge, skill, and the capacities of public and private institutions that promote and facilitate energy efficiency and DSM programmes.

Energy conservation can be started by implementing low cost measures, such as replacement of inefficient lamps with energy efficient CFL, improving the production process, and installing new and higher efficiency equipment. . Here, technology transfer is less important, but action, through measurable projects and programmes is more important to reach an effective emission reductions.

Transfer of technology should be encouraged and promoted for technologies related to industrial processes, in particular energy intensive industries such as steel, pulp and paper, cement, chemical, textile, and petroleum refining:

1. Energy efficiency technology for the iron and steel industry such as: electric arc furnace (EAF) to replace blast furnace (BF)/basic oxygen furnace (BOF), smelting reduction, near net shape casting, scrap preheating and dry coke quenching, substitution of coke and coal with plastic waste for injection to blast furnace.
2. Energy efficiency technology for the pulp and paper industry. This would include efficient pulping and drying, shoe press, condebelt drying, and power recovery technology such as: black liquor gasification combine cycle, and use of biomass and/or landfill gas as feedstock for power generation facilities.
3. Energy efficiency technology for the chemical industry such as: stream crackers technology like higher temperature furnace, gas turbine integration, advanced distillation column and combined d refrigeration plant.
4. Energy efficiency technology for the cement industry such as: pre-calciner kilns and roller mills.

More detailed technology options and policies for energy efficiency technology for industry are discussed in the TNA industry sector report.

To support activities of technology transfer for industry in particular, a technology database of energy efficiency industrial technologies, economic assessment, vendor information and best practice case studies are required to provide information and knowledge to the respective parties.

Additional measures such as energy labeling and product rating systems should also be established in order to enhance market penetration of energy efficiency appliances and equipment. Moreover, specific regulations, to promote energy efficiency products to be available in the market are also needed. In general, government should provide legal and regulatory instruments, incentive and disincentive packages; to encourage more energy efficiency and DSM oriented actions for industry and the commercial sectors. These are needed to ensure larger energy efficiency and conservation efforts in these sectors.

5. IDENTIFICATION OF BARRIERS AND POLICY NEEDS

5.1. Barriers

A number of barriers that can hinder and remain as challenges for the technology transfer process in the energy sector in Indonesia are identified through the review available, policy documents, research and presentations from government official and stakeholders in the energy sector (government entities, private sector and NGOs). These barriers are of different categories such as: Institutional and policy, economic and investment, information, awareness, and human resources.

Institutional and Policies:

a. Insufficient long-term policies, regulations and targets, to ensure the deployment of low GHG emissions and energy efficient technologies: The Government of Indonesia has established targets for energy mix policies, but has not yet incorporated the means to achieve the targets. Revision to the current targets should be ongoing, to reflect the most feasible steps.
b. Insufficient operational policies: Several umbrella and macro policies exist, however detail and operational policies are not available.
c. Insufficient coordination, among inter-agency policies and measures between key government agencies that are dealing with technology development and transfer. This barrier is expected to be lifted in the near future, after the establishment of a new body: the National Energy Committee (Dewan Energi Nasional) and the National Commission on Climate Change (Dewan Nasional Perubahan Iklim).
d. Lack of policies that place an environmental mandate on the private and public sectors, impacting on the deployment of new and advanced GHG emissions mitigation technologies.

Economic, Investment and Markets:

a. Limited public financial resources for making significant investments in R&D and deployment of advanced and new energy technologies. The limitations of public funding and the high cost of advance capital investment are the main barriers for commercialization of technology development and deployment. It will need high private sector and/or bilateral or multilateral assistance for technology development and application.
b. A poor investment climate discourages private sector investment in advanced technology and renewable energy technologies.
c. Limited financial instruments and incentive mechanisms for renewable energy and energy conservation technologies.
d. d. Unpredictable economics of (new) technology: Most new and advanced energy and power technologies have just entered into the commercial market. For some technologies, reference plants are still limited and the economics vary, depending on a number of factors. Predictable economics help companies that are interested in developing energy projects, by risk management and implementing power purchase agreements (PPA).
e. Energy pricing neither reflects the cost of production and availability of resources, nor the environmental impact. Currently heavy subsidies are given to fossil fuels and electricity. Cost-based energy prices will improve the feasibility of new and advanced low carbon technologies.

Human Resources and Industrial Support:

a. Lack of skilled and professional human resources in new technologies, renewable technologies, advanced fossil fuel technologies, and in DSM technologies.
b. Limited local industrial based support and service providers, except for micro-hydro and photovoltaic.
c. Limited R&D in GHG emissions mitigation technologies, both for conventional and new technologies.

Information and Awareness:

a. A limited database on renewable energy potential, particularly for wind, biomass, and ocean.
b. Lack of information among investors on potential low carbon technology market.
c. Lack of information and awareness among governmental organizations, private companies and public on the benefits of energy efficient technologies.

5.2. Policy and Action Needs

Policy and action needed to overcome barriers are listed in the table below. The implementation of policies and action are needed to ensure the effectiveness of policies and development of the potential market.

Table 5.1: Barrier Assessment and Policy and Action Needs

Identified Barrier	Policy and Action Need
Institutional and Policy	
Insufficient long-term policy, regulation and target	Set clear long-term policy and target on energy based on long-term economic objective, technology maturity and resources availability.
Insufficient operational policy	Develop and implement detail operational policies that able to support projects in utilizing new and renewable energy technologies.
Insufficient inter-agency policies and measures	Develop effective coordination mechanism of National Energy Committee (DEN) and National Commission on Climate Change (DNPI) and key sector agencies and ministries.
Lack of environmental mandate policies and regulation	Develop policies and regulation that encourage domestic industry to produce energy efficient appliances and stimulate the power sector to emit low emissions (supply side) and consumers to use energy efficient technology (demand side).
Economic, Investment and Market	
Limited public financial resources	Improving climate investment for private sector, actively looking for grants and technical assistance for R&D, and pilot project.
Poor investment climate	Creation of enabling environment for private investment.
Limited financial instrument and incentive mechanism for RE and Energy Conservation	Create RE & Energy Conservation Fund Establish Energy Service Company (ESCO)
Unpredictable economic of new technologies	Establish a set of parameter for cost of investment for each technology, such as: cost of capital, rate of return, payback period, etc and secure package; to minimize the risk of investment
Energy pricing does not reflect true cost of production, resource availability and externalities	Develop and implement the pricing policies that reflect cost of production and energy supply. Create effective and well-targeted subsidy mechanism for the low income and the poor user.
Human Resources and Industrial Support	
Lack of skilled and professionals in new, renewable and advanced fossil fuel technologies, and in DSM technologies.	Organize series of trainings on energy conservation and energy efficiency techniques and good practices; and renewable energy. Bring the energy efficiency and RE topic into the curriculum of engineering and science fields of study in universities.
Limited industrial base support and service provider locally.	Enhance cooperation and technical assistance with particular countries for technologies needed. Developing pilot projects

Identified Barrier	Policy and Action Need
Limited R&D in GHG emissions mitigation technologies both conventional and new technologies.	Enhance R&D cooperation for new and advanced technologies with countries and other institutions. Pursue for joint research project with industrial application possibility.
Information and Awareness	
Limited database on renewable energy potential	Establishment of the data-base through more measurements, analysis , data collection, and pilot projects.
Lack of information among investors on potential low carbon technology market	Establishment of an specialized information system for market and investors
Lack of information and awareness among governmental organization, private companies and public on the benefits of energy efficient technologies	Develop awareness raising campaign to keep different stakeholders informed on the potential technology market and the benefits of the energy efficiency and energy saving technologies. Organize TV and radio programs and advertising campaigns (public relation).

6. CONCLUSION AND RECOMMENDATION

6.1. Conclusion

1. Indonesia has vast potential energy resources both fossil fuel and renewable energy. Fossil fuels, like oil and gas, have been exploited for some decades and their resources are now depleted, while coal resources are still abundant but with high extraction rates over the last decade. Some scenarios suggest that Indonesia will be able to use its oil and gas resources for the next few decades - and even longer for coal - if investment in new oil and gas basins are undertaken.. Renewable energy sources are vast, but have been poorly developed in the last few decades. Recently the government has set up policies and action to enhance the utilization of renewable energy sources, in particular for rural energy supplies and electrification, although their sustainability and impact have yet to be revealed..

2. Current administration has instigated policies to reduce share of oil in national energy mix by 2025, but increasing the share of coal and renewable energy sources through Presidential Decree on National Energy Policy. Long-term policies and commitments are needed, beyond this current administration, to ensure effectiveness of long-term targets. The establishment of a National Energy Committee is expected to give clear long-term targets and inter-sector, inter-agency policies and regulations that may support the development and deployment of low carbon and GHG emissions mitigation technologies.

3. Emission scenarios from the energy sector of Indonesia indicate that, if targets of energy mix promulgated by the Presidential Decree on National Energy Policy can be achieved, they will be effective in making substantial emission reductions in the energy sector. Further analyses, using MARKAL models to gauge the impact of GHG emissions mitigation and low carbon technologies deployment in the energy system suggest that CO2 emissions can be reduced.

4. The selection of technology is based on the supply and demand side approach. In the market, there are advanced technologies for fossil fuels, renewable and energy conservation and DSM technologies. Some of the technologies have been widely applied for years, but some are just entering the market.

5. Most of the new technologies ion the supply side has higher capital costs compared to conventional fossil fuel based combustion technology. However, as the technology matures and becomes more widely deployed with carbon values that are integrated into the cost of energy production, new technology will be very competitive against the older ones. Due to climate change, with the accelerated R&D for low carbon technologies in recent years, more options will be available in the near future.

6. Most technologies on the demand side are widely available in the market. For low cost energy efficiency measures, technology transfer is not required but for more complicated, high cost and advanced industrial DSM measures, transfer of technology is needed.

7. Selection of technology, using general selection and specific selection criteria suggest the following high priorities for technology transfer: (i) advanced thermal power plants based on clean coal technology; (ii) geothermal technology, in particular flash steam and binary cycle, (iii) biomass power technology. Second priorities are renewable energy technologies: (i) small and medium wind power technology for low speed wind; (ii) solar photovoltaic and (iii) small and mini hydro technology. It is identified that several mitigation measures can be implemented, such as improving the efficiency of power plants that can significantly reduce CO_2 with less cost. To ensure the implementation, policies and regulations are needed.

8. There are several barriers identified: institutional and policy; economic, market, and investment;

human resources and industrial support; information and awareness. Effective technology transfer can be ensured, if action can be taken to remove those barriers.

6.2. Recommendation

1. Further economic, financial and technical analyses are needed for priorities and selected technologies on the supply side, in particular advanced power generation,

2. To ensure effective technology transfer, the Government must prepare transfer of technology principles and rules and detail a road map for selected priority technologies.

3. To enhance domestic capacity, in regard to human resources and industrial support, the Government must actively solicit bilateral and multilateral cooperation in R&D, technology promotion and pilot projects in some key selected technologies and renewable technology.

4. Restructure current energy pricing policies, to reflect production costs and energy sources: important in creating market-based incentives for deployment of GHG emissions mitigation technologies.

5. On the supply and demand side, some low cost options of GHG emissions mitigation are available. Government policies and regulations, incentive and disincentive packages mandating and promoting rewards for GHG emissions reductions, as well as energy efficient use, are needed to ensure all sectors are taking into account GHG emissions mitigation measures in their activities.

Table 6.1: Example of Industrial Technology for GHG Emission Reduction

Sector	Energy Efficiency	Fuel Switching	Power Recovery	Renewables	Feedstock Change	Product Change	Material Efficiency
Sector wide	Benchmarking; energy management systems, boilers, furnaces, lightning, and heating/ventilation/ air conditioning; process integration	Coal to natural gas and oil	Cogeneration	Biomass, Biogas, PV, Wind Turbines, Hydropower	Recycled input	-	-
Iron & Steel	Smelt reduction, near net shape casting, Scrap preheating, Dry coke quenching	Natural gas, oil or plastic injection into the BF	Top gas pressure recovery, By-product gas combined cycle	Charcoal	Scrap	High strength steel	Recycling, High strength steel, Reduction process losses
Chemicals	Membrane separations, Reactive distillation	Natural gas	Pre-coupled gas turbine, pressure recovery turbine, H2 recovery		Recycle plastic, bio-feedstock	Linear low density polyethylene, high-performance plastics	Recycling, Thinner film and coating, reduced process losses
Petroleum Refining	Membrane separation, refinery gas	Natural gas	Pressure recovery turbine, hydrogen recovery	Biofuels	Bio-feedstock		
Cement	Precalciner kiln, Roller mill, fluidized bed kiln	Waste fuels, biomass	Drying with gas turbine, power recovery	Biomass fuels	Slags, pozzolanes	Blended cement, Geo polymers	
Pulp & Paper	Efficient pulping, Efficient dying, Shoe press, Condebelt drying	Biomass, Landfill gas	Black liquor gasification combined cycle	Biomass fuels (bark, black, liquor)	Recycling, Non-wood fibres	Fibre orientation, thinner paper	Reduction cutting and process losses
Food	Efficient drying, Membranes	Biogas, Natural gas	Anaerobic digestion, gasification	Biomass, By products, Solar Drying			Reduction process losses, closed water used

Source: IPCC (2007)

Table 6.2: Summary of Mitigation Technologies Available for Supply Side

Identified Supply Side Technology	Present Situation	Technology Input	Emission Reduction Potential	Investment Cost	Remark
Advanced thermal power technology/ clean coal technology	Pulverized coal power plant; Thermal efficiency: 33%, 1tonne CO_2/MWh	Sub-critical pulverized coal power plant, 36% efficiency	0.70tonnes CO_2/MWh (w/o CO_2 capture)	1,200US$/kWe	With and without CO_2 capture
			0.83tonnes CO_2/MWh (with CO_2 capture)	2,300 –2,400US$/kWe	
		Supercritical and ultra-supercritical pulverized coal power plant, 40% – 46% efficiency	0.17tonnes CO_2/MWh (w/o CO_2 capture)	1,300 – 1,400US$/kWe	With and without CO_2 capture
			0,89tonnes CO_2/MWh (with CO_2 capture)	2,300 – 2,400US$/kWe	
		Cogeneration	0.325tonnes CO_2/MWh	1,000 – 1,100US$/kWe	
		IGCC, 38% – 41% efficiency	0.168tonnes CO_2/MWh	1,100 – 1,300US$/kWe	With pre-combustion & without CO_2 capture
			0.898tonnes CO_2/MWh	1,800US$/kWe	
		Coal upgrading	Vary depending on quality of coal		5% emission reduction of conventional PC
		Improve efficiency	1% efficiency increase will reduce 2 - 2.5% CO_2 emission		
Fuel switching	Combine cycle gas turbine to replace HSD generator	Gas to replace HSD	N.A.	N.A.	
		Coal to gas (50%)	0.5tonnes CO_2/MWh	750US$/kWe	Abatement cost: 8.5US$/tonne CO_2

Identified Supply Side Technology	Present Situation	Technology Input	Emission Reduction Potential	Investment Cost	Remark
Utilization of renewable energy technology	More than 95 % of primary energy are supplied by fossil fuels: oil, coal and gas.	Biomass power – Direct combustion			
		Biomass power – Co-firing	15 - 20 % of emission reduction depending on the main fuel		
	Government set the target to reduce oil but increase new and renewable energy up to 15 % of total primary energy mix	Biomass power- gasification	Avoid coal emission per energy produced.		
		Geothermal - Flash steam	0.9 – 1tonnes CO_2/MWh (base on typical PC power plant as baseline	1250 – 1300US$/kWe	Depend on the baseline
		Geothermal - Binary cycle		1600 – 1700US$/kWe	
		Geothermal - Hot dry rock		4500US$/kWe	
		Photovoltaic – Single crystal/ Mono crystal		5500 – 6000US$/kWe	
		Wind turbine		1600 – 2000US$/kWe	
		Micro and Mini Hydro		2500 – 3000US$/kWe	
		Advanced Hydro Power			
		Nuclear Power: PWR/ BWR 2nd Generation	0.85 – 0.9tonnes CO_2/MWh (base on typical PC power plant as baseline)	1500 – 2500US$/kWe	
		Nuclear Power PWR/ BWR 3/3+ generation		5500 – 8000US$/kWe	

Technology	Efficiency Measure	Result	Sector
CFL (Compact Fluorescent Lamp)	Replacement of incandescent bulb with CFL	Efficient light bulb can reduced up to 80 % of energy use.	Household and commercial
Use of solar water heater	The use of solar water heater for producing hot water	Reducing electricity consumption up to 50 %	Households, commercial, and some industries
Electronic Ballast	Replacement of magnetic ballast with electronic ballast	20 % reduction of energy use.	Household and commercial
High Efficiency AC	Replacement of standard air conditioner (AC) with high efficiency AC	Standard AC CoP = 2.5 High efficiency AC CoP = 3.3 (COP: Coefficient of Performance) Reducing energy consumption up to 50%,	Households
Hydrocarbon Refrigerant	Replacement of CFC with hydrocarbon refrigerant	Electricity saving up to 20%.	Households and commercial
BAS (Building Automatic System)	The application of BAS to monitor lightning and energy use in building	Electricity saving 10 – 20%	Commercial
Variable Speed Drive	Applied VSD in fan system	VSD in fan system can reduce electricity consumption up to 20%	Industry
High Efficiency Chiller	Replacement of normal chiller with high efficiency chiller	COP normal chiller = 4.0 COP high efficiency chiller = 5.0	Commercial and industry
High Efficiency Electric Motor	Replacement of normal electric motor with high efficiency electric motor	High efficiency can reduce energy consumption up to 25%	Industry

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Appendix 1: List of CDM Biomass Projects (until September 2008)

Project	Project Owner	Description
BKR Biomass 4MWe Condensing Steam Turbine Project	PT Bukit Kapur Reksa (BKR)	Installation of on-site biomass-based power facilities at PT BKR's palm oil refinery and processing plant in Riau Province (Sumatra) for electricity generation and steam for internal use. The project installed: 45tonnes/hour, 30bar steam boiler, 1.2MWe back pressure, 2.8MWe full condensing steam turbine. It produces electric power around 2.2MW.
CK Biomass 2.4MWe Condensing Steam Turbine Project	PT Cahaya Kalbar Tbk (CK)	Installation of on-site biomass-based power facilities at the PT Cahaya Kalbar Tbk (CK) palm oil production plant at Pontianak on West Kalimantan in Indonesia for the generation of electricity and steam for internal use. The plant includes 35tonnes/hour, 40 bar steam boiler; 25tonnes/hour will be used for the condensing steam turbine; 2.4MWe full condensing steam turbine. It produces 2.4MW electricity output.
Pelita Agung Agrindustri Biomass Cogeneration Plant	PT Pelita Agung Agrindustri; Mitsubishi UFJ Securities Co. Ltd.	Installation of three parallel trains of combined heat and power (CHP) units each consisting of a boiler and a turbine in the company's integrated palm oil processing complex in Bengkalis, Riau Provinces, Sumatra. The feedstock is empty fruit bunch (EFB). In total, the system will have the capacity to deliver up to 9.2MWe (gross) of electricity, and 105MWth (thermal) of steam.
Mandau Biomass Power Plant	PT Adei Plantation & Industry	Construction of 6MWe biomass power plant that will utilize empty fruit bunch, palm kernel shell, fiber as residue from the process of palm mill. The Project involves the installation of a biomass power generator plant consisting of a biomass boiler and a steam turbine attached to an electricity generator arranged sequentially. The biomass boiler is capable of delivering 25,000kg/hour of superheated steam at 50bar. The steam turbine is a fully condensing turbine capable to deliver 6MW of electricity and about 1,000kWh of which is consumed by the Project itself to operate pumps, instrumentation, and material movement.
Partial Fuel Switching From Coal to Biomass Residues (Rice Husk and Saw Dust) in Boilers for Electricity and Heat Generation	PT Pura Barutama and NEDO	Located in Kudust Distric, Central Java, the purpose of the project is to reduce the utilization of coal. Technology employed is the "chain grate" combustion system, in the baseline as well as in the project. The steam is utilized to produce electricity in the Power Plant 2 x 7.5MW capacity, while in the Paper Mill it is used to produce process steam. The generated electricity is primarily used for own need, when there is an electricity surplus, it will be sold to the local utility (PT PLN (Persero)) grid. The partial replacement of coal by biomass residues (rice husk and saw dust) by about 30% will result in the reduction of coal use since the output power is maintained at the same level. The reduction of coal use will also reduce the emission of Greenhouse Gas.

Project	Project Owner	Description
4 MW Biomass Power Plants, Using Waste Wood Chips & Saw Dust	PT Rimba Partikel Indonesia (RPI)	T nt and the facilities on the grounds and also to sale to outside. The equipment introduced under this project will include Biomass power (2.4MW) supplied to the currently existing equipment and facilities, plus the power necessary for running the generators themselves (0.7MW). Consideration has also been given to avoidance of overloads, so the equipment introduced will have a power generation capacity of 4MW. The project plans to use 2,601tonnes/month of a mixture consisting of undried offcuts, sawdust, and waste of veneer as fuel. The project located in Kaliwungu, Kendal District, Central Java Province.
Listrindo Kencana Biomass Power Plant	PT Listrindo Kencana, PT Sawindo Kencana, Misubishi UFJ Securities.	PT Listrindo Kencana ("Listrindo) is constructing a 12MW biomass power plant that will utilize biomass residue (empty fruit bunch, EFB) from palm oil mills as fuel. The Project is located within a palm oil processing complex belonging to PT Sawindo Kencana ("Sawindo"), on the Island of Bangka, in the Province of Bangka-Belitung, East of Sumatra, Indonesia. The purpose of the Project is to supply renewable electricity to the island's electricity grid. The plants consumes 46,000tonnes EFB/year. The project is estimated to generate 73,032MWh energy/year.
PTMM Biomass to Electricity Project 26.4MW(e)	PT Musim Mas	The project aims to produce electricity from biomass residues (EFB, fiber and shell) from the palm oil mills located in North Sumatra, Indonesia. The project burn in total 210tonnes/hour biomass residue to run five high steam biomass boilers to generate 26.4MWe electric power to supply the grid and the factory's processing facility.
PTIP Biomass to Electricity Project (7MW)	PT Intibenua	Construction of 7MWe biomass power plant that will utilize empty fruit bunch, palm kernel shell, fibre as residue from the process of palm mill. The Project involves the installation of a biomass power generator plant consisting of a biomass boiler and a steam turbine. The electricity produced is for internal use only.
Nagamas Biomass Cogeneration Project in Indonesia	Permata Hijau Group, Mitsubishi UFJ Securities Co., Ltd	Installation of a high-pressure steam biomass-fired boiler (installed capacity: 40tonnes/hour, 50 bar) to produce steam and generate 3MW electric power. The Project will consume approximately 59,400tonnes/year of palm kernel (PK) shell for thermal and electric energy generation. The project located in Dumai, Riau Provinces.
Tapioca Starch Production Facilities Effluent Methane Extraction And On-site Power Generation Project in Lampung Province, Republic of Indonesia	PT Budi Acid Jaya; Sumitomo Corp.	The Project activity involves the installation of a closed anaerobic wastewater treatment and biogas extraction system at an existing tapioca starch manufacturing plant and its auxiliary facilities for treatment of organic wastewater, which is currently treated at an open lagoon based system in Lampung province. The collected biogas will be utilized for electricity generation, which will be used on-site. The project will utilize 16,900m^3 waste water produced daily from the production process of tapioca starch to generate 5 – 8MW electric power.
Amurang Biomass Cogeneration Project	PT Cargill Indonesia and EcoSecurities	The Amurang Biomass Cogeneration Plant Project consists of a cogeneration facility that will combust waste biomass (coco shell, coco husk, palm kernel shell); the project is located in North Sulawesi, Indonesia. The combustion of the biomass will generate enough electricity and heat to meet the requirements of the copra crushing facility, which will process 500tonnes copra/day. The biomass waste will be utilized as fuel to run steam boiler to produce saturated steam/heat equal to 4.3MWth and 3MWe electric power.

Project	Project Owner	Description
MSS Biomass 9.7MWe Condensing Steam Turbine	PT Murini Samsam (MSS)	The project consists of the construction of a new boiler and condensing steam turbine with 9.7MW total capacities for the production of electricity running on Palm Kernel Shell (PK Shell) and palm kernel fibre. Both PK Shell and fibre are biomass produced as by-products from the production of palm oil and palm kernels from palm fruit in a Palm Oil Mill. Steam turbine and boiler require about 146,500MT of palm kernel a year. Additional PK Shell is obtained from other POM around the project location. The project located in Dumai, Riau Province.
MNA Biomass 9.7MWe Condensing Steam Turbine	PT Multimas Nabati Asahan (MNA)	The project consists of the construction of a new boiler and condensing steam turbine with 9.7MW total capacities for the production of electricity running on Palm Kernel Shell (PK Shell) and palm kernel fibre. Both PK Shell and fibre are biomass produced as by-products from the production of palm oil and palm kernels from palm fruit in a Palm Oil Mill. Steam turbine and boiler require about 157,000Mt PK/year. Additional PK Shell is obtained from other POM around the project location. The project located in North Sumatra Province.

Source: Indonesia Designated National Authority (DNA) CDM database, UNFCCC's CDM website. Author compilation.

CHAPTER - II

TRANSPORTATION SECTOR

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CHAPTER II – TRANSPORTATION SECTOR

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1. BACKGROUND

1.1. Aims

Indonesia ratified the United Nations Framework of Climate Change Convention (UNFCCC) through Act No. 6, in 1994 and the Kyoto Protocol through Act No. 17, in 2004. "*...Article 4.5 of the Convention defines technology needs assessments (TNAs) as, a set of country-driven activities that identify and determine the mitigation and adaptation technology priorities of Parties. They involve different stakeholders in a consultative process to identify the barriers to technology transfer and measures to address these barriers through sectoral analyses. These activities may address soft and hard technologies, such as mitigation and adaptation technologies, identify regulatory options and develop fiscal and financial incentives and capacity-building.*" [UNFCCC: Technology Transfer Framework] Stakeholders are governments, private sector entities, financial institutions, NGOs and research/education institutions. The aims of Indonesia's TNA can be itemized as follows:

- Contribute to the global efforts towards sustainable development and, in particular, the protection of the climate system
- Communicate Indonesia's needs for environmentally sound technologies (ESTs) to the UNFCCC Conference of the Parties (COP) and the global community
- Resource documents to identify and accentuate ESTs needed by Indonesia and mark those, which require support and co-operation from developed countries
- Set the foundation for a database for ESTs

1.2. Objectives

- Identify, analyze, and prioritize technologies, which could form the basis for a portfolio of Technology Transfer programmes aiming GHG emissions mitigation
- Identify human and institutional capacity needs that ensure the smooth development, transfer and acquisition of environmentally sound technologies
- Enlist interests and commitment from key stakeholders and partnerships to support investment and/or barrier-removal actions for enhancing the commercialization and diffusion of high-priority technologies

1.3. Scope

The scope of Indonesian Technology Needs Assessment – Transportation Sector embraces road transportation, as it consumes with about 88% the largest share of primary energy among all modes of transportation in Indonesia from total primary energy consumption in the transportation sector. Another reason is that road transportation data is readily available to support analysis. An analysis for other modes of transportation, such as railroad, ferry, air transport and sea transport, is more difficult to include within this strict time frame, as it requires sufficient data for numerous advance calculations. Thus, it has been decided to include only road transportation in this year's (2008) Transportation Sector TNA report. Later in forthcoming TNA reports, other modes of transportation will be included.

This Transportation Sector TNA addresses the general situation of road transportation in Indonesia and analyses the environmentally sound technology available as well as the cost and potential of greenhouse gas (GHG) emissions mitigation from deployment of such technologies over the next two decades. This Transportation Sector TNA reviews the current stage of Indonesia's road transportation, trends, GHG emissions from road transportation, environmentally sound technology options and priorities based on policies, planning and technological capacity.

1.4. Approach

This Transportation Sector TNA was developed during a series of stakeholders' informal and formal meetings, through data gathering, observation and literature studies, as well as workshops. Stakeholders of the Indonesian transportation sector include the Ministry of Transportation (MoT) and other government agencies, academician/universities, research and development agencies, financial institutions and non-government organizations (NGOs).

2. EXISTING CONDITIONS IN INDONESIA

2.1. Introduction

The recent Fourth Assessment Report (AR 4) of the Intergovernmental Panel on Climate Change (IPCC) suggests that CO_2 concentration has reached with 379ppm a higher level than natural CO_2 concentration levels for the last 650,000 years. Scientists believe that rising concentrations of greenhouse gases (GHG) in the earth's atmosphere mostly came from anthropogenic causes, resulting from economic and demographic growth over the last two centuries, overriding this natural variability, which leads to irreversible climate change.

The development of transportation has a close relationship to economic growth, as it gives great mobility to people and allows a wide distribution of freight. However, most modes of transportation have adverse effects on the environment. One of the side effects is the contribution to increased GHG emissions. At a global level, transportation contributes up to 13.1% of total GHG emissions.

Technologies used in the transportation sector are being continuously developed in line with the advances of technology in the automotive and energy sectors, as well as traffic systems, development in rail transport, and new shipping technologies. In Indonesia, road transportation vehicles are commonly fueled by gasoline and diesel fuel; diesel-fueled and electric-powered trains for rail transport, diesel-fueled vessels for maritime transport, and gas-fueled aircrafts for air transport. Road transport potentially emits more gaseous emissions into the atmosphere especially in the metropolitan areas, so the use of low emission vehicles and the implementation of effective and efficient traffic management and systems could be envisaged and assessed.

GHG emissions from motorized transport are caused by three factors, namely: engine technology, type of fuel used, and engine maintenance – or lack of condition. Engine technology is related to how energy changes from fuel to motor energy on crankshaft, through the fuel-burning process and oxygen occurring inside the combustion chamber. Thermal energy is produced and in turn it will produce combustion gases that move the piston. The types of fuels define the type of combustion gases. Engine running condition defines how good is the combustion quality, which, in turn, will define the types of combustion that releases GHG emissions.

Land and maritime transport, with small and medium power engines, generally use gasoline-fueled and diesel-fueled motor engines, whereas air transport with medium and huge power generally use jet propulsion engines. Transport fleets with small-power engines used in Indonesia like motorcycles, city transport cars, and private cars, generally use gasoline or diesel engines. Transport fleets with medium power engines like buses, mini-buses, trucks, vessels, and locomotives generally use diesel engines.

Alternative fuels In Indonesia, like Compressed Natural Gas (CNG) and Liquid Petroleum Gas (LPG) for road transport fleets, have been introduced and used since the 1980s. Vehicles fueled by CNG or LPG are equipped with CNG or LPG converter kits without a need to change the engine. The use of CNG and LPG for land transport is still limited to public transport and some private cars. Constraints for using CNG are high investment cost for the converter kits and the availability of filling stations, which is low since they require huge investments. Heavy CNG fuel tanks of limited capacity add to the overall weight ratio of a car, which reacts on engine performance when the car is fully loaded. Constraints on LPG use are the cost of LPG converter kits and fuel consumption, which is 10 – 20% higher than that of gasoline, while the price of LPG is only about 20% lower than that of regular gasoline. In order to extend the use of CNG and LPG for road transport vehicles, many filling stations will have to be built, incentives for the users have to be provided, and sufficient CNG or LPG energy supplies have to be guaranteed.

Many other alternative fuels like solar energy, electric and hybrid electric, alcohol (ethanol, methanol), and hydrogen have been demonstrated and some have been practically used in developed countries to power vehicles. Alternative fuels could be envisaged and further assessed for their implementation in Indonesia. While developing and introducing the use of alternative fuel technologies, other technologies in traffic management systems like ITS and the improvement of public transport could be also assessed for application, particularly in urban areas.

In case of inner-city transportation, there are some ongoing latent problems to be solved, such as:

- Air pollution from motorized vehicle exhaust can endanger people's health as well as damage the environment.
- Global warming and climate change
- Fossil fuels are dominantly used, although resources are depleting.
- Energy efficiency in land transportation is not optimal.
- The use of natural gas and non-fossil fuel is still low.
- Development of sustainable and environmentally friendly transportation means is not a priority.
- A lack of facilities for non-motorized vehicles exists.
- The noise pollution and vibrations from traffic are ongoing latent problems.

2.2. Transportation Sector in Indonesia

Transportation sector in Indonesia is the biggest consumer of primary energy. In 2005 the primary energy consumption for this sector was about 33,264 thousand kiloliters, or 48.0% of total primary energy consumption in Indonesia, while the industrial, household and power sectors consume 21.9%, 19.1%, and 11.0%, respectively. Land-based transportation is the biggest user of primary energy in the country as it consumes 47.5% of the country's primary energy consumption, as compared to 0.5% of non-land transportation (air and sea).

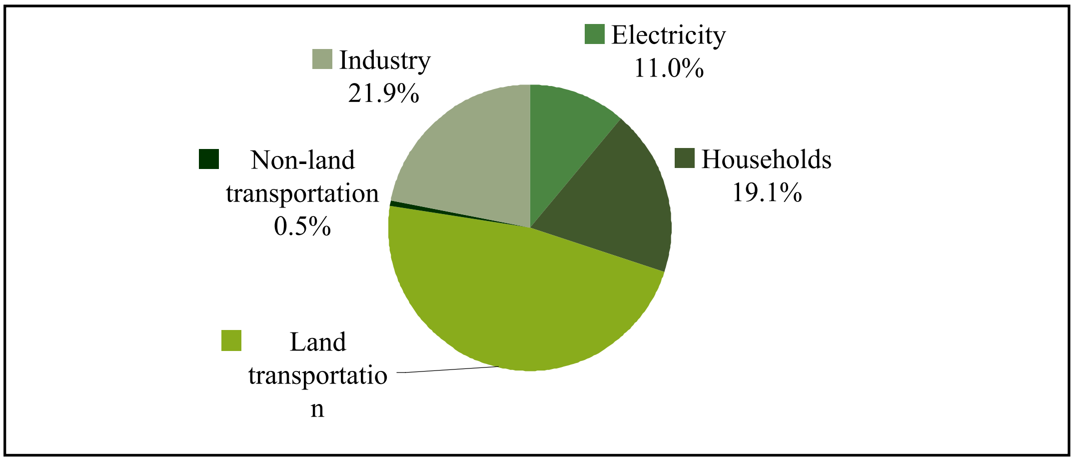


Figure 2.1: Primary Energy Consumption by Sector in Indonesia, 2005

Primary energy consumption by transportation modes in Indonesia can be seen in Figure 2.2. Road transportation consumes 88% of the Indonesian transportation sector's total primary energy consumption. While sea transportation, air transportation, and railroad and ferry consume only a moderate amount of 7%, 4%, and 1% respectively. This is the reason that the Transportation Sector TNA will focus on road-based transportation, while not excluding the other transportation modes in Indonesia.

Fuel consumption in road transportation in Indonesia is depicted in Figure 2.3. Passenger cars dominate the energy consumption at 36%, followed by trucks, buses, and motorcycles at 32%, 19%, and 13%

respectively. This trend could be problematic for Indonesia in the near future as the number of passenger cars grows faster than any other public transport mode, thus increasing the need for fuel. While the number of motorcycles grows as fast as that of passenger cars, motorcycles consume only a small amount of fuel. Total motorcycle fuel consumption is ranking fourth, after passenger cars, trucks, and buses.

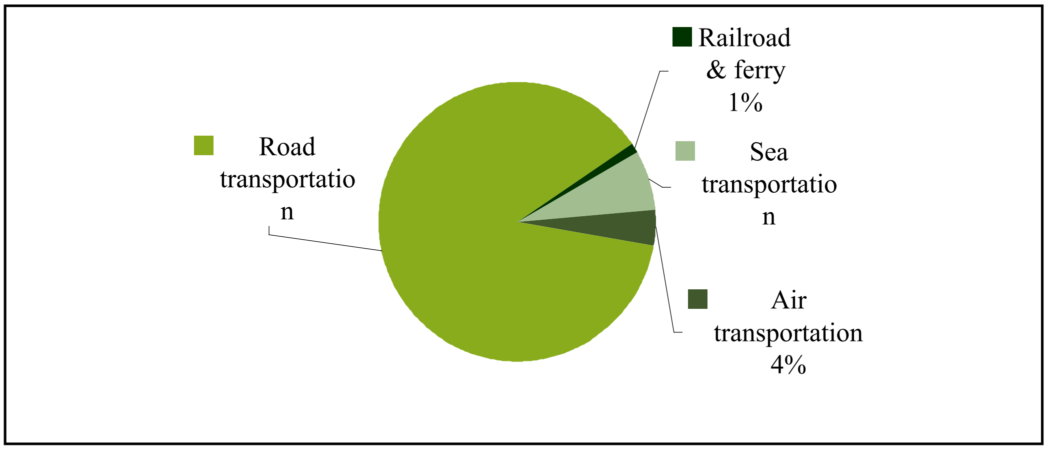


Figure 2.2: Primary Energy Consumption by Mode of Transportation, 2005

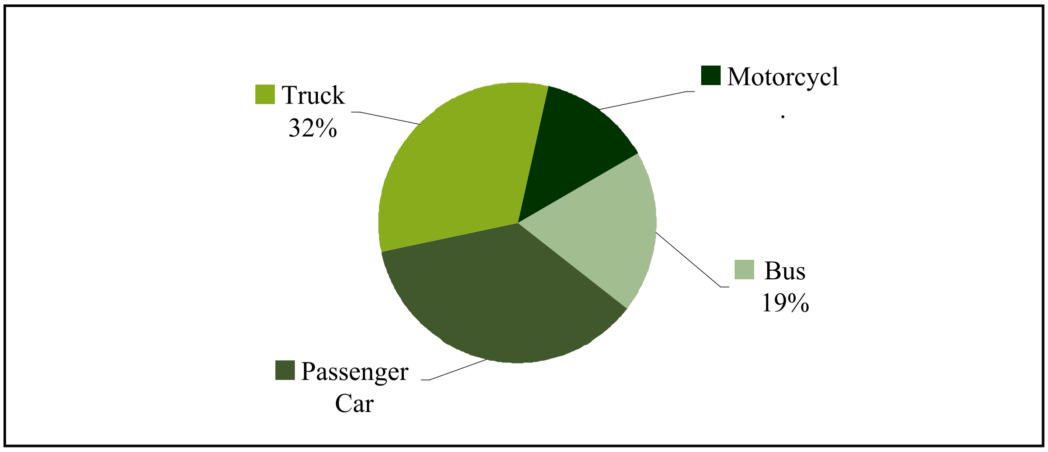


Figure 2.3: Primary Energy Consumption by Mode of Road Transportation, 2005

Energy consumption from the transportation sector leads to air pollution, mainly in big cities. If the Indonesian government is willing to control air pollution, it should start here. However, controlling air pollution from this sector will not be easy, as the number of transport vehicles increases by 8% - 12% annually.

According to research results of the Environment Protection Agency in 2005, in cities such as Jakarta, Bandung, Semarang and Surabaya – all on Java island – motorized vehicles are the main source of air pollution. The transportation sector contributes 98.8% of total GHG emissions in Jakarta, including 73.4% of released nitrogen oxides (NO_x) and 88.9% of released hydrocarbons (HC). The use of leaded gasoline by most of the vehicles contributes to air pollution and has a pejorative affect on public health.

2.3. Policy and Regulations

The development of the transportation sector in Indonesia lies in the responsibility of two ministries:

Ministry of Public Works, for developing transportation infrastructure, and the Ministry of Transportation, for developing and establishing transportation planning, -systems and management.

According to Presidential Decree No. 7/2005 on The Direction of National Middle-Term Development Plan 2004 – 2009, the transportation development in Indonesia can be improved by:

- Rehabilitation and maintenance programmes for land transportation facilities and systems
- Development programmes for sustainable land transportation facilities and systems in cities, namely:
    - Development of city transportation, which is environmentally friendly and regionally-based,
    - Application of environmentally friendly land transportation technologies,
    - Design a Master Plan for the development of environmentally friendly land transportation technologies, including the use of alternative energy.

Over the past 10 years, the Government of Indonesia and local government have promulgated a number of decrees, ministerial statements and regulations aimed at encouraging the use of CNG and LPG, to reduce air pollution. Current regulations and policies relating to the implementation of CNG programmes in Indonesia and more specifically for the Greater Jakarta are as follows:

Blue Sky Programme for the Transportation Sector in Indonesia: Greater Jakarta Pilot Project.

2.3.1. Policy and Regulation

a. Act Number 14/1992, regarding Traffic and Land Transportation; regulates the traffic and land transportation, including the road network, driver behavior, drivers' licenses, the role and responsibilities of traffic police, road classes, traffic accidents, tariffs, levies, penalties, etc.
b. Government Regulation Number 42/1993, regarding the Inspection of Motor Vehicles on the Road; regulates the role and responsibilities of the inspector of motor vehicles on the road, the inspection procedures, the inspection subjects, the inspection equipment, etc.
c. Government Regulation Number 44/1993,regarding Vehicle and Driver; regulates the technical requirements of motor vehicles including brakes, lamps, etc.; technical feasibility of making motor vehicles legal to drive on the road , the color and measurements of traffic signs, drivers' license classes, etc.
d. Government Regulation Number 41/1999, regarding Air Pollution Prevention, regulates air pollution prevention including the technical requirements of motor vehicle exhaust, the air pollution ambience, noise level ambience, sources of air pollution or noise, air pollution or noise prevention, and the cost burden on the government as well as the private sector.
e. Decree of the Minister of Environment Number 35/1995, regarding Vehicle's Exhaust Gas Emission Standards.
f. Decree of the Minister of Environment Number 45/1997, regarding Air Pollution Standard Index.
g. Decree of the Minister of Transportation Number 63/1993, regarding Operation Standards of Vehicle, Trailer truck, Container Car, and others.
h. Decree of the Minister of Transportation Number 71/1993, regarding Periodic Testing of Motor Vehicles.
i. Decree of the Minister of Transportation Number KM 64/1993, regarding Technical Requirements of CNG Utilization on Motor Vehicles.
j. Letter of Statement of Directorate General of Land Transportation Number C.108. AJ.402/2/15/1991, regarding Approval of CNG Conversion Kit "Renzo Landi" and Tank "Faber" Equipment Installation.

k. Letter of Statement of Directorate General of Land Transportation Number C.109. AJ.402/2/14/1991, regarding Approval of CNG Conversion Kit "Renzo Landi" and Tank "Faber" Equipment.
l. Letter of Statement of Head of the Environmental Protection Agency (BAPEDAL) Number 107/1997, regarding Technical Guidance on Calculating and Reporting on the Air Pollution Standard Index.
m. The Decree of the Governor of DKI Jakarta Number 1222/1990, regarding Vehicle Emissions Quality Standard in DKI Jakarta.
n. The Decree of the Governor of DKI Jakarta Number 95/2001, regarding Emissions Inspections and Maintenance of Private Cars; and
o. The Decree of the Governor of DKI Jakarta Number 551/2001, regarding Ambient Air Quality Standard.

2.3.2. Current Programmes

a. Letter of Statement of the Governor of DKI Jakarta Number 28/1990, regarding the Use of CNG/ LPG for Public Transport/Taxis. In relation to this letter, the Office of Traffic and Transportation (DLLAJR) of DKI Jakarta issued the Letter of Announcement Number 1648/- 18.11.3219, dated February 26, 1990, regarding the Obligation of Using CNG/LPG for Taxis. This has been sent to all taxi companies in DKI Jakarta;
b. Letter of the Governor of DKI Jakarta Number 2508/-1.824.132, dated August 3, 1993, regarding the Willingness to Build/Install CNG Dispensers at Gasoline/Diesel Pump Station (SPBU). The development of a CNG filling station is a requirement for building new SPBU.
c. In order to accelerate the development of the CNG filling station network, to support the CNG utilization program in DKI Jakarta, the Governor of DKI Jakarta has issued Letter number 2605/-1.824.133, dated August 16, 1994, stating that every new permit for building SPBU has to give priority to the development of CNG filling stations;
d. Decree of the Ministry of Finance Number 1249/KMK.01/1989, dated November 14, 1989, regarding Tariff Determination of Import Duty of Conversion Kits to be 5%; This ministerial decree will give incentives to the import and the use of conversion kits to reduce the GHG emissions.
e. Decree of the Ministry of Finance Number 801/KMK.00/1992, dated July 23, 1992, regarding Tariff Determination of Import Duty of CNG Compressor or LPG Pump to be reduced from 5% to 0% (in accordance with the Decree Number 380/KMK.01/1996); This ministerial decree will give incentive to CNG and LPG filling stations.
f. CNG specifications for motor vehicles in Indonesia have been determined by the Director General of Oil and Gas in the Letter of Statement Number 10K/DJM/1993, dated February 1, 1993. This regulation will give guidance to the CNG conversion manufacturers as well as to the CNG filling stations on CNG specifications.
g. In accordance with the Letter of Statement of Pertamina's President Director Number Kpts - 050/ C00000/2003-S3, dated August 4, 2003, the CNG Price is 700Rp./liter premium equivalent (lpe), including the fee for the owner of CNG filling station which is to be 310Rp./lpe; This national oil company regulation will give incentives to CNG filling stations, since they will be given substantial fees, compared to other types of oil and gas.
h. Letter of the Minister of Transportation Number KH.97/AJ.001/MPHB, dated August, 1995, regarding CNG Programmes to the President of the Republic of Indonesia, reporting the operation of fully dedicated CNG buses, and the Letter of State Secretary Number R- 197/M.Sesneg/9/1995, stating that the procurement of new buses for 1996/1997 should use fully dedicated CNG engines; This regulation transmits a decisive policy on the type of new CNG-engine buses to be operated in Indonesia main cities.

i. Letter of the Minister of Environment that appeals for support to the command of the President in the Blue Sky Programme The letter has been sent to the Governor of the Indonesian Bank, Indonesian Military Commander and the Minister of Tourism, Post and Telecommunication in which all operational cars of the above institutions can hopefully be converted to use CNG. However, these appeals will not have much effect and only a number of vehicles will be using CNG possibly, because the price of a CNG-powered car is higher than that of a gasoline-powered car.
j. Letter of the Minister of Energy and Mineral Resources Number 4185/30/MEM.M/2000, dated October 11, 2000, regarding the Recommendation to increase CNG Utilization; In practice only big buses operating in the main cities of Indonesia are using CNG.
k. Letter of the Minister of Energy and Mineral Resources Number 4897/30/MEM.M/2000, dated November, 2000, regarding CNG Utilization.
l. Letter of the Minister of Environment Number B-948/MENLH/5/2001, dated May 31, 2001 regarding the Improvement of CNG utilization/environmentally friendly fuel; Blue Sky Programme for the Transportation Sector in Indonesia: Greater Jakarta Pilot Project.

2.4. Greenhouse Gas Emissions Inventory and Mitigation Scenario

Based on "Indonesia: The First National Communication under UNFCCC" (1999), total GHG emissions from Indonesia in 1994 were 886.47million tonnes of CO_2. This figure is quite low compared to those of industrialized countries.

CO_2 emissions in the transportation sector in Indonesia have constantly almost doubled in a decade and the trend of GHG emissions shows higher rates in 2000, compared to the previous decade.

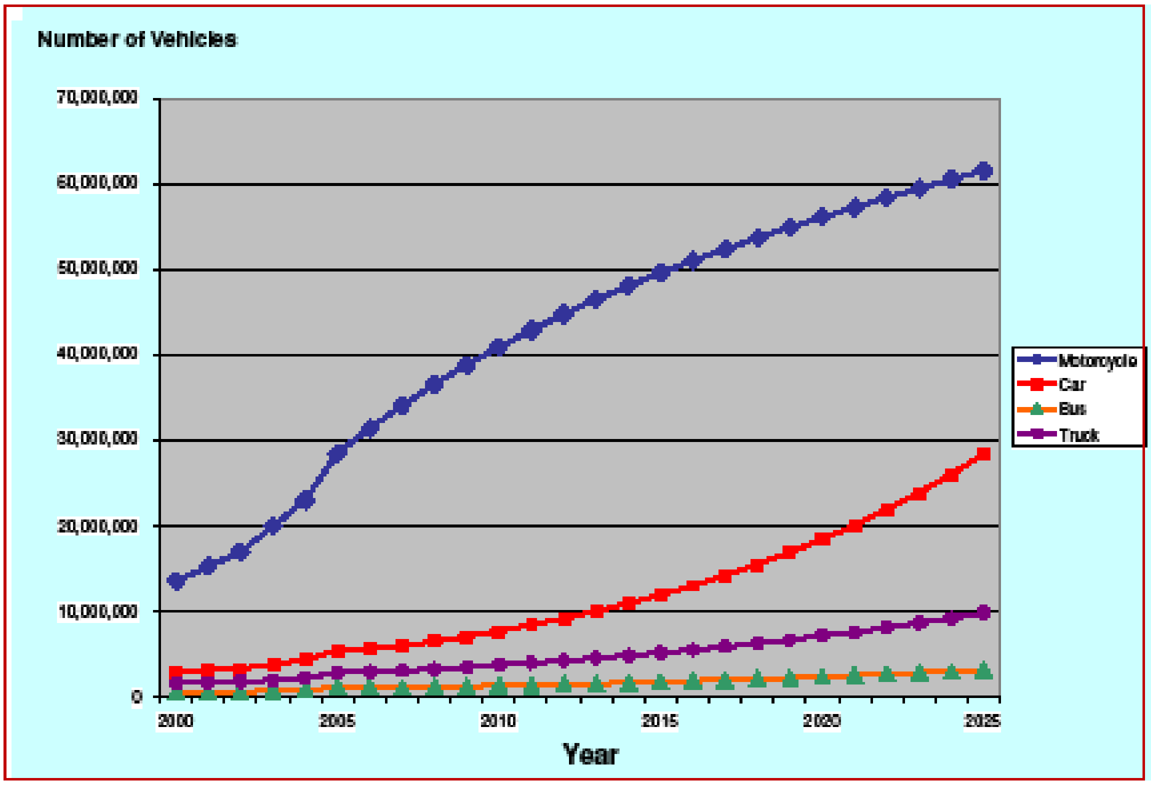
- 28.37million tonnes CO_2 in 1990
- 40.20million tonnes CO_2 in 1995
- 54.41million tonnes CO_2 in 2000
- 67.68million tonnes CO_2 in 2005

Total CO_2 emissions increase by 6% annually and, during 1990-2005, on average, the transportation sector contributed 24% of total CO_2 emissions increase. .

Based on data on the number of vehicles and motorcycles provided by the Directorate General of Land Transportation, Department of Transportation and data on energy consumption of vehicles provided by the Department of Energy and Natural Resources, the calculation of CO_2 from road transportation can be deduced using IPCC methodology.

2.4.1. Projected Greenhouse Gas Emissions

The quantity of vehicles used for road transportation in Indonesia is shown per mode of transportation in Figure 2.5. The number of motorcycles is the highest, compared to other vehicles. The ease in purchasing a motorcycle in Indonesia, the comparatively low price, and low fuel consumption has enticed many people to use motorcycles. In 2025, motorcycle numbers are predicted to reach more than 60million units. Cars will rank second at a number of 23.7million units in 2025, while trucks and buses rank third and fourth, respectively.



Note: Data table in appendix

Figure 2.5: Vehicle Quantity by Mode of Road Transportation, 2000-2025

The number of units and the amount of CO_2 emissions in 2007 is listed for each mode of road transportation in Table 2.1.

Table 2.1: Vehicle Quantity and GHG Emissions by Mode of Road Transportation, 2000-2007

Year	Motorcycle		Car		Bus		Truck	
	Units	Tonnes CO_2	Units	Tonnes CO_2	Units	Tonnes CO_2	Units	Tonnes CO_2
2000	13,563,020	6,034,691	3,038,913	14,528,401	666,280	5,461,729	1,707,134	14,227,982
2001	15,275,070	6,796,446	3,261,807	15,594,010	687,770	5,637,890	1,759,547	14,664,814
2002	17,002,140	7,564,883	3,403,433	16,271,094	714,222	5,854,726	1,865,398	15,547,021
2003	19,976,380	8,888,233	3,885,228	18,574,454	798,079	6,542,131	2,047,022	17,060,753
2004	23,055,830	10,258,395	4,464,281	21,342,784	933,199	7,649,757	2,315,779	19,300,689
2005	28,556,500	12,705,847	5,494,034	26,265,815	1,184,918	9,713,185	2,920,828	24,343,425
2006	31,463,480	13,999,271	5,716,421	27,329,000	1,186,479	9,725,981	3,015,784	25,134,828
2007	34,094,730	15,170,011	5,992,350	28,648,158	1,188,416	9,741,860	3,133,602	26,116,774

Source: Indonesian Police, Director General of Land Transportation, Automotive and Motorcycle Manufacturers' Association

The share, each mode of road transportation contributed to the total number of vehicles in Indonesia in 2007, is depicted in Figure 2.5.

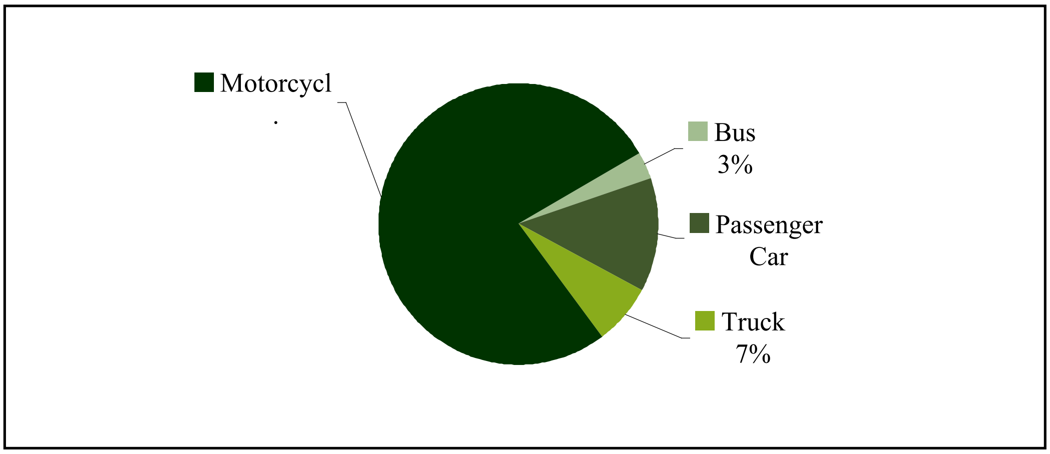


Figure 2.5: Share of each Mode of Road Transportation from total Vehicle Quantity, 2007

The share, each mode of road transportation contributed to the total amount of CO_2 emissions from road transportation in Indonesia in 2007, is depicted Figure 2.6.

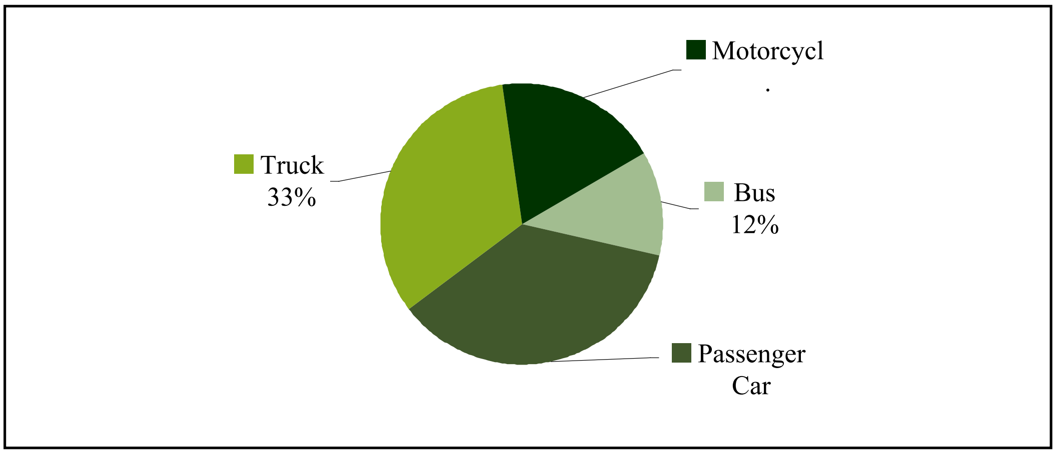
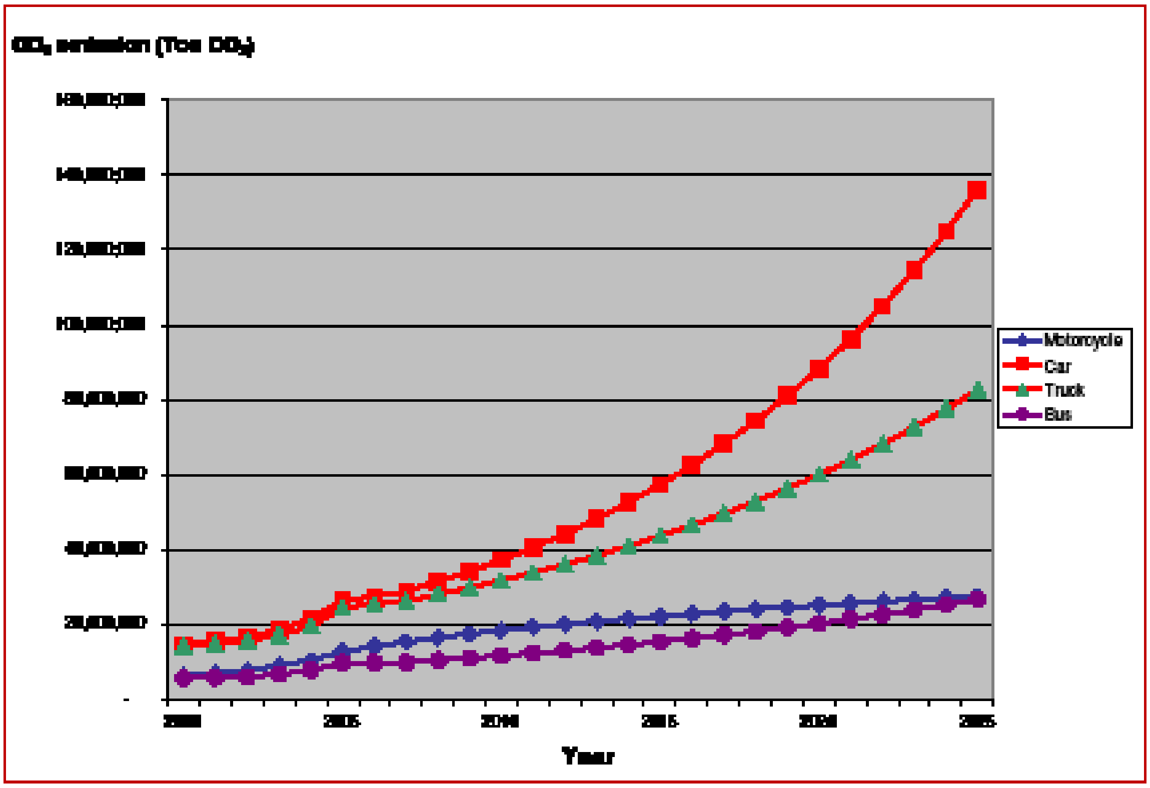


Figure 2.6: GHG Emissions by Mode of Road Transportation, 2007

Projections of CO_2 emissions by mode of road transportation are presented in Figure 2.8 for 2000 – 2025. It can be seen, that cars emit the highest quantity of CO_2 compared to other vehicles, because they consume larger amounts of fuel. On the contrary, even though motorcycle numbers are the highest compared to other vehicles, total CO_2 emissions from motorcycles are relatively low. Thus it is important to pay more attention to car technology to reduce CO_2 emissions from road transportation.



Note: Data table in appendix

Figure 2.8: Projected GHG Emissions by Mode of Road Transportation, 2000-2025

2.4.2. Greenhouse Gas Emissions Mitigation Scenario

Based on international experiences and the availability of technology, proposed options to reduce GHG emitted by the transportation sector are as follows:

- *Improve fuel efficiency on current vehicles*
  Improving fuel efficiency will not only reduce operational costs, but it will also reduce GHG emissions per km traveled. Vehicles being fuel-efficient are mostly new vehicles.
- *Introduce new vehicle concepts having lower/no GHG emissions*
  New vehicle concepts such as hybrid cars and fuel cell cars usually have lower GHG emissions. In the case of electric cars, the GHG emissions are zero.
- *Substitute gasoline and diesel fuel by fuels with a lower carbon content*
  Substituting gasoline and diesel fuel for passenger cars, buses and trucks by fuels with a lower carbon content such as unleaded gasoline and bio-diesel, which would significantly reduce emissions
- *Shift to low emission travel modes*
  Shifting to lower emission travel modes, such as public transportation, will reduce the GHG emissions per passenger, compared to traveling in private cars
- *Reduce travel*
  Reducing distance of travel, especially unnecessary travel, is the easiest way to reduce GHG emissions. There are no costs and no emissions.

Projected GHG emissions from the road transportation sector will be discussed according to the type of the vehicle, namely: cars, motorcycles, buses, and trucks. Please note that the term "motorcycles" in

Indonesia is equivalent to “motorbikes” in European terms.

There are two kinds of activities to reduce CO_2 emissions from the transportation sector:

- Adopt/Adapt advanced vehicle technologies with less/no CO_2 emissions, and
- Improve transportation management, including advanced transportation control and development of mass rapid transit systems.

For passenger cars, hybrid vehicle technology is proposed to reduce CO_2 emissions, while for buses and trucks, bi-fuel vehicles, which run on either gasoline/diesel or CNG, are considered as options for reducing CO_2 emissions. For all vehicles, including motorcycles, regular improvements in engine efficiency by auto manufacturers are aimed for reducing total fuel consumption in Indonesia by 1% per year. Improvement of transportation management systems, including the application of an Intelligent Transportation System (ITS) have to be undertaken to achieve a reduction of total fuel consumption from road transportation by 15% per year.

A reduction of CO_2 emissions from motorcycles through the improvement of engine efficiency (“advanced engine” - AE) and transportation demand management (TDM)/ Intelligent Transportation System (ITS), is shown in Figure 2.9. The BAU scenario describes the use of a conventional motor, while the AE scenario depicts the impact of using an advanced engine. The TDM scenario assumes the introduction/ improvement of a transportation management system for conventional engines (CE). The TDM+AE scenario is a combination of TDM and AE. It is optimistically predicted, that CO_2 emissions from road transportation by motorcycles can be reduced by 12.8% in 2025.

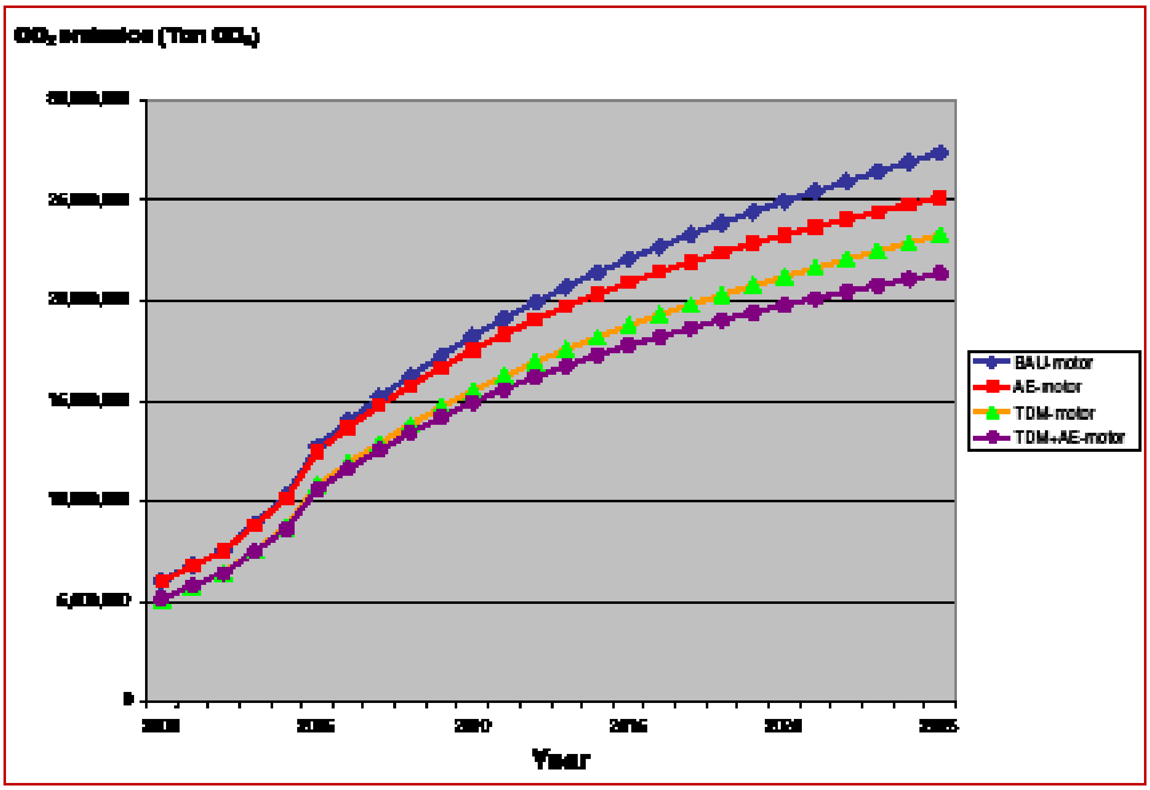


Figure 2.9: Potential GHG Emissions Reduction from Road Transportation by Motorcycle (Different Scenarios)

Plans to reduce CO_2 emissions from cars will be achieved mainly by using hybrid vehicles. If 50% and 100% of new cars are hybrids by 2008 and 2015, respectively, a CO_2 emissions reduction as depicted in Figure 2.10 can be achieved. As before, the BAU scenario describes the use of a conventional engine, while the AE scenario depicts the impact of using an advanced engine (e.g. hybrid -vehicle). The TDM scenario assumes the improvement of the transportation management system for BAU engines. The TDM+AE scenario is a combination of TDM and AE. By 2025, the implementation of the afore-mentioned scenarios could reduce CO_2 emissions from road transportation by cars by 36.1%.

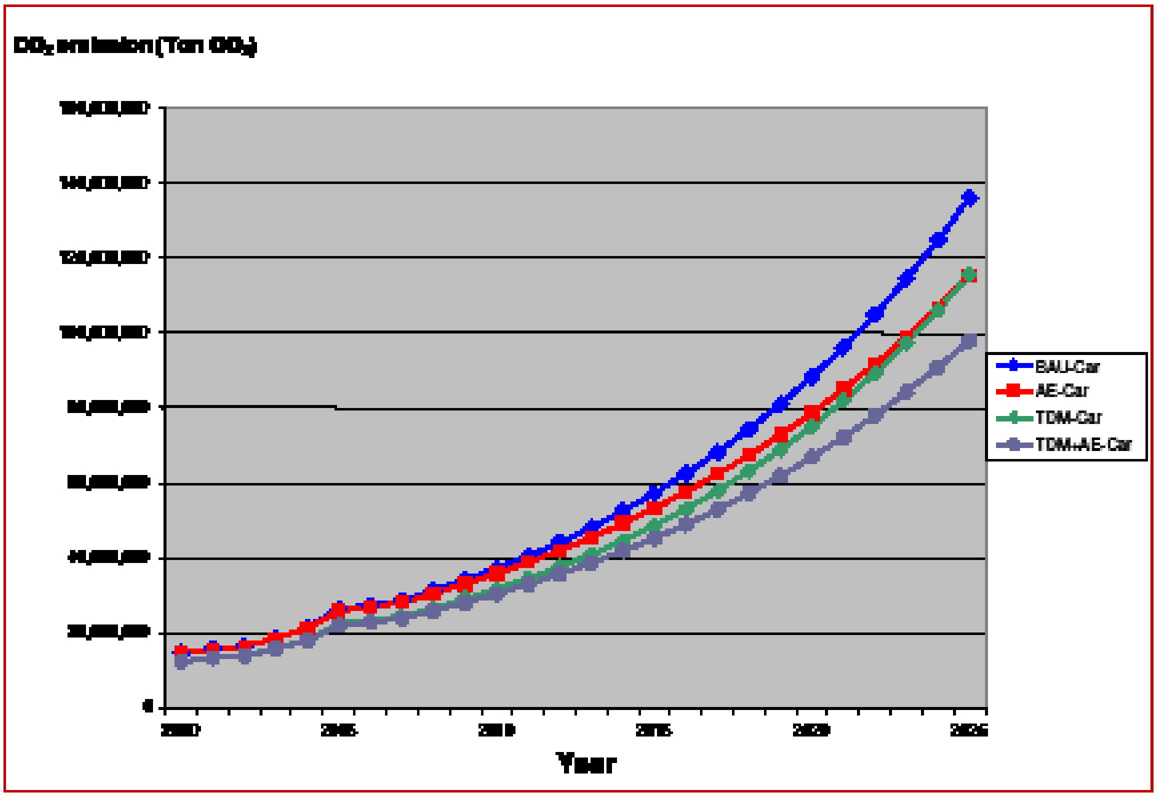


Figure 2.10: Potential GHG Emissions Reduction from Road Transportation by Passenger Car (Different Scenarios)

For buses and trucks, the plan to reduce CO_2 emissions involves the use of bi-fuel vehicles, which can run on gasoline/diesel or CNG. An introduction of such bi-fuel buses and trucks in 2008 would lead to a reduction of CO_2 emissions from road transportation by these vehicles, as can be seen in the following figures. The notation of scenarios in Figure 2.12 and Figure 2.13 are the same as before. By 2025, total CO_2 emissions reduction from road transportation by buses and trucks is predicted to reach 29.4% and 25.2%, respectively.

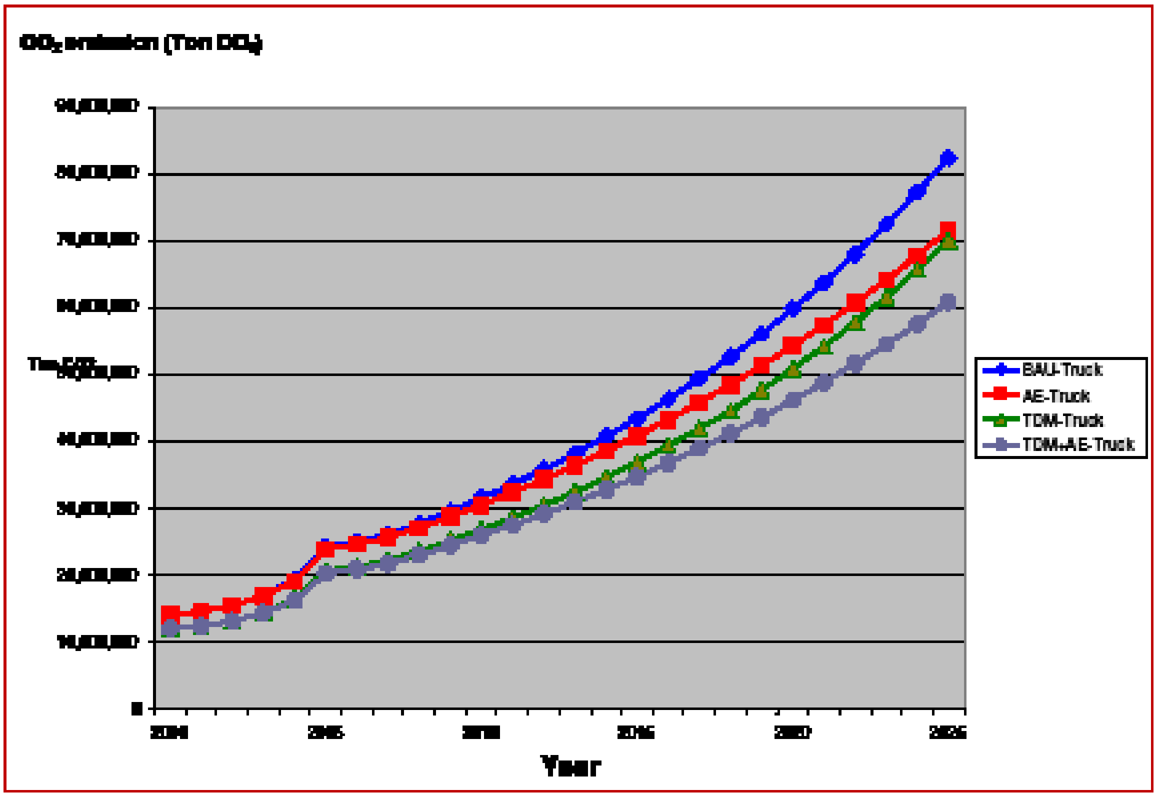


Figure 2.11: Potential GHG Emissions Reduction from Road Transportation by Bus (Different Scenarios)

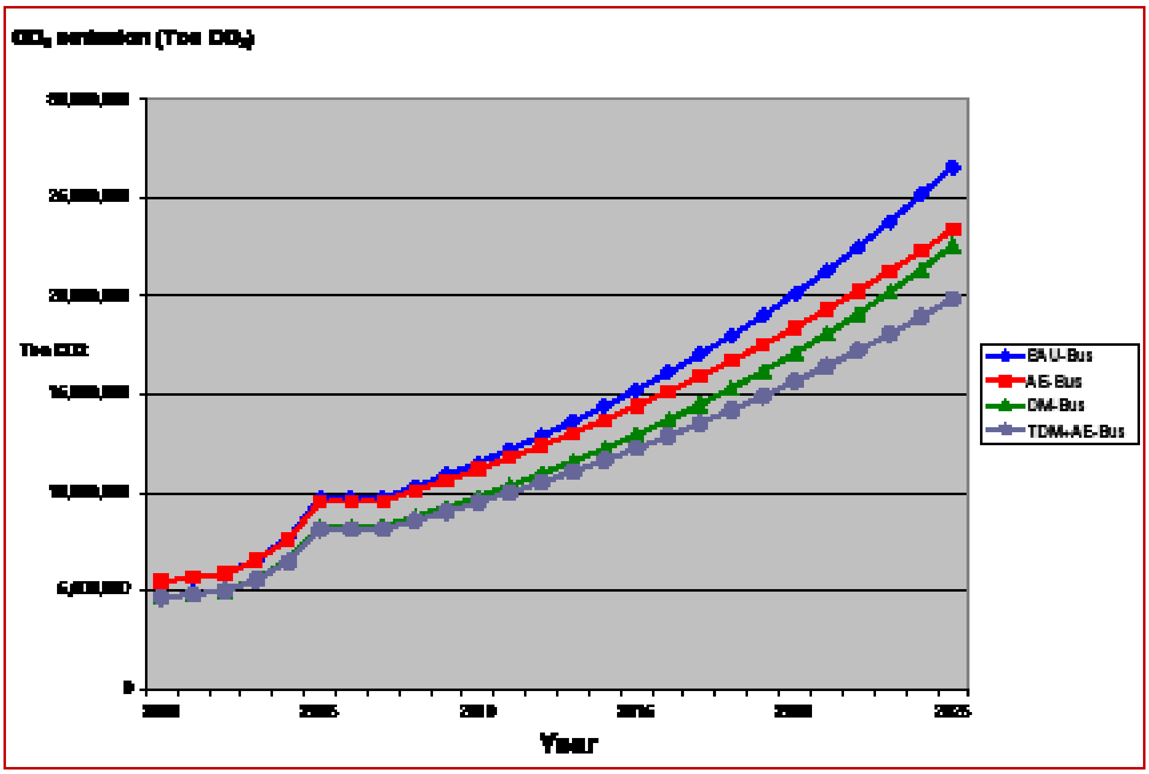


Figure 2.12: Potential GHG Emissions Reduction from Road Transportation by Truck (Different Scenarios)

Total CO_2 emissions reduction for all vehicles used for road transportation can be calculated by using the following equation:

$$R_T = \frac{\sum_a R_a}{E_T}$$

Where ER_T equals the total CO_2 emissions reduction through the above-mentioned measures for different transportation modes. ER_a describes the CO_2 emission reduction from each mode of road transportation. And E_T is the total amount of CO_2 emissions. By adopting the described environmentally sound technologies, total CO_2 emission reduction from road transportation could be up to 30%.

2.4.3. Contribution to Development Objectives

CO_2 emissions reduction contributes to development objectives in three ways:

- Creating development benefits,
- Creating implementation potential,
- Contributing to climate change response goals.

Development benefits involve job creation, capacity building (e.g. production, know-how), economic structure change (e.g. change to more export oriented), and transportation security.

Implementation potentials include marginal costs, commercial readiness, technology availability and applicability.

Contribution to climate change response goals means the GHG emissions reduction potential (enhancement of CO_2 sinks), indirect effect on emission reduction of other air pollutants and conservation of energy.

2.4.4. Available Options for the Future

In anticipating the increase of GHG emissions caused by the transportation sector, it is the right time to ~~undertake the transfer of such technologies, which potentially reduce GHG emissions. For the transfer~~ of environmentally sound technologies both the superiority and inferiority of new technologies to be applied in Indonesia must be considered. New technologies may offer significant advantages over the old ones, but their introduction and use require careful planning. Further assessments will be necessary in order to define the best strategies to implement environmentally sound technologies.

The application of environmentally sound technologies and measures in the transportation sector does not always mean the adoption of advanced technologies only. There are several means of transportation, which emit only a low amount of GHG, and also other measures to be conducted for the abatement of GHG emissions in the transportation sector. Among these measures are an efficient traffic management system and the encouragement of people to save energy, through the implementation of economic fuel use principles.

However, the application of advanced technologies has enormous potential to improve fuel efficiency. Only 15% of the fuel's energy in a vehicle's tank is used to move the car down the road or to operate accessories like air- conditioning or power steering. The rest of the energy is lost. Even modern internal combustion engines convert only one third of the energy of the fuel into useful work, while the rest is lost. The further development of vehicle technologies not only aims at increasing the speed and the capacity of the car, but also leads to direct efficient and environmentally friendly vehicles. So far, zero- and low-emission vehicles, using alternative fuels like solar energy, electric power, fuel cell, hybrid electric, ethanol, methanol, CNG and propane, have been developed for the market.

Considering the application of alternative new technologies for GHG emissions mitigation, attention should be paid to some alternative measures, which can potentially reduce GHG emissions from road transportation too. Among these are:

- Strengthen regulations on vehicle emissions and fuel economy standards;
- Introduce traffic systems with a minimal impact on the environment;
- Re-design communities to encourage walking, biking and using mass rapid transport systems (public transport);
- Encourage tele-commuting and similar trip reduction programs;
- Provide incentives to promote eco-driving;
- Introduce and spread the use of low-emission, fuel-efficient vehicles;
- Develop a transportation infrastructure for hubs such as airports, sea ports, roadside terminals and stations, which would function as sinks by creating small forests around the hubs.

3. TECHNOLOGY CRITERIA AND OPTIONS

3.1. Selection Criteria for Technology Assessment

The selection of technologies is based on general and specific-selection criteria.

3.1.1. General Criteria

The list of general criteria below is in accordance with national interests and policies for technology transfer:

Table 3.1: General Criteria for Technology Selection

General criteria	Sub-Criteria
a. Conformity with national regulation and policy	• Food security (FS) • Natural resource security (NR) • Energy security (ES) • Incentive for participation (IP)
b. Institutional and human development	• Capacity building (production & know how) (CB)
c. Technology effectiveness	• Reliability of technology (RT) • Easiness of wider use of technology, including local contribution support of technology application (ET)
d. Environmental effectiveness	• Greenhouse gas emissions reduction (GR) • Improvement of local environmental quality (LE)
e. Economic efficiency and cost effectiveness	• Capital and operational costs relative to alternatives (COC) • Commercial availability (market) (CA)

3.1.2. Specific Criteria

Specific selection criteria reflect the priorities and situation of the transportation sector as listed below:

Table 3.2: Specific Criteria for Technology Selection

Specific Criteria	Sub-Criteria
a. Consistency with national policy & target and specific local situation	• Relevant to existing energy policy & target (EP) • Utilization of local energy resources (LER)
b. Economics and cost-effectives of technology	• Total capital cost (TC) • Internal Rate of Return (IRR) • Payback period (PR) • Abatement cost (AC)
c. Technology development	• Advance but proven technology (AD) • Possibility for local manufacturing & production (PLB)
d. Social acceptability	• Good impact for socio-economic development (LED)

3.2. Technology Options

A GHG emissions mitigation scenario is launched through the introduction of technologies, systems and measures. Note that GHG emissions mitigation in the transportation sector can be achieved not only through the implementation of certain technologies, but also through so called systems and measures. The list of technologies, systems and/or measures and their explanations are as follows:

A. Vehicle Technology

A.1. *Lightweight Material*: A 10% weight reduction from a vehicle's total weight, can improve fuel economy by 4 – 8%, depending on changes in vehicle size and whether or not the engine is down-sized. There are several ways to reduce vehicle weight including switching to high strength steels (HSS), replacing steel by lighter materials such as aluminum (Al), Magnesium (Mg), and plastics, evolution of lighter design concepts and forming technologies.

A.2. *Aerodynamic Improvement*: Improvements have been made in the aerodynamic performance of vehicles over the past decade, but substantial additional improvements are possible. Improvement in aerodynamic performance offers important gains for vehicles operating at higher speeds, e.g. long-distance trucks and light-duty vehicles operating outside congested urban areas. For example, a 10% reduction in the co-efficient of drag (C_D) of a medium sized passenger car would yield only a 1% reduction in average vehicle forces in the city (with 31.4 km/h average speed), whereas the same drag reduction on the highway (with 77.2 km/h average speed) would yield about 4% reduction in the average forces. These reductions in vehicle forces translate reasonably well into similar reductions in fuel consumption for most vehicles. Variations in engine efficiency with vehicle force may negate some of the benefits from drag reduction, unless engine power and gearing are adjusted to take advantage of the reduction, in terms of fuel.

A.3. *Econometers and Cruise Control:* Econometers permit constant evaluation of the vehicle's fuel efficiency level. An econometer on the car dashboard has two liquid crystal displays (LCDs), the first displaying speed (knots), fuel consumption (liter/hour), and average consumption (liter/hour), while the 2^{nd} LCD displays total distance (1/10 mile), total consumption (liters), and an efficiency factor. Cruise control (sometimes known as speed control or auto-cruise) is a system that automatically controls the rate of motion of a motor vehicle. The driver sets the speed and the system will take over the throttle of the car, to maintain the same speed. By having econometers and cruise control in the car, bus or truck, it is a lot easier to manage fuel efficiency.

A.4. *Fuel Cell Technology*: A fuel cell produces electricity directly from the reaction of hydrogen and oxygen. The only by-product is water. A fuel cell vehicle utilizes the electricity produced by the fuel cell to power motors at the vehicle's wheels. Fuel-cell vehicles are similar to battery-electric vehicles, in that they are powered by electricity, but they do not have to be recharged like battery vehicles. A fuel cell vehicle has an on-board storage tank, which could be filled at hydrogen filling stations, similar to gasoline vehicle refueling. Vehicles, which run on pure hydrogen, are true zero-emission vehicles. Some vehicle manufacturers, however, are developing fuel cell vehicles, which use hydrocarbons, such as methanol (a liquid fuel derived most commonly from natural gas) or gasoline. Using hydrocarbons to operate fuel cell vehicles would result in tail-pipe air pollutant emissions, reducing fuel cells' overall environmental benefits.

A.5. Improved Exhaust Treatment: Realized in a catalyst trap, exhaust gas re-circulation (EGR), intake and exhaust systems of heavy-duty vehicles and/ or vehicles with limited diesel applications. Technical feasibility: continuation after treatment improvement, thus allowing continued use of the internal combustion engine (ICE). The application of EGR shows a slight decrease for significant NO_x reduction and increased back-pressure reduces efficiency in diesels. The environmental impact is estimated with: up to 97% control of HC and CO, up to 87% control of Ox, and up to 85% control for particulate. Market potential time frame: 0 – 5 years.

A.6. Improved Combustion: Realized in ceramic components, ignition systems, flow- dynamic variable valves and turbine engines improved combustion offers incremental improvements. Technical feasibility: a good variety and availability of technology, should be integrated with current ICE with 5 – 10% engine-efficiency gains and also reduces NO_x, particulate and CO_2. Market potential time frame: 0 – 10 years.

A.7. Fast Warm-Up: Realized in thin walled engines, start/stop, with flywheel storage and incremental improvements. Technical feasibility: transient time decreased by 50%. Has < 10% average reduction, and <30% reduction in first 60 – 120 seconds. Market potential timeframe: 0 – 10 years.

A.8. Drag and Rolling Resistance Reduction: Realized in drag coefficient reduction, reduced rolling resistance, and reduced bearings friction. There is a commercial potential for improvement in low-friction bearings and lubrications. Low-friction tyres to be tested. Technical feasibility: Continuation of improvements, dependent on material properties & cost of manufacture. Study on basic physics. Has a speed-sensitive benefit, gains of 1 – 5% possible. Reduction of all emissions, in proportion to efficiency gains. Market potential time frame: 0 – 10 years.

A.9. Structural Weight: Used in light structures, bonded/composite structures, and light power-trains. Commercial/demonstrated bonded structures in limited use and composite materials in most vehicles. Technical feasibility: continuation of improvements, limited by material properties and the relative cost of manufactures. With 0.2 – 0.4% gain for every 1% of weight reduction. Reduction of all emissions, in proportion to efficiency gains, has greater effect on acceleration emissions (urban traffic) as vehicle inertia is diminished. Market potential: 0 – 10 years.

A.10. Continuously Variable Transmissions (CVT): Realized in drive-lines and suspensions, electronic shift, and multi-step lock-up. Commercial/demonstrated CVT available. High power CVT in prototype Lock-up and electronic control. Technical feasibility: CVT/IVT (Infinitely Variable Transmission) has a widespread use in future years. An Hybrid power-train is feasible' with CVT/IVT registering a 10 – 15% gain over manual while CVT or IVT electronic drives could further increase this conversion efficiency. Reduction of all emissions, in proportion to efficiency gains, engine operations optimized and decreasing emissions even more than efficiency improvement. Market potential time frame: 0 – 10 years.

A.11. On-board Electronic Control: For constant speed drive and efficient components. Demonstrated as constant speed systems. Technical feasibility: highly feasible for constant speed, and high efficiency accessory systems, having a 5% efficiency gain. Emission reductions facilitated by on-board electronic controls and sensors. Market potential time frame: 0 – 10 years.

A.12. Shift Indicator Light: The car's shift indicator light (S.I.L.) is a device designed to help the driver get even better gas mileage from the car. Studies have shown that an optimal fuel economy is obtained by shifting gears at low engine revolutions per minute and high relative engine load. The car's S.I.L. is calibrated to show the driver when to shift for improved mileage- *without sacrificing smooth acceleration.* The use of the S.I.L. is simple. One has to shift to next higher gear as soon as the light comes on. One may find, after using the S.I.L. for some time, that his/her natural shifting rhythm will adapt to the S.I.L.'s suggestion. Some drivers may even shift before the light comes on. Obviously, there will be times when one needs to shift later than the light would indicate (for example, when climbing hills or trailer towing). Using the light regularly, however, should result in a mileage improvement of 6% or more, depending on how one normally drives.

A.13. Dual Cooling Circuit: A hydraulic circuit for controlling the application of pressurized cooling fluid to the clutches of a dual clutch transmission, including a cooling unit in fluid communication with a source of the pressurized cooling fluid and adapted to exchange heat from the cooling fluid with another media. The circuit also includes at least one regulator in fluid communication with the source of the pressurized cooling fluid and separately in fluid communication with the cooling unit, and with the clutches. The regulator is adapted to provide the cooling fluid to the clutches. The circuit further includes at least one control actuator, adapted to selectively control the regulator. This can provide a first variable predetermined amount of cooling fluid from the cooling unit to the clutches, as primary cooling, and a second variable predetermined amount of cooling fluid, from the source to the clutches, thereby supplementing the cooling fluid from the cooling unit.

A.14. Tire Inflation Monitor: A Tire Pressure Monitoring System (TPMS) is an electronic system designed to monitor the air pressure inside all the pneumatic tyres on automobiles, airplane undercarriages, straddlelift carriers, forklifts and other vehicles. The system is also sometimes referred to as a Tire Pressure Indication System (TPIS), which reports realtime tire pressure information to the driver of a vehicle - either via a gauge, a picto-gram display, or a simple low pressure warning light. TPMS are being used on more and more new vehicles. Low tires are potentially dangerous, especially if a vehicle is heavily loaded and traveling at high speeds during hot weather. A low tire, under these conditions, is a blowout waiting to happen. The inflation pressure of the tires should be checked regularly, but many motorists let it slide. That is why TPMS are coming into use. Tires are designed to operate within a certain pressure range. The recommended inflation pressure can usually be found in the vehicle's manual and on a decal, which may be located in the glove box or door jam. The recommended inflation pressure is designed to give the best combination of ride comfort, load carrying capacity and rolling resistance. The maximum cold inflation pressure on the sidewall of a tire is NOT the recommended inflation pressure. It is a maximum limit for the tire only. The recommended inflation pressure for most passenger car tires is 32 to 34psi (cold).

A.15. Low Rolling Resistance Circuit: To ensure mobility is environmentally-friendly and possible, tires need to have not only low rolling resistance, but also low rolling noise. This characteristic is measured on two tracks located at some distance from each other, whereby the tire and road noise can be determined. Exterior and interior noise is measured on standardized surfaces. The vehicle's engine, transmission and drives are encapsulated for the test, so that only the rolling noise is measured. These tracks allow rolling noise to be measured on tires for cars as well as for trucks and buses.

A.16. Efficient Alternators: The electrical demand in modern trucks, buses and automobiles has dramatically increased as mechatronic electric motor driven devices replace less efficient mechanical and hydraulic subsystems. Radiator cooling fans, water pumps, and air conditioning compressors reduce parasitic loads and increase fuel economy; while mandated safety lighting levels are increased for on-road trucks; and the demand for evermore electric motor driven safety and luxury accessories continues. Trucks buses and specialty vehicles emanating from automobile manufacturers require on-board vehicle alternators/generators with increased power generating capability at both operating and idling speeds to supply the needed power. To increase fuel economy, more efficient alternators are required.

A.17. 0W-5W/20 Oils: It is a fully synthetic oil that will keep the engine running smoothly in a relatively long period of time, causing a fuel efficient operation of car.

A.18. Electronic Water Pump: Electronic Water Pump (EWP) controllers are used for optimum temperature control. The EWP controller has a microprocessor, which will supply the pump with the voltage that will run it at exactly the right flow rate to maintain the set engine temperature. Set the temperature on the controller for maximum power and fuel efficiency. With the ignition on, the EWP will run on after a hot engine shut down, eliminating heat soak. This option requires the removal of the thermostat and either the mechanical pump impeller from the pump shaft, or the bypass of the water pump pulley from the belt set-up, using a shorter belt.

A.19. Heat Battery: Most electricity in cars is used for heating - the air, the water and the human comfort zone. There is a heat storage tank called Heat Battery that can cut heat-energy usage by 50-70%. Successfully used in Germany, this is is currently being launched in the U.K.

A.20. *Efficient AC Systems* or Mobil Air Conditioning (MAC) Systems contribute to GHG emissions in two ways: by direct emissions from leakage of refrigerants and indirect emissions from fuel consumption. Since 1990, significant progress has been made in limiting refrigerant emissions due to the implementation of the Montreal Protocol. The rapid switch from CFC-12 (global warming potential of 8100) to HFC-134a (global warming potential of 1200) has led to a decrease in the CO_2-eq emissions from 850MtCO_2-eq in 1990 to 609MtCO_2-eq in 2003, despite the continued growth of the MAC system fleet (IPCC, 2005). Refrigerant emissions can be decreased by using new refrigerants with a much lower global warming potential, such as HFC-152a or CO_2, restricting refrigerant sales to certified service professionals, as well as better servicing and disposal practices. Although the feasibility of CO_2 refrigerant has been demonstrated, a number of technical details have still to be overcome. Since the energy consumption for MAC is estimated to be 2.5-2.7% of total vehicle energy consumption, a number of solutions have to be developed, in order to limit the energy consumption of MAC. This includes such improvements of the design of MAC systems, the control systems and airflow management.

A.21. *Idling Stop/Start (42V System)*: To meet increasing electrical power demands, auto-makers are moving to increase vehicle battery voltage from today's 14V to approximately 42V. Next generation cars will have even more electronics and require a power source with an output of more than 3kW, the limit of today's 14V systems. A 42V system will deliver around 8kW and allow better management of the higher power requirements. A 42V system sets the stage for advanced technologies that will allow a switch from mechanical belt-driven systems to electrically powered ones. Possibilities include electric power steering, electro-mechanical brakes, electrical heating-, ventilation and air-conditioning systems, electro-magnetic valve trains, integrated starter-generators and electronic ride control systems.

A.22. Heat Pump for AC: The heat pump serves as an air conditioner by absorbing heat from indoor air and pumping it outdoors. The heat pump contains an indoor coil, which, in turn, contains a very cold liquid refrigerant. As indoor air passes over the indoor coil, the refrigerant-cooled coil absorbs heat from the air and so quickly cools that air. The cooled air cannot hold as much moisture as it did at a higher temperature and, thus, the excess moisture condenses on the outside of the coil, resulting in the de-humidification of the air. The cooled, de-humidified air is then forced (by a fan) into the duct system, which, in turn, circulates it throughout the building.

A.23. *Adaptive Cruise Control (ACC)*: Adaptive Cruise Control is an expansion of the existing cruise control systems, which, in general, maintains vehicle speed through a link in the vehicle's power train. The potential key benefits of ACC systems include the following:

- Reduction in accident rates for vehicles fitted with collision avoidance type systems,
- Reduction in driver fatigue,
- Increase in fuel efficiency due to very gradual speed increase/decrease in traffic, and
- Interconnection to more advanced future systems.

A.24. *Gasoline Direct Injection (GDI)*: is the latest variant of fuel injection employed in modern two-stroke and four-stroke petrol engines. The petrol/gasoline is highly pressurized and injected via a common fuel line directly into the combustion chamber of each cylinder, as opposed to conventional multi-point fuel injection that occurs in the intake tract or the cylinder port. Gasoline direct injection enables stratified fuel charge (ultra lean burn) combustion for improved fuel efficiency and reduced emission levels at low load. The major advantages of a GDI engine are increased fuel efficiency and high power output. In addition, the cooling effect of the injected fuel and the more evenly dispersed mixtures allow for more aggressive ignition timing curves. Emission levels can also be more accurately controlled with the GDI system.

A.25. *6-Speed Automatic Transmission*: Compared to the 5-speed, the 6-speed automatic transmission provides:

- a reduction in fuel consumption,

- a reduction in exhaust emissions,
- improved acceleration values, and
- a reduction in noise.

A.26. No Torque Converter: A torque converter is a modified form of fluid coupling, which is used to transfer rotating power from a prime mover, such as an internal combustion engine or an electric motor, to a rotating driven load. Like a basic fluid coupling, the torque converter normally takes the place of a mechanical clutch, allowing the load to be separated from the power source. As a more advanced form of fluid coupling, however, a torque converter is able to multiply torque when there is a substantial difference between input and output rotational speed, thus providing the equivalent reduction gear.

A.27. Hybrid Vehicle without Torque Converter: A method for controlling a drive train for a hybrid vehicle is provided. The drive train has at least one internal combustion engine, a torque converter and an operational link to at least one drivable axle, an electrical energy store, and an electrical machine, which is usable as a generator, for charging the electrical energy store during a recuperation operation. The electrical machine is provided on the pump wheel and the operational link is being provided on the turbine wheel of the torque converter. A torque is introduced from the drivable axle, via the operational link and through the turbine.

B. Alternative Fuel

B.1. Cellulosic Ethanol: Cellulosic ethanol is a bio-fuel produced from wood, wood-chips, grass or other by-products of lawn and tree maintenance, from corn stover, switch-grass, miscanthus and other non-edible parts of plants, more precisely from the ligno-cellulose these plants contain. Ligno-Cellulose is a structural material, which is the largest contributor to the mass of plants. It is composed mainly of cellulose, hemi-cellulose and lignin. Production of ethanol from ligno-cellulose has the advantage of using abundant and diverse raw materials, which is an advantage compared to limited sources like corn and cane-sugars. On the other hand it requires a greater amount of processing, to make the sugar monomers available to the micro-organisms that are typically used to produce ethanol by fermentation. Switch-grass and miscanthus are the major bio-mass materials being studied today, due to their high productivity per acre. Cellulose, however, is contained in nearly every natural, free-growing plant, tree, and bush, in meadows, forests, and fields all over the world, without agricultural effort or cost needed to make it grow. According to the U.S. Department of Energy studies, conducted by the Argonne Laboratories of the University of Chicago, one of the benefits of cellulosic ethanol is that it reduces GHG emissions by 85% over re-formulated gasoline. For comparison: Starch ethanol (e.g., from corn) production mostly uses natural gas to provide energy for the production process and may not reduce GHG emissions at all - depending on how the starch-based feedstock is produced. A study by Nobel Prize winner Paul Crutzen found ethanol produced from corn and sugarcane had a "net climate warming" effect, when compared to oil (Wikipedia, 2008).

B.2. Bio-diesel: Bio-diesel refers to a non-petroleum-based diesel fuel consisting of long chain alkyl (methyl, propyl or ethyl) esters and is produced during the transesterification of vegetable oil or animal fat (tallow). It can be used (alone or blended with conventional petrodiesel) in un-modified diesel-engine vehicles. Bio-diesel has to be distinguished from straight vegetable oil (SVO), pure plant oil (PPO) and used vegetable oil (UVO) - sometimes referred to as waste vegetable oil (WVO), which can be used as fuels in *converted* diesel vehicles (Wikipedia, 2008).

B.3. Ethanol from Sugar Cane: More than half of the world's ethanol is produced from sugar and sugar by-products, with Brazil being, by far, the world leader. Currently, there is no commercial production of ethanol from sugar cane or sugar beets in the United States, where 97% of ethanol is produced from corn. Technically, the process of producing ethanol from sugar is simpler than converting corn into ethanol. The conversion of sugar requires only a yeast fermentation process, whereas the conversion from corn requires additional cooking and the application of enzymes. The energy requirement for converting sugar into ethanol is about half of that for corn. However, the technology and direct energy costs are two of several factors, which determine the feasibility of ethanol production. Other factors include relative production costs (including feedstock), conversion rates, proximity to processing facilities, alternative prices and government policies, facility construction and processing costs. As other countries have shown that it can be economically feasible to produce ethanol from sugar - and other new sources for feedstock are also researched - interest in the United States in ethanol production from sugar has increased.

B.4. Compressed Natural Gas (CNG): Compressed Natural Gas is a fossil fuel substitute for gasoline (petrol), diesel, or propane fuel. Although its combustion does produce greenhouse gases, it is a less carbon intense alternative to those fuels, and it is much safer than other fuels in the event of a spill (natural gas is lighter than air, but disperses quickly when released). CNG is made by compressing natural gas (which is mainly composed of methane), to less than 1% of its volume at standard atmospheric pressure. It is stored and distributed in hard containers, at a normal pressure of 200 – 220bar (2,900 – 3,200psi), usually in cylindrical or spherical shapes. CNG's volumetric energy density is estimated to be 42% of LNG's (because it is not liquefied) and 25% of diesel's. CNG is used in traditional gasoline internal combustion engine cars, which have been converted into bi-fuel vehicles (gasoline/CNG). Natural gas vehicles are increasingly popular in Europe and South America. Due to rising fuel prices and environmental concerns, CNG is starting to be used also in light-duty passenger vehicles and pickup trucks, medium-duty delivery trucks, transit and school buses, and trains (Wikipedia, 2008).

B.5. Liquefied Natural Gas (LNG): Liquefied natural gas or LNG is natural gas (primarily methane), which has been converted to a liquid form for the ease of storage or transport. LNG takes up about 1/600th the volume of natural gas at a stove burner tip. It is odorless, colorless, non-toxic and non-corrosive. Hazards include flammability, freezing and asphyxia, if inhaled. The liquefaction process involves removal of certain components, such as dust, helium, water and heavy hydrocarbons, which could cause difficulty downstream. The natural gas is then condensed into a liquid at close to atmospheric pressure (maximum transport pressure set around 25kPa or 3.6psi) by cooling it to approximately −163°C (−260°F). The reduction in volume makes it much more cost-efficient to transport LNG over long distances, where pipelines do not exist. Where moving natural gas by pipelines is not possible or economical, LNG can be transported by specially designed cryogenic sea vessels (LNG carriers) or cryogenic road tankers. The energy density of LNG is 60% lower than that of diesel fuel (Wikipedia, 2008).

B.6. Liquefied Petroleum Gas (LPG): Liquefied petroleum gas (also called LPG, GPL, LP Gas or autogas) is a mixture of hydrocarbon gases, used as a fuel in heating appliances and vehicles. It replaces more and more chloro-fluorocarbons as an aerosol propellant and a refrigerant, to reduce damage to the ozone layer. Varieties of LPG bought and sold, include mixes that are primarily propane, mixes that are primarily butane, and the more common mixes, including both propane (60%) and butane (40%), depending on the season: in winter more propane, in summer more butane. Propylene and butylenes are usually also present in small concentrations. A powerful odorant, ethanethol, is added so that leaks can be detected easily. The international standard is EN-589. LPG is usually derived from fossil fuel sources, being manufactured during the refining of crude oil or extracted from oil or gas streams, as they emerge from the ground (Wikipedia, 2008).

C. Transport Demand Management (TDM)

C.1. Improved Public Transport: The Agency for the Assessment and Application of Technology (BPPT) has investigated whether increasing the frequency of buses and trains would attract a sufficient number of extra passengers, to make such efforts economically and environmentally viable. The calculations show that making specific efforts to reduce traveling time on long journeys, would be environmentally beneficial.

The calculations are based on data from the Ministry of Transport's regular studies of transport habits, coupled with model calculations of travel time. The BPPT scientists conclude that a general doubling of bus and train frequencies will be neither economically nor environmentally viable. Instead, it is proposed that the following strategies should be followed:

- Improvement of conditions for long journeys, i.e. trains and regional bus routes, especially in combination with increased speed. Improvements would be viable if the increased frequency is offset by the introduction of shorter trains. The most significant improvement for long journeys would be better co-ordination between the various buses and trains.
- Efforts should be made to improve the frequency of urban buses, specifically aimed at achieving better coordination with regional traffic.
- The introduction of smaller buses would be environmentally beneficial in cases where the service is currently poor, e.g. in rural areas. The introduction of upon-request services etc. would allow greater adaptation to customer demand and result in time savings, with less effort.
- Improving the frequency of public transport in the Greater Jakarta area is hardly likely to be environmentally viable. The most important means for achieving environmental benefits would be to reduce the travel time of buses and trains.

C.2. Intelligent Transportation Systems (ITS): The term intelligent transportation system refers to efforts to add information and communication technology to the transport infrastructure and vehicles to manage factors, which typically correlate with each other: vehicle loads and routes, to improve safety and reduce vehicle wear, transportation times and fuel consumption. Interest in ITS raised because of problems caused by traffic congestion, which could be solved using a synergy of new information technology for simulation, real-time control, and communications networks. Traffic congestion has been increasing worldwide, as a result of increased motorization, urbanization, population growth, and changes in population density. Congestion reduces efficiency of the transportation infrastructure and increases travel time, air pollution, and fuel consumption (Wikipedia, 2008).

D. Non-motorized Measures

D.1. The Cycle Rickshaw (Becak): The cycle rickshaw, being a small-scale local means of transport, is also known by a variety of other names such as rickshaw, pedicab, bugbug, cyclo, or trishaw. Cycle rickshaws are human-powered, often used on a for hire basis, equipped with one or more seats for carrying passengers in addition to the driver. Cycle rickshaws are widely used in major cities around the world and are usually found in major urban centers, tourist attractions, and events that draw large crowds. Many cycle rickshaws have replaced less-efficient rickshaws that are pulled by a person on foot. The vehicle is powered by a driver, as one would a bicycle, though some increasingly popular configurations are equipped with an electric motor to assist the driver. The vehicle is usually a tricycle, though some quadracycle models exist and some bicycles with trailers are configured as rickshaws. The configuration of driver and passenger seats vary by design, though passenger seats are usually located above the span of the longest axle. For example, in most areas of South Asia, the passenger seat is located behind the driver on a ”delta” tricycle, while in Indonesia and Vietnam, the driver sits behind the passenger seat on a ”tadpole tricycle”. In the Philippines, the passenger seats are usually located beside the driver (Wikipedia, 2008).

D.2. Cart (Bendi / Dokar): A dokar is the jingling, horse-drawn cart found throughout the archipelago of Indonesia. The two-wheeled carts are usually brightly colored with decorative motifs and bells, and the small horses or ponies often have long tassels attached to their bridle. A typical dokar has bench seating on either side, which can comfortably fit 3 – 4 people. However, their owners try to pack in 3 – 4 families plus bags of rice and other paraphernalia.

In Java, there is the andong or delman, a horse-drawn wagon, designed to carry 6 people. In some parts of Indonesia, such as Gorontalo and Manado in northern Sulawesi, the bendi can be found, which is basically a small dokar carrying two passengers.

D.3. Bicycle: The Bike 2015 Plan is the City of Jakarta's vision to make bicycling an integral part of daily life in Jakarta. The plan recommends projects, programmes and policies for the next ten years, to encourage use of this practical, non-polluting and affordable mode of transportation.

The Bike 2015 Plan has two overall goals:

- To increase bicycle use, so that 5% of all trips, less than 5km, are by bicycle.
- To reduce the number of bicycle injuries by 50% from current levels.

The plan has eight chapters, each with a specific goal:

- Bikeway Network – Establish a bikeway network that serves all Jakarta residents and neighborhoods.
- Bicycle-friendly Streets – Make all of Jakarta's streets safe and convenient for bicycling.
- Bike Parking – Provide convenient and secure short-term and long-term bike parking throughout Jakarta.
- Transit – Provide convenient connections between bicycling and public transit.
- Education – Educate bicyclists, motorists, and the general public about bicycle safety and the benefits of bicycling.
- Marketing and Health Promotion – Increase bicycle use through targeted marketing and health promotion.
- Law Enforcement and Crash Analysis – Increase bicyclists' safety through effective law enforcement and detailed crash analyses.
- Bicycle Messengers – Expand the use of bicycle messengers; improve their workplace safety and public image (Draft, City of Jakarta Governmental Office, 2008)

D.4. Walking: In Indonesia, pedestrian walkway- and cycling improvements are usually implemented by local governments, sometimes with funding and technical support of regional or state/provincial transportation agencies. It usually begins with a pedestrian and bicycle plan to identify problems and promote projects. Implementation may require special funds, either shifting funds within existing transportation plans, a new budget allocation, or grants. It is useful to develop a multi-modal level-of-service rating systems, which accentuates the convenience and comfort of walking and cycling. *Complete Streets* means that roadways are designed to accommodate all modes, including walking and cycling. It involves street-scaping and road space reallocation in appropriate roadway projects. It can also involve field surveys to identify, where barriers exist for non-motorized travel, planning and funding to correct these problems. It often requires new relationships between different levels of the government, such as match funding and maintenance agreements between state/provincial transportation agencies and local governments.

3.3. Cost Analysis

The calculation and cost analysis will become quite complex, if all transport analyses are included. Therefore in this Transportation Sector TNA, only a number of cost analyses are introduced and proceeded only for sample calculations.

3.3.1. Vehicle Technology

The hybrid car uses a conventional internal combustion engine (gasoline or diesel) and an electric battery, which helps to decrease engine size, thus reducing fuel consumption. The car battery receives electric energy from the car itself, e.g. through the re-generation of break power when the engine is idling. The energy will be used, when the car needs additional power, e.g. accelerating or maneuvering. Power support from the battery can reduce fuel consumption significantly in some cases up to 40% compared to the fuel consumption of a conventional engine. Another benefit is, that hybrid vehicles do not need new infrastructures such as battery-charging stations.

Today's gasoline engines emit 209.5g CO_2/km in average. New vehicles in the European Union do already release lower CO_2 emissions than that, i.e. 186g CO_2/km and 160g CO_2/km in 1996 and 2005, respectively. The final target of the European Union by 2012 is to operate cars with very low emissions, i.e. 120g CO_2/km. The existing hybrid vehicle emits 80 – 116g CO_2/km.

A simple analysis of the abatement costs of passenger cars and buses is conducted by calculating annual vehicle prices (meaning vehicle prices divided by the vehicles' optimum lifetime, e.g. 5 years), annual fuel costs and GHG emissions. The abatement cost of a technology is the additional cost to be paid for this technology compared to BAU to reduce GHG emissions by one unit of CO_2. It is estimated as follows: The annual operations and maintenance costs of the old technology are subtracted from the sum of annual investment, operations and maintenance cost of the technology to be introduced and divided by the annual GHG emissions reduction to be achieved by such an implementation.

Table 3.1: Simple Abatement Cost Analysis for Hybrid Cars

Car Type	Cost (price and fuel)	CO_2 emissions	Abatement cost
	(US$/year)	(kg CO_2/year)	(US$/kg$CO_2$)
Gasoline	4,889	5,321.786	
Hybrid	7,573	3,203.405	1.260

Table 3.2: Simple Abatement Cost Analysis for bi-fuel CNG Buses

Car Type	Cost (price and fuel)	CO_2 emissions	Abatement cost
	(US$/year)	(kg CO_2/year)	(US$/kg$CO_2$)
Diesel bus	5,895	8,162.522	
CNG bus	7,454	6,177.966	0.796

3.3.2. Transport Demand Management

Transport Demand Management, especially Intelligent Transportation Systems, provides a technological solution to the problem of growing congestion in metropolitan cities. This system is applied' to control and manage traffic and the infrastructure, to achieve a safer transportation system, an improved traffic control system and the increased efficiency of transit systems and traffic infrastructure. The development of this system requires a large investment and technically skilled officials. Its benefit is the reduction of traffic congestion and an increased efficiency of energy use in the transportation sector, which will reduce GHG emissions in turn. The implementation of a ITS needs an intense assessment and careful planning to adapt to local transportation systems. General costs and benefits of this technology are shown in the following table.

Table 3.3: General Costs and Benefits from installing an Intelligent Transportation System

Technologies	Costs	Benefits	Benefits or Costs
Intelligent Transportation System	Total costs depend on the size of the system and type of technology used	• Reduce congestion, energy consumption, incident and emissions. • Increase road capacity and speed. • Improve transit customer service. • Most aspects of ITS infrastructure contribute to time savings	The total cost for ITS implementation is estimated with 978million US$[1].

The improvement of the public transport system is one of the GHG emissions mitigation measures with a potential to reduce CO_2 emissions by 30%. After an improvement the public transport system is expected to attract more people to rather use it than to drive by themselves. The general costs and benefits of improvement of public transport are described in the table below.

Table 3.4: General Costs and Benefits from improving Public Transport

Technologies	Costs	Benefits	Benefits or Costs
Improvement of public transport	Investment on building railways, operating more trains improving shelters/ stations and other infrastructure change. Transit scheduling and public awareness.	• Reduce total vehicle miles. • Reduce congestion and emissions.	Total cost for the improvements of public transport is predicted with 434.8million US$[1].

[1] Singapore spent around 125 million US$ in 1995 for Electronic Road Pricing (ERP)

4. TECHNOLOGY SELECTION

4.1. Selection Process

The process of technology selection has been undertaken by applying general and specific criteria to listed technology as mentioned before in sections 3.1.1 General Criteria and 3.1.2 Specific Criteria, with each criterion weighted according to expert judgment and additional information such as literature and projects' report.

The scoring tables can be found in the following. The numeric values are determined for each indicator, as follows:

- H: High value/ high relevance/ high impact, score: 5
- M: Medium value/ relevant/ moderate impact, score: 3
- L: Low value/ less relevant/ low impact, score: 1
- NR: Not relevant/ not applicable

Table 4.1: Transportation Sector - Technology Selection Process Using General Criteria

Measures and Technologies	General Criteria											TP
	FS	NR	ES	IP	CB	RT	ET	GR	LE	CoC	CA	
A. Vehicle Technology												
Lightweight material	NR	L	L	H	H	H	H	M	M	L	M	**32**
Aerodynamic improvement	NR	L	L	H	H	H	H	M	M	L	L	**30**
Econometers and cruise control	NR	L	L	L	L	L	L	M	L	L	M	**14**
Fuel cell technology	NR	H	H	L	M	H	L	L	H	L	M	**30**
Improved exhaust treatment	NR	L	L	H	H	L	M	H	H	L	L	**28**
Improved combustion	NR	L	L	L	L	M	L	L	L	L	M	**14**
Fast warm-up	NR	L	L	L	L	L	L	M	L	H	L	**16**
Drag and rolling resistance reduction	NR	L	L	L	L	L	L	L	L	M	L	**12**
Structural weight	NR	L	L	L	L	L	L	L	L	L	L	**10**
Continuously variable transmission	NR	L	H	M	M	H	M	H	H	M	H	**38**
On-board electronic control	NR	L	H	M	L	L	L	L	L	L	L	**16**
Shift indicator light	NR	L	L	L	L	L	L	L	L	L	L	**10**
Dual cooling circuit	NR	L	L	L	L	L	L	M	L	L	L	**12**
Tire inflation monitor	NR	L	L	L	L	M	L	L	L	M	L	**16**
Low rolling resistance circuit	NR	L	L	L	L	L	L	M	L	L	L	**14**
Efficient alternators	NR	L	L	L	L	L	L	L	L	L	L	**12**
0W-5W/20 oils	NR	L	L	L	L	M	L	L	L	H	M	**20**
Electronic water pump	NR	L	L	M	L	L	M	L	M	L	M	**16**
Heat battery	NR	L	L	L	L	L	L	L	L	L	M	**12**
Efficient AC system	NR	L	H	L	M	M	L	L	L	M	H	**24**
Idle stop/start (42V system)	NR	L	L	L	M	L	L	L	L	L	L	**12**
Heat pump for AC	NR	L	L	L	M	L	L	L	L	M	L	**14**
Adaptive cruise control	NR	L	H	L	L	H	L	L	M	M	L	**22**
Gasoline direct injection	NR	L	H	M	M	L	M	H	H	M	H	**34**
6-speed automatic transmission	NR	L	H	L	L	M	L	L	L	L	L	**16**

Measures and Technologies	General Criteria											TP
	FS	NR	ES	IP	CB	RT	ET	GR	LE	CoC	CA	
No torque converter	NR	L	L	L	L	L	L	M	L	L	M	**14**
Hybrid vehicle without torque converter	NR	L	L	L	L	L	L	M	L	L	L	**12**
B. Alternative Fuel												
Cellulosic ethanol	L	M	H	L	M	L	M	H	M	L	L	**27**
Biodiesel	L	M	H	H	H	M	H	M	M	H	H	**43**
Ethanol from sugar cane	L	M	H	H	M	M	H	M	M	L	H	**39**
Compressed natural gas	L	H	H	H	L	H	M	H	H	H	H	**45**
Liquid natural gas	L	H	H	H	L	H	M	H	H	H	H	**45**
Liquid petroleum gas	M	H	H	H	M	H	H	H	H	H	H	**51**
C. Transport Demand Management												
Improvement of public transport	NR	L	H	H	H	H	H	H	H	H	H	**46**
Intelligent transportation system	NR	L	H	H	H	H	H	H	H	M	H	**44**
D. Non-motorized measure												
Tricycle (Becak)	NR	H	H	H	L	H	H	H	H	H	H	**46**
Cart (Bendi/Dokar)	NR	H	H	H	L	H	H	H	H	H	H	**46**
Bicycle	NR	H	H	H	M	H	H	H	H	H	H	**48**
Walking	NR	H	H	H	H	H	H	H	H	H	H	**50**

Note: H: High value/ high relevance/ high impact (5), M: Medium value/ relevant/ moderate impact (3); L: Low value/ less relevant/ less impact (1); NR: nil – not relevant/ no impact (0), TP: Total point

The results of the selection process, using general criteria, indicate that the following vehicle technologies are higher ranked than their competitors in vehicle technology.

- Continuously Variable Transmission,
- Gasoline direct injection,
- Lightweight material,
- Aerodynamic improvement, and
- Fuel cell technology.

The ranking of alternative fuels with regard to general criteria is as follows:

- LPG,
- LNG,
- CNG, and
- Biodiesel.

The results after applying general selection criteria to the two measures for Transport Demand Management have the same value, meaning that both alternatives are at the same level.

- Improvements of public transport, and
- Intelligent transportation systems.

Finally, the results for the four available options for non-motorized measures from the highest to the lowest rank are as follows:

- Bicycle,
- Tricycle,
- Cart, and
- Walking.

After selecting technologies according to general criteria, specific criteria were applied to key technologies and measures. The results can be seen in the following table.

Table 4.2: Transportation Sector - Technology Selection Process Using Specific Criteria

Measures and Technologies	Specific Criteria									TP
	EP	LER	TC	IRR	PB	AC	AD	PLB	LED	
A. Vehicle Technology										
Lightweight material	M	M	L	L	L	H	M	M	M	28
Aerodynamic improvement	M	M	L	L	M	M	M	M	M	24
Econometers and cruise control	L	L	M	L	L	L	M	L	L	13
Fuel cell technology	H	M	M	L	L	H	H	M	M	29
Improved exhaust treatment	H	M	L	L	L	L	L	L	H	19
Improved combustion	L	L	L	H	L	L	H	L	L	17
Fast warm-up	L	L	H	L	L	L	L	L	L	13
Drag and rolling resistance reduction	M	L	L	L	L	L	L	L	L	11
Structural weight	L	L	L	L	L	M	M	L	L	13
Continuously variable transmission	H	M	L	L	L	H	H	H	L	27
On-board electronic control	L	L	L	L	L	L	L	L	L	9
Shift indicator light	L	L	M	M	L	L	L	H	M	19
Dual cooling circuit	L	L	L	M	M	L	L	L	L	13
Tire inflation monitor	L	L	L	H	L	L	L	L	L	13
Low rolling resistance circuit	L	L	L	L	L	L	L	L	L	9
Efficient alternators	L	L	L	M	L	M	L	L	M	15
0W-5W/20 oils	L	H	H	H	H	L	L	H	M	31
Electronic water pump	L	L	L	L	L	L	L	H	M	15
Heat battery	L	H	H	H	L	L	L	H	L	25
Efficient AC system	M	L	L	H	L	M	M	L	L	19
Idle stop/start (42V system)	L	L	L	L	L	L	L	L	M	11
Heat pump for AC	M	L	L	H	L	L	L	M	M	19
Adaptive cruise control	M	L	M	L	L	M	M	M	L	19
Gasoline direct injection	H	M	L	L	L	H	H	H	L	27
6-speed automatic transmission	L	L	L	L	L	L	L	L	L	9
No torque converter	L	L	L	M	L	L	M	L	L	13
Hybrid vehicle without torque converter	L	L	L	L	L	L	M	M	L	13
B. Alternative Fuel										
Cellulosic ethanol	L	M	L	L	L	L	L	L	L	11
Biodiesel	H	H	H	L	M	H	M	H	H	37
Ethanol from sugar cane	M	M	M	L	L	M	L	L	L	17
Compressed natural gas	H	H	H	M	M	H	L	H	M	35
Liquid natural gas	H	H	H	H	M	H	L	H	M	37
Liquid petroleum gas	H	H	H	H	M	H	L	H	M	37
C. Transport Demand Management										
Improvement of public transport	H	M	M	M	L	H	H	M	H	33
Intelligent transportation system	H	M	M	M	M	H	H	M	M	33

Measures and Technologies	Specific Criteria									TP
	EP	LER	TC	IRR	PB	AC	AD	PLB	LED	
D. Non-motorized measure										
Tricycle (Becak)	H	H	H	H	M	H	L	H	H	**37**
Cart (Bendi/Dokar)	M	H	H	M	M	H	L	H	H	**35**
Bicycle	H	H	H	H	M	H	L	H	H	**39**
Walking	L	M	H	H	H	H	L	H	L	**31**

Note: H: High value/ high relevance/ high impact (5), M: Medium value/ relevant/ moderate impact (3); L: Low value/ less relevant/ less impact (1); NR: nil – not relevant/ no impact (0), TP: Total point

The results of the selection process, using specific criteria, indicate that the following vehicle technologies are higher ranked than their competitors in vehicle technology.

- 0W-5W/20 oils,
- Fuel cell technology,
- Lightweight materials,
- Gasoline direct injection, and
- Continuously Variable Transmission.

The ranking of alternative fuels with regard to specific criteria is as follows:

- LPG,
- LNG,
- Biodiesel, and
- CNG.

The results after applying specific selection criteria to the two measures for Transport Demand Management have the same value, meaning that both alternatives are at the same level.

- Improvements of public transport, and
- Intelligent transportation systems.

Finally, the results for the four available options for non-motorized measures from the highest to the lowest rank are as follows:

- Bicycle,
- Tricycle,
- Cart, and
- Walking.

4.2. Technologies Selected

Consolidating the results of the selections according to general and specific criteria, as discussed in the previous section, technologies and measures prioritized to reduce GHG emissions in the transportation sector are listed below.

Table 4.3: Selection: Environmentally Sound Vehicle Technology for Indonesia's Transportation Sector

Technology	Benefits regarding GHG emissions mitigation	Fuel Savings	Cost	TP
Continuously Variable Transmission (small cars)	10-15% gain over manual transmission	~ 7%	150 – 200US$/car	65
Gasoline direct injection	High fuel efficiency & low GHG emissions load	3 – 4%	125 – 175US$/car	61
Lightweight material	Improved fuel economy	4 – 8%	200 – 500US$/car	60
Fuel cell technology	Fuel efficient operation of car		3,000 – 5,000US$/car	59
0W-5W/20 Oil	Engine running smoothly for long period of time		5US$/liter	51
Additional Information for non-prioritized technology				
No Torque Converter		3 – 4%	Nil	27
Hybrid Vehicles without Torque Converter		30 – 40%	3,000 – 5,000 US$/car	25
6-Speed Automatic Transmission		4 – 5%	100 – 500 US$/car	25

Table 4.4: Selection: Alternative Fuels to be used by Indonesia's Transportation Sector

Alternative fuel	Benefits regarding GHG emissions mitigation	Potential CO_2 Reduction	Cost	TP
LPG	Reduce damage to ozone layer	~ 20% of BAU scenario	0.350US$/kg	88
LNG	Low emission, energy density 60% lower than diesel	~ 20% of BAU scenario	0.500US$/kg	82
Biodiesel	Low emission non-petroleum based fuel	~ 70% of BAU scenario	0.500US$/liter	80
CNG	Low emission mostly for bus & truck, energy density 25% lower than diesel	~ 30% of BAU scenario	0.155US$/kg	80
Additional Information for non-prioritized alternative fuels				
Ethanol from sugar cane		~ 60% of BAU scenario		56
Cellulosic ethanol		~ 90% of BAU scenario		38

Table 4.5: Selection: Transport Demand Management Systems for Indonesia's Transportation Sector

TDM system	Benefits	Cost	TP
Improvement of Public Transportation	Reduced total kilometer traveled	10million US$/Corridor	79
	Reduced travel time		
	Less fuel consumption		
	Lower cost per km per passenger		
Intelligent Transport System	Increased accessibility	978million US$ per 600 km^2 (whole system)	77
	Reduced total kilometer traveled		
	Reduced travel time		
	Less fuel consumption		

Table 4.6: Selection: Environmentally Sound Non-Motorized Measures for Indonesia's Transportation Sector

Non-motorized technologies/ measures	Benefits	Cost	TP
Bicycle	Zero emission, human-powered	100US$/bicycle for 1 person	87
Tricycle (Becak)	Zero emission, human-powered	400US$/tricycle for 3 persons	83
Cart (Bendi / Dokar)	Zero emission, horse-powered	1,000US$/cart for 5 persons	81
Walking	Zero emission, human-powered	Nil	81

4.3. Impact on Greenhouse Gas Emissions Mitigation

The implementation cost and impact of environmental sustainable transportation technologies/ measures/ systems, selected for GHG emissions mitigation in Indonesia were already described in the tables above.

Due to the complexity of calculating aggregated cost of environmentally sound vehicle technology, alternative fuel, transport demand management systems, and non-motorized technologies/ measures, only the simplified cost structure is calculated in this Transportation Sector TNA and presented as cost per vehicle, cost per kg or per liter of fuel, cost per TDM mode, and cost per non-motorized technology/ measure.

5. IDENTIFICATION OF BARRIERS AND POLICY NEEDS

5.1. Barriers

The main barriers and policy needs to support the implementation of the afore-mentioned mitigation measures are listed in the following table and involve several categories: finance, legal framework/ institution/ organization, technology, economy, politics, information, and social.

Table 5.1: Main Barriers and Policy Needs by Category

Barriers	Policy needs
Financial	
High cost of new technologies, unsuitability to host financial conditions	Convert technology investment (capex) to operational cost (opex)
Lack of investment capital	Cooperation with international donors
Lack of financing instruments	Develop best practice financing instruments
Legal / Institutional / Organizational	
Lack of legal and regulatory framework	Develop best practice legal and regulatory framework
Weak connection among different stakeholders	Increase cooperation among different stakeholders through mutual understanding, frequent meetings and communication to achieve the national goals
Limited institutional capacity, management and organizational experience	Increase institutional capacity, management and organizational experience through cooperation with international donors
Technological	
Low technical capabilities and lack of technology knowledge base, inability to assess, select and adapt appropriate technologies	Develop technical capabilities, which will help to develop technology knowledge-based as well as ability to assess, select, and adapt appropriate technologies through a cooperation with international agencies
Lack of infrastructure	Develop technological infrastructure through a cooperation between the Agency of Assessment and Application of Technology and international agencies
Lack of technological standards and institutions for supporting the standards	Develop technological standards through a cooperation between the Agency for National Standard and international agencies
Inflation	Manage and minimize the inflation rate
Economic instability	Manage and stabilize the economy
Disturbed or non-transparent markets	Provide symmetric information for all stakeholders
Political	
Corruption	Fight against corruption through the National Corruption Eradication Commission

Barriers	Policy needs
Political instability	Increase political stability
Interventions in domestic market (subsidies, encouragement, fees)	Develop an open market for all players
Information	
Lack of technical information	Provide open and symmetric information for all stakeholders
Lack of demonstrated track records for environmental sustainable technologies (EST)	Develop a database for previous track records
Lack of financial information	Develop an open financial information system
Social	
Lack of awareness and social acceptance, insufficient understanding of the advantage of new technologies, social biases	Publicize the advantages and weaknesses of new technologies through demonstration plots, decrease the social biases
Lack of confidence in the economic, commercial and technical viability of technologies	Publicize the economic, commercial, and technical viabilities of new technologies
Consumer preference	Educate consumers on advantages and weaknesses of technologies

5.2. Institutional Analysis

Government institution coordination is needed for implementing the low carbon concept in the Indonesian transportation sector. It is also important to have policies and regulations in place to improve road transportation, enhance natural gas distribution pipelines, adapt natural gas prices and support GHG emissions mitigation and adaptation. There are many parties involved in the development and implementation of the low carbon concept for the transportation sector, including the key stakeholder:

1. Central Government:
    - Ministry of Energy and Mineral Resources
    - Ministry of Communication/Transportation
    - Ministry of Finance
    - Ministry of Industry and Trade
    - Ministry of Environment
    - Ministry of Labor and Transmigration
    - Oil and Gas Executing Body for Upstream Activity
    - Oil and Gas Authorizing Body for Downstream Activity

2. Local Government:
    - Office of Traffic and Land Transportation
    - Local Environmental Impact Management Agency

3. Natural Gas Producer/CNG Filling Station Owner
    - PT. Pertamina (National Oil Company)
    - PT. PGN (National Gas Company)
    - CNG Filling Station Owner

4. Bus/Taxi Companies

5.3. Institutional Barriers and Policy Needs

For transferring environmentally sound technologies, institutional barriers and policy needs, as stated in Table 5.1, have to be considered before setting up minimum institutional capacities and capabilities, as well as instigating policies to reduce GHG emissions and to achieve a better environment for Indonesia. All weaknesses stated in the mentioned table have to be overcome and become strengths so that institutional barriers can be removed and significant policies for the implementation of mitigation measures can be installed. For example, the economic instability, under the economic category of barriers, has to be transformed into economic stability first. The barrier assessment and policy and action needs can be seen in the following table.

Table 5.2: Barrier Assessment and Policy & Action Needs by Institutional Responsibility

Identified Barrier	Policy and Action Need
Institutional and Policy	
Insufficient long term policy, regulation and target	Set clear long-term policy and target on efficient transportation systems and technologies based on long-term economic objectives, technology maturity and resources availability.
Insufficient operational policy	Develop and implement detailed operational policies, which support projects on new efficient transportation systems and technologies.
Insufficient inter-agency policies and measures	Develop effective coordination mechanism between the National Transportation Committee (DTN), the National Council for Climate Change (DNPI) and key sector agencies and ministries.
Lack of environmental mandate policies and regulations	Develop policies and regulations, which encourage the domestic industry to produce efficient transportation systems and technologies.
Economic, Investment and Market	
Limited public financial resources	Improving investment climate for the private sector, actively looking for grants and technical assistance for R&D, and pilot projects.
Poor investment climate	Create an environment for private investment.
Limited financial instruments and incentive mechanism for efficient transportation systems and technologies	Create a Public Transportation Fund. Establish a Public Transportation Service Company (PTSCO) under the local government.
Unpredictable economic losses/ benefits of new technologies	Establish a set of parameters to assess the investment cost of each technology, such as: cost of capital, internal rate of return, payback period, etc. and secure package; to minimize the risk of investment into transportation systems and technology.
Fuel prices do not reflect true cost of production, resource availability and externalities	Develop and implement fuel price policies, which reflect the cost of production and fuel supply. Create effective and well-targeted subsidy mechanisms for the low income/ poor user, and students.

Human Resources and Industrial Support	
Lack of skilled workers and professionals for new transportation systems and technologies.	Organize a series of trainings on new transportation systems and technologies. Bring the topic of efficient transportation systems and technologies into the curriculum of science and engineering studies at universities.
Limited base of transportation industry and local service providers	Enhance cooperation and technical assistance on transportation systems and technologies between Indonesia and particular countries. Develop transportation systems and technologies pilot projects.
Limited R&D on GHG emissions mitigation measures both for conventional and new transportation technologies.	Enhance the cooperation on R&D for new and advanced technologies between Indonesia and other countries/ institutions. Pursue s joint research project with potential for industrial application.
Information and Awareness	
Limited database on efficient and effective transportation systems and technologies	Establish a database (enhance measurement and analysis, support data collection) and introduce pilot projects.
Lack of information among investors on potential transportation systems and technologies application	Establish a specialized information system for market and investors.
Lack of information and awareness among governmental organizations, private companies and the public on the benefits of efficient transportation systems and technologies	Develop an awareness raising campaign to keep different stakeholders informed about the potential technology market and the benefits of efficient transportation systems and technologies. Organize TV and radio programs and advertising campaigns (public relation).

6. CONCLUSION AND RECOMMENDATION

6.1. Conclusion

Environmentally sound transportation technologies and policies play a major role in promoting economic development, while minimizing the local costs of traffic congestion, road accidents and air pollution. Programmes towards environmentally sound transportation involving advanced vehicle technologies, alternative fuels, transport demand systems and non-motorized solutions offer long-term global climate benefits in tandem with immediate improvements in local air quality.

Hybrid vehicles, powered flexibly by gasoline/ diesel and electricity, and vehicles running on bio-fuel or bi-fuel (CNG) emit low amounts of GHG. Their implementation needs investment, intense assessment and careful planning though. But they are already used in other countries. Furthermore, conventional vehicles could run with mixed, less carbon intense fuels, i.e. mixing between gasoline/diesel and 10% of bio-ethanol or 5% of bio-diesel. Thus by introducing and using mixed fuels in conventional vehicles in the near term, an adoption of new technology e.g. hybrid vehicles becomes less urgent. Bi-fuel vehicle technology has been partly introduced and used in Indonesia already.

Fuel switching and alternative fuels such as solar energy, propane (LPG), CNG, ethanol and methanol can substitute carbon intense diesel as an energy source for vehicles and help to reduce GHG emissions. They could also be applied in the public transport as a pilot project for thoughtful application.

Another potential measure to be implemented is Transport Demand Management particularly Intelligent Transport Systems. But further assessment is needed regarding the type and suitability of such systems in Indonesia.

The improvement of public transport systems is one of the alternatives for GHG emissions mitigation measures, which is urgent.

6.2. Recommendation

In order to minimize the increase of GHG emissions in the air resulting from transportation activities in Indonesia, the application of environmentally sound transportation technologies should be envisaged. These would include hybrid gasoline/diesel-electric powered and bi-fueled (CNG) vehicles. The Central Government of Indonesia, along with local governments should play leading roles in any future action. The application of environmentally sound transportation technologies should be encouraged by the Government of Indonesia through strategic measures and actions, involving all stakeholders (including private, public and society). Measures to be implemented involve the “Zero Growth Vehicles” policy in major cities in Indonesia. The development of mass rapid transit systems especially in the metropolitan areas should be set as a priority by the Central and regional Governments, since it has a significant potential of reducing GHG emissions.

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Appendix 1: Technology Needs Assessment in Transportation Sector (Car Only)

No.	GHG Emissions Reduction Option	Present Condition	Technological Input	Reduction Potential *	Investment Cost	Abatement Cost *	Remarks
				(mio t CO_2)		(US$/ t CO_2)	
1	More efficient & fuel saving vehicles	Not yet adopted by assembled cars in Indonesia. Have been adopted by imported/ built-up cars.	Direct injection (4%)	6.06	175US$/veh.	N.A.	Increase of efficiency by 1% will reduce CO_2 emissions by 2.5%
			Automatic trans. (5%)	7.58	500US$/veh.	N.A.	
			Continuously Variable Transmission (CVT) (7%)	10.61	200US$/veh.	N.A.	
			No torque converter (4%)	6.06	Nil	N.A.	
			Hybrid vehicle (40%)	60.60	5,000US$/veh.	1,250US$/t CO_2	
2	Switching to low carbon fossil fuels to reduce emission	All types of alternative fuels have been introduced in Indonesia. However, the fuels supply discontinued due to market-oriented suppliers.	Cellulosis Ethanol (90%)	136.35	N.A.	N.A.	
			Biodiesel Fuel (70%)	106.05	N.A.	N.A.	
			Ethanol from Sugar (60%)	90.00	N.A.	N.A.	
			CNG (30%)	45.45	N.A.	N.A.	
			LNG (20%)	30.30	N.A.	N.A.	
			LPG (20%)	30.30	N.A.	N.A.	
3	Transport management system (TMS)	Already implemented as pilot projects in some smaller cities in Indonesia e.g. Tegal, Batam, but not yet in metropolitan cities such as Jakarta.	ATCS (15%)	22.73	180,000US$ (1 CC room & 6 intersection)	N.A.	
			ITS (15%)	22.73	125mio US$ (Singapore, 1995)	N.A.	

*) In 1994 baseline GHGs emission in Indonesia counted 886.47million tons CO_2 (First National Communication 1999).
*) Land-based transportation consumes the highest share of primary energy in the country, in total 47.5%, with cars contributing 17.1% of that share.

Appendix 2: Parameters of Energy Intensity - Baseline Scenario (BAU)

Fuel Type	Passenger Car	Motorcycle	Bus	Truck
Mogas	12.55	1.17	-	8.84
Diesel Oil	1.25	-	18.00	18.30
LPG	0.01	-	-	-
CNG	0.02	-	0.19	-

Source: Department of Energy and Mineral Resources - Energy Information Center, *Indonesian Energy Outlook 2010*, July 2002, Appendix A.2, Table A.2.4 Transport Sector, p.104

Appendix 3: Road Transport CO_2 Emission Factors

Fuel Type	Default (kg/TJ)	Lower	Upper
Motor Gasoline	69.300	67.500	73.300
Diesel Oil	74.100	72.600	74.800
LPG	63.100	61.600	65.600
Kerosene	71.900	70.800	73.700
Lubricant	73.300	71.900	75.200
CNG	56.100	54.300	58.300
LNG	56.100	54.300	58.300

Source: IPCC: Intergovernmental Panel on Climate Change. *2006 IPPC Guidelines Vol.2: Energy - Chapter 3 – Mobile Combustion*, Table 3.2.1, p.3.16

Appendix 4: Projected Quantity of Vehicles in Indonesia, 2000 - 2025

Year	Motorcycle	Car	Bus	Truck
2000	13,563,017	3,038,913	666,280	1,707,134
2001	15,492,148	3,261,807	687,770	1,759,547
2002	17,002,140	3,403,433	714,222	1,865,398
2003	19,976,376	3,885,228	798,079	2,047,022
2004	23,055,834	4,464,281	933,199	2,315,779
2005	28,556,498	5,494,034	1,184,918	2,920,828
2006	32,983,840	5,716,421	1,186,479	3,015,784
2007	37,192,768	5,992,350	1,188,416	3,133,602
2008	41,096,841	6,534,355	1,256,533	3,340,428
2009	45,410,719	7,125,384	1,328,555	3,560,905
2010	50,177,419	7,769,872	1,404,705	3,795,935
2011	55,444,473	8,472,653	1,485,219	4,046,477
2012	61,264,402	9,239,000	1,570,348	4,313,555
2013	67,695,241	10,074,663	1,660,357	4,598,261
2014	74,801,116	10,985,911	1,755,525	4,901,759
2015	82,652,884	11,979,581	1,856,148	5,225,288
2016	91,328,843	13,063,128	1,962,538	5,570,172
2017	100,915,504	14,244,682	2,075,026	5,937,818
2018	111,508,464	15,533,106	2,193,962	6,329,730
2019	123,213,352	16,938,068	2,319,715	6,747,509
2020	136,146,885	18,470,108	2,452,676	7,192,863
2021	150,438,034	20,140,720	2,593,257	7,667,611
2022	166,229,305	21,962,438	2,741,897	8,173,694
2023	183,678,163	23,948,929	2,899,056	8,713,180
2024	202,958,604	26,115,098	3,065,223	9,288,274
2025	224,262,886	28,477,196	3,240,915	9,901,325

Source: Department of Transportation, National Statistics Agency, Indonesian Motorized Vehicle Industries Association, National Police.

Appendix 5: Projected GHG Emissions for Land Transportation (Different Scenarios), 2000 – 2025

Year	BAU (CE)	AE	TDM	TDM - AE
GHG Emission Reduction (t CO_2)				
2000	40,252,801	40,252,801	34,214,881	34,214,881
2001	42,789,746	42,764,376	36,371,284	36,349,720
2002	45,237,725	45,163,396	38,452,066	38,388,886
2003	51,065,570	50,816,405	43,405,734	43,193,945
2004	58,551,626	58,003,019	49,768,882	49,302,566
2005	73,028,271	71,755,832	62,074,031	60,992,458
2006	76,865,545	75,362,870	65,335,713	64,058,439
2007	81,055,235	79,259,282	68,896,950	67,370,390
2008	87,665,673	85,340,884	74,515,822	72,539,752
2009	94,838,601	91,868,248	80,612,810	78,088,011
2010	102,623,701	98,874,839	87,230,146	84,043,613
2011	111,075,185	106,396,659	94,413,907	90,437,161
2012	120,252,211	114,472,443	102,214,380	97,301,576
2013	130,219,355	123,143,858	110,686,452	104,672,279
2014	141,047,111	132,455,728	119,890,044	112,587,369
2015	152,812,452	142,456,268	129,890,584	121,087,828
2016	165,599,438	153,197,336	140,759,522	130,217,735
2017	179,499,883	164,734,705	152,574,900	140,024,499
2018	194,614,088	177,128,353	165,421,975	150,559,100
2019	211,051,642	190,442,772	179,393,896	161,876,357
2020	228,932,304	204,747,302	194,592,458	174,035,207
2021	248,386,962	220,116,482	211,128,918	187,099,010
2022	269,558,696	236,630,434	229,124,892	201,135,869
2023	292,603,932	254,375,266	248,713,342	216,218,976
2024	317,693,715	273,443,501	270,039,658	232,426,976
2025	345,015,104	293,934,543	293,262,839	249,844,362

Notes: 1. BAU (CE) – Business as usual (Conventional Engine), 2. AE – Advanced Engine, 3. TDM – Advanced Demand Management

Appendix 6: Example of CO_2 Emissions Calculation from Car

CO_2 Emissions from Cars 2005	
Number of Car 2005	5,494,030
Fuel Consumption for one car	12.550BOE
	12.550 x 0.006119TJ
	0.0769345TJ
Total Fuel Consumption	5,494,030 * 0.0769345TJ
	421.906TJ
CO_2 Emission Factor	69.300TJ
Total CO_2 Emission	421,906TJ * 69.300kg/TJ
	29,238,035t

CHAPTER - III

INDUSTRY SECTOR

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1 BACKGROUND

1.1 Aims

Indonesia ratified the United Nations Framework of Climate Change Convention (UNFCCC) through Act No. 6, in 1994 and the Kyoto Protocol through Act No. 17, in 2004. "*...Article 4.5 of the Convention defines technology needs assessments (TNAs) as, a set of country-driven activities that identify and determine the mitigation and adaptation technology priorities of Parties. They involve different stakeholders in a consultative process to identify the barriers to technology transfer and measures to address these barriers through sectoral analyses. These activities may address soft and hard technologies, such as mitigation and adaptation technologies, identify regulatory options and develop fiscal and financial incentives and capacity-building."* [UNFCCC: Technology Transfer Framework] Stakeholders are governments, private sector entities, financial institutions, NGOs and research/education institutions. The aims of Indonesia's TNA can be itemized as follows:

- Contribute to the global effort towards sustainable development and, in particular, the protection of the climate system
- Communicate Indonesia's needs for environmentally sound technologies (EST) to the UNFCCC Conference of the Parties (COP) and the global community
- Resource documents to identify and prioritize EST needed by Indonesia and mark those, which require support and co-operation from developed countries
- Set the foundation for a database for EST

1.2 Objectives

- Identify, analyze and prioritize technologies, which could form the basis for a portfolio of Technology Transfer programmes aiming GHG emissions mitigation
- Identify human and institutional capacity needs that ensure the smooth development, transfer and acquisition of environmentally sound technologies
- Enlist interest and commitments from key stakeholders and partnerships to support investment or barrier removal actions for enhancing the commercialization and diffusion of high priority technologies

1.3 Approach

In 2006 the total number of medium- and large-scale companies in Indonesia counted more than 21,000 units, operating in different industry sub-sectors. The Industry Sector TNA focuses on seven energy intensive industry sub-sectors: Cement, Iron & Steel, Pulp & Paper, Glass & Ceramics, Petrochemicals, Textiles and Food & Beverages. For these energy intensive industry sub-sectors energy audits have already been conducted. Therefore, data on energy use, data on fossil fuels used as raw material/ feedstock for

industrial processes, as well as general data on energy conservation and -diversification activities is available for these industry sub-sectors.
A detailed analysis will be given for Cement, Iron & Steel, and Pulp & Paper industry only, because sufficient primary data is available only for these three industry sub-sectors. Due to the mentioned data limitation the discussion will be less comprehensive for the other industry sub-sectors.
The estimation of GHG emissions reduction potential and the assessment of technology needs in the Indonesian industry sector concentrates on industrial energy use and industrial production processes. CO_2 is the main GHG resulting from both activities. Hence in this Industry Sector TNA emission reviews will be limited to CO_2 as the major GHG emitted by the industry sector.

Where possible the structure of this Industry Sector TNA follows the standard guidelines of the United Nations Development Programme (UNDP), "Conducting Technology Needs Assessment for Climate Change" as suggested by the UNFCCC.

1.4 Stakeholders Participation Process

The second phase of updating the Industry Sector TNA was started in March, 2008 and was conducted by the industry sector team members, as well as members from the Ministry of Industry (MoI), Agency for the Assessment and Application of Technology (BPPT), the German Technical Cooperation (GTZ), industry representatives and industrial associations.

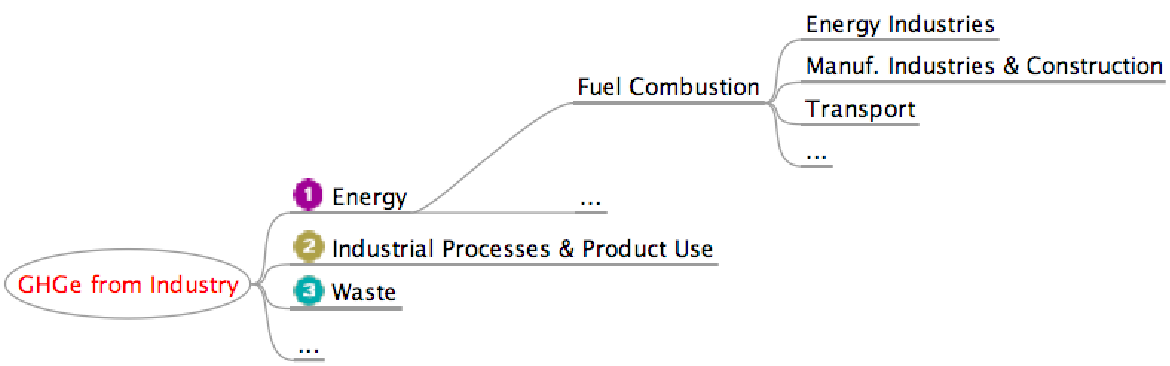
The stakeholder participation process has been long, with many technical meetings and workshops, such as:

- Kick-off workshop with all stakeholders of Indonesia's TNA;
- Several meetings for reviewing the Industry Sector TNA;
- Analysis of energy audits carried out in the Indonesian industry sector;
- Workshop with energy intensive industry sub-sectors: Representatives from the Cement, Iron & Steel and Pulp & Paper industry gave presentations on their current implementations of Cleaner Production and Energy Efficiency (CP-EE) measures to reduce resource and energy consumption and hence reduce greenhouse gas emissions. About 40 industry representatives and industrial associations from Cement, Steel, Pulp & Paper, Ceramic and related agencies attended this workshop;
- Workshops and meetings to develop chapters in the Industry Sector TNA for each industry sub-sector;
- Sending questionnaires to companies operating in Indonesia to identify the potential application of new technologies;
- Analysis of reports and comments of international reviewers;
- Special meetings with industry representatives and industrial associations, to establish an agreement on GHG emissions reduction through energy conservation, energy diversification and technology transfer;
- Meetings with international reviewers;
- Workshops to finalize the draft report of this Industry Sector TNA; and
- Consolidation meeting to discuss the Industry Sector final draft report and cross-sectoral issues among all TNA sectors before the final review by international reviewers took place.

2 EXISTING CONDITION IN INDONESIA

2.1 Introduction

The main greenhouse gas resulting from industrial activities is CO_2. Sources for GHG emissions from the industry sector are among others (1) energy use and (2) industrial processes (Intergovernmental Panel on Climate Change: "1996 IPCC Guidelines for National Greenhouse Gas Inventories").



Both activities are drawn on fossil fuels, which are used for electricity and heat production and as feedstock in industrial processes such as natural gas for the Fertilizer industry, coal for the Steel industry and kerosene and gasoline for the Chemical industry. Based on the "Handbook of Energy and Economic Statistics of Indonesia" (Ministry of Energy and Mineral Resources), the industry sector's share of total commercial final energy consumption in Indonesia is about 53% (including feedstock for industrial processes), or about 47%, if the natural gas utilization for feedstock of the fertilizer production process is not included. Based on the "Statistics of Large and Medium Industry" (Badan Pusat Statistik), the total number of national large and medium sized industries was about 21,000 units in 2006 throughout Indonesia. The growth of the industry sector goes parallel to the growth of the national economy. Under a positive economic growth rate the industry sector will grow too and total GHG emissions from the industry sector will hence increase.

2.1.1 Energy Use

In the industry sector energy is used for heating, electricity generation and cogeneration (heat and power). Energy for heating can be divided into direct heating (furnace) and indirect heating (boiler). Furnaces are commonly used in the Cement, Food & Beverages, Wood and Ceramic industries, whereas boilers are important for Food & Beverages, Fertilizer, Pulp & Paper and many other industries. As boiler and furnace specifications and capacities vary, the analysis in this Industry Sector TNA focuses on several energy intensive industry sub-sectors and particularly those, which have conducted energy audits and/ or energy conservation activities.

2.1.2 Industrial Processes

GHG emissions are also produced from a variety of industrial activities, which are not related to energy use, e.g. industrial processes, industrial wastewater. Industrial processes cause chemical reactions or physically transform materials. During these processes, many different greenhouse gases can be released, including CO_2, CH_4, N_2O, and PFC. Industry sub-sectors, which produce CO_2 emissions during their industrial production processes are the Cement industry, Chemical industry, such as Fertilizer, Lime, Soda

Ash, Adipic Acid, Carbides, Caprolactam, Halocarbons, Petrochemicals, Metal industry such as Iron & Steel, Ferroalloys, Aluminum, Magnesium, Pulp & Paper industry and Food & Beverages industry, all of which will be developed in conjunction with the national economic development.

Due to lack activity data for CO_2 emissions estimation, discussions and analysis of industrial processes in this Industry Sector TNA focus only on the industry sub-sectors: Cement, Iron & Steel and Pulp & Paper. An overview of industrial processes, which have the potential to produce GHG emissions, is presented in the following table.

Table 2.1: Potential GHG Emissions from Industrial Processes

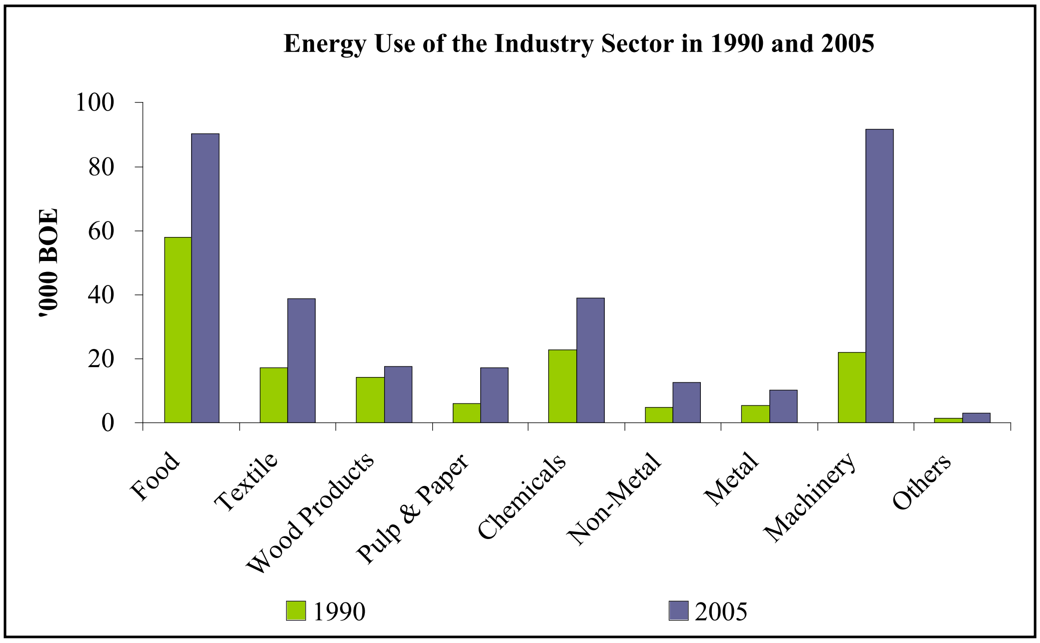
Process	**Greenhouse Gases**						**Ozone and Aerosol Precursors**
	CO_2	CH_4	N_2O	PFC	SF_6	HFC	
Mineral Products							
Cement production	x						x
Lime production	x						x
Limestone use	x						
Soda Ash production & use	x						
Asphalt roofing							x
Road paving							x
Other	x	x					x
Chemical industry							
Ammonia	x						x
Nitric acid			x				x
Adipic acid			x				x
Urea			x				
Carbides	x	x					x
Caprolactam			x				
Petrochemicals		x	x			x	x
Metal Production							
Iron, steel and ferroalloys	x	x					x
Aluminium	x	x		x	x		x
Magnesium	x				x		x
Other metals	x	x			x		x
Other							
Pulp & paper							x
Food & beverages production							x
Production of halocarbons				x	x	x	
Use of halocarbons and SF6				x	x	x	
Other sources	x	x		x	x	x	x

Source: Intergovernmental Panel on Climate Change: "Revised 1996 IPCC Guidelines for National Greenhouse Gas Inventories", Reference Manual (Volume 3), Table 2.1.

2.2 National Plan

In 2006, final energy utilization of the Indonesian industry sector equaled 264million barrels of oil equivalent (BOE) (excluding biomass). It is estimated, that this figure will increase to up to 952million BOE in 2025. Generally, energy utilization in the Indonesian industry sector is not yet as efficient in average as in other countries, because aged technologies are still applied in the industry sub-sectors. Due to the high commercial energy consumption in the industry sector and the relatively low efficiency of energy utilization, it is necessary to analyze energy efficiency per industry sub-sector and to find options for technology improvement in terms of efficiency and productivity.

Energy intensity measures the energy efficiency of a nation's economy. The indicator is calculated as units of energy per unit of gross domestic product (GDP). The indicator is not limited to an energy efficiency analysis of economies only, but can be applied for single sectors also. In the industry sector energy intensity describes the energy required (GJ) to produce one unit of output (tonne or Rp.). In terms of figures the average energy intensity of the industry sector in Indonesia decreased between 1990 and 2000. Besides a possible improvement of energy efficiency, a reason for this result might be the financial crisis and the instability of the Indonesian Rupiah, both impacting an indicator measured in GJ/Rp. This explanation might be strengthened by the following figure, which shows that the overall energy use of the industry sector has increased due to industrial growth.



Source: "Handbook of Energy and Economic Statistics of Indonesia" (Ministry of Energy and Mineral Resources), 2006

Figure 2.1: Energy Use of Various Indonesian Industry Sub-Sectors in1990 and 2005

Especially energy intensive industry sub-sectors such as Cement, Iron & Steel, Pulp & Paper, Ceramics and Fertilizer industry could note down an increase in production (capacity) and added value. At the same time these industry sub-sectors continued their efforts to improve energy efficiency and decrease their energy intensity. The trend to energy audits, technology substitution and production process improvement is on-going. An exception of this trend is the Textile industry, where the use of inefficient equipments is still common practice. The Ministry of Industry has a "Partnerships Program on Energy Conservation in the Industrial Sector" for machinery restructuring in the Textile industry. For this programme the Government of Indonesia (GoI) provided a budget of about 1,636million US$, allocated for the replacement of old, inefficient Textile machinery e.g. with higher speed textile production equipment.

Several other activities, which have been conducted by the Ministry of Industry towards energy conservation in some energy intensive industry sub-sectors, are presented in the following table. Such efforts are expected to encourage similar industry sub-sectors to undertake energy conservation activities.

Table 2.2: Examples of Energy Conservation Measures conducted in Indonesian Industry Sector

Industry Sub-Sector	Total Activities	Technology	Investment (Mio US$)
Cement	9	- Blended Raw Material - Alternative Fuel (palm kernel shell, rice husk)	114.3
Iron & Steel	71	- Utilization of coal gasification - Changing of electric furnace technology - Reheating fuel furnace	236.6
Pulp & Paper	81	Recycling processes (product and waste)	3,240.0
Textile	2,726	Restructuring of machinery	1,635.6
Total			5,226.5

Source: Ministry of Industry

Future energy conservation opportunities in the industry sub-sectors Cement, Iron & Steel, Glass & Ceramic, Pulp & Paper, Petrochemicals, Textile, Food & Beverages, and Engine & Equipment industry are presented in the table below, which is based on the results of energy audits.

Table 2.3: Energy Conservation Potential of Indonesian Industry Sector

No.	Industry Sub-Sector	Energy Conservation Potential (%)
1	Cement	15 - 22
2	Steel	11 - 32
3	Glass & Ceramic	10 - 20
4	Pulp & Paper	10 - 20
5	Petrochemical	12 - 17
6	Textile	20 - 35
7	Food & Beverages	13 - 15

Source: Ministry of Industry

As described, the development of the Indonesian industry sector leads towards energy conservation. In the following the potential and barriers are discussed in detail.

2.3 Resources Use and Potential

Refinery products – In 2007 potential crude oil resources were estimated with 57billion barrels crude oil and reserves with 9billion barrels crude oil. At a production level of 348million barrels crude oil/year as in 2007, the Reserves-to-Production ratio (R/P), thus the remaining amount of a non-renewable resource expressed in years, is about 24 years. Analyzing the size of resources, reserves and R/P of crude oil, energy diversification seems to be a logical choice for the industry sector in Indonesia to secure energy supply and reduce energy costs.

Coal - Potential coal resources counted about 91billion tonnes coal and reserves about 19billion tonnes coal in 2007. National coal production added up to 207million tonnes coal/year. Therefore the R/P for coal can be estimated with about 93 years.
Natural gas –In the same year potential natural gas resources were about 335TSCF natural gas and reserves about 165TSCF natural gas. If the production level stays constant at 2.79TSCF natural gas/year as in 2007, reserves will last for about 59 years.

2.4 **Existing Regulations and Policies**

Regulations related to energy utilization in the industry and other sectors are Law No. 30/2007, Presidential Regulation No. 5/2006, the Strategic Plan on National Energy Conservation Program Development, 2005-2025 and Presidential Regulation No. 28/2008.

Law No.30/2007 concerning energy development in Indonesia - The law incorporates several provisions, whose implementation will affect GHG emissions mitigation, i.e. provisions, which support energy conservation and the development of new and renewable energy through (dis)incentive mechanisms. The energy sector must utilize energy efficiently in order to support national development continuously. Energy users and energy efficiency equipment manufacturers, who implement energy conservation measures, will receive privileges and/or incentives from the central and/or local governments. The implementation of provisions concerning energy conservation and renewable energy development has to be regulated by a Government Regulation. The operational stipulation of this Government Regulation is under preparation (status June 2009).

Presidential Regulation No. 5/2006 - Fossil fuels, utilized in the domestic industry, are refinery products such as gasoline, kerosene, diesel and fuel oil, as well as coal, LPG and natural gas. The utilization of refinery products in the industry sector is relatively high with a share of about one fifth. Due to the limited crude oil resources, Indonesia meanwhile became a net oil importer. The increase of the crude oil price leads to the rise of the industry sector's raw material costs, causing higher production costs. On the other hand Indonesia has relatively large coal and natural gas reserves, which could be used to substitute refinery products. Indonesia's national energy mix policy, formulated in Presidential Regulation No. 5/2006, targets the reduction of current oil consumption until 2025 by a substitution from other energy sources. Until 2025 crude oil consumption has to reach **less** than 20% of the national energy mix, natural gas more than 30%, coal more than 33%, bio-fuel more than 5%, geothermal more than 5%, new and renewable energy, particularly biomass, nuclear, hydropower, solar power, and wind power more than 5%; and liquefied coal more than 2%. The national energy mix policy reflects consideration of the importance of alternative energy utilization, energy conservation, and energy security aims to enable secure energy supply. If implemented as intended, carbon emissions are predicted to be lower than the Business as Usual (BAU) in 2025 on a 2005 baseline. This is due to the fact, that energy mix policy implementation in the industry sector means mainly a substitution of refinery products by natural gas, but also biomass (rice husk, palm kernel shell) and others, which are even less carbon intensive as sources of energy than fossil fuels (on a net calorific basis). In order to achieve the strived energy mix the Ministry of Industry already encourages the substitution of refinery products by coal, which is commonly used in the Cement industry for kiln heating, and natural gas being promoted in Textile, Iron & Steel, Ceramic and Fertilizer industry.

Strategic Plan on National Energy Conservation Program Development 2005 – 2025 - The main energy conservation program covers campaigns, information, education and trainings. It focuses demand side management, standardization and energy savings labeling, partnership programs, energy manager;

incentives and budgeting; and other regulations. Based on all regulations, efficient energy utilization and energy diversification are choices, which must be taken by the industry sector and will make it more competitive.

Presidential Regulation No. 28/2008 about National Industrial Policy - is aimed to strengthen competitiveness of the manufacturing industry as a driver of economic growth – supported by “macro economic stability, qualified public institutions, an improved industry structure with increasing role for Small-to-Medium Enterprises (SME) and improved productivity”. The objective is to achieve balanced roles between SME and large industries, so Indonesia will become recognized worldwide by 2030 as an industrialized country. Furthermore, the Presidential Regulation anticipates the problems about energy in the industry sector (meeting future demand, fossil fuel resource depletion and gradual withdrawal of energy pricing subsidies).

Industrial Policy, which will regulate energy consumption in the industry sector, is still under development. This policy will be implemented in medium term during 2009 to 2014 and will regulate some activities, including:

1. Support new technology in the energy sector.
2. Create motivation for enterprises to implement energy conservation activities and energy diversification.
3. Conduct energy audits for the industry sector.
4. Promote technology based on “energy efficiency” means.
5. Support enterprises to implement renewable energy such as biodiesel.
6. Promote of the concept of energy managers.

3 INITIAL REVIEW OF OPTIONS AND RESOURCES

3.1 Greenhouse Gas Inventory of Indonesian Industry Sector

The figure below shows the calculated CO_2 emissions of Indonesia's industry sector in 2005, which counted round 110million tonnes CO_2. The estimations are based on the industry sector's fossil fuel consumption as presented later in this chapter. The highest share of the industry sector's GHG emissions was produced by three energy intensive industry sub-sectors: Cement & Non-Metallic Minerals, Pulp & Paper, and Iron & Steel.

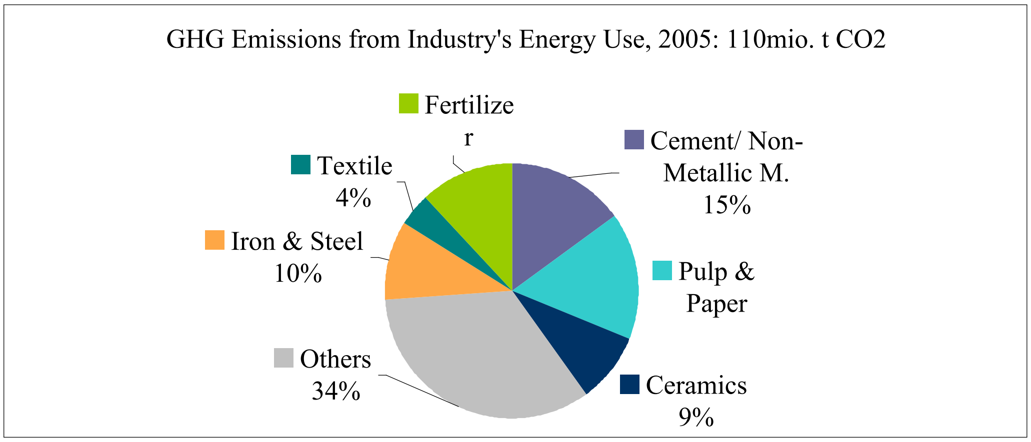


Figure 3.1: GHG Emissions from Energy Use of Indonesian Industry Sector, 2005

In addition to GHG emissions released from energy use, GHG were also emitted during the industrial processes of clinker (Cement industry), ammonia (Fertilizer industry) and steel (Iron & Steel industry) production. Total GHG emissions of industrial processes in these three industry sub-sectors were estimated with 23.06million tonnes CO_2 in 2006. The estimations are based on the industry sector's production or fossil fuel use as presented later in this chapter. The share of each of the three industry sub-sectors is depicted in the following figure. It shows that clinker production is responsible for the largest share of GHG emissions, while steel production can be accounted for the smallest share.

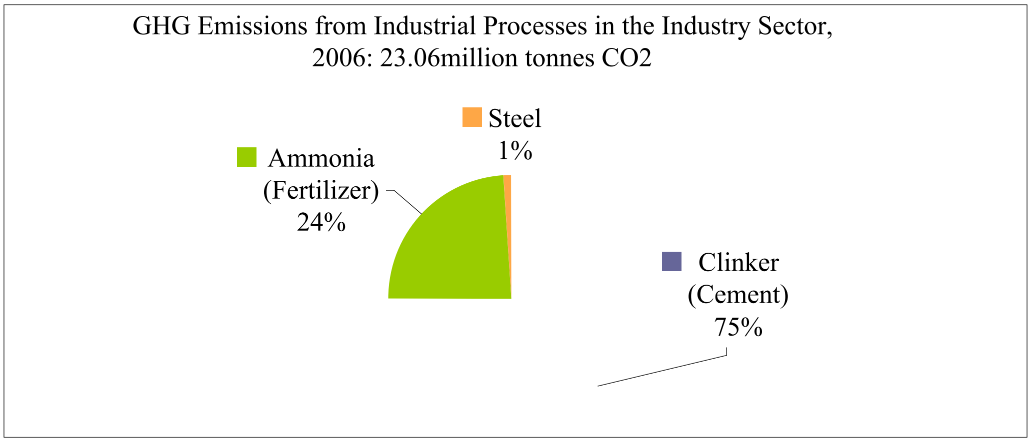


Figure 3.2: GHG Emissions from Industrial Processes of Indonesian Industry Sector, 2006

3.2 Mitigation Potential

3.2.1 Energy Use

The analysis of potential GHG mitigation in the Indonesian industry sector is conducted by establishing two energy demand projection scenarios, i.e. the Business as Usual (BAU) scenario and the improved energy efficiency and energy diversification (EFFICIENT) scenario.

Under BAU, the energy demand will develop according to the 2006 (base year) pattern until 2025. Any effort to reduce energy consumption, such as improved efficiency or the implementation of demand side management and energy diversification, are not considered and excluded from this scenario. Energy demand of various industry sub-sectors is expected to increase and to follow their production capacity growth.

A projection of the energy demand of various industry sub-sectors under BAU is presented in the following table. The average energy demand growth during 2006 - 2025 period is estimated with 6.5% per year. The figures do not involve natural gas used as feedstock in the Fertilizer industry or coal used as a reducing agent in the Steel industry. Both will be discussed in the industrial process section. Fuel demand for captive power generation and for vehicles in the industry sector is also excluded from the estimations and will be discussed in the Energy- and Transport Sector TNA instead.

Table 3.1: Projection of Energy Demand of Indonesian Industry Sector (BAU), 2005 - 2025

Industry Sub-Sector	Fuel Type	Unit	Demand				
			2005	2010	2015	2020	2025
Cement & Non-Metallic Minerals	Oil product	thousand kl	728	941	1,279	1,486	1,773
	Coal	mio. tonnes	11	15	20	31	34
	Natural Gas	MMCF	16,562	28,950	59,757	111,983	223,252
Iron & Steel	Oil product	thousand kl	713	880	1,480	1,959	2,095
	Coal	mio. tonnes	1	1	2	4	6
	Natural Gas	MMCF	81,752	125,877	205,893	333,759	540,003
Pulp & Paper	Oil product	thousand kl	1,247	1,410	1,530	2,283	2,769
	Coal	mio. tonnes	7	7	7	9	10
	Natural Gas	MMCF	33,285	50,504	76,337	114,791	169,285
Textile	Oil product	thousand kl	461	518	701	937	1,135
	Coal	mio. tonnes	1	2	5	10	18
	Natural Gas	MMCF	207	218	258	336	465
Fertilizer	Oil product	thousand kl	767	1,007	1,738	3,544	4,859
	Coal	mio. tonnes	6	8	10	12	15
	Natural Gas	MMCF	33,395	146,358	190,624	218,579	298,548
Total	Oil product	thousand kl	3,917	4,756	6,728	10,209	12,631
	Coal	mio. tonnes	26	32	43	67	85
	Natural Gas	MMCF	165,202	351,906	532,870	779,448	1,231,552
Ceramics	Oil product	thousand kl	380	Projection of industry sub-sector not in focus.			
	Coal	mio. tonnes	8				
	Natural Gas	MMCF	37,846				

Industry Sub-Sector	Fuel Type	Unit	Demand				
			2005	2010	2015	2020	2025
Miscellaneous	Oil product	thousand kl	3,725	Projection of industry sub-sectors not in focus.			
	Coal	mio. tonnes	3				
	Natural Gas	MMCF	114,354				

Source: Center R&D for Source, Environment and Energy, Ministry of Industry

The EFFICIENT scenario considers existing opportunities for implementing energy conservation activities, environmentally sound technology and energy diversification in the Indonesian industry sector. Energy demand projections under EFFICIENT are presented below. The table shows that an implementation of the mentioned measures can reduce energy demand by 8,545PJ compared to BAU during 2006 - 2025. The average energy demand growth under EFFICIENT is projected with 6.3% per year.

Table 3.2: Projection of Energy Demand of Indonesian Industry Sector (EFFICIENT), 2005 – 2025

Industry Sub-Sector	Fuel Type	Unit	Demand				
			2005	2010	2015	2020	2025
Cement & Non-Metallic Minerals	Oil product	thousand kl	728	675	626	580	538
	Coal	mio. tonnes	11	14	18	24	30
	Natural Gas	MMCF	16,562	26,856	52,133	101,542	184,207
Iron & Steel	Oil product	thousand kl	713	667	623	582	544
	Coal	mio. tonnes	1	1	2	3	6
	Natural Gas	MMCF	81,752	119,013	190,365	299,425	458,173
Pulp & Paper	Oil product	thousand kl	1,247	1,201	1,157	1,098	1,073
	Coal	mio. tonnes	7	7	7	9	10
	Natural Gas	MMCF	33,285	45,177	66,711	96,849	140,340
Textile	Oil product	thousand kl	461	455	450	444	439
	Coal	mio. tonnes	1	2	4	8	14
	Natural Gas	MMCF	207	217	252	322	453
Fertilizer	Oil product	thousand kl	767	738	693	675	660
	Coal	mio, tonnes	6	7	9	22	33
	Natural Gas	MMCF	33,395	143,208	182,335	203,387	373,470
Total	Oil product	thousand kl	3,917	3,737	3,549	3,378	3,253
	Coal	mio. tonnes	26	30	40	66	93
	Natural Gas	MMCF	165,202	334,471	491,796	701,526	1,156,644

Source: Center R&D for Source, Environment and Energy, Ministry of Industry

Based on the energy demand projections GHG emissions were calculated using IPCC methodology, with the results presented below. An implementation of energy conservation activities and energy diversification in boilers, furnaces, and motor drives will reduce GHG emissions by 14.49% in 2025. During 2006 – 2025 accumulated GHG emissions under the BAU scenario sum up to 4,453million tonnes CO_2, Under the EFFICIENT scenario 3,808million tonnes CO_2 will be released.

A comparison of GHG emissions under the BAU- and EFFICIENT scenario is presented in the following figure for various industry sub-sectors. It shows, that the highest GHG emission reduction after the implementation of energy conservation activities and energy diversification can be expected in the Chemical industry (excluding Fertilizer), followed by Fertilizer, Cement, Iron & Steel, and Pulp & Paper industry.

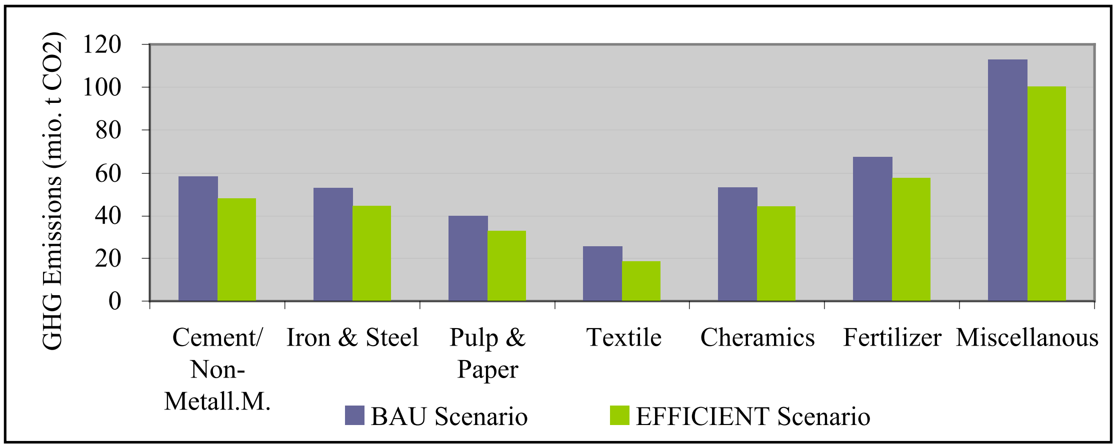


Figure 3.3: Projection of GHG Emissions from Energy Use by Indonesian Industry Sub-Sector, BAU and EFFICIENT in 2025

3.2.2 Industrial Processes

In some industry sub-sectors, GHG emissions are not only produced from energy use but also during industrial processes or from raw material. Currently, information on industrial process types and commodity utilization is limited. Accurate information is available about natural gas used as feedstock/ raw material for ammonia production in the Fertilizer industry and coal used as a reducing agent in the Iron & Steel industry. In addition, there is information on clinker production in Cement industry. These commodities will be used to analyze GHG emissions emanating from the industry sector's production processes. Compared to other industry sub-sectors, the GHG emissions from industrial processes of the three mentioned industrial sub-sectors are relatively high.

Table 3.3: Projection of Clinker Production, Natural Gas and Coal Demand in Industrial Processes in Indonesia, 2006 - 2025

Scenario	I. Sub-Sector	Product/ Fuel Type	Unit	Production/ Demand				
				2006	2010	2015	2020	2025
BAU	Cement	Clinker	tonnes	34,170,726	38,424,163	41,618,593	44,798,934	47,860,768
	Fertilizer	Feedstock: Natural gas	BCF	102	102	110	140	189
	Iron & Steel	Reducing agent: Coal	tonnes	112,624	142,017	189,975	254,332	340,347
EFFI-CIENT	Cement	Clinker	tonnes	34,761,065	33,318,768	34,099,611	36,159,168	38,046,965
	Fertilizer	Feedstock: Natural gas	BCF	102	102	110	140	189
	Iron & Steel	Reducing agent: Coal	tonnes	112,624	142,017	189,975	254,332	340,347

The projections above underlay the following assumptions:
Cement industry – Under the BAU scenario the clinker-to-cement ratio remains the same until 2025

with 0.975t clinker/t cement, while it reduces to 0.815t clinker/t cement under the EFFICIENT scenario. The clinker production emission coefficient is 0.5071tonnes CO_2/tonne clinker (default recommended by "1996 IPCC Guidelines for National Greenhouse Gas Inventories").

Fertilizer industry – The demand for natural gas as feedstock remains the same under the BAU- and EFFICIENT scenario, because natural gas can hardly be substituted by other materials, which might have lower carbon contents or by non-energy materials. The demand for natural gas as feedstock will grow with 3.27% per year due to an increase of ammonia production. The ammonia production emission coefficient is 0.525kg CO_2/m^3 natural gas as feedstock (default recommended by "1996 IPCC Guidelines for National Greenhouse Gas Inventories").

Iron & Steel industry - The demand for coal as a reducing agent remains the same under the BAU- and EFFICIENT scenario, because coal can hardly be substituted by other materials, which might have lower carbon contents or by non-energy materials. The demand for coal as a reducing agent will grow with 5.99% per year due to an increase of Iron & Steel production. The emission coefficient for Iron & Steel production using coal as reducing agent is 2.5tonnes CO_2/tonne coal as reducing agent (default recommended by "1996 IPCC Guidelines for National Greenhouse Gas Inventories").

Under the BAU scenario GHG emissions from industrial processes will increase from 23.1million tonnes CO_2 in 2006 to 36.3million tonnes CO_2 in 2025 - with clinker production contributing 69% to that, followed by natural gas as the fertilizer industry's feedstock contributing 29% and by coal as the Iron & Steel industry's reducing agent contributing 2%. In 2025 the GHG emissions estimated under the assumptions of the EFFICIENT scenario will count 14% less than GHG emissions under BAU. Cumulative GHG emissions during 2006 – 2025 for BAU- and EFFICIENT scenario will be 567.2million tonnes CO_2 and 500.3million tonnes CO_2, respectively.

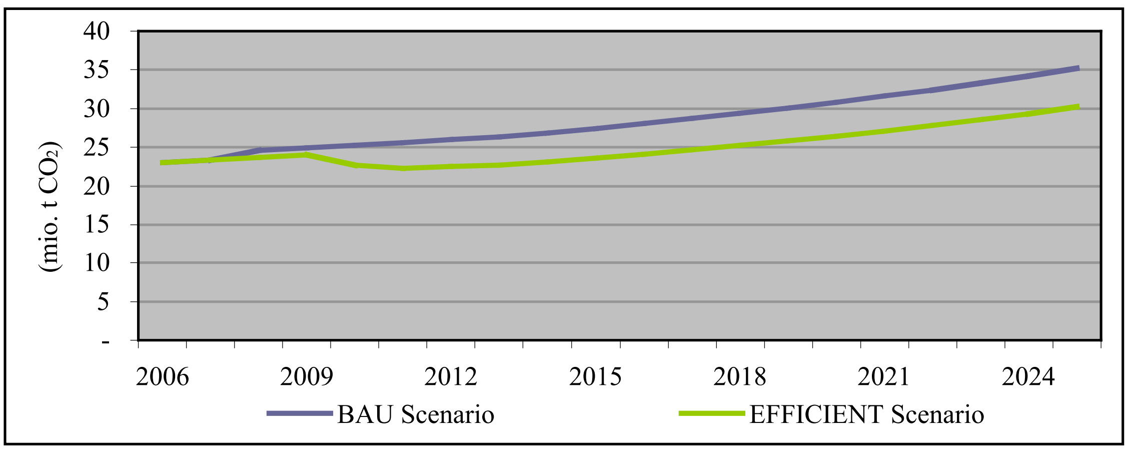


Figure 3.4: Projection of GHG Emissions from Industrial Processes in Indonesia, 2006 - 2025

A detailed analysis of the current state of each industry sub-sector and a discussion of energy conservation measures and environmentally sound technologies to be applied to achieve GHG emission reductions according to the EFFICIENT scenario are given in the subsequent chapters.

3.3 Key Sector Issues

3.3.1 Energy Prices

Fossil fuel prices to be paid by the Indonesian industry sector equal the (world) market prices. The only exception is natural gas, which is used as Fertilizer industry's feedstock and is regulated by the

Government of Indonesia (GoI).

Refinery products - Domestic refinery product prices for the industry sector are based on Mid Oil Platts Singapore (MOPS) price plus a delta magnitude, which is negotiated among the GoI, BPH Migas and Pertamina. The latter are the business entities, which distribute refinery products all over Indonesia. The negotiated delta is a summation of constant 10 % value added tax (VAT), distribution costs and Pertamina's profit margin. Refinery product prices equal the average of the previous two weeks' prices. They are applied for the following two weeks. Refinery product prices are therefore not real time prices. Distribution costs and Pertamina's profit margin will add up to 15% of the negotiated delta, although Pertamina's profit margin can be reduced to compensate crude oil price increases. Furthermore, refinery product prices are depot prices; which means that delivery costs from Pertamina's depots to industry sites must be paid by the industry.

Coal - During the crude oil price high in July 2008, coal supply for the Indonesian industry sector was insecure, because coal producers preferred to export. Compared to the price, which could be realized at export destinations, the achievable domestic price is relatively low. The implementation of Domestic Market Obligation (DMO) for coal and the Indonesian Coal Price Reference (ICPR) is expected to solve these problems. Both aim to secure continued domestic coal supply and to optimize the state revenue. The obligations refer to Presidential Decree No.5/2006 on National Energy Policies, which states that by 2025 coal shall contribute 33% to the national energy mix.

Natural gas - The natural gas price is regulated by the GoI and does not fully follow the market mechanisms. Natural gas producers and distributors have profit margins, but still the domestic natural gas price is lower than the international natural gas price. In natural gas sales negotiations, the GoI is represented by BPMIGAS as the agency responsible for oil and gas upstream and by PTPGN or Pertamina as the GoI's business entity responsible for natural gas distribution. Until July 2008, the highest domestic natural gas price ever reached equaled 5.5US$/MMBTU. In medium- and long-term, there will be a DMO for every gas producer similar to the DMO for coal, in order to increase domestic natural gas use as stated in Presidential Regulation 5/2006.

Electricity – The price, which has to be paid by the industry sector for electricity, is also not fully based on a market price, even though economic aspects are considered. Electricity prices for the industry sector are regulated by the GoI and vary according to demand.

3.3.2 Access to Energy

Refinery products - It is relatively easy to obtain refinery products, because they are available from more than 110 sea-fed depots all over Indonesia. A sea-fed depot can receive refinery products from seven oil refineries in Indonesia, located on the islands of: Sumatra (2), Java (3), Kalimantan (1), and West Papua (1). However, it should be noted, that sometimes transportation to depots is disturbed, particularly during high tide seasons. Therefore refinery products distribution to consumers may also be disrupted. The reason is, that national refinery products stock lasts for only 23 days and the number of tankers operating is limited. A short-term solution would be to increase the number of tankers; whereas a long-term solution would be the expansion of national refinery products stock capacities.

Coal - Indonesia is a coal producer exceeding 220million metric tonnes coal in 2008 alone. Around 70% of the produced coal is exported, with the remaining 30% allocated for domestic demands. Currently problems similar to those experienced for refinery product supply also impact the coal supply. During high tide seasons, coal barges cannot unload at designated ports resulting in a disruption of coal supplies to consumers. Supplies are often delayed, because coal producers are reluctant to sell to domestic consumers, since prices on the export market are higher domestic market prices.

Natural gas - Natural gas demand occurs mainly on the island of Java, while natural gas reserves there are limited. Natural gas fields in Java are relatively old and cannot always fulfill the existing contracts with the industry sector. Therefore a gas pipeline from the island of Sumatra to the neighboring island of Java has been built to transport natural gas to Java. An LNG receiving terminal, which can re-gasify LNG, will also be available in the future. If there is a natural gas shortage, the Fertilizer industry is set priority and will be supplied with natural gas first. Other industry sub-sectors have to cope with the remaining gas reserves. Furthermore, gas pressure and quality are low. Each of these constraints increases operation costs of the industry sector.

Electricity - Electricity supply to industry has also been disrupted lately, because production capacity is lagging behind the demand. High crude oil prices led to an increase in natural gas and coal prices. Hence electricity generation became more expensive. These conditions limit the GoI's ability to provide subsidies for electricity generation. In order to solve the problem, the GoI asked the industry sector to change the working hours, in order to avoid unsatisfiable demand peaks and reduce power plant load factors.

4 TECHNOLOGY CRITERIA AND OPTIONS

4.1 Selection Criteria of Technology Assessment

In general, technology to be transferred and used in the industry sector should match the following characteristics/ criteria.

Low cost technology - In the industry sector all efforts to increase efficiency of production processes and energy utilization should be low cost perspectives. In other words, although additional investment for such efficiency increase is necessary, savings in operations and maintenance costs (e.g. via energy savings) have to be achieved to such an extent, that the investment can be returned within a short period. If a sufficient economic benefit cannot be obtained, the industry sector will not attempt to improve efficiency.

Increase of competitiveness via improved efficiency – A second criterion for the consideration of technology transfer in the Indonesian industry sector is the level of competitiveness increase. Improved technology can increase the efficiency of the production process and energy consumption and thus raise production capacity, reduce production costs and make the industry more competitive. The higher the potential for production costs savings as a result of technology adaptation is, the more likely the technology will be installed.

Proven technology - In addition to these two criteria, the technology to be transferred should be proven to advance, should be available in the market and should not be a prototype.

Minimum dependency on technology "owner" - In relation to a minimum dependency on the technology owner, it must be ensured, that service for any technology transferred can be managed by local technicians and the technology can be operated by the industry itself.

GHG emission reduction - Last but not least, the new technology must bear the potential to contribute to GHG emissions reduction, whereby the aims of the Industry Sector TNA could be justified.

4.1.1 General Criteria

In accordance with national interests and policies general criteria are set for national technology transfer priorities in the industry sector as follow:

Table 4.1: General Criteria for Technology Selection

General criteria	Sub-Criteria
a. Conformity with national regulation and policy	• Food security (FS) • Natural resource security (NR) • Energy security (ES) • Incentive for participation (IP)
b. Institutional and human development	• Capacity building (production & know how) (CB)
c. Technology effectiveness	• Reliability of technology (RT) • Easiness of wider use of technology, including local contribution support of technology application (ET)
d. Environmental effectiveness	• Greenhouse gas emissions reduction (GR) • Improvement of local environmental quality (LE)
e. Economic efficiency and cost effectiveness	• Capital and operational costs relative to alternatives (COC) • Commercial availability (market) (CA)

4.1.2 Specific Criteria

Specific selection criteria reflect the priorities and situation of the industry sector as listed below:

Table 4.2: Specific Criteria for Technology Selection

Specific Criteria	Sub-Criteria
a. Availability in the market	• Possible for local manufacturing and production (LM) • Proven technology (PT) • Minimum dependency on technology owner (DTO)
b. Operation of technology	• Can be operated by the industry itself (CO)
c. Efficiency improvement in production process and consumption	• Efficiency in production process (EPP) • Efficiency in energy consumption (EEC)
d. Technology Application	• Implementation in Indonesia (IMI)

4.2 Resources and Technology Options Review

The potential a certain technology bears, to make a production process more efficient and optimize energy use, depends on the state of advancement of an industry sub-sector particularly on the technology, which is currently in use. The review of the condition of technology used in Indonesia will be limited to those energy intensive industry sub-sectors, which technology examples are provided for. Generally, technologies to reduce GHG emissions from the industry sector can be grouped as follows:

- **Energy efficiency -** Improve energy efficiency of current boiler, furnace, motor drives, and captive power technologies:
    - Electrical facilities: lighting, water facilities, loads, receiving and distribution systems, air compressors;
    - Heat facilities: heat insulation, steam system, combustion and flue gas, exhaust gas heat recovery; and
    - Utility facilities: heat pump system, cogeneration system, air conditioning, upgrading and process improvement.
- **Fuel switching/ alternative fuels -** Substitute refinery products by fuels with a lower emission factor such as biomass fuels
- **Recycling** - Recycling is the best-documented material efficiency option for the industry sector
- Introduce new technology concepts with lower GHG emissions

4.2.1 Cement Industry

About 5% of global CO_2 emissions originate from cement production - about half of it from energy use and half from industrial processes (International Energy Agency, GHG R&D Programme: "Emission Reduction of Greenhouse Gases from the Cement Industry", 23-Aug-2004). In 2005 Indonesia ranked as the 10th largest cement producer in the world (Mahasenan, Natesan; et al.: "The Cement Industry and Global Climate Change: Current and Potential Future Cement Industry CO2 Emissions", Greenhouse Gas Control Technologies - 6th International Conference, 2003, Oxford: Pergamon, pp. 995–1000).

In 2007 nine cement companies with a total capacity of 47.47million tonnes cement operated in Indonesia. The year before the total population of Indonesia counted 222.05million inhabitants. The average cement demand per capita was 157.77kg cement/person per year. The BPPT MARKAL Team assumes that the average population growth rate is about 1.1%/year; therefore the total national population will have increased to up to 273.22million inhabitants in 2025. Cement consumption will rise continuously in relation to the national economy growth, which is assumed with 6.5%/year through 2025. Hence, the cement demand per capita will increase up to 170.86 kg/person per year until 2025.

As already discussed fossil fuel reserves are limited and the price of fossil fuels is steadily increasing leading to high costs for raw materials and fuels. A further reduction of coal and electricity demand via energy efficiency increase, the use of alternative fuels and product changes impacting the fuel demand during industrial production processes would result in cost savings and (in)direct GHG emission reductions for Indonesian cement industry. The cost structure of cement production is presented in the following figure. The target of the national Cement industry is to fulfill domestic cement demand for an affordable price with the least impact on the environment.

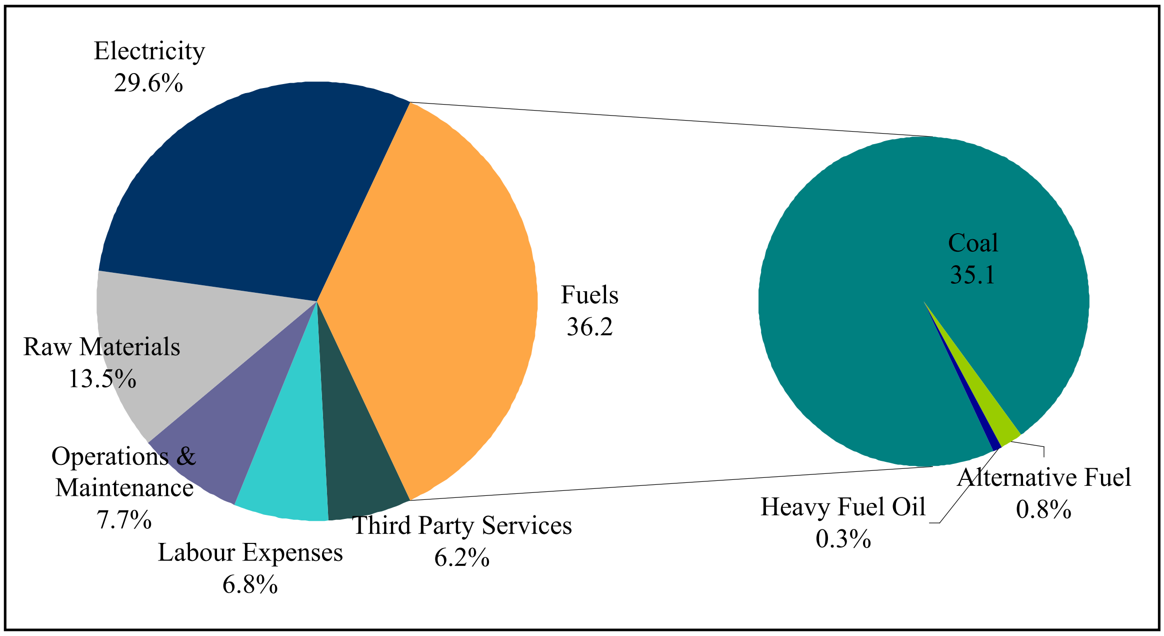


Figure 4.1: PT. Holcim Indonesia - Cost Structure of Cement Production

Energy use - Although cement production is energy intensive, progress towards energy use reduction has been made in Indonesia. At the end of the 1970s several cement companies were still using the very energy intensive wet process for their production[1]. Technology substitution from wet- to dry process could reduce energy intensity by about a half meanwhile. Today all companies use the dry process, but still with a variety of technologies, ranging from very efficient to little efficient.

Energy efficiency: Industrial systems which may include lighting, compressed air, steam systems, process heating systems, pumps, fans, industrial motors and combined heat and power (CHP) support industrial processes, so they are engineered for reliability rather than energy efficiency. Industrial systems that are over-sized in an effort to create greater reliability, can result in energy lost to excessive equipment cycling, less efficient part load operation and system throttling to manage excessive flow. Waste heat and premature equipment failure from excessive cycling and vibration are side effects of this approach that contribute to diminished, not enhanced reliability.

Lack of knowledge about system controls and competing objectives of the plant maintenance staff (i.e. reliability rather than efficiency) are the key barriers to the uptake of more efficient industrial systems. Facility plant engineers are typically evaluated on their ability to avoid disruptions and constraints in production processes, not energy efficient operations. Similarly when plant equipment fails, to avoid

[1] Energy intensity is energy required (in GJ) to produce a unit of output (tonne or million Rp.).

disruption to production, plant engineers swiftly replace the broken component with a working version of the same; missing the opportunity for a applying a more efficient component or system. Energy efficiency research and skills acquisition must be done in a systematic way to enable plant engineers to make informed decisions through both their routine plant maintenance and their crisis-based repairs (Econoler International/ The World Bank: "Assistance to the Government of Indonesia's Demand-side Management Program", Final Report, January 2006).

Two of the nine cement companies operating in Indonesia, PT. Holcim and PT. Indocement, have implemented efficiency improvements in some of their production lines and thus were able to reduce the energy consumption for clinker production. In 2007, production of 12.7million tonnes clinker needed about 2million tonnes coal (790kcal/kg clinker) and about 1.4TWh electricity (~105kWh/tonne cement).

The installation of high-efficiency classifiers during raw material preparation and grinding for example resulted in a higher (raw) material fineness, more stable mill operation, and less mill stops due to rejection of overloads. Furthermore, the use of this technology reduced electricity demand by 1.2kWh/tonne cement with a total energy cost saving of 211,600US$/year. Electricity demand could also be reduced by 1.0kWh/tonne clinker after the installation of adjustable speed drives in raw mill fans, which resulted in total cost savings of 476,000Rp./hour (51.2US$/hour). Another example is the modification of the kiln burner, which led not only to energy savings but also to a sharper flame, which better satisfies process requirements, to an ease of burner operation control, to better coating formation (longer brick lifetime), to the ability to burn alternative fuels, to better clinker microstructure and hence to a sufficient cement strength according to product portfolio requirements (blended cement). Another example is the conversion to a grate cooler, particularly the installation of a fixed grate inlet cooler chamber, which improved the cement quality and helped to save energy by reducing the specific heat consumption. The latter was lessened from 3,327MJ/t clinker to 3,091MJ/t clinker, which equals a 7% CO_2 emission reduction from clinker production.
There is potential for the improvement of energy efficiency in the production lines of other Indonesian cement producers too by using such technologies and measures. Requirements have might be producer specific and have to be analyzed.

Fuel switching/ Alternative fuels: Cement production is an energy-intense production process. Most cement kilns today use coal and petroleum coke as primary fuels, and to a lesser extent natural gas and fuel oil. GHG emissions from stationary fuel combustion in the kiln could be reduced by substituting coal and petroleum coke by alternative fuels e.g. agricultural waste such as rice husk and palm kernel shell and saw dust, instead of fossil fuels. These alternative fuels are assumed to be carbon neutral. Other non-carbon neutral alternative fuels are synthetic fuels, rubber, sorted municipal waste, and crude palm oil (CPO). Except for CPO, prices for alternative fuels are relatively low, because they are waste products. There is a tendency to a price increase for alternative fuels though, due to competition of use, import tariffs, limitations through waste policy, etc. This trend as well as transportation cost of alternative fuels to the production side and supply reliability, which might be limited due to e.g. seasonality, have to be considered by cement producers. Overall fuel costs savings are expected by switching from fossil to alternative fuels.

Alternative fuels are used by PT. Indocement Indonesia and PT. Holcim Indonesia already.

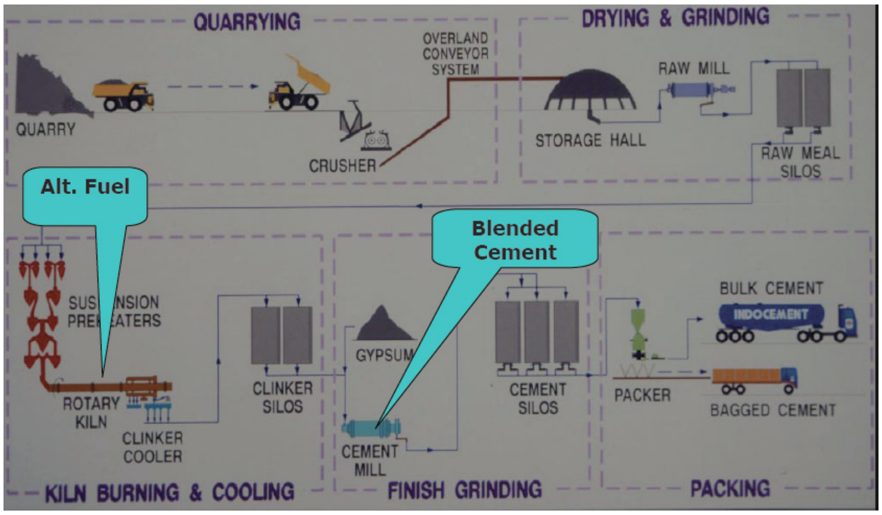
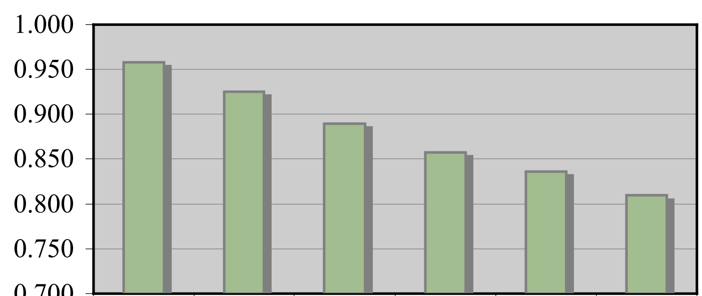


Figure 4.2: PT. Indocement Indonesia - Cement Production Process

<u>Industrial process</u> - Besides GHG emissions from energy use, CO_2 is released during the production process of clinker, an intermediate product, which cement is made from. High temperatures in cement kilns cause the chemical change of raw materials into clinker. This process is called calcination - calcium carbonate, one of the raw materials for cement production, is transformed in the following reaction: $CaCO_3 = CaO + CO_2$. CO_2.

Blended cement: Clinker production is an emission intensive process. GHG emissions from cement production can be reduced significantly by decreasing the amount of clinker in a cement product. The method is called cement blending - a percentage of clinker in a cement product is substituted by alternative materials such as fly-ash and natural pozzolana such as trass, etc. Two of the nine cement companies operating in Indonesia, PT. Holcim and PT. Indocement, have implemented cement blending already. The percentage of clinker in one unit cement is expressed by the clinker-to-cement ratio. PT. Holcim for example could reduce the clinker-to-cement ratio from 95.8% in 2003 to 80.9% in 2008 in one of its production units by blending cement (among other process changes). This translates into a CO_2 emissions reduction during the production process of 12% - 14%. Cement blending bears the potential for GHG emissions reduction also in other production units and in the seven other Indonesian cement companies.



Year	2003	2004	2005	2006	2007	2008
clinker-to-cement ratio (t clinker/t cement)	0.958	0.925	0.889	0.857	0.836	0.809

Figure 4.3: PT. Holcim Indonesia - Development of the Clinker-to-Cement Ratio

Recycled concrete: Recycled concrete is a large part of blended material in some countries, e.g. Netherlands 70% and is growing in prominence as governments world-wide attempt to modernize policies dealing with waste from construction and demolition with a view to material efficiency and landfill avoidance. The recovery of concrete falls between standard definitions of reuse and recycling: concrete is broken down into aggregates (granular material), generally to be used in road works, but also as aggregates in new concrete. Recovering concrete has two main advantages: it reduces the use of new virgin aggregate and the associated environmental costs of exploitation and transportation, and it reduces landfill of valuable materials. While in some countries near full recovery of concrete is achieved, in most parts of the world the potential to recover concrete is overlooked and it ends up as unnecessary waste in landfill. This is generally the result of low public concern, as the waste poses relatively low hazard risks compared to other materials.

The following environmentally sound technologies and measures have been implemented already by PT. Holcim Indonesian and PT. Indocement Indonesia.

Table 4.3: PT. Holcim Indonesia/ PT. Indocement Indonesia - Energy Conservation Measures

Technology Input	Fuel Saving	Emission Reduction	Cost
	(kWh/t clinker)	(kg CO_2/t clinker)	(US$)
Raw material preparation: Install adjustable speed drive in raw mill	18.0-19.0	13.1-13.9	2,500,000
Raw material preparation/ grinding: Modify high-efficiency classifier	1.2	0.9	426,000
Clinker production: Use alternative fuels	55.6	12.2	15,750,000
Clinker production: Modify kiln burner			161,294
Clinker production: Install fixed grate inlet cooler	65.6	7%	1,075,269
Product change: Blended cement		15.0-24.0	20,000,000
Variable speed drive, Low-velocity classifier, Vibrating screen cement pre-grinder, Optimize hydraulic roller crusher, Install meter in every section & "reroute" power cable, Cut off selected equipments during peak power time	20.0	14.6	2,688,172

More options available for Cement industry are listed below.

Table 4.4: Environmentally Sound Technologies/ Measures for Cement Industry

Options	**Specific electricity savings (kWh/t cement)**		**Specific fuel savings (kWh/t cement)**		**Estimated Paypack Period (1) (years)**
	Lower	Upper	Lower	Upper	
1 Raw Materials Preparation					
Efficient transport system	3.20	3.20	-	-	> 10 (1)
Raw meal blending	1.50	3.90	-	-	N/A (1)
Process control vertical roller mill	0.80	1.00	-	-	1
High-efficiency roller mill	10.20	11.90	-	-	> 10 (1)
High-efficiency classifiers	4.30	5.80	-	-	> 10 (1)
Fuel preparation: Roller mills	0.70	1.10	-	-	N/A (1)
2 Clinker production					
Use alternative fuel	-	-	146.54	-	1
Energy Management & Control Systems	1.20	2.60	29.31	58.61	1 – 3
Seal Replacement	-	-	5.86	5.86	< 1
Shell Heat Loss Reduction	-	-	26.38	90.85	1
Heat recovery power generation	18.00	18.00	-	-	3
Optimize Grate Cooler	1.80	1.80	17.58	35.17	1 – 2
Conversion to Grate Cooler	2.40	2.40	67.41	67.41	1 – 2
Combustion System Improvement	-	-	29.31	114.30	2 – 3
Indirect Firing	-	-	38.10	55.68	N/A
Low-pressure drop Suspension Pre-heater	0.50	3.50	-	-	> 10 (1)
Addition of Pre-Calciner or Upgrade	-	-	35.17	158.26	5 (1)
Conversion of Long Dry Kiln to Pre-Heater	-	-	105.51	213.94	> 10 (1)
Conversion of Long Dry Kiln to Pre-Calciner	-	-	161.19	322.38	> 10 (1)
Efficient Mill Drives	0.80	3.20	-	-	1
3 Finish Grinding					
Energy Management & Process Control	1.60	1.60	-	-	< 1
Improved Grinding Media in Ball Mills	1.80	1.80	-	-	8 (1)
High Pressure Roller Press	7.00	25.00	-	-	> 10 (1)
High-Efficiency Classifiers	1.70	6.00	-	-	> 10 (1)
4 Plant Wide Measures					

Options	Specific electricity savings (kWh/t cement)		Specific fuel savings (kWh/t cement)		Estimated Paypack Period (1) (years)
	Lower	Upper	Lower	Upper	
Preventative Maintenance (insulation, compressed air systems maintenance)	5.00	5.00	11.72	11.72	< 1
High Efficiency Motors	5.00	5.00	-	-	< 1
Adjustable Speed Drives	5.50	7.00	-	-	2 - 3
Optimization of Compressed Air Systems	2.00	2.00	-	-	< 3
Efficient Lighting	0.50	0.50	-	-	N/A
5 Product Change					
Blended Cement	15.00	15.00	354.62	354.62	< 1
Limestone Portland Cement	3.00	3.00	87.92	87.92	< 1
Use of Steel Slag in Clinker (CemStar)	-	-	46.89	46.89	< 2
Low Alkali Cement	N/A	N/A	46.89	117.23	Immediate
Reduced Fineness of Cement for Selected Uses	14.00	14.00	-	-	Immediate

Source: Ernst Worrell and Christina Galitsky. "Energy Efficiency Improvement Opportunities for Cement Making: An ENERGY STAR® Guide for Energy and Plant Managers", Environmental Energy Technologies Division, Lawrence Berkeley National Laboratory, January 2004, LBNL-54036
Notes: Payback periods are calculated on the basis of energy savings alone. In reality this investment may be driven by other considerations than energy efficiency (e.g. productivity, product quality), and will happen as part of the normal business cycle or expansion project. Under these conditions the measure will have a lower payback period depending on plant-specific conditions.

Furthermore the Ministry of Industry supports the following measures as options for GHG emissions reduction in Indonesian Cement industry. No exact data on fuel savings, GHG emissions reduction potential or required upfront investment is available for these options though:

- Plant wide measures: Energy Control Center (ECC)
- Plant wide measures: Minimize ingress of false air into the kiln, cooler, coal mill, cement mill and raw mill circuits
- Product Change: Use of Limestone with low CaCO3.
- Product Change: Mineral components in cement (MIC)

After discussing with the Ministry of Industry, some of the Indonesian cement companies and the Indonesian Cement Association agreed on a scenario plan for the implementation of environmentally sound technology, which aims to reduce CO_2 emissions until 2025, as can be seen below.

Table 4.5: Scenario Plan for Implementation of Environmentally Sound Technologies/ Measures in Indonesian Cement Industry

	2005	2010	2015	2020	2025
Energy diversification	Alternative fuel: Palm Shell, other biomass, etc.				
			Alternative fuel: Municipal solid waste		
			Alternative fuel: Biogas		
					Alternative fuel: Hazardous waste
Optimization of clinker production	Energy management and process control system				
	Kiln burner modification				
	Kiln shell heat loss reduction				
		Improvement of refractories			
			Conversion to grate cooler		
					Waste Heat Recovery
Optimization of material preparation/ grinding	High-efficiency classifiers				
		Low-velocity classifier			
		Install vibrating screen cement pre-grinder			
			Optimization of Hydraulic Roller Press		
			Install Cement Vertical Mill		
Plant wide measures for optimization	Efficient Lighting				
	Minimize ingress of false air				
	Cut off some equipments during peak power time				
		Preventative maintenance (insulation, compressed air system, maintenance)			
		Energy Control Center (ECC)			
		Install adjustable speed drive			
		Install meter in every section and “reroute” power cable.			
			High-efficiency motor drives		
			Optimization of compressed air systems		
Cement Raw Material Reduction	Produce clinker by reducing C_3S				
	Reducing Clinker-to-cement ratio by substituting with materials such as fly ash, etc.				
	Mineral components in cement (MIC)				

Source: Ministry of Industry

The following figure shows the GHG emissions reduction scenario (EFFICIENT) for Cement industry. By installing the aforementioned measures and technologies, Cement industry's GHG emissions will be gradually reduced by 17.41% until 2025 compared to BAU scenario.

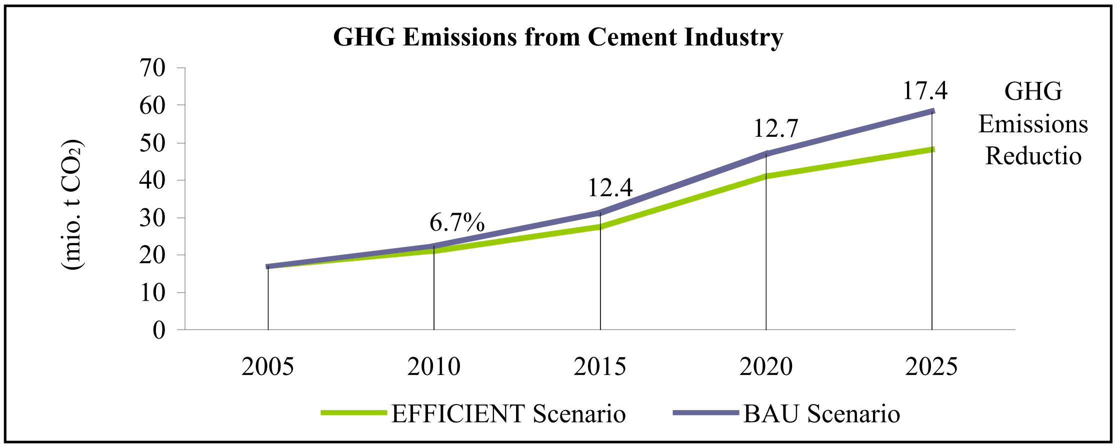


Figure 4.4: Projection of GHG Emissions from Indonesian Cement Industry, 2005 - 2025

Based on the industry sub-sector growth rate predicted by the Ministry of Industry, cement production will reach a multiple of today's production level until 2025 with an accordingly increase of GHG emissions and emissions intensity. In 2005 GHG emissions intensity of cement production was 1.061tonne CO_2/tonne cement. Based on BAU projections GHG emissions from each tonne of cement will increase to 1.158tonne CO_2/tonne cement until 2025. Whereas under the assumptions of the EFFICIENT scenario GHG emissions intensity can be decreased to 0.956tonne CO_2/tonne cement until 2025 (seen in the following).

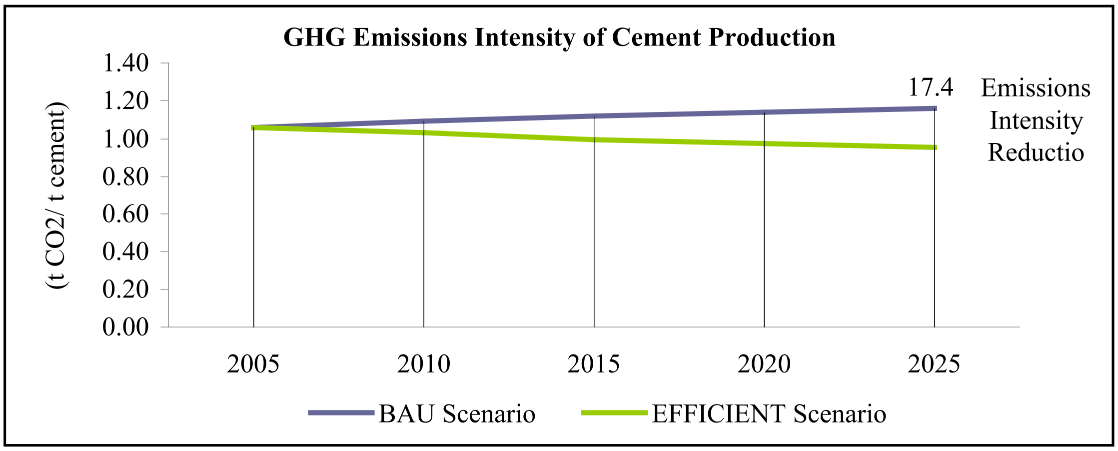


Figure 4.5: Projection of GHG Emissions Intensity of Indonesian Cement Industry, 2005 - 2025

4.2.2 Iron & Steel Industry

The steel industry belongs to the energy intensive industry sub-sectors, utilizing fossil fuels for energy use and as reducing agents in the industrial production process. The World Steel Association ranked Indonesia as the 37th among the world's major steel producing countries in 2007. Currently there are 71 Iron & Steel plants operating in Indonesia, having a production capacity of 15.4million tonnes/year (2007). According to the Ministry of Industry most Iron & Steel producing companies have not yet implemented energy efficiency measures in their production lines; therefore bearing a significant optimization potential.
The largest steel company in Indonesia is PT. Krakatau Steel located in the province of Banten. PT.

Krakatau Steel belongs to the advanced Iron & Steel producing companies, having implemented state-of-the-art technology already. The production capacity of PT. Krakatau Steel reaches 3.8million tonnes/ year.

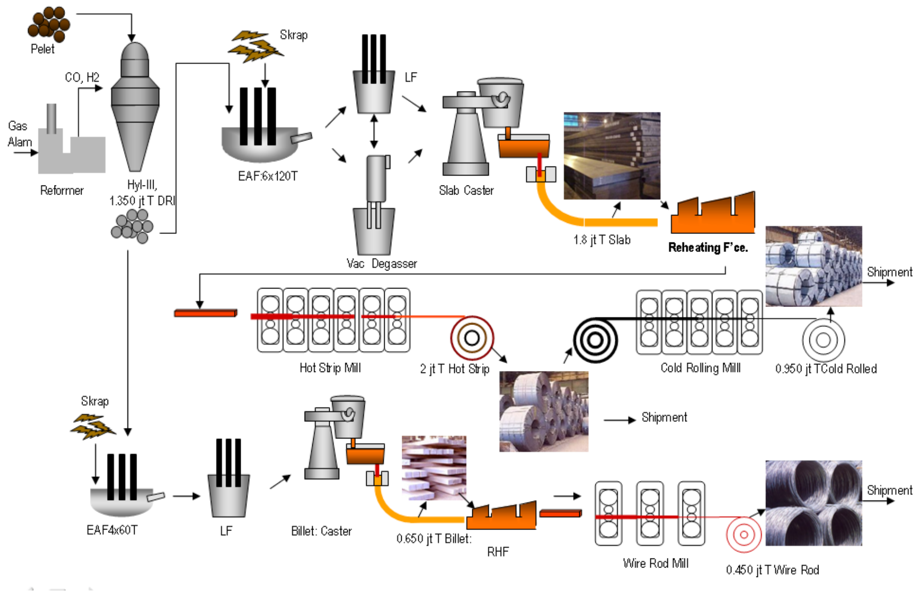


Figure 4.6: PT. Krakatau Steel Indonesia - Steel Production Process

Energy use - Energy consumption of PT. Krakatau Steel, as the largest Indonesian Iron & Steel producer, is dominated by electricity use (54% being divided into 40% for steelmaking, 11% for rolling and 3% for iron making), followed by natural gas (42% being divided into 35% for iron making, 5% for rolling and 2% for steelmaking), and refinery products (4%).

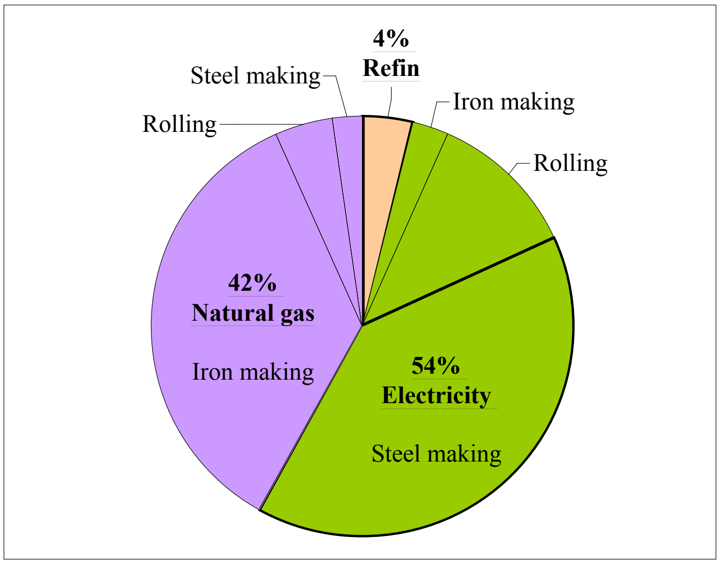


Figure 4.7: PT. Krakatau Steel Indonesia - Energy Consumption

***Energy audits/ Energy management systems**:* The high share of electricity in the Iron & Steel industry's energy mix makes electricity generation a process to be analyzed for optimization potential. Also the production processes of iron making, steelmaking and rolling have to be further examined regarding their energy efficiency. Therefore, energy audits and energy management systems need to be used in steel plants to identify opportunities for reducing energy use, which in turn reduces GHG emissions.

Energy Efficiency: Approximately 10% of total energy consumption in steel making could be saved through improved energy and materials management. The potential for energy efficiency improvement varies between steel plants based on the production route used, product mix, energy and emissions intensities of fuel and electricity, and the boundaries chosen for the evaluation (IPCC, 2007).
Opportunities for efficiency improvement during steelmaking are presented in the following figure.

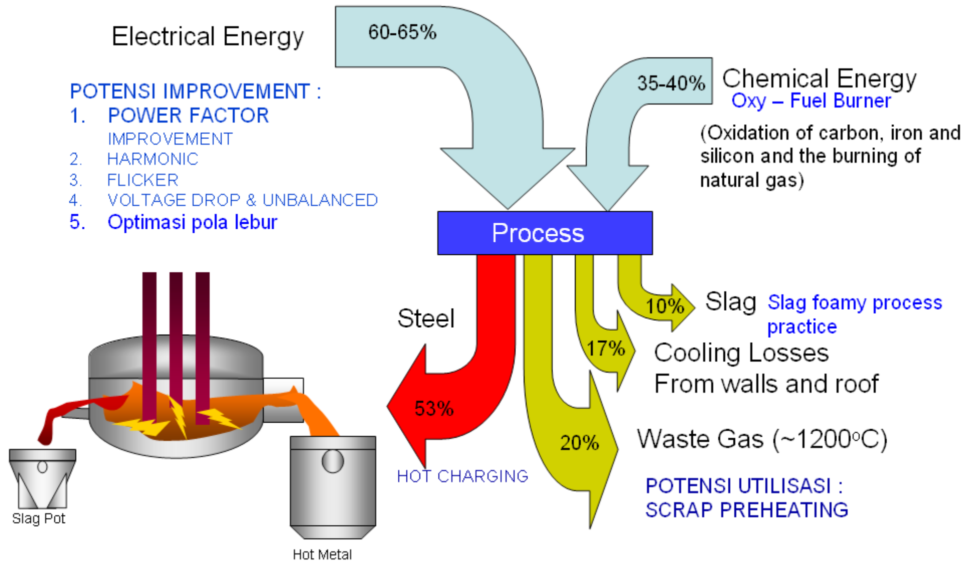


Figure 4.8: Opportunities for Energy Conservation in Steelmaking Process

Fuel Switching: Furthermore, fuel switching, including the use of waste materials, is mentioned as an energy conservation measure for the Iron & Steel industry. Technology to use wastes such as plastics as alternative fuel and feedstock for steel production has already been developed. Pre-treated plastic wastes can be recycled in coke ovens and blast furnaces, reducing GHG emissions by reducing both emissions from incineration and the demand for fossil fuels (IPCC, 2007). Fuel switching has already been implemented in some processes by PT. Krakatau Steel Indonesia.

Recycling*:* Recycling is the best-documented material efficiency option for the industry sector and is used in steel production already. Recycling of steel in electric arc furnaces accounts about a third of world production and typically uses 60–70% less energy (IPCC, 2007). Recycling will also result in the reduction of the amount of coal used as a reducing agent in the Iron & Steel making process and in an overall reduction of GHG emissions from industrial processes.

Several efforts taken by PT. Krakatau Steel Indonesia to reduce energy demand are listed in the table below. The company has implemented energy conservation activities, which reduced GHG emissions by 0.12million tonnes CO_2/year. Total energy savings from this first energy conservation phase were about 51.61GWh/year. Currently, PT. Krakatau Steel is conducting a second phase of energy conservation, which is expected to reduce energy consumption by another 150.47GWh/year and to reduce GHG emissions by 0.15million tonnes CO_2/year. The company also plans to conduct a third phase of energy conservation with an energy consumption reduction potential of 1,561.00GWh/year and a GHG emissions reduction potential of 0.25million tonnes CO_2/year.

Table 4.6: PT. Krakatau Steel Indonesia - Energy Conservation Project

No.	Project	Energy saving	Energy Saving	GHGe reduction
		(kWh/year)	(US$/year)	(t CO_2/year)
A. Finished Project				
1	Power Demand Control (Steelmaking)	18,600,000	2,021,739	13,466
2	Dedusting System Optimization (Steelmaking)	20,000,000	2,173,913	14,480
3	Water Cooling Panel Optimization (Steelmaking)	809,036	9,630	585
4	Optimization in Ladle Pre-heating (Steelmaking)	12,198,400	70,734	2,500
5	Fuel Substitution (Hot Rolling Mill)	-	8,695,652	84,450
	Total	**51,607,436**	**12,967,391**	**115,481**
B. On Going Project				
1	Energy Control Center (ECC) (KORPORAT)	60,469,000	4,347,826	100,000
2	Fuel Oil Substitution (Cold Rolling Mill)	-	3,260,869	28,150
3	Coal Gasification at Calcination Plant	-	217,391	-
4	Oxygen Lancing at Electric Arc Furnace (Steelmaking)	90,000,000	6,471,000	20,000
	Total	**150,469,000**	**14,297,086**	**148,150**
C. Planned Project				
1	Scrap Pre-heater (Steelmaking)	55,560,000	3,994,764	10,000
2	Slabs/ Billets Hot Charging (Steelm.-Hot rolling)	146,678,400	150,326	32,884
3	Thin Slab Mill Technology (Steelm.-Hot rolling)	222,240,000	15,979,056	90,000
4	Zero Reformer (Iron making)	1,136,555,917	18,109,768	120,000
	Total	**1,561,000,000**	**38,233,914**	**252,884**

More environmentally sound technologies and measures available for Iron & Steel industry are listed in the following table. In this Industry Sector TNA the discussions of the Iron & Steel industry is considering the process only from the smelter up to the final product. It does not include iron ore preparation and cokes production.

Table 4.7: Environmentally Sound Technologies/ Measures for Iron & Steel Industry

Options	Fuel Savings	Electricity Savings	Primary Energy Savings*	Annual Operating Costs	Retrofit Capital Cost	CO2 Emissions Reduct.**
	(kWh/t crude steel)			(US$/t crude steel)		(kgC/t)
Iron Making - Blast Furnace						
Pulverized coal injection to 130kg/thm	191.67	-	191.67	(1.78)	6.24	11.42
Pulverized coal injection to 225kg/thm	141.67	-	141.67	(0.89)	4.64	8.45
Injection of natural gas to 140kg/thm	222.22	-	222.22	(1.78)	4.46	13.35

Options	Fuel Savings	Electricity Savings	Primary Energy Savings*	Annual Operating Costs	Retrofit Capital Cost	CO2 Emissions Reduct.**
	(kWh/t crude steel)			(US$/t crude steel)		(kgC/t)
Top pressure recovery turbines (wet type)	-	27.78	83.33	-	17.84	4.29
Recovery of blast furnace gas	16.67	-	16.67	-	0.27	0.98
Hot blast stove automation	91.67	-	91.67	-	0.27	5.49
Recuperator hot blast stove	19.44	-	19.44	-	1.25	1.19
Improved blast furnace control systems	100.00	-	100.00	-	0.32	5.93
Steelmaking – Basic Oxygen Furnace						
BOF gas + sensible heat recovery	255.56	-	255.56	-	22.00	12.55
Variable speed drive on ventilation fans	-	-	2.78	-	0.20	0.14
Integrated Casting						
Adopt continuous casting	66.67	22.22	136.11	(5.35)	11.95	36.06
Efficient ladle pre-heating	5.56	-	5.56	-	0.05	0.27
Thin slab casting	869.44	158.33	1,358.33	(31.33)	134.25	177.60
Integrated Hot Rolling						
Hot charging	144.44	-	144.44	(1.15)	13.09	7.18
Process control in hot strip mill	72.22	-	72.22	-	0.61	3.59
Recuperative burners	169.44	-	169.44	-	2.18	8.38
Insulation of furnaces	38.89	-	38.89	-	8.73	1.91
Controlling oxygen levels and VSDs on combustion air fans	80.56	-	80.56	-	0.44	3.95
Energy-efficient drives (rolling mill)	-	2.78	8.33	-	0.17	0.39
Waste heat recovery (cooling water)	8.33	-	8.33	0.06	0.70	0.46
Integrated Cold Rolling and Finishing						
Heat recovery on the annealing line	47.22	2.78	52.78	-	1.55	2.73
Reduced steam use (pickling line)	30.56	-	30.56	-	1.61	1.55
Automated monitoring and targeting system	-	33.33	105.56	-	0.63	5.51
General						
Preventative maintenance	119.44	5.56	136.11	0.02	0.01	9.74
Energy monitoring and management system	30.56	2.78	38.89	-	0.15	2.60
Cogeneration	8.33	97.22	305.56	-	14.52	22.39
Variable speed drive: flue gas control, pumps, fans	-	5.56	16.67	-	1.30	0.40

Source: Ernst Worrell, Nathan Martin, and Lynn Price. "Energy Efficiency and Carbon Dioxide Emissions Reduction Opportunities in the U.S. Iron and Steel Sector", Environmental Energy Technologies Division, Lawrence Berkeley National Laboratory, July 1999, LBNL-41724

Notes:

*) Primary energy saving is calculated based on the average efficiency of power plants in US as well as transmission and distribution losses in US.

**) CO_2 emission reduction for each technology is calculated based on: average CO_2 emission per GJ of fuel used in US Iron & Steel industry and grid emission factor in US

The following figure shows the GHG emissions reduction scenario (EFFICIENT) for Iron & Steel industry. By installing the aforementioned measures and technologies, Iron & Steel industry's GHG emissions will be gradually reduced to 15.36% compared to BAU scenario.

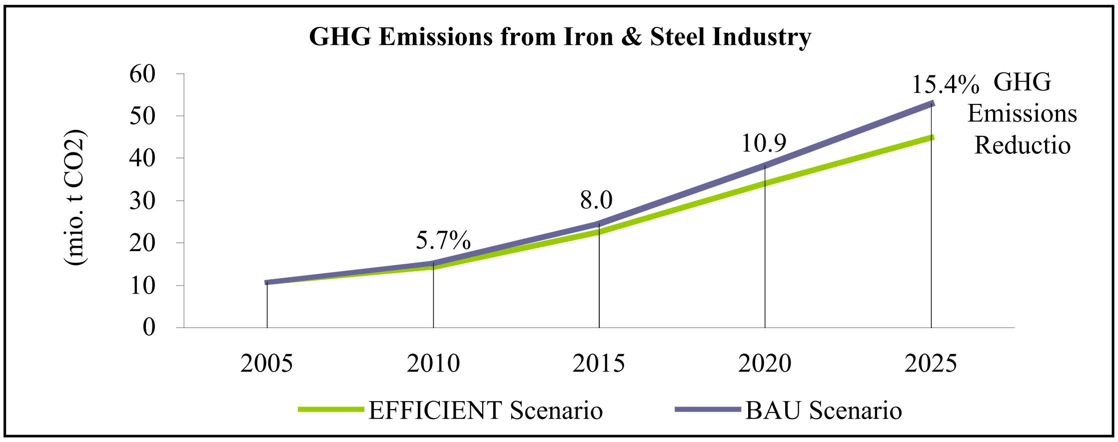


Figure 4.9: Projection of GHG Emissions from Indonesian Iron & Steel Industry, 2005 - 2025

Based on calculations of the Ministry of Industry (MoI), GHG emissions intensity for steel production counted 12.98tonnes CO_2/tonne steel in 2005. It is predicted by the MoI, that not only the amount of steel produced will increase to up to 77tonnes steel/year until 2025, but also the GHG emissions intensity of steel production will raise to 13.50tonnes CO_2/tonne steel in 2025 (BAU scenario). Based on calculations under the EFFICIENT scenario, which assumes the implementation of energy conservation measures and environmentally sustainable technology, GHG emissions intensity could be reduced to 11.58tonne CO_2/tonne steel in 2025, which means a 15.36% reduction compared to BAU.

4.2.3 Pulp & Paper Industry

Pulp & Paper production is a highly diverse, increasing global industry and belongs to the energy-intense industries. In Indonesia there are 81 Pulp & Paper companies with a total production of 17million tonnes of Pulp & Paper in 2007. According to the Ministry of Industry most Pulp & Paper producing companies have not yet implemented energy efficiency measures in their production lines; therefore bearing a significant optimization potential.
The analysis on energy conservation opportunities for Pulp & Paper industry in this Industry Sector TNA is based on the experiences of PT. Pindo Deli as one of the Pulp & Paper companies, which have already implemented efficient technology. PT. Pindo Deli has a production capacity of 107,856tonnes paper/month.

Energy Use – In Pulp & Paper industry GHG emissions from energy use can be reduced via using efficient, environmentally sound technology, optimizing production processes and switching to fuels with less carbon content.

Energy Efficiency/ Combined Heat and Power: The Pulp & Paper industry is already one of the global leaders in the use of combined heat and power (CHP) systems or cogeneration. CHP systems produce electrical power and thermal energy from the same fuel, yielding more usable energy as either power or steam and hence reducing GHG emissions and the demand for fossil fuels. In Indonesia there is still a potential to increase the use of CHP systems. PT. Pindo Deli has started condensate heat recovery

activities, which help to save 23,760tonnes steam/year and hence 229,030tonnes CO_2/year. To further reduce the demand for steam and hence the demand for fossil fuels a steam trap treatment programme has been conducted to reduce steam losses from 10,199tonnes steam/month to 8,165tonnes steam/month. In total his programme can save 30,157tonnes steam/year and reduce natural gas consumption by 1.22million m^3 natural gas/year. Furthermore, replacing regular presses with a shoes press roll system will not only increase de-watering and speed paper drying, but also improve the quality of the product and result in steam savings (1% moisture reduction results in 4% steam saving). Steam savings are predicted to be 40,800tonnes steam/year by using a shoe press roll system, which helps to reduce natural gas consumption by 141,984tonnes natural gas/year and GHG emissions by 416,013tonnes CO_2/year.
Via the use of poly disc filters 37.44MWh electricity/year could be saved by PT. Pindo Deli, which reduced GHG emissions by 1,401tonnes CO_2/year. Via adding chemicals to the pulp in the pulp refinery system electricity consumption could be reduced from 800kWh/tonne paper to 500kWh/tonne paper resulting in a GHG emissions reduction of 4,100tonnes CO2/year. Furthermore, a replacement of refiner blades decreased electricity demand from 200kWh/tonne pulp to 140kWh/tonne pulp leading to GHG emission reductions of 1,576tonnes CO_2/year.

Fuel switching/ Alternative fuel: In the beginning of 1980s, PT. Pindo Deli conducted an energy diversification programme, switching from industrial diesel oil (IDO) to natural gas. The economic benefits of fuel switching from IDO to natural gas were large fuel cost savings in particular the elimination of cost for pre-heating, volume loss due to sedimentation in storage tanks and replacement of air heating elements. In average 144,852tonnes CO_2/year were avoided by switching from IDO to natural gas.
Fuel switching, especially the use of biomass as fuel, is common practice in the Pulp & Paper industry worldwide. The industry sub-sector is more reliant on biomass fuels than any other industry. In developed countries biomass provides 64% of the fuels used by wood products facilities and 49% of the fuel used by pulp, paper and paperboard mills. Besides the increased use of biomass and energy efficiency improvements in the Pulp & Paper industry during the last decades[2], the use of biomass fuels still offers the largest potential to reduce fossil fuel consumption by displacing carbon-intensive electricity from the grid with biomass-based generated electricity (IPCC, 2007).

Recycling: Recovery rates for waste paper in developed countries are typically at least 50%. A number of studies find that paper recycling reduces life-cycle emissions of GHG emissions compared to other means of managing used paper. The analyses however are dependent on study boundary conditions and site-specific factors and it is not yet possible to develop reliable estimates of the global mitigation potential related to recycling in the Pulp & Paper industry (IPCC, 2007)

Industrial wastewater - The Pulp & Paper industry produces large volumes of wastewater, which contain high levels of degradable organics. Besides GHG emissions from energy use, the industrial sub-sector emits therefore also methane (CH_4) from industrial wastewater. In 2005 PT. Pindo Deli set the target to reduce water consumption in some production lines. Reducing water consumption automatically reduces the fibers that run off into the effluent and hence reduce CH_4 emissions. PT. Pindo Deli could improve its water recovery systems, which helped to reduce fresh water demand by 52tonnes water/tonne pulp and to save 132tonnes pulp fibre/month.

[2] Since 1990, CO_2 emission intensity of the European paper industry has decreased by approximately 25%, the Australian Pulp & Paper industry about 20%, and the Canadian Pulp & Paper industry over 40%. Fossil fuel use by the US Pulp & Paper industry declined by more than 50% between 1972 and 2002 (IPCC, 2007)

The following table summarizes the mentioned activities and technologies implemented by PT. Pindo Deli Indonesia.

Table 4.8: PT. Pindo Deli Indonesia - Energy Conservation Measures

Technology Input	GHG emissions reduction	Total cost savings	Other annual savings	Investment Cost
	(t CO2/year)	(US$/year)	(unit/year)	(US$)
Fuel switching in heat recovery steam generator: IDO to natural gas	144,852	460,000		153,000
Fuel switching in circulating fluidized-bed system: Coal to alternative fuel (solid waste)	27,108	2,610,000	87,000t coal	
Poly Disc Filter	1,401	69,000	449MWh electricity	114,000
Refiner Blade Replacement	1,576	124,800	2,160MWh electricity	
Use of chemicals in pulp refinery system	4,100	324,480	Annual chemical costs: 539,280US$	
Using Shoe press machine	416.613	3,420,000	Production capacity +10%, Steam consumption -10%	10,000,000
Steam Traps Treatment	153,287	366,142	1,220,680m^3 natural gas	200,000
Changing Paper Press Surface from Groove to Drill and Groove Type	400,000	450,000		
Condensate Heat Recovery	229,030	237,000		200,000
Process Water Recovery System			318,240t Water, 1,591t Pulp fibre	

More environmentally sound technologies and measures available for Pulp & Paper industry are listed in the following table.

Table 4.9: Environmentally Sound Technologies/ Measures for Pulp & Paper Industry

Options	Fuel Savings	Electricity Savings	Primary Energy Savings	Carbon Savings	Retrofit Cost of Measure	Annual Operating Cost Change
	(kWh/t)	(kWh/t)	(kWh/t)	(kg C/t)	(US$/t)	(US$/t)
Raw Materials Preparation						
Ring style debarker	-	5.56	8.33	0.50	1.30	(0.01)
Cradle debarker	-	8.33	13.89	0.80	25.80	-
Enzyme-assisted debarker	-	5.56	11.11	0.70	3.90	-
Bar-type chip screens	97.22	-	138.89	3.10	1.50	(0.70)
Chip conditioners	58.33	-	83.33	1.90	N/A	(0.40)
Improved screening processes	97.22	-	138.89	3.10	1.50	(0.70)
Belt conveyors	-	5.56	11.11	0.70	N/A	(0.50)

Options	Fuel Savings	Electricity Savings	Primary Energy Savings	Carbon Savings	Retrofit Cost of Measure	Annual Operating Cost Change
	(kWh/t)	(kWh/t)	(kWh/t)	(kg C/t)	(US$/t)	(US$/t)
Fine-slotted wedge wire baskets	-	169.44	344.44	19.40	N/A	N/A
Pulping: Mechanical						
Refiner Improvements	-	225.00	452.78	25.60	7.70	2.60
Biopulping	(138.89)	566.67	947.22	60.10	27.00	9.40
Pulping: Thermomechanical (TMP)						
RTS	-	305.56	619.44	35.00	50.00	-
LCR	-	141.67	288.89	16.30	N/A	-
Thermopulping	-	305.56	611.11	35.00	226.70	N/A
Super Pressurized groundwood	-	741.67	1,500.00	84.70	220.00	(2.60)
Heat recovery in TMP	1,680.56	(150.00)	2,088.89	37.40	21.00	18.00
Improvements in Chemi-TMP	-	305.56	619.44	35.00	300.00	N/A
Pulping: Chemical						
Continuous digesters	1,750.00	(75.00)	2,333.33	48.10	196.00	-
Continuous digester modifications	269.44	-	386.11	8.80	1.30	0.20
Batch digester modifications	888.89	-	1,263.89	28.80	6.60	0.50
Chemical Recovery						
Falling film black liquor evaporation	222.22	0.28	316.67	10.10	90.00	-
Tampella recovery system	805.56	-	1,147.22	23.90	N/A	N/A
Lime kiln modifications	127.78	-	127.78	7.82	2.50	N/A
Extended Delignification and Bleaching						
Ozone bleaching	-	2.78	5.56	0.30	149.50	(2.00)
Brownstock washing	2.78	13.89	30.56	1.50	50.00	(2.30)
Washing presses (post-delignification)	108.33	-	152.78	3.50	17.00	(0.50)
Papermaking						
Gap forming	-	41.67	83.33	4.70	70.00	0.70
High consistency forming	416.67	41.67	675.00	18.20	70.00	0.70
Extended nip press (shoe press)	444.44	-	633.33	14.40	37.60	2.20
Hot pressing	169.44	-	241.67	5.50	25.70	-
Direct drying cylinder firing	291.67	-	416.67	9.50	111.20	1.40
Reduced air requirements	211.11	5.56	311.11	7.50	9.50	0.10
Waste heat recovery	138.89	-	197.22	4.50	17.60	1.60
Condebelt drying	444.44	19.44	675.00	16.70	28.20	-
Infrared profiling	194.44	(22.22)	233.33	3.80	1.20	-
Dry sheet forming	1,388.89	(208.33)	1,552.78	21.20	1,504.00	-
General Measures						
Optimization of regular equipment	-	27.78	55.56	3.40	N/A	1.00
Energy-efficient lighting	-	13.89	27.78	1.60	1.20	(0.01)
Efficient motor systems	-	172.22	347.22	19.60	6.00	-

Options	Fuel Savings	Electricity Savings	Primary Energy Savings	Carbon Savings	Retrofit Cost of Measure	Annual Operating Cost Change
	(kWh/t)	(kWh/t)	(kWh/t)	(kg C/t)	(US$/t)	(US$/t)
Pinch analysis	497.22	-	705.56	16.10	8.00	-
Efficient Steam Production and Distribution						
Boiler maintenance	350.00	-	497.22	11.30	-	0.06
Improved process control	150.00	-	211.11	4.80	0.40	0.08
Flue gas heat recovery	69.44	-	100.00	2.30	0.70	0.09
Blowdown steam recovery	63.89	-	91.67	2.10	0.80	0.11
Steam trap maintenance	497.22	-	705.56	16.10	1.20	0.09
Automatic steam trap monitoring	247.22	-	352.78	8.00	1.20	0.16
Leak repair	150.00	-	211.11	4.80	0.30	0.03
Condensate return	744.44	-	1,058.33	24.10	3.80	0.54
Fiber Substitution						
Increase use of recycled paper	3,722.22	583.33	6,222.22	186.00	485.00	(73.90)

Source: N. Martin, N. Anglani, D. Einstein, M. Khrushch, E. Worrell, and L.K. Price. "Opportunities to Improve Energy Efficiency and Reduce Greenhouse Gas Emissions in the U.S. Pulp and Paper Industry", Environmental Energy Technologies Division, Lawrence Berkeley National Laboratory, July 2000, LBNL-46141

The following figure shows the GHG emissions reduction scenario (EFFICIENT) for Pulp & Paper industry. By installing the aforementioned measures and technologies, Pulp & Paper industry's GHG emissions will be gradually reduced by up to 17.52% compared to BAU scenario until 2025.

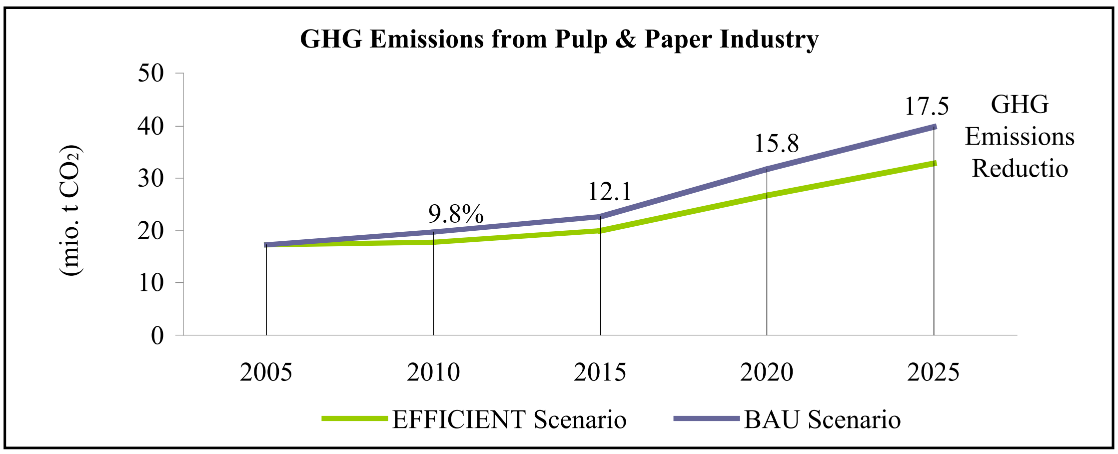


Figure 4.10: Projection of GHG Emissions from Indonesian Pulp & Paper Industry, 2005 - 2025

Based on predictions of the Ministry of Industry (MoI), Pulp & Paper production will reach 55million tonnes/year in 2025. GHG emissions intensity for Pulp & Paper production counted 5.57tonnes CO_2/tonne Pulp & Paper in 2005. It is predicted by the MoI, that not only the amount of Pulp & Paper produced will increase, but also the GHG emissions intensity will raise to up to 6.29tonnes CO_2/tonne Pulp & Paper in 2025 (BAU scenario). Based on calculations under the EFFICIENT scenario, which assumes the implementation of energy conservation measures and environmentally sustainable technology, GHG emissions intensity could be reduced to 5.19tonnes CO_2/tonne Pulp & Paper in 2025, which means a 17.52% reduction compared to BAU.

4.2.4 Textile Industry

The textile industry belongs to the less energy-intensive industry, but runs one of the longest production chains in manufacturing industry. The fragmentation and heterogeneity of its outputs makes it difficult to classify industrial practices and to compare Indonesian practices with international norms. Products are numerous and depend on the type of fibres used, the density and quality of the thread, the colours and the process being operated. In Indonesia the textile industry ranks among the most important industries due to its size, encompassing more than 2,700 medium- and large-scale textile plants.

Energy Use - According the Indonesian Ministry of Industry Indonesia's Textile industry uses outdated technology leading to inefficient textile production processes with a high energy demand and low production capacity. In order to increase efficiency, almost textile machinery in 2,726 plants must be restructured/ substituted by the latest technology. The Ministry of Industry has a "Partnerships Program on Energy Conservation in the Industrial Sector" for machinery restructuring in the Textile industry. For this programme the Government of Indonesia provided a budget of 1,635.6million US$, allocated for the replacement of old, inefficient Textile machinery e.g. with higher speed textile production equipment. Based on data of the Ministry of Industry textile industry has an energy conservation potential of 20-35%. The replacement of machinery in dyeing and finishing units in one textile plant in the province of West Java was mentioned as an example for the energy conservation and GHG emissions reduction potential. By replacing machinery in this textile plant energy consumption could be reduced by 45% from 82.7TJ/year to 45.0TJ/year. GHG emissions were hence decreased by 44% from 10,800tonnes CO_2/year to 6,000tonnes CO_2/year

Energy audits/ Energy management systems: Since Textile industry is such a large industry in Indonesia, data collection is a challenging task. Currently there is only average data available for all textile industry sub-sectors, not being grouped into spinning (cotton, wool, etc.), man-made fibers (polyester, nylon 6, nylon 66, rayon), weaving (fabric, carpet, etc.), wet processing (dyeing, finishing, etc.) and non-woven yet. More detailed information, clarifying the contribution of each of the textile industry's sub-sectors, has to be collected (by process and by different types of factories). For calculating the electricity and heat consumption in detail, the four main activities of the production process have to be analysed: spinning[3], weaving and knitting[4], wet processing[5] and stitching (sewing)[6].

Fuel switching: The substitution of carbon intense fossil fuels such as coal for electricity and heat production by e.g. natural gas or alternative fuels, is another option for the Textile industry to reduce GHG emissions. Due to the implementation of the Presidential Decree 5/2006, which targets the adaptation of the national energy mix, fuel switching is supported by the Ministry of Industry for the Textile industry.

[3] Spinning: The production from fibres to spun yarn takes place through the spinning process and constitutes the first stage. Spinning involves opening/blending, carding, combing, drawing, drafting and spinning. It uses four types of technologies: ring spinning, rotor spinning, air jet spinning and friction spinning. The advantage of ring spinning is, that it can be widely adapted for spinning different types of yarn (Energy Manager, 2008: Bureau of Energy Efficiency/ Ministry of Power India in cooperation with Deutsche Gesellschaft fuer Technische Zusammenarbeit (GTZ) GmbH:"Energy Manager: Economic Analysis of Energy Efficiency Improvement Options in the Indian textile industry").

[4] Weaving: After spinning the yarn is weaved to make fabrics in looms. The two main technologies used during the weaving process are shuttle and shuttleless. Shuttleless has higher productivity and produces better quality of output (Energy Manager, 2008).

[5] Wet processing: Most woven fabrics retain the natural colour of the fibres from which they are made and are called "grey fabrics" at this stage. These fabrics then undergo several different processes including bleaching, printing, dyeing and finishing; these are grouped under the category of wet processing, which is the third stage. It covers all processes in a textile unit that involve some form of wet or chemical treatment. The wet processing process can be divided into three phases: preparation, coloration, finishing. It uses different types of technologies depending on the type of yarn/ fabric that are dyed. Jigger, winch, padding, mangle and jet-dyeing are some of the important dyeing machines. Similarly, there are different types of printing: direct printing, warp printing, discharge printing, resist printing, jet printing, etc (Energy Manager, 2008).

[6] Stitching: Finally, the stage from fabrics to garments is done by stitching (Energy Manager, 2008).

Industrial wastewater - Besides GHG from energy use, the textile industry also releases methane (CH_4) from industrial wastewater of the production process. Mitigation options for GHG emissions from industrial wastewater are not in the scope of this Industry Sector TNA though.

The following table lists those technology options available for Textile industry, which have the potential for energy conservation and the reduction of GHG emissions.

Table 4.10: Environmentally Sound Technologies/ Measures for Textile Industry

Options	Investment	Energy Savings		Pay-back Period
	('000 US$)	(GWh/year)	('000 US$)	(years)
Spinning Unit				
Replacement of old energy-inefficient transformers with energy efficient ones (two 1250 kVA, two 1000 kVA transformers)	42	0.39	28	1.5
Replacement of energy-inefficient motors with energy-efficient ones for ring frames and open end spinning machines: Ring frame: 18.5 kW - 10 motors, Open end spinning machine: 22 kW - 11 motors/ 15 kW - 11 motors	25	0.34	24	1.1
Installation of energy-efficient lighting system—replacement of conventional copper ballast and tube lights with electronic ballast and energy-efficient tube lights. Replacement of 1172 tube lights and chokes with 880 energy-efficient tube lights and 440 chokes	11	0.15	10	1.1
Installation of energy-efficient fans for humidification plants (along with energy-efficient motors of appropriate capacity). Replacement of 28 fans (265 kW motors); present fan efficiency - 45%; improved fan efficiency - 68%	67	0.48	34	2.0
AC variable frequency drive for fans of humidification plants - total 28 drives	31	0.15	10	3.0
Investment for long term measure				
Diesel engine operated captive power plant	2,182	–	522	4.2
TOTAL	**2,383**	**1.50**	**643**	**3.7**
Composite Mills				
Replacement of energy-inefficient motors with energy-efficient ones for humidification plants Total number=48; Rating=15 MW	35	0.38	27	1.3
Installation of energy-efficient lighting system—replacement of conventional copper ballast chokes and tube lights with electronic ballast chokes and energy-efficient tube lights. Replacement of 3000 conventional tube lights and chokes with 1130 energy-efficient tube lights and 565 electronic chokes	14	0.71	51	-
Installation of energy-efficient fans for humidification plants (along with energy-efficient motors of appropriate capacity). Total 48 fans with 340.5 kW power consumption; present fan efficiency - 45%; improved fan efficiency - 68%	2	0.82	58	-

Options	Investment	Energy Savings		Pay-back Period
	('000 US$)	(GWh/year)	('000 US$)	(years)
Low liquor ratio jet dyeing machine	17	0.16	21	-
Energy-efficient RF dryer	120	1.35	166	-
Fourth effect caustic recovery plant	22	–	38	-
Energy-efficient submersible pump	10	0.05	4	2.6
Investment for long term measure				
Energy-efficient coal-fired water tube boiler with bag-filter	611	–	98	6.3
Naphtha-fired gas turbine with waste heat recovery boiler	26,184	–	4,077	6.4
TOTAL	**27,016**	**3.5**	**4,539**	**6.0**

Source: ADB, 1998 and ARRPEEC, 2003.
Note: kVA: kilo Volt Amps

The following figure shows the calculation of the GHG emissions reduction scenario (EFFICIENT) for Textile industry. By installing the aforementioned measures and environmentally sound technologies, Textile industry's GHG emissions will be gradually reduced to 27.79% in 2025 compared to BAU scenario.

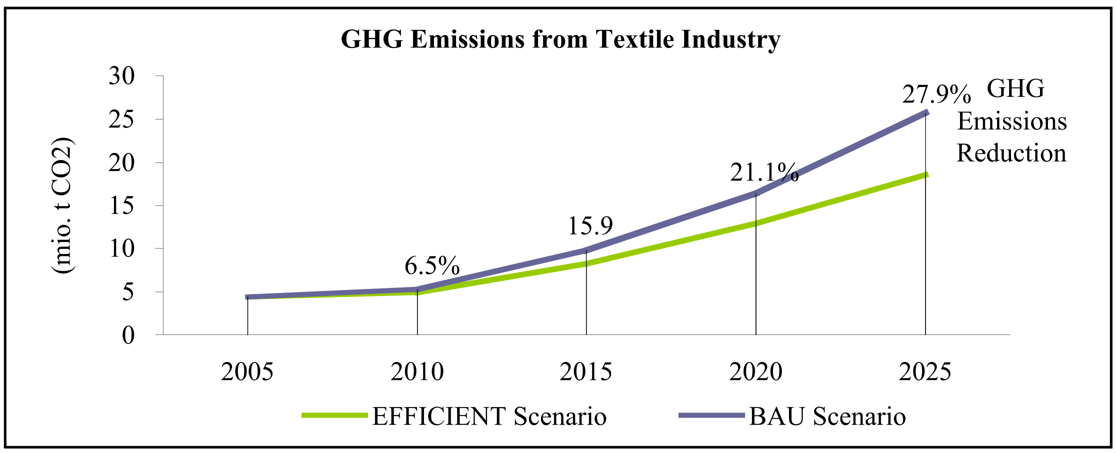


Figure 4.11: Projection of GHG Emissions from Indonesian Textile Industry, 2005 - 2025

GHG emissions intensity for Textile production counted in average 5.57tonnes CO_2/tonne textile in 2005. It is predicted by the Ministry of Industry, that not only the amount of textiles produced will increase significantly until 2025, but also the GHG emissions intensity will raise to up to 3.27tonnes CO_2/tonne textile in 2025 (BAU scenario). Based on calculations under the EFFICIENT scenario, which assumes the implementation of energy conservation measures and restructuring of machinery, GHG emissions intensity could be reduced to 2.36tonnes CO_2/tonne textile in 2025, which means a 27.79% reduction compared to BAU.

4.2.5 Glass & Ceramics Industry

Glass & Ceramics production is classified under the industry sub-sector non-metallic minerals. The production processes of both, glass and ceramics, are energy intensive. Production capacity of the 80 ceramic plants and 82 glass plants in Indonesia counted 5.36million tonnes in 2007. The following table lists those process-related technology options available for Glass & Ceramics industry, which bear energy conservation potential and help to reduce GHG emissions.

Table 4.11: Environmentally Sound Technologies/ Measures for Glass Industry

Batch Preparation	
• Grinding—new technology	• High-efficiency motors
• Mixing	• Adjustable/ variable speed drives
• Fluxing agents	• High efficiency belts
• Reduce batch wetting	• Conveyor belt systems
• Selective batching	• Cullet separation and grinding systems
• Optimize conveyor belts	• Cullet preparation
• Re-sizing of motors	
Melting Task—Changes to Existing Furnaces	
• Process control systems	• Refractories/ Insulation
• Minimize excess air/reduce air leakage	• Properly position burners
• Premix burners	• Sealed burners
• Adjustable speed drives on combustion air fans	• Low-NOx burner
• Waste heat boiler	• Recuperative burners
• Bubbler	• Vertically-fired furnaces
Melting Task—Furnace Designs	
• End-fired furnaces	• Increase size of the refrigerator
• Regenerative furnaces	• SORG® Flex Melter
Melting Task—Oxy-Fuel Furnaces	
• Synthetic air	• Heat recovery from oxy-fuel furnace
• Oxygen enriched air staging	• High luminosity burners (oxy-fuel)
• Oxy-fuel furnace	• Tall crown furnace (oxy-fuel)
Melting Task—Cullet Use and Pre-heating	
• Use more cullet and or filter dust	• Batch and cullet pre-heating
Melting Task—Electric Furnaces	
• Top-heating	• Replace by fuel-fired furnace
• Optimize electrode placement	
Forehearths and Forming	

• Process control	• Oxy-Fuel fired forehearth
• High efficiency forehearths	• Improved insulation
Annealing and Finishing	
• Controls	• Insulation
• Optimize plant lay-out	• Product drying system upgrade
• Reduce air leakage	• Glass coating
Emerging Technologies	
• Oscillating combustion	• Advanced glass melter
• Segmented melter	• Air-bottom cycle
• Plasma melter	• Glass fiber recycling
• High speed convection	• Use of waste glass in cutting
• Reengineer process to spend less time in tank	• Other emerging technologies
• Submerged combustion melting	

Source: Ernst Worrell, Christina Galitsky, Eric Masanet, and Wina Graus. "Energy Efficiency Improvement and Cost Saving Opportunities for the Glass Industry: An ENERGY STAR® Guide for Energy and Plant Managers", Environmental Energy Technologies Division, Lawrence Berkeley National Laboratory, March 2008, LBNL-57335-Revision

4.2.6 Petrochemical Industry

The chemical industry is highly diverse with thousands of companies producing tens of thousands of products in quantities varying from a few kilograms to thousands of tonnes. The chemical industry belongs to the energy intensive industries worldwide with a high contribution to global GHG emissions. According to the International Energy Agency (IEA) the share of industrial energy used for ammonia, ethylene, propylene and aromatics production (worldwide) has increased from 6% to 15% between 1971 and 2006 and hence belongs to the top energy consumers in industry nowadays. Among the different groups of chemical producers a key sub-sectors is the petrochemical industry especially fertilizer production. Currently the Indonesian petrochemical industry's share of world's petrochemical industry's total production is around 0.5% to 1.5%. The total number of fertilizer plants operating in Indonesia equals 15 with a total capacity of 6.78million tonnes in 2006. Urea and ammonia production can both be integrated in one plant in Indonesia. Indonesian fertilizer industry is one of the largest urea producers in the world using new generation plants with the latest technology. However, some old generation urea plants are still operating. For those plants the implementation of energy efficiency measures in production processes and the use of environmentally sound equipment offer large opportunities to reduce GHG emissions. Options, which have been implemented already, are listed in the table below.

Table 4.12: Indonesia Fertilizer - Energy Conservation Measures

Sub area	Observation	Energy efficiency option	Technical	Economical	Environmental
Focus Area 1: Utility Plant					
Package Boiler Combustion Efficiency	- Boiler is controlled manually from control room - Incomplete combustion on high load boiler operation	A detailed inspection on burner, boiler control and oxygen trim	Cleaning the burner resulted in an energy demand decrease from 793Mcal/ tonne steam to 737Mcal/ tonne steam	Annual cost savings: 4,78Billion Rp. = 562,353US$	Annual energy savings: 281.96TJ Annual GHG emissions reduction: 4313.96tonnes CO2
Boiler Blowdown Optimization	- Boilers have both intermittent and continuous mechanisms for controlling blowdown - Conductivity 70 – 75mho, while set boiler 150mho	Reducing the amount of blow down and hence increasing the conductivity	- Measurement - Valve checking. - Identification of other materials required	Annual cost savings: 29.7million Rp. = 3,994US$	Annual savings: 5,940m^3 water
Forced draft fan operation	- The fans outlet dampers are manually operated from the control room based on the amount of excess air required for combustion - Poorly controlled of excess air resulting in poor combustion efficiency	- Using variable turbine speed control - Increasing boiler efficiency by outlet damper control	- Technical calculation on equipment modification or replacement - Identification of other materials required		
Power Factor Correction	- Installed capacity of GTG: 18.36MW; Actual plant requirement: Only 9MW, 5.8MVAR. - No power factor meter available from the GTG to the lowest voltage feeder, GTG is operating at 0.84 under normal conditions - Power factor is about 0.4-0.55	- Installing capacitor bank to increase power factor - Electrical system monitoring by installing appropriate meter			Annual energy savings: 28,000kWh Annual GHG emissions reduction: 20,272tonnes CO_2
Focus area 2: Compressed Air System					
Compressed air system and Instrument air quality	- Process uses desiccant dryer, which consumes steam and electric power. - Dew point is more than enough to get the quality needed.	Desiccant dryer will be replaced with an adequately sized refrigeration dryer	- Calibration of flow meter FT3137		

Compressed air system and Compressed air pressure	- Current operating pressure: 4.5 – 4.75barg (normal operating pressure: 6.5 –7.0barg) - Air system supplied from the first stage compressor in the ammonia plant is with 9.0barg too high for a normal operation at 4.5barg. - Reduction of the pressure range from 6.5 – 7.0barg to 5.5 – 6.0barg	Reducing energy consumption by decreasing air compression	- Conducted measurement: Air flow from ammonia plant is 40Nm3/hour - Piping on 101J will be analyzed further	Overhaul cost 275million Rp. = 32,353US$	Annual energy savings approximately 8%
Focus area 3: Urea and NH3 Pipework Losses					
Urea and NH3 Plant Pipework Losses and Steam & condensate pipework losses	- Inefficiency on steam trap at urea plant (blowing), oversized and leakage on turbine steam, no steam trap on prilling tower - Condensate being wasted on prill tower about 3-4Tph due to broken flange - Condensate being wasted on air pre-heater about 4Tph	Reduce energy consumption by replacing dryer	- Replacement of 20 broken steam traps - Repaired steam trap on steam turbine and prilling tower - Repaired condensate return hidder and air pre-heater at prilling tower	Steam trap cost = 523,529US$ Annual cost savings: = 32,588US$	Energy savings: 72tonnes steam/hour = 199.03TJ/year Annual GHG emissions reduction: 3045.15tonnes CO_2
Focus area 4: Cooling Water					
Cooling water system	- Temperature of cooling water supply was with 32°C too high - Possible damage on heat exchanger - The intercoolers (124CA & 124CB) of the Syn Gas Compressor (103J): Syn Gas outlet temperatures of 63°C and 51°C (target 38.6°C), - 200lt/mnt leakage on cooling water	- Cooling inefficiency on intercooler 124CA and 124CB - Maintenance required on cooling water basin.	- Leakage repair, temperature 52 C - Replacement and repairs	Repair cost = 5,882US$ Annual cost savings: = 55,882US$	Energy savings: 2,62MMBTU/hour Annual GHG emissions reduction: 42,294tonnes CO_2

4.2.6 Food & Beverages Industry: Sugar Production

Most food industry products are major commercial commodities and are quite energy intensive. The most important products from a climate perspective are sugar, starch and corn refining, since these can be a source of fuel products (IPCC, 2007).

Indonesia's sugar industry has an large energy conservation potential, since most plants are using outdated technology – some older than 100 years. In order to increase energy efficiency and national sugar production capacity, the replacement of all machinery is the best choice for the sugar industry according to the Ministry of Industry.

Despite the effects of machinery replacement, energy demand could also be reduced by using the cane waste of sugar production as fuel. Such alternative fuel use will lead to a reduced fossil fuel demand and to a reduction of GHG emissions. In order to optimize the use of biomass waste for energy utilization more efficient technology is needed.

5 TECHNOLOGY SELECTION

Among the existing technologies for GHG emissions reduction, those to be applied in Indonesia have to be selected according to stringent criteria. Technologies with a better fuel/product efficiency and less costs have to be introduced in Indonesia. To achieve such introduction incentives have to be created.

5.1 Selection Process

The process of technology selection has been undertaken by applying general and specific criteria to listed technology as mentioned before in section **Error! Reference source not found. Error! Reference source not found.**, with each criterion weighted according to expert judgment and additional information such as literature and projects' report.
The scoring tables can be found in the Appendix. The numeric values are determined for each grade, as follows:

- H: High value/high relevance/high impact, score: 5
- M: Medium value/relevant/moderate impact, score: 3
- L: Low value/less relevant/low impact, score: 1
- NR: not relevant, not applicable

The selection process, using general and specific criteria in this Industry Sector TNA, is limited to Cement, Iron & Steel and Pulp & Paper industry, due to incomplete information for other industry sub-sectors. In Textile and Sugar industry the prioritization of options follows the recommendations and policies of the Ministry of Industry.

Table 5.1: Selection: Environmentally Sound Technologies for Indonesian Cement Industry

No.	First Priority	Second Priority	Third Priority
1.	Use of limestone with low $CaCO_3$.	Alternative fuels	Kiln burner modification
2.	Reducing clinker-to-cement ratio by substituting clinker with materials such as fly ash, etc.	Energy management and process control system	Conversion to grate cooler
3.	Mineral components in Cement (MIC)	Waste heat recovery of cement kiln exhaust gas for raw meal pre-heater	Install meter in every section and "reroute" power cable
4.	Preventative maintenance (insulation, compressed air system, maintenance)	High-efficiency classifiers	Optimization of hydraulic roller crusher
5.	Install variable speed drive	Optimization of compressed air systems	Install vibrating screen cement pre-grinder
6.	Kiln shell heat loss reduction	Refractories	
7.	Minimize ingress of false air	High-efficiency motor drives	

Table 5.2: Selection: Environmentally Sound Technologies for Indonesian Iron & Steel Industry

No.	First Priority	Second Priority	Third Priority
1.	Slabs/ billets hot charging	Preventative maintenance	Variable speed drive: flue gas control, pumps, fans
2.	Thin slab mills technology (hot rolling)	Energy monitoring and management system	De-dusting system optimization (steelmaking)
3.	Optimization in laddle pre-heating	Zero reformer	Energy-efficient drives (rolling mill)
4.	Oxygen lancing at electric arc furnace (steelmaking)	Waste heat recovery	Heat recovery on the annealing line
5.	Scrap pre-heater (steelmaking)	Process control in hot strip mill	Reduced steam use (pickling line)
6.	Power demand control	Recuperative burners	Automated monitoring and targeting system
7.	Fuel substitution	Insulation of furnaces	Controlling oxygen levels and VSDs on combustion air fans
8.	Adopt continuous casting	Energy Control Center	

Table 5.3: Selection: Environmentally Sound Technologies for Indonesian Pulp & Paper Industry

No.	First Priority	Second Priority
1.	Changing paper press surface from groove to drill/ groove type	Waste heat recovery
2.	Refiner improvement: Refiner blade replacement	Optimization of regular equipment
3.	Using shoe press machine	Blow-down steam recovery
4.	Use chemicals in pulp refinery system	Steam trap maintenance
5.	Steam traps treatment	Increase use of recycled paper
6.	Condensate heat recovery	Energy management and process control system
7.	Continuous digesters	
8.	Continuous digester modifications	
9.	Boiler maintenance	
10.	Leak repair	

Due to the use of outdated technology in both, Indonesian Textile and Sugar industry, the option selected for these industry sub-sectors is machinery replacement and for Sugar industry the implementation of advanced and efficient technology for combusting bagasse as an alternative fuel.

5.2 Available Options in the Future

An implementation of the technology needs for reducing GHG emissions in the Indonesian industry sector has been outlined in the chapters above for seven industry sub-sectors. It has to be accomplished, in several steps including short-term and medium-term implementation.
Short-term implementation is obliged for the technology needs listed as "First Priority" in the tables above. Whereas, medium-term implementation is requested for technology options listed as "Second priority" and/or "Third Priority". The exceptions are Textile and Sugar industry, where replacement of machinery with advanced and efficient technology was set an urgent priority. Also important for the Sugar industry is the implementation of advanced and efficient technology for combusting bagasse as an alternative fuel.

Besides the mentioned technologies, capacity building and awareness raising has to happen in the Indonesian industry sector, to emphasize the importance of implementing environmentally sound technology, explain accrued benefits and reiterate simple methods for GHG emissions reduction.

Financial support and technology transfer are substantial, to assist the Indonesian industry sector with implementing the mentioned technology options. Other measures required for GHG emissions reduction in the Indonesian industry sector are:

- Strengthen regulations on process emissions and energy intensity standards;
- Introduce demand side management systems with minimal impact on the environment;
- Redesign those facilities, which produce high emissions;
- Provide incentives to promote eco-processing;
- Introduce and spread the use of low emission and fuel-efficient technologies.

6 IDENTIFICATION OF BARRIERS AND POLICY NEEDS

6.1 Institutional Barriers decelerating Technology Transfer

1. Currently there is no schema to minimize import taxes on environmentally sound technology;
2. GoI's role is not optimal in order to facilitate financial loan schemes;
3. There exist difficulties in identifying companies, which are willing to replace equipment;
4. The calculation of investment required to replace existing technology with environmentally sound technology is problematical;
5. Energy management has not yet become a priority;
6. A lack of human resources with knowledge about energy management is experienced in the Indonesian industry sector;
7. An energy saving culture is not developed yet;
8. Incentives and disincentives for energy users are not established yet. This conclusion also applies to measures such as incremental cost mechanisms (incentives for companies, which implement energy conservation measures through financial loan schemes);
9. There is no technology transfer system supporting the reduction of GHG emissions;
10. Cost schemes, which regulate the correlation between income taxes and import taxes on environmentally sound technology are not yet developed.

6.2 Institutional Policies accelerating Technology Transfer

1. The Government of Indonesia supports the implementation of environmentally sound technology in the industry sector via policies and regulations such as tax incentives, etc.
2. Motivation is built in the Indonesian industry sector for implementing energy conservation measures and energy diversification.
3. Energy audits are provided for the industry.
4. "Energy efficient technology and low carbon technology" are promoted.
5. Enterprises are assisted to use renewable energy
6. The concept of an energy manager is promoted.

7 CONCLUSION AND RECOMMENDATION

7.1 Conclusion

1. This Industry Sector TNA focuses on seven energy intensive industries, i.e. Cement, Iron & Steel, Pulp & Paper, Textile, Glass and Ceramics, Petrochemical, and Sugar industry.
2. This Industry Sector TNA concentrates on GHG emissions from the industry sector's energy use and industrial production processes.
3. The appraisal of the urgency of implementing certain technology needs is consistent with the results of the technology priority selection presented for each industry sub-sector in the tables Table 5.1 to Table 5.3.
4. Due to limited data, detailed technology needs could not be identified in this Industry Sector TNA for Textile, Glass & Ceramics, Petrochemicals and Sugar industry. Therefore in this Industry Sector TNA the following measures have been proposed for the mentioned industry sub-sectors only: textile machinery replacement, advance "biomass to energy" technology for bagasse utilization in Sugar industry, data base development, technology identification, monitoring & evaluation and capacity building.
5. Implementation of environmentally sound technology in the Indonesian Cement industry can reduce GHG emissions by 17.41% in 2025.
6. Implementation of environmentally sound technology in the Indonesian Iron & Steel industry can reduce GHG emissions by 15.36% in 2025.
7. Implementation of environmentally sound technology in the Indonesian Pulp & Paper industry can reduce GHG emissions by 17.52% in 2025.
8. Implementation of environmentally sound technology in the Indonesian Textile industry, can reduce GHG emissions by 27.79% in 2025.

7.2 Recommendations

1. In order to reduce GHG emissions from the Indonesian industry sector, it is necessary to transfer technology according to the prioritization presented in the tables Table 5.1 to Table 5.3.
2. The Industry Sector TNA is implemented under the UNFCCC, through public and/or private partnerships, bilateral, multilateral and other technology transfer mechanisms.
3. The Government of Indonesia is commited to minimize the existing barriers and to provide policy support, so that the implementation of technology transfer can be maximized.

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Appendix 1: Technology Assessment using General and Specific Criteria – Cement Industry

Environmentally Sound Technologies/ Measures - Cement Industry -	General Criteria											TP	Specific Criteria							TP	Total
	FS	NRS	ES	IP	CB	CoC	CA	RT	ET	GR	LE		LM	PT	DTO	CO	EPP	ECC	ImI		
1) Clinker production																					
Alternative fuels	L	NR	H	M	L	H	L	M	M	H	L	28	H	M	H	H	L	L	H	25	**53**
Energy management and process control system	NR	NR	H	L	M	H	M	H	M	H	M	33	M	H	H	L	H	H	L	25	**58**
Kiln burner Modification	NR	NR	M	L	L	M	H	M	M	L	L	21	M	M	L	H	L	M	H	21	**42**
Kiln shell heat loss reduction	NR	NR	H	L	L	M	H	H	M	M	L	27	H	H	H	H	M	M	H	31	**58**
Heat recovery	NR	NR	H	L	M	L	H	H	L	H	M	29	L	H	L	H	NR	H	H	22	**51**
Conversion to grate cooler	NR	NR	M	L	L	L	M	M	M	L	L	17	H	M	L	M	L	M	H	21	**38**
Improved refractories	NR	NR	M	L	L	L	M	H	H	M	L	23	H	H	H	M	M	L	H	27	**50**
2) Raw material preparation/ grinding																					
High-efficiency classifiers	NR	M	M	L	L	H	M	H	M	L	L	26	H	H	H	M	H	L	H	29	**55**
High-pressure roller crusher	NR	NR	M	L	L	L	M	M	M	L	L	17	L	H	M	L	H	M	L	19	**36**
Optimization of hydraulic roller crusher	NR	NR	M	L	L	M	H	H	M	L	L	23	H	H	H	M	M	M	H	29	**52**
Finishing process – Introduction of pre-grinder	NR	NR	M	L	L	M	H	H	M	L	L	23	H	H	H	M	M	M	H	29	**52**
Improved grinding media (ball mills)	NR	NR	M	L	L	M	H	M	H	L	L	23	L	H	H	L	M	L	M	19	**42**
3) Plant wide measures																					
Preventative maintenance (insulation, compressed air system)	NR	H	H	L	L	H	H	M	H	M	H	38	H	H	H	H	H	M	H	33	**71**
Efficient lighting.	NR	NR	L	L	L	H	H	M	H	L	NR	22	H	H	H	H	NR	M	H	28	**50**
Energy Control Center (ECC)	NR	NR	H	L	M	H	M	H	L	M	M	29	L	H	L	M	NR	M	M	16	**45**
Install adjustable speed drive.	NR	NR	M	L	L	L	H	H	M	M	NR	22	L	H	L	M	L	M	H	19	**41**
High-efficiency motor drives	NR	NR	M	L	L	M	H	H	M	M	L	25	L	H	L	H	L	M	H	21	**46**
Optimization of compressed air systems	NR	NR	M	L	L	H	H	H	M	M	L	27	H	H	H	M	L	M	H	27	**54**
Minimize ingress of false air	NR	NR	H	L	L	H	H	H	H	M	L	31	H	H	H	H	L	M	H	29	**60**
Expert Optimizer	NR	NR	M	L	M	H	H	M	M	M	L	27	H	H	H	H	H	M	M	31	**58**

Environmentally Sound Technologies/ Measures - Cement Industry -	General Criteria											TP	Specific Criteria							TP	Total
	FS	NRS	ES	IP	CB	CoC	CA	RT	ET	GR	LE		LM	PT	DTO	CO	EPP	ECC	ImI		
Install meter in every section and "reroute" power cable	NR	NR	M	L	L	H	H	H	H	M	NR	28	H	H	H	H	NR	M	H	28	**56**
Cut off selected equipment during peak power time.	NR	NR	M	M	L	H	H	M	H	L	NR	26	H	H	H	H	NR	M	H	28	**54**
4) Product change																					
Use Limestone with low $CaCO_3$.	NR	H	NR	H	L	H	H	H	H	H	L	37	H	H	H	H	NR	NR	H	25	**62**
Blended cement (substitute some materials with fly ash, , etc.	NR	H	M	H	L	H	H	H	H	H	L	40	H	H	H	H	NR	M	H	28	**68**
Mineral components in cement (MIC)	L	H	NR	H	L	H	H	H	H	H	L	38	H	H	H	H	NR	NR	H	25	**63**

Appendix 2: Technology Assessment using General and Specific Criteria – Iron & Steel Industry

Environmentally Sound Technologies/ Measures - Iron & Steel Industry -	General Criteria											TP	Specific Criteria							TP	TOTAL
	FS	NRS	ES	IP	CB	CoC	CA	RT	ET	GR	LE		LM	PT	DTO	CO	EPP	EEC	ImI		
Options already applied at one Indonesian Iron & Steel plant																					
Power demand control (steelmaking)	NR	NR	M	L	L	H	H	H	M	M	L	26	H	H	H	H	L	H	H	31	**57**
Dedusting system optimization (steelmaking)	NR	NR	L	L	L	M	H	H	H	L	H	27	H	H	H	H	L	L	H	27	**54**
Water cooling panel optimization (steelmaking)	NR	NR	L	L	L	H	H	H	H	L	L	24	H	H	H	H	L	L	H	27	**51**
Optimization in ladle pre-heating (steelmaking)	NR	NR	H	L	L	H	H	H	H	H	L	33	H	H	H	H	L	H	H	31	**64**
Fuel substitution	NR	NR	H	L	L	H	H	H	H	H	L	33	H	H	H	H	L	L	H	27	**60**
Energy Control Center	NR	NR	H	L	L	H	H	H	M	M	M	31	M	H	M	H	L	H	H	27	**58**
Oxygen lancing at electric arc furnace (steelmaking)	NR	NR	H	L	L	L	H	H	H	M	L	27	H	H	H	H	L	H	H	31	**58**
Scrap pre-heater (steelmaking)	NR	NR	H	L	L	M	H	H	H	H	L	31	H	H	H	H	L	H	H	31	**62**
Slabs/ billets hot charging (steelmaking – hot rolling)	NR	NR	H	L	M	L	H	H	H	H	H	31	M	H	M	H	L	H	H	27	**58**
Thin slab mills technology (steelmaking – hot rolling)	NR	NR	H	L	H	L	H	H	H	H	H	33	L	H	M	H	M	H	H	27	**60**
Zero reformer (iron making)	NR	NR	H	L	M	L	M	H	L	M	L	27	L	H	M	H	L	H	H	25	**52**
Other existing options																					
Integrated Casting																					
Adopt continuous casting	NR	M	H	H	H	L	H	H	M	M	L	36	L	H	H	H	H	H	L	27	**63**
Integrated Hot Rolling																					

Environmentally Sound Technologies/ Measures - Iron & Steel Industry -	General Criteria											TP	Specific Criteria							TP	TOTAL
	FS	NRS	ES	IP	CB	CoC	CA	RT	ET	GR	LE		LM	PT	DTO	CO	EPP	EEC	ImI		
Process control in hot strip mill	NR	NR	M	L	L	M	H	H	H	M	L	27	L	H	L	H	H	M	H	25	**52**
Recuperative burners	NR	NR	H	L	L	M	H	M	M	H	M	29	M	H	M	H	L	H	L	23	**52**
Insulation of furnaces	NR	NR	M	L	L	M	H	H	H	L	L	25	H	H	H	H	L	M	H	29	**54**
Controlling oxygen levels and VSDs on combustion air fans	NR	NR	M	L	L	M	H	M	M	L	L	21	L	H	L	H	M	M	L	19	**40**
Energy-efficient drives (rolling mill)	NR	NR	M	M	L	M	H	H	L	M	L	25	L	H	L	H	L	M	H	21	**46**
Waste heat recovery (cooling water)	NR	NR	H	H	L	L	H	H	M	H	M	33	M	H	L	H	L	H	H	25	**58**
Integrated Cold Rolling and Finishing																					
Heat recovery on the annealing line	NR	NR	H	L	L	M	H	H	M	M	M	29	M	H	M	M	L	M	L	19	**48**
Reduced steam use (pickling line)	NR	NR	M	L	L	H	H	H	L	M	M	27	H	H	M	H	L	M	H	27	**54**
Automated monitoring and targeting system	NR	NR	M	L	L	L	H	H	H	M	L	25	L	H	L	H	L	M	H	21	**46**
General																					
Preventative maintenance	NR	NR	M	L	L	H	H	H	H	M	M	31	H	H	H	H	H	H	H	35	**66**
Energy monitoring and management system	NR	NR	M	L	L	H	H	H	H	M	L	29	M	H	H	H	L	H	H	29	**58**
Variable speed drive: flue gas control, pumps, fans	NR	NR	M	L	L	M	H	H	M	M	L	25	L	H	L	H	L	L	H	19	**44**

Appendix 3: Technology Assessment using General and Specific Criteria – Pulp & Paper Industry

Environmentally Sound Technologies/ Measures - Pulp & Paper Industry -	**General Criteria**											**TP**	**Specific Criteria**							**TP**	**TOTAL**
	FS	NRS	ES	IP	CB	CoC	CA	RT	ET	GR	LE		LM	PT	DTO	CO	EPP	EEC	ImI		
Options already applied at one Indonesian Pulp & Paper plant																					
Fuel switching in heat recovery steam generator: Switch from IDO to natural gas	NR	NR	L	L	L	L	H	H	L	H	H	25	L	H	L	H	NR	H	H	22	**47**
Fuel switching in circulating fluidized-bed system: Switch from coal to alternative fuel (solid waste)	NR	NR	L	M	L	L	H	M	L	L	L	17	L	H	L	H	L	H	H	23	**40**
Poly disc filter	NR	NR	H	M	L	H	H	H	H	M	L	27	H	H	H	H	L	M	H	20	**47**
Refiner improvement: refiner blade replacement	NR	NR	H	M	L	H	H	H	H	M	L	33	H	H	H	H	L	M	H	29	**62**
Use of chemicals in pulp refinery system	NR	NR	H	M	L	H	H	H	M	M	L	31	H	H	M	H	L	M	H	27	**58**
Steam traps treatment	NR	NR	M	M	L	H	H	H	H	M	L	31	H	H	M	H	L	M	H	27	**58**
Using shoe press machine	NR	NR	H	M	L	L	H	H	H	H	L	31	L	H	L	H	H	H	H	27	**58**
Changing paper press surface from groove to drill and groove type	NR	NR	H	M	L	H	H	H	H	H	L	35	H	H	H	H	H	H	H	35	**70**
Condensate heat recovery	NR	NR	M	M	L	H	H	H	L	M	M	29	H	H	H	H	L	M	H	29	**58**
Process water recovery system	NR	L	L	M	L	H	H	H	M	L	M	28	H	M	M	NR	NR	L	L	13	**41**
Other existing options																					
Raw materials preparation																					
Biopulping	NR	NR	M	M	L	H	H	M	H	M	L	29	M	H	L	H	M	M	L	21	**50**
Pulping: Thermomechanical (TMP)																					
Thermopulping	NR	NR	L	L	L	L	H	H	M	L	L	19	M	H	M	H	L	L	H	23	**42**
Super pressurized groundwood	NR	NR	L	L	L	L	H	L	L	L	L	13	L	H	L	H	L	L	L	15	**28**

Environmentally Sound Technologies/ Measures - Pulp & Paper Industry -	General Criteria											TP	Specific Criteria							TP	TOTAL
	FS	NRS	ES	IP	CB	CoC	CA	RT	ET	GR	LE		LM	PT	DTO	CO	EPP	EEC	ImI		
Heat recovery in TMP	NR	NR	M	L	L	L	H	M	L	M	L	19	H	H	M	H	NR	H	L	24	**43**
Improvements in Chemi-TMP	NR	NR	M	L	L	L	H	M	M	L	L	19	H	H	L	H	L	M	L	21	**40**
Pulping: Chemical																					
Continuous digesters	NR	NR	M	L	L	L	H	H	M	H	L	25	H	H	H	H	H	H	H	35	**60**
Continuous digester modifications	NR	NR	M	L	L	M	H	H	M	M	L	25	H	H	H	H	M	H	H	33	**58**
Batch digester modifications	NR	NR	L	L	L	L	H	H	M	L	L	19	H	H	H	H	M	M	H	31	**50**
Chemical Recovery																					
Falling film black liquor evaporation	NR	L	NR	L	L	L	H	M	M	NR	H	20	H	H	M	H	L	L	M	23	**43**
Tampella recovery system	NR	L	NR	L	L	L	H	M	M	NR	M	18	L	H	M	H	L	L	L	17	**35**
Lime kiln modifications	NR	NR	L	L	L	L	H	L	M	M	H	21	M	H	L	H	L	L	L	17	**38**
Extended Delignification and Bleaching																					
Ozone bleaching	NR	NR	NR	L	L	H	H	H	H	NR	L	23	H	H	H	H	L	NR	H	26	**49**
Brownstock washing	NR	NR	NR	L	L	H	H	M	H	NR	M	23	H	H	H	H	L	NR	H	26	**49**
Washing presses (post-delignification)	NR	NR	NR	L	L	M	H	L	H	NR	L	17	H	H	H	H	L	NR	H	26	**43**
Papermaking																				-	**-**
Gap forming	NR	NR	L	L	L	M	H	M	H	L	L	21	H	H	H	H	L	L	M	25	**46**
High consistency forming	NR	NR	L	L	L	M	H	L	H	L	L	19	H	H	H	H	L	L	L	23	**42**
Extended nip press (shoe press)	NR	NR	H	M	L	L	H	H	H	H	L	31	L	H	L	H	H	H	H	27	**58**
Hot pressing	NR	NR	M	L	L	L	H	H	H	L	L	23	H	H	H	H	H	L	H	31	**54**
Direct drying cylinder firing	NR	NR	M	L	L	M	H	H	M	M	L	25	H	H	H	H	L	M	H	29	**54**

Environmentally Sound Technologies/ Measures - Pulp & Paper Industry -	General Criteria											TP	Specific Criteria							TP	TOTAL
	FS	NRS	ES	IP	CB	CoC	CA	RT	ET	GR	LE		LM	PT	DTO	CO	EPP	EEC	ImI		
Reduced air requirements	NR	NR	L	L	L	L	H	H	M	NR	L	18	H	H	H	H	L	NR	H	26	**44**
Waste heat recovery	NR	NR	H	M	L	L	H	H	M	M	M	29	M	H	H	H	NR	H	M	26	**55**
Condebelt drying	NR	NR	L	L	L	L	H	H	M	L	L	19	L	H	L	H	L	L	L	15	**34**
Infrared profiling	NR	NR	L	L	L	L	H	H	M	NR	NR	17	L	H	L	H	NR	NR	L	13	**30**
Dry sheet forming	NR	NR	L	L	L	L	H	M	M	L	L	17	H	H	M	H	L	L	M	23	**40**
General Measures																					
Optimization of regular equipment	NR	NR	L	L	L	M	H	H	L	M	H	25	H	H	H	M	H	M	H	31	**56**
Energy-efficient lighting	NR	NR	L	L	L	H	H	H	H	L	NR	24	H	H	H	H	NR	L	H	26	**50**
Efficient motor systems	NR	NR	M	L	L	M	H	H	H	M	NR	26	H	H	L	H	L	M	H	25	**51**
Pinch analysis	NR	NR	M	L	L	H	H	H	L	L	NR	22	H	H	M	L	NR	M	L	18	**40**
Efficient Steam Production and Distribution																					
Boiler maintenance	NR	NR	L	L	L	H	H	H	M	M	H	29	H	H	H	H	NR	H	H	30	**59**
Improved process control	NR	NR	L	L	L	L	H	H	M	L	H	23	H	H	H	H	H	L	H	31	**54**
Fuel gas heat recovery	NR	NR	M	L	L	M	H	H	L	M	M	25	H	H	H	H	NR	H	H	30	**55**
Blowdown steam recovery	NR	NR	L	L	L	L	H	H	M	M	H	26	H	H	H	H	NR	H	H	29	**535**
Steam trap maintenance	NR	NR	M	L	L	H	H	H	H	M	M	31	H	H	M	H	NR	M	H	26	**57**
Automatic steam trap monitoring	NR	NR	L	L	L	M	H	H	H	M	M	27	L	H	L	H	NR	M	L	16	**43**
Leak repair	NR	NR	M	L	L	H	H	H	H	M	H	33	H	H	H	H	NR	M	H	28	**61**
Condensate return	NR	NR	M	L	L	L	H	H	M	M	H	27	H	H	H	H	NR	M	M	26	**53**
Fiber Substitution																					
Increase use of recycled paper	NR	H	NR	L	L	H	H	H	H	L	H	33	H	M	H	H	NR	NR	H	23	**56**
Energy Management																					
Energy Control Center (ECC)	NR	NR	M	L	L	H	H	H	M	L	L	25	L	H	L	H	NR	H	H	22	**47**
Energy management and process control system	NR	L	M	L	L	H	H	H	M	L	L	26	H	H	M	H	M	H	H	31	**57**

CHAPTER - IV

FORESTRY SECTOR

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CHAPTER IV - FORESTRY SECTOR

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1. BACKGROUND

Indonesia is a country with forestland of about 120.3 million ha[1] (or about 60% of land in the country), spreading into seven geographical areas including beach forest, peat forest, mangrove forest, low land tropical rain forest, savanna, and mountain to alpine forest.

The forest area is divided into four categories namely: (a) Conservation forest (20.50 million ha), (b) Protection forest (33.50 million ha), (c) Production forest (58.26 million ha) and (d) Production forest which could be converted to other uses (8.01 million ha). The forest is important not only for national economy development and the livelihood of local people, but also for global environment. Indonesian forest is the home of mega-diversity, the source of genetic materials for various purposes now and in the future, and one of the custodians of the world tropical peat land. Peat land alone, recorded as the highest carbon storage as well as source of emissions, covers about 17 million ha (10% of the country's area), and plays an important role for the environment, economic and social functions.

With the global importance in both, bio-diversity and climate change, the mitigation of and adaptation to climate change in the forestry sector is crucial and must be an integral part of national development policy and programmes.

According to UNFCCC, developed country Parties should support the development and enhancement of endogenous capacities and technologies for developing the country (Article 4.5). The effectiveness of developing country Parties in implementing their commitments under the Convention is related to financial resources and availability of technology transfer (Article 4.7). Furthermore, countries with forested areas need to be given full consideration to actions necessitated under the Convention, including those related to funding and technology transfer (Article 4.8). The Bali Action Plan (COP-13/CP.1 Element 1 (b) (ii)) emphasized the importance of enhanced national/international action on mitigation of climate change. This includes consideration of nationally appropriate mitigation actions by developing country parties in the context of sustainable development, supported and enabled by technology, financing and capacity-building.

1.1. Aims

Indonesia ratified the United Nations Framework of Climate Change Convention (UNFCCC) through Act No. 6, in 1994 and the Kyoto Protocol through Act No. 17, in 2004. "*...Article 4.5 of the Convention defines technology needs assessments (TNAs) as, a set of country-driven activities that identify and determine the mitigation and adaptation technology priorities of Parties. They involve different stakeholders in a consultative process to identify the barriers to technology transfer and measures to address these barriers through sectoral analyses. These activities may address soft and hard technologies, such as mitigation and adaptation technologies, identify regulatory options and develop fiscal and financial incentives and capacity-building."* [UNFCCC: Technology Transfer Framework] Stakeholders are governments, private sector entities, financial institutions, NGOs and research/education institutions.

[1] hectare

Taking into account the COP 4/CP.7 decision, and considering national and forestry sector circumstances, the Technology Needs Assessment was carried out in order to facilitate the selection of technology and capacity building necessary to increase the effectiveness of actions to tackle the challenges in managing forest resources in Indonesia, including the improvement of forest management and enhancing rehabilitation of degraded forest, thus contributing to reducing emissions from de-forestation and forest degradation, and enhancing sink capacity of the forest.

1.2. Scope

In 2001 Indonesia identified technologies, which would help to reduce greenhouse gas (GHG) emissions in key sectors including forestry. During the work especially the status of prospects for and barriers to their implementation were analyzed. The technologies identified were known as activities in forestry terms, for example: enhancement of natural regeneration, reduced-impact logging, re-forestation, plantation forest (HTI), agro-forestry, afforestation, and private forest (hutan rakyat). Barriers, which were identified, included technology barriers (e.g. lack of knowledge on species-site matching, and use of indigenous technology), institutional and regulatory barriers (e.g. frequent policy changes, lack of law enforcement), and the impact of socio-economic, financial and cultural barriers (e.g. land tenure, access to forest resources, low financial return of forest investment, traditional/adat practices/claims).

1.3. Stakeholder Participation Process

Stakeholder process in this TNA was coordinated under the Working Group on Technology Transfer (WGTT) and processed within forestry sector. WGTT has conducted several workshops and invited representatives from government, the private sector, NGOs and academia, where a forestry component was also discussed. Coordinating meetings with key government institutions was also done by WGTT. For the forestry component, there have been extensive stakeholders'[2] communications on forest and climate change coordinated and/or co-organized by the Ministry of Forestry, prior to and after COP-13, where technology and capacity-building needs were among the issues discussed. In this regard, information gathered, both during stakeholders' consultations, which were designed specifically for TNA coordinated by the WGTT, as well as forest and climate consultation processes, combined with expert judgment and policies in the forestry sector, were the basis of identifying technology needs.

[2] involving government institutions (central and local governments), private sectors, NGOs, academia, country partners and international organizations.

2. EXISTING CONDITION IN INDONESIA

2.1. National Plan

Recognizing the unique role of forest in climate stabilization and as a life-support system, and considering the problems of de-forestation and forest degradation, Indonesia has implemented five priority policies since 2000, as follows:

1. Combating illegal logging and forest fires;
2. Restructuring forestry-sector industries, including the enhancement of plantation development;
3. Forest rehabilitation and conservation;
4. Securing forestland: strengthening the legal status of state forestland; and
5. Strengthening the economy of local communities.

Along with the implementation of the five priority policies, forest loss has decreased significantly. Based on the Ministry of Forestry data, forest loss has decreased from 1.7 million ha per year between 1985 and 1997 to the highest loss of 2.8 million ha per year during 1997-2000, falling to 1.2 million ha per year during 2000-2005.

Through the five priority policies, the government of Indonesia has set up targets as the following:

1. Combating illegal logging: law enforcement, through an inter-sectoral approach;
2. Forest & land rehabilitation: 5 million ha between 2003-2009) and forest conservation (institutional strengthening in protected-area management);
3. Forestry sector restructuring through enhancement of timber plantation and industry restructuring: HTI[3] 9 million ha by 2014 using genetically improved seeds and improved production of forest management;
4. Strengthening the economy of local communities: community forest (HTR[4] 5.4 million ha by 2014, HR[5] 8 million ha by 2025); and
5. Securing forestland: strengthening the legal status of state forestland.

The following supporting initiatives are expected to contribute considerably to the success of the implementation of the five priority policies:

1. *Improving forest monitoring system*. The system of forest monitoring is crucial for efficient and effective forest resource management. The lack of reliable data and information has hindered the operationalisation of the policies/programmes. A Forest Resource Information System (FRIS), now under development, is aimed at improving data and information available for all forest types including operational planning, and decision-support tools for policy makers. The system also overlaps with National Carbon Accounting System (NCAS) which is also under development. The system requires participation from all relevant participants at various levels, and regular monitoring/updating.

2. *Improving forest governance* through increased transparency and combating corruption. Forest governance is one of the most critical issues in achieving sustainable forest development. Lack of transparency and corruption, in most cases, become significant barrier to the implementation of the policies/programmes. Increased transparency will increase public trust, while combating corruption will increase efficiency of the resource used and effectiveness of the programme

[3] HTI (Hutan Tanaman Industri) : large-scale timber plantation in state forestland, mostly monoculture, managed by private and state-owned enterprises,

[4] HTR (Hutan Tanaman Rakyat) : small scale timber-based plantation (15 ha/household) in state forestland, combined trees-crops, managed by small holders/communities,

[5] HR (Hutan Rakyat) : household timber-based plantation, monoculture/combined trees-crops, in private/non-forestland.

implementation.

The five priority policies have been translated into short, medium, and long-term planning. Table 2 describes mitigation potentials of the forestry sector, at the same time it also shows how the five priority policies were translated into four different timeframes of planning and how climate-change issues are integrated into the forestry sector policies. Detailed explanations are as follows:

Hutan Tanaman Industri (HTI)
HTI is a large-scale timber plantation on state forestland, managed by private or state- owned enterprises through a concession holding system. The plantation consists mainly fast-growing species to feed the pulp and paper industries. Plantation forest in Java, however, is managed by a state owned company 'PERUM PERHUTANI' through Government Regulation No 15/1972, with teak as the predominant species. Plantation forest in Indonesia accounted for 5.6 million ha, with approximately 1.8 million ha in Java (major species : teak, pine, mahagony, dalbergia, falcataria) and approximately 3.8 million ha outside Java (major species: *Acacia mangium, Acacia crassicarpa, Eucalyptus pellita*, Gmelina, and some Dipterocarp species).

Hutan Tanaman Rakyat (HTR)
As part of the fourth priority policy 'Strengthening the economy of local communities', the government has set up a small scale timber-based plantation programme on state forestland. Each eligible household may manage up to 15 ha, and grow combined trees-crops. To facilitate the programme, the government provides a revolving fund from the Reforestation levy (8 million Rp. or around 800USD/ha).

Hutan Rakyat (HR)
Hutan Rakyat has been long practiced by farmers, especially in Java. This household timber-based plantation on private/non-forestland, with monoculture/combined trees-crops, has grown quite rapidly over the past 10 years, including in the outer islands. Teak is the most-preferred species, followed by *Albizia falcataria*, Gmelina, and other species.

Management of Natural Production Forest
Production forest is managed under two different regimes. One is a selection logging system, with enrichment planting, applied to natural forest, while a clearcutting system is applied to plantation forest[6]. The natural production forest covers areas of about 58.26 million ha. The challenge is in managing natural production forest mainly: illegal logging and unsustainable logging practices. Although the concept of Reduced Impact Logging (RIL) has been understood and, based on some studies, it is feasible to implement, but the practice remains low. Lack of records on enrichment-planting undertaken by concession holders after logging, has also made evaluation difficult, as to what improvements are needed to manage the forest sustainably.

Management of Conservation Forest
Conservation forest is managed by the Central Government, represented by implementing institutions in the regions. There are currently 473 units of conservation forest throughout Indonesia, consisting of 50 units of National Parks, 249 units of Nature Reserves, 76 units of Wildlife Sanctuaries, 21 units of Grand Forest Park, 124 units of Strict Conservation Reserves and 14 units of hunting park. The conservation forest is crucial for bio-diversity conservation, where many genetic resources are kept for current and future uses - locally, nationally and globally. Despite the global importance which conservation forest holds, resources to manage the forest are limited. There exist many unknown species of flora and fauna, including endangered species, which may be useful in the future. Nevertheless, most conservation forests are under increasing threat from deforestation and forest degradation.

[6] Plantation forest in this case refers to HTI and HTR

Management of Protection Forest

Management of protection forest is under local government authority. Other than for watershed protection, Indonesian protection forest (33.5 million ha) can be a significant carbon storage. However, forest encroachment, unsustainable utilization and increasing demand for land for other sector-developments, have been the major causes of deforestation and degradation in protection forest. Although community-based non-timber forest cultivation is permitted in the area, violation of the rules has frequently occurred.

Rehabilitation of degraded forest and land

Government programmes on rehabilitation of degraded forest and land have been intensified since 2003, with the target of 5 million ha up to 2009, directed to degraded conservation forest, protection forest and non-forestland, while rehabilitation of degraded production forest is the responsibility of the concession holders. An insufficient supply of good quality planting materials and lack of knowledge on silviculture and species characteristics were among the biggest challenges at the beginning of the programme. Furthermore, lack of records on the realization of the programme has constrained the monitoring and evaluation of programme implementation.

Forest Restoration

The Government of Indonesia has recently issued regulation Ministry of Forestry Decree No 159/Menhut-II/2004 on Forest Restoration. Under this regulation, concession holders may be given the concession called ‘HPH Restorasi’ (i.e. Restoration Forest Concession) to manage degraded natural production forest for 60 years, with the first five years logging-free logging. This allows forests to recover or to reach certain conditions when sustainable logging becomes feasible. Depending on the forest condition, the concession holder may need to restore the forest through silvicultural intervention. As this is a new approach, it is anticipated that there will be technical challenges related to silvicultural aspects of the species. The technical challenges might not be as high as now, if there were good records available on lessons learnt from these enrichment planting activities after logging.

2.2. Resources Use and Potential

Traditionally, forest was a resource upon which many Indonesian people depend for their subsistence and customary activities. Later, along with the shift of national development direction during the 1970s, forestry also generated employment as well as business opportunities. The forestry sector provided direct employment of about 1.35% of the labor force or 5.40%, including indirect employment, in the early 1990s. MoF (2005) estimated that within the total population of about 206.6 million, about 36 million people relied on forestry both in the formal and informal sectors. The forestry sector had been the second back-bone of national economic development between the 1980s and 1990s and will continue as one of the prime movers of economic development.

Forests, within the context of climate change, can be as *source or sink.* Good practice in management of production forests, conservation and protection forests, as well as limiting conversion of forest to non-forest, and forest-fire prevention, contribute to reduction of CO_2 emissions and increase resilience to climate changes. Rehabilitation of degraded forest, timber and estate crops plantation development in degraded land will enhance sink capacity of forests which eventually also increase resilience to climate changes. Furthermore, through these activities, forest functions such as bio-diversity, genetic -resources conservation and, watershed protection can be sustainably maintained and can also provide socio-economic functions for forest dwellers.

2.3. Resources Use and Potential

The use of forest resources in Indonesia follows the rules applied to each of the four forest functions/ categories. First, conservation forest, managed to conserve biological diversity, the source of genetic resources needed for food crops, medicinal plants, wood and non-wood forest species domestication. Second, protection forest, important to maintain hydrological functions watershed protection and soil conservation. Third, production forest, provides timber and non-timber products, and is managed through selective cutting of natural forest and clear cutting of plantation forests. The forth category is conversion forest, forest area which can be converted for other land uses.

Wood products had been contributed significantly to Indonesia's exports, especially between 1980 – 1990. Along with deforestation problems in the tropics, Indonesia has lost approximately 1.7 million ha of its forest per year during the period 1985 – 1997. The highest forest loss occurred during 1997-2000, reaching the figure of 2.8 million ha per year. The latest published data (MoF, 2007) showed that net forest lost has decreased during 2000-2005, reaching about 1.2 million ha. Hence, it is understandable that the volume of harvested wood-products decreased from 26.2 million m^3 in 1990 to 11.2 million m^3 in 2005. The importance of non-wood forest products increased during the same period (food products, medicinal plants, rattan etc). According to FAO (2005), it was reported that the volume of fuel-wood declined from 357.000 m^3 in 1990 to 171.000 m^3 in 2000 and only 79.000 m^3 in 2005.

2.4. Existing Regulations and Policies

Forestry has faced considerable challenges in the past 10 years, which demand are focus and reorientation of forest policies. In this regard, the forestry sector has set up five priority policies, namely: (1) combating illegal logging and its associated illegal trade; (2) forestry sector restructuring through enhancement of timber plantation and industry restructuring; (3) forest rehabilitation and conservation; (4) strengthening the economy of local communities and (5) securing forest areas. The five priority policies have been translated into short, medium, and long-term planning.

The legal and policy framework already exists. This contributes to creating enabling conditions for climate-mitigation actions, through reducing emissions from de-forestation and forest degradation, sustainable forest management, forest conservation and, through enhancement of carbon stocks from forest restoration, afforestation and re-forestation. Some relevant regulations are presented below:

1. UU No. 5/1990, Laws regarding conservation of biological resources and it's ecosystem.
2. UU 41/1999, Forestry Law
3. PP No. 6/2007 to No. 3/2008, Forestland-use and -development of forest management planning and forest utilization
4. Minister of Forestry Decree No. P.51/Menhut-II/2008 from 5-September-2008 to Ministerial Decree No.P.21/Menhut-V/2007, Implementation of Land and Forest Rehabilitation Movement).
5. Presidential Decree No 4/2005 tentang pemeberantasan penebanagan kayu illegal di kawasan hutan dan distribusinya di Indonesia (President Instruction No. 4/2005 regarding against illegal logging in forest area and it distribution in Indonesia).
6. PP No 4/2001, Prevention of environment disturbance and pollution from forest fire.
7. UU No. 25/2004, National development planning system).
8. Presidential Decree No. 32/1990, prohibition to use peat land over 3 m depth
9. Minister of Forestry Regulation No. P.14/Menhut-II/2004, A/R CDM
10. Minister of Forestry Regulation on REDD (in the finalization stage).

3. INITIAL REVIEW OF OPTIONS AND RESOURCES

3.1. Greenhouse Gas Inventory of Indonesian Forestry Sector

First National Communication (1999) reported Indonesia's GHG emissions from several sources including land use, land use change and forestry (LULUCF). LULUCF was recorded to contribute about 74% of the emissions, energy and industrial processes, each contributing some 23% and 3% respectively. The preparation of the Second National Communication (SNC) is currently in progress.

The only recent compilation of carbon stock change data is contained in FAO – Forest Resources Assessment (2006), using the 1996 IPCC GPG (changes in carbon stock equal emissions of CO_2, when tonnes of carbon stock is multiplied by 3,67 to convert into CO_2). The following table shows the forest change data as contained in the Forest Resource Assessment (FRA) 2005 Indonesia country report (FAO, 2006).

Table 1: Forest Change Data according to Indonesia's Country Report in FRA 2005

	Unit	1990	2000	2005
Area change	ha	116,567	97,852	88,495
Volume	mio. m^3	13,442	8,022	5,216
Biomass change	mio. t	33,736	20,203	13,091
Carbon stocks	mio. t	17,108	10,303	6,911
CO_2 Emissions (annual)	mio. t		2,497	2,490
			Carbon Stock change yearly 1990 - 2000	Carbon Stock change yearly 2000 – 2005
			680.5	678.4

There are uncertainties related to data sources and inventory technology. If the data reported by FAO are correct, then Indonesia lost 24% of forest area and 61% of forest biomass volume (degradation) within the period 1990 to 2005. Because of the unavailability of data, Indonesia did not report on soil carbon stock changes, which is leaving the reported figures quite uncertain, as the country has a large presence of forest-peatland. To include all the carbon pools (following the IPCC carbon in peat soil may be reported as soil organic matter) may increase the carbon value of forest by three or four times and emissions, related to peat degradation and fires, will increase accordingly. These figures may mean that LULUCF-related emissions are higher, due to the omission of soil carbon pool changes. On the other hand, the rate of deforestation has halved in 2007 (from 2 million to 1,08 Million ha/year), which implies a significant reduction of CO_2 emissions at a rate of approximately 50% of forestry sector emissions.

Despite the uncertainty surrounding the data situation, Indonesia has already a forest monitoring system, which is on the right track for REDD. The strategy to have a National Forest Inventory, with an independent assessment of forest area changes, adequately reflects the IPCC suggestions to assess GHG emission from forest.

3.2. Mitigation Potential

Climate-change mitigation in forestry can be achieved through activities, which enhance sink and reduce/ avoid emissions. Referring to Table 1, sink enhancement can be achieved through forest plantation (HTI, HTR, HR) and rehabilitation of degraded protection forest and conservation forest, while emissions reduction/avoidance can be achieved through improved management of natural forests (production forest/HPH, protection forest, and conservation forest). The following table depicts mitigation options and potentials in the forestry sector.

Table 2: CO_2 Emissions Mitigation Potential of various Measures in Forestry

Program	Cumulative Area (mio. ha) and CO_2 Absorbed/Stored (mio. t CO_2 /ha)			
	2007 - 2009	2009 - 2012	2012 - 2025	2025 - 2050
Sink Enhancement: Forest Plantation				
HTI	3.6 (105.5)	7.2 (210.9)	9.31 (272.8)	11.62 (340.5)
HTR	3.6 (105.5)	5.4 (158.2)	9.00 (263.7)	12.98 (380.3)
HR	2.0 (58.6)	4.0 (117.2)	8.00 (234.4)	8.00 (234.4)
Sink Enhancement: Forest Rehabilitation				
Protection Forest	0.5 (na)	1.0 (na)	5.0 (na)	17.9 (na)
Conservation Forest	1.5 (na)	2.0 (na)	5.0 (na)	11.4 (na)
Emission Reduction: Management and Improvement of Natural Forest				
Production Forest (HPH)	23.12 (3.39)	23.12 (3.39)	23.12 (3.39)	23.12 (3.39)
Protection Forest	13.39 (19,643)	14.39 (21,110)	19.39 (28,445)	31.29 (45,902)
Conservation Forest	10.24 (15,022)	15.39 (22,577)	20.39 (29,912)	21.66 (31,775)

Source of data: Programmes for 2007 - 2009 and 2010 -2025 from MoF (2005a, 2005b, 2006a, 2006b), ICRAF (2000) , Programmes for 2025 -2050 derived from hypothetical data, Adaptation programmes developed through policy interpretation

Assumptions: (a) Forest Plantation (HTI, HTR, HR) with 10 year rotation, absorbs carbon of about 8 t/ha/year or ~29,3 t CO_2/ha/year (MoF, 2005b), (b) Production forest, store carbon of about 200 t/ha (~736 t CO_2/ha), (c) Undisturbed forest in protection forest and conservation forest, store carbon of about 400 t/ha (~1467 t CO_2/ha), (d) Forest Rehabilitation in conservation and protection forests (n.a. for carbon absorbed/stored because trees planted in these area can be scattered or in patches within the defined area and no data available yet)

3.3. Key Sector Issues

Climate change in forestry can be addressed from both sink (maintain and enhance) and source (reduce/avoid emission). Existing forestry sector policies and programmes may contribute to such efforts; however, a number of relevant issues need to be addressed, particularly:

- Forest governance needs improvement in almost all aspects, including those relating to institutional capacity and human-resources qualities;
- Technical and methodological aspects relating to estimation and monitoring of carbon stocks and flows, carbon emissions, and enhancement of carbon stocks, at various forest types;
- Capacity and awareness of stakeholders; and
- Financial aspects relating to support for capacity building, technology adoption and maintenance, approaches to and incentives for the efforts in maintaining forest resources which have local, national, and global importance.

4. TECHNOLOGY CRITERIA AND OPTIONS

4.1. Selection Criteria of Technology Assessment

Technology transfer priorities are assessed and selected using a multiple criteria analysis. Two sets of criteria are determined: general criteria and specific criteria. The general criteria are based on national-wide interests and priorities, while specific criteria are reflecting the priorities, current policies & objectives and the situation of the forestry sector.

4.1.1. General Criteria

Sustainable forest management (SFM) for sustainable development is a basic principle in managing forest resources. Sustainability from three different aspects (economy, social, ecology) is the basis in establishing criteria and indicators for the SFM. Technology used in the forestry sector which must comply with the SFM criteria for the economic, social, and ecological aspects. <u>It should be noted that technology discussed here does not include down-stream forest technology such as forest-based industries which should be covered under the TNA for the industrial sector</u>. For the technology-needs assessment purposes, use of the following guide for general criteria can be explained as follows:

<u>a . Conformity with National Regulation and Policy</u>
Technology criteria used for the forestry sector were adopted from the general criteria of sustainable forest management. The role of Indonesia's forests is one as the prime mover of national development and as a resource on which millions depend for their livelihood, as well as providing provides environmental services both for national and international communities. These are translated into regulatory frameworks which are consistent with national regulations, programmes and activities, which are in line with national policies as described in long-term, medium and short term planning.

<u>b . Institutional and Human Development</u>
From the institutional and human-development perspective, technology used in forestry must contribute to improving human and institutional capacities, while aiming to increase efficiency in resource-use and effectiveness of the technology used.

<u>c. Technology Effectiveness</u>
Technology selection must serve the needs of users, consider the existing and potential capacities in terms of human resources and institutional capacities. as well as financial resources to maintain and improve the technology.

<u>d. Environmental Effectiveness</u>
Technology selection must seek one/s with lowest environmental negative impacts and, where feasible, must seek the one/s which contribute to the improvement of environmental conditions. For example, the use of *Reduced Impact Logging* technology may contribute to the improvement of the remaining forest-stands after harvesting.

<u>e. Economic Efficiency and Cost Effectiveness</u>
Low cost technology must be the first option used in selecting technology; however, it must also consider the *trade- off* between costs and quality from using the selected technology. In forest inventory or forest carbon accounting, for example, there is always a *trade-off* between the increase in level of accuracy of data as against the information produced and costs incurred.

4.1.2. Specific Criteria

The specific technology criteria used for the Forestry Sector TNA were adopted from general criteria for sustainable forest management (especially for natural forest, plantation forest, and community based forest), which have been enforced by the Ministry of Forestry to be implemented in Indonesian forest management. They are also used by the Indonesian Eco-labeling Institute (LEI) for voluntary forest certification.

The criteria, based on expert judgment, are relevant to the assessment of the technology needs carried out. Moreover, the development of the criteria for sustainable forest management had been carried out through intensive stakeholders consultation on REDD and other forest-climate issues both at the national and provincial/ district level.

Table 4.1: Specific Criteria for Technology Selection

Specific Criteria	Sub-Criteria
a. Sustainability of production function	• Sustainability of forest resources • Sustainability of forest products • Sustainability of business
b. Sustainability of ecological function	• Stability of ecosystem • Survival of endangered/ endemic/ protected species
c. Sustainability of social functions	• Secure community-based forest tenure system • Assure resilience and development of economy • Assure continuity of social and cultural integration • Assure nutritious status and health of community • Assurance of mutual work agreements
d. Technology	• Availability of Technology • Applicability • Least cost • Provide good result to increase production of forest

a . Sustainability of Production Function

- Sustainability of forest resources: assurance of land for forest plantation areas, secured forestland-use, planning and implementation of forest arrangement, based on their function and type, protection against encroachment and conversion, fire control, appropriate silvicultural system, and the existence and variety of non-timber forest products.
- Sustainability of forest products: potential tree stand, appropriate harvesting and monitoring, growth and yield, environmentally- friendly forest harvest systems and tree improvement for forest plantation.
- Sustainability of business: production management, finance, contribution to local economic development, human resource and management.

b. Sustainability of Ecological Function

- Stability of ecosystem: land and water quality sustainability, proportion of well-functioned forest area, protection of flora and fauna, management of soil, water and forest structure.
- Survival of endangered / endemic / protected species: proportion and well-designed protected area, reduce damage intensity, secure endangered / endemic / protected plant, wildlife species and habitat.

c. Sustainability of Social Functions

- Secure community-based forest tenure systems: clear boundaries, access of the community to control traditional forest and forest-product utilization.
- Assure resilience and development of economy: be able to support the continuation of inter-generation livelihood, compensation for the use and implementation of the community's traditional knowledge in the management system and ensure the community's access to business opportunities.
- Assure continuity of social and cultural integration: guarantee of human rights, social and cultural integration and empowerment of community.
- Assure nutritious status and health of the community.
- Assurance of mutual work agreements: minimum wage, fair pay and implementation of health and safety regulation.

d. Technology

- Ensure the availability of Technology although it may need modification
- Applicability: technology can be applied by all stakeholders
- Least cost: technology is relatively cheap and thus it will provide economical benefit for the stakeholder
- Provide good results to increase production of forest, environmental friendliness, and social impact on the community.

4.2. Resources and Technology Options Review

In terms of natural resources, Indonesian forests are categorized and managed according to the function of forest such as: production, protection, and conservation.

Sustainable forest management (SFM) principles need to be applied in managing conservation forest (20.5 m ha), protection forest (33.5 m ha), production forest (58.26 m ha) and production forest, which can be converted to other uses (8.01 mio. ha). Technology intervention is needed, not only to improve forest practices in the field, but also in improving data accuracy, for example, remote-sensed data on forest-cover change, with different resolutions resulting in different data on forest loss. This is critical when related to the estimation and monitoring of carbon stocks and the associated changes in the effort in reducing emissions from de-forestation and forest degradation. Availability and accuracy of data and the capacity relating to the estimation and monitoring of carbon stocks and flows, are as important as the availability or access to technology. Furthermore, in order to facilitate management practices, technology needs identification suggesting that forest fire prevention, molecular/DNA based log-tracking to assist in curbing illegal logging, are among important technologies to improve natural forest management. In addition, reduced impact logging (RIL) may improve natural production forest management.

Forest plantation, which consisted of timber plantation (HTI), small scale timber-based plantation (HTR) and household timber-based plantation (HR), is expected to increase the increment from 28 m^3 to 50 m^3/ha/year, if technology intervention can be realized. The National Movement on Forest and Land Rehabilitation (GERHAN), which was aimed at
triggering self-reliance planting activities by all stakeholders, is expected to support rehabilitation of degraded land. In plantation forest management, technologies or measures which are needed, includes: silviculture (seed technology, land preparation, planting); maintenance; (fertilizing and weeding; and spacing); growth and yield modeling (forest inventory; yield regulation / allowable cut and rotation); genetic improvement, especially to increase productivity and quality of timber; site species matching to give a good effect on survival rate and growth of plantation; and forest protection (pest, disease, and forest fire); and measurement of carbon sequestration.

Table 3 shows the identified technologies for mitigation (in this case sink enhancement and emission reduction), costs, and other relevant aspects of technology in forestry sector.

Table 3: Cost, Mitigation Potential, Performance, Access & Availability of different Technologies/ Measures

Climate Change related Programme/ Technology/ Measure	Cost: Establish Plantation*	Mitigation Potential in 2025***	Performance Characteristic	Access & Availability	Weight
	(USD)	(mio. t CO_2)			(%)
SINK ENHANCEMENT					
Silviculture	389.4	770.9	Increase the yield by 78.6%	Easy and available	19.47
Growth and yield	318.6				15.93
Advanced Tree improvement	354.0				17.70
Site-species matching	300.8				15.04
Pest, disease, and fire control	354.0				17.70
Carbon related measurement and monitoring for carbon sequestration activities	283.2				14.16
Total	**2,000**	**770.9**			**100.00**
Climate Change related Programme/ Technology/ Measure	Cost: Maintain Forest**	Mitigation Potential in 2025***	Performance Characteristic	Access & Availability	Weight
EMISSION REDUCTION					
Reduced Impact Logging (RIL)	250	75,373	Deforestation rate decrease and forest is sustainable	Easy and available	25.00
Forest fire prevention : Zero burning on plantation site preparation & vegetation management	250				25.00
Curbing illegal logging : Molecular/ DNA based for log tracking	250				25.00
Estimation and monitoring of carbon stocks and flows, carbon emissions at various forest types	250				25.00
Total	**1,000**	**75,373**			**100.00**

Notes:
* Cost of plantation establishment after application of appropriate technology is about 2,000USD/ha, compared with current government standard 550USD.
** Cost of natural forest maintenance after application of technology is about 1,000USD/ha.
*** In 2025 total plantation is estimated 26.31 Mha.
**** In 2025 total natural forest to be maintained 62.9 Mha.

5. TECHNOLOGY SELECTION

5.1. Mitigation technology

Forestry is an unique sector, the problems in management are complex and, in most cases, the barriers are more on institutional aspects rather than technology. For this reason, assessment of technology needs in this report was undertaken not only to identify the needs for technology support, but also to incorporate capacity-building needs as well as raising awareness.

Sustainability of forest resources is crucial for the continuation of national development. Sustainable management of forest resources is a form of mitigation and adaptation measures, which is a survival issue for Indonesia. As a country with thousands of islands and high dependency on the agricultural sector (agriculture, forestry, fishery, livestock), Indonesia is vulnerable to climate change, not only from an environmental aspect but also from the economic and social repercussions. Simple guidance on development without sacrificing environment in the context of climate changes means any increase in CO_2e emissions must be balanced through increasing CO_2e sequestration by forest and marine vegetation (Salim 2007). There remain challenges needing to be resolved, while some barriers do not require technology support but, rather, need capacity- building and the raising of awareness. Table 4 describes the results of identification of technology needs for mitigation of climate change in the forestry sector, while adaptation will be elaborated separately (the 3rd) TNA. The priority technologies selected for mitigation in Table 4 are consistent with sustainable forest management principles, as described in general criteria developed in chapter 4 TECHNOLOGY CRITERIA AND OPTIONS, namely technology, environment, social implications and productivity.

The criteria for selection of technology are based simply on a weighting process to choose these technologies. Each technology is based on criteria of sustainable forest management, namely production, social implications, environment and technology that consider their value, availability and requirement. Impact on the environment is one of the considerations in selection of the criteria of technology. Technology priorities are ranked based on the total score. The result of scoring shows that technology for sink enhancement, through establishment of plantations, is more a higher priority compared to emissions reduction.

Table 4: Selected Technologies/ Mitigation Measures

No.	Program/ Activities	Selected Technology	Specific Criteria				Total Score
			Tech	Env	Soc	Prod	
1	**Sink Enhancement**						
1a	Industrial Forest plantation (HTI)	Silvicultural technology,	H	H	M	H	11
		Growth and yield modeling technology	M	M	M	H	9
		Advanced Tree improvement	H	M	M	H	10
		Pest, disease, weed and fire management	H	M	M	H	10
1b	Small scale forest plantation (HTR, HR)	Silvicultural technology,	H	M	H	H	11
		Site species matching	M	M	M	M	8
		Pest, disease, weed and fire management	H	M	M	H	10
1c	Rehabilitation/ restoration	Site species matching	M	H	M	M	9
1d	1a, 1b, 1c	Carbon related measurement and monitoring for carbon sequestration activities	H	M	L	M	8
2	**Emission Reduction**						
2a	Management improvement of natural forests	RIL in production forest	M	M	L	M	8
2b	Curbing Illegal Logging	Use of Mollecculair Biology to support chain of custody (e.g. DNA analysis for log tracking)	H	M	L	M	8
2c	Forest fire prevention and control	Zero burning technology	M	M	M	M	8
2d	2a, 2b, 2c	Carbon related measurement and monitoring for reduced emission activities	H	M	L	M	8

Note:
0 = (N) Not relevant/no impact/not available
1 = (L) Less value/less impact/low availability/low requirement
2 = (M) Medium value/medium impact/medium availability/medium requirement
3 = (H) High value/high impact/highly available/high requirement
Tech = Technology, Env = Environment, Soc = Social, and Prod = Productivity

5.2. Impact to GHG Mitigation

Any technology selected in the forestry sector, to achieve sustainable forest management, has a significant contribution to the mitigation of CO_2 emissions. As shown in Table 2, programmes of forest plantation establishment, such as establishment of timber estates, small-scale plantations and forest rehabilitation, would increase sink enhancement. Furthermore, efforts to reduce de-forestation and forest degradation would reduce CO_2 emission the from forestry sector.

5.3. Contribution to development objectives

The objective of forestry sector development in Indonesia is to achieve sustainable utilization of forest resources, in terms of sustainable production, social impact and environment. Any technology selected to achieve sustainable forest management, has been designed to support the objectives of development. Simple guidance on development, without sacrificing environment in the context of climate change, means any increase in CO_2e emission must be balanced through increasing CO_2e sequestration by forest and marine vegetation (Salim 2007).

Technology in forestry mitigation also contributes to development objectives, as it provides benefits to target groups as shown in Table 5.

Table 5: Target Group/Beneficiaries of Selected Technologies/ Measures

No.	Program/ Activities	Selected Technology	Target Group/ Beneficiaries
1	**Sink Enhancement**		
1a	Industrial Forest plantation (HTI)	Silvicultural technology, Growth and yield modeling technology Advanced Tree improvement Pest, disease, weed and fire management	Private Sector, Research institutions, Universities
1b	Small scale forest plantation (HTR, HR)	Silvicultural technology, Site species matching Pest, disease, weed and fire management	Small growers, local governments
1c	Rehabilitation/ Restoration	Site species matching	Government institutions at all levels, relevant actors
1d	1a, 1b, 1c	Carbon related measurement and monitoring for carbon sequestration activities	Research institutions, relevant institutions/ actors
2	**Emission Reduction**		
2a	Management improvement of natural forests	RIL in production forest	Forest Concessions, Government Institutions Research Institutions, Universities
2b	Curbing Illegal Logging	Use of Molecular Biology to support chain of custody (e.g. DNA analysis for log tracking)	Research institutions, law enforcement authorities
2c	Forest fire prevention and control	Zero burning technology	Forest Concession, Research Institutions. Local Government
2d	2a, 2b, 2c	Carbon related measurement and monitoring for reduced emission activities	Research institutions, relevant institutions/ actors

5.4. Available options in the future

Options of technology in the future are basically developed based on sustainable forest management criteria that include production, social impact and environmental aspects. Moreover, the availability of state-of-the-art technology, that significantly can improve the sustainable forest management, should also be considered. One such is that forest characterizes slow growth and presents extensive areas that need protection. These would require technology of silviculture, biotechnology and tree improvement to raise the quality and quantity of woods as carbon sink, as well as technology in forest protection (from pest, disease, weed and fire). However, because the vulnerability of forest resources also relates to human activities, welfare and consequently other sectors, not only technology in forestry and other sectors, but also capacity-building and awareness need to be improved. In relation to carbon accounting, the applicable technology is more advanced than the currently available.

6. IDENTIFICATION OF BARRIERS AND POLICY NEEDS

6.1. Institutional Barriers decelerating Technology Transfer

As mentioned earlier, the use of forest resources in Indonesia follows the rules applied to each of the four forest functions/categories. First, conservation forest, with the aim to conserve biological diversity, the source of genetic resources needed for food crops, medicinal plants, wood and non-wood forest species domestication. Second, protection forest, which is important to maintain hydrological function, water-shed protection and soil conservation. Third, production forest, provides timber and non-timber products, and is managed through selective cutting for natural forest and clear cutting for plantation forests. The forth category is production forest which can be converted for other land uses.

To date, practice of forest management has not followed sustainable principles. Barriers for SFM practice include institutions and social barriers, as well as technical and financial barriers. Discussion of challenges and barriers are thus focused on these four aspects. It should be noted that institutional and social challenges on forest plantation development (for sink enhancement) and natural forest management (for emissions reduction) are similar. For this reason, discussions on institutional and social barriers address both plantation and natural forest management, while discussions on technical and financial barriers address plantation and natural forest management separately.

The institutional and social aspects, the challenges and barriers are identified below.

Challenges:

- High demand of forest conversion i.e. for mining and agriculture; urban development increases the threat for forest existence;
- Coordination among government institutions, both at the central and autonomous governments;
- Institutional Capacity in enforcing SFM implementation, conflict resolution, and policy formulation;
- Inter-sectoral Policies;
- Investment incentives, in terms of policy and regulatory measures.

Barriers:

- Lack of law enforcement, effective forestry administration and poor public service
- Low satisfactory level on public services (e.g. lengthy and complex process to obtain a particular licence).

6.1.1. Sink Enhancement

Technical and financial challenges that frequently facie the development of forest plantation to meet the target (50 m^3/ha/year) are among the the following:

- Existing Land-clearing methods without fire are still too expensive;
- Long gestation period in forestry investment has made forest plantation investment less attractive, compared to other commodities such as estate crops plantation;
- High risk of of forest-fires, pests, sand disease (threat to forest health);
- Low productivity of trees planted, due to lack of appropriate silvicultural practices and the absence of genetically-improved seeds;
- Lack of appropriate growth and yield models that can best estimate the future yield and assist in yield scheduling and forest management as a whole.

Barriers:

Researches on silviculture, tree improvement, -growth and yield are constrained by limited

budget, limited qualified researchers and limited laboratory equipment;
- Lack of well-trained operators, who are willing to work in remote areas;
- Lack of data and information for forest carbon accounting;
- Poor availability of good quality planting materials of some tree species with reasonable prices.

6.1.2. Emission reduction

Management of Natural Production Forest

The challenges in managing natural production forest are mainly: illegal logging and unsustainable logging practices. Although the concept of Reduced Impact Logging (RIL) has been understood and based on some studies, it is feasible to implement, the practice remains low. Lack of records on enrichment planting carried out by concession holders after logging has also added difficulties in evaluating what improvements are needed in order to manage a sustainable forest

Management of Conservation Forest

Despite the global importance of conservation forests, resources are limited. There are many unknown species of flora and fauna, as well as endangered species, which may be useful in the future, none the less, most conservation forests are under increasing- threat, including de-forestation and forest degradation. The main threats to the natural forest stem originate principally from illegal logging and forest encroachment.

The challenges are still extant because of the following barriers:
- Molecular /DNA timber-tracking as a robust method in combating illegal logging is still expensive to develop;
- Lack of a complete and updated information system on forest carbon stock which covers sub-national level;
- Implementation of RIL is less attractive, as the practice of unsustainable timber- harvesting creating big profits still continues.

6.2. Institutional Policies accelerating Technology Transfer

6.2.1. Sink Enhancement

On institutional and social aspect:
- Strengthen the capacity of forestry and other related institutions;
- Strengthen the on-going process of law enforcement;
- Encourage synergizing the three pillars of good governance (government, private sector, civil society);
- Develop effective communications and mutual understanding with stakeholder.

On technical and financial aspects:
- Encourage donor agencies to increase grants and to intensify technology-transfer and know-how;
- Establish appropriate international market mechanisms to facilitate this;
- Develop attractive incentive schemes to encouarge investors in forest plantations;
- Increase research budget for silviculture, tree improvement, growth and yield and site-species matching;
- Encourage businesses to accept research results, to ensure good quality and good productivity of plantation forests;
- Facilitate and conduct effective training for field workers;

- Develop particular policies to improve remuneration for qualified and highly- skilled workers in remote areas.

6.2.2. Emission reduction

On instittutional and social aspect:

- Increase capacity forest aparatus (at central and local level) in law enforcment and public service;
- Strengthen forest law-enforcement to help reduce illegal timber harvesting which, in turn, will encourage forest concessionaires to implement RIL.

On the technical and financial aspects:

- Develop a relatively-cheap Molecular /DNA-based data and maps for timber-tracking with simple methods;
- Prepare hardware and software to complete and up-date information forest carbon accounting and monitoring (at national and sub-national levels);
- Develop effective systems to control and to prevent forest-fires.

7. CONCLUSION AND RECOMMENDATION

Mitigation and adaptation to climate changes in the forestry sector have already been instilled in forestry policies and programmes. Barriers to these policies need to be removed, not only through technological support, but also capacity building and the raising of awareness.

Technology, capacity building and the awareness level needed to support policy implementation should include all those mechanisms under CDM, REDD, and other carbon-trading entities.. While north-south transfer of technology faces various constrains, south-south technology transfer should be encouraged and facilitated.

As stated in available options in the future, technology needed to improve forest practices towards sustainable forest management and thus contributing positively to climate change mitigation, includes: technology of tree improvement and biotechnology to improve quality and quantity of woods as carbon sink, as well as technology in forest protection, carbon accounting and monitoring.

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CHAPTER - V

AGRICULTURE SECTOR

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1. BACKGROUND AND APPROACH

1.1. Background

About 80 percent of the Indonesian population lives in the agricultural sector. Various sub-sectors including food crops, estate crops, and cattle have contributed remarkably to the national income, although the country is now facing the economic crisis. In every five-year development planning program (REPELITA) and in the medium period development planning (RPJM), the agriculture sector has a high priority. Indonesia had reached a self-sufficient food state by 1984, after agricultural intensification was conducted. In addition, various industrial sectors such as the food industry need raw materials from various agricultural products. The need for agricultural products, in many aspects of life, tends to increase while the population is also increasing. This is the reason that the agricultural sector is still one of the priority sectors in the development program of the country.

Extreme climate has becoming a threatening phenomenon for agricultural vulnerability in Indonesia in recent years and the resultant floods and droughts have had a serious impact on agricultural productivity, especially food crops. The government has directed efforts to create awareness of impact through climate variability and the dynamics of extreme climate, as well as formulating a strategy for handling the impact. Furthermore, the implementation of action plans to these ends, could lead to a sustainable agriculture sector in the country. However, many other programs, aimed at promoting public awareness for the active participation of the public, planners and policy makers in anticipating the impact of climate change within the country.

The pressure for sufficient agricultural production is growing in the country due to climate extremes of El-Nino and La-Nina whereby agricultural areas are often severely damaged, leading to lost production.

Vulnerable agriculture has suffered from climatic extremes, including floods, droughts, the occurrence of crop pests and diseases whose frequency and intensity have increased. Flood has been a natural phenomenon of which several factors play a role especially the increase of the rainfall intensity. The occurrence of high intensity rainfall in relatively short periods has lead to an increase of floods and stagnant water, sometimes for weeks. Areas vulnerable to floods are also determined by the presence of upstream critical watersheds in which the water cannot be retained and the excess rainfall flows as surface runoff to downstream areas having a detrimental effect on food crops downstream.

Crops grow beyond any dry spell period in which El-Nino inevitably has an effect – often on an annual basis, although it has also been recorded that the magnitude of any dry-spell impact was changing in some areas due to hydrological characteristics. Nevertheless, the magnitude of drought has generally increased with time and, thus, it would be I appropriate to adapt to drought variability in food- crop production system that could lead towards further food security in the country.

A phenomenon called *season-break* has led farmers to leave their crops and a lack of rainfall during any rainy season has often been unprecedented and most farmers have failed to anticipate this sometimes planting after sporadic rain, assuming that the real rainy season has started, only to learn this was not correct and, without rain, their crops could not survive anymore. To start again after the first failure, would cause delay in the second crops during the dry season. The impact of drought during *season-break* is normally less than that due to decrease of rainfall.. Rainfall during the dry season is low and it is not enough to maintain crop water requirements. Drought occurs not only in rain-fed rice areas but also in irrigated areas especially at the end of irrigation channels.
Availability of water for agriculture in the country has been decreased due to several factors including (a) catchment degradation where the water retention capacity of the catchments decrease and does not give enough base flow, (b) degradation of dam and other water storage capacity, and (c) climate (especially rainfall amount) extremes.
Attacks by pests and diseases are still essential limiting factors for crop production in Indonesia and a climate extreme is also a factor that has influenced the pattern and distribution of crop pests and diseases in Indonesia. During La-Nina, when the relative humidity increases, the proliferation of pests and diseases increases. Furthermore, erratic planting times increased the incidence of pests and diseases, especially on rice-based cropping systems.

The objectives of this Technology Needs Assessment (TNA) are to assess technology requirements and their potential for mitigation (and adaptation, which will be dealt with in a later report). This TNA is formulated, based on discussions and communication with and lesson learned from various stakeholders. Since the mitigation (and adaptation) needs to be done by different sub-sectors in agriculture, communication and confirmation of technology needs have been undertaken. Discussions and workshops involving sub-sectors of the Ministry of Agriculture have also been implemented to better assess and formulate the technology needs. A similar approach has also been conducted by the working group lead by Indonesian Agency for Technology Assessment and Implementation (BPPT).

1.2. Approach

The technology needs assessment for the agriculture sector cover paddy field/wetlands, perennial crops (oil palm), peat soil, and livestock. These sub-sectors were chosen by considering the vulnerability levels of each, to extreme climate events, especially flood and drought, and constitute a priority in the agricultural development program. They also contribute to GHG emission.

The assessment comprises mitigation and adaptation and considers other aspects of climate prediction, monitoring, and dissemination for mainstreaming, for practical and sustainable reasons. Concerning the monitoring and dissemination, several activities have been reported such as: (a) climate field school (reported by Indonesian Agency for Meteorology and Geophysics/ BMG) and Directorate of Plant Protection, Ministry of Agriculture and (b) climate information network (reported by Indonesian Agro-climate and Hydrology Research Institute/IAHRI, Agency for Agricultural Research and Development). The concern of the assessment is categorized into technology options, priority/key technology, barriers, and modalities.

Mitigation
Mitigation efforts to reduce impact of climate change are also urgent and should be executed comprehensively into integrated action with adaptation activities. Several strategies of mitigation may be introduced through (a) land and water management by which less emission can be achieved, (b) introducing crop varieties which result in less emissions and (c) integrated crops-livestock management. Each strategy can be implemented in consideration with local farming-specific. Intermittent irrigation for rice field and is one of the strategies of land and water management that may reduce CH_4 emission. It is

urgent to facilitate farmers in implementing a water-management system for their rice fields. In general, farmers prefer to maintain standing water in the field as high as 20 cm without any consideration to drain it, after a period of 2 – 4 weeks. This leads to a condition that a rice field produces much CH_4. Whereas, intermittent irrigation provides an aerobic condition where oxidation processes occur. Introducing crop varieties is also an option to be presented to farmers. Crop selection and breeding seem to be alternatives to less emission crops varieties. Research institutes such as the Indonesian Center for Rice Research are becoming very important in providing new rice varieties with less emission. Developing rain-fed rice may also be possible to reduce CH_4 emissions, and intermittent irrigation can reduce by 50 – 60% of CH_4 emissions from rice fields (Setyanto et al., 2003).

Integrated crops-livestock management is another strategy, which may contribute to reduced emissions. Manure should be converted into compost for fertilizer and fresh manure, which may not emit greenhouse gases such as CH_4 can also be converted into bio-gas, to produce energy for electricity, cooking and other proposes which may help farmers.

Adaptation

Climate uncertainties and variability are the most widespread factors determining the agricultural vulnerability of Indonesia. Global climate change has been considered in the agricultural development program, in order to adapt farming systems to those climate problems. Based on the data and information of the impact of extreme climate events on agricultural production and other problems related to the growth and distribution of pest and diseases, the appropriate adaptation strategies urgently need to be formulated. Adaptation to extreme climate is the strategy by which an agricultural production system should be directed to apply to drought, flood (submergence), pests and diseases.

As extreme climate has often made the agricultural production system vulnerable to drought, In order to sustain the growth and production of crops, adaptation to drought has been directed to improve the water availability during dry spells. The paucity of available water leads to unfavorable growth of cultivated crops especially in a seasonal-based cropping system. Efforts to provide more water have been made through many strategies, including a water harvesting system using channel reservoirs and mini water-pond, combined with efficient water use through applied irrigation.

The water-harvesting capacity of a channel reservoir depends upon its dimensions and the characteristics of the stream where it is constructed. Roughly, the gross potential of water available in the channel reservoir can be calculated through the catchment areas and the annual rainfall. Crop varieties, tolerant to drought, have also been introduced to farmers to adapt to drought during dry-spells.

Flood mitigation in agricultural areas has been conducted to reduce crop submergence and loss of yields. Downstream agricultural areas, especially in coastal regions need to be protected from coastal flood hazards. This can also be conducted through the introduction of a reservoir channel. Adaptation of crop growth and production to submerged hazards has been done through the introduction of crop varieties, resistant to submerged conditions.

To adapt to climatic uncertainty, arrangement of crop timetables is very urgent and should be combined with the prediction of the favorable time for planting as well as the amount of water available. Best planting time was becoming a question for farmers to start their crops in many areas in the country. As many have experienced in the country, planting times between places differ, due to climate extreme. For example, the initial planting time is earlier than normal during a La-Nina year and later than normal during an El-Nino year.

To anticipate the future climate condition with concern to appropriate agricultural planning and to avoid failure in harvesting the crops, climate prediction needs to be established. Many models of climate prediction have been created by various national and international institutions. The one that has been used and developed by the Indonesian Agency for Agricultural Research and Development (IAARD), through the Indonesian Agro-climate and Hydrology Research Institute, is the Kalman Filter model.

Since the climate in the country varies spatially and temporally, the accuracy of the model used also varies. Its accuracy also differs with the length of the period to be predicted. As shown in the validation process, the model is accurate for a short period (3 months) compared to the longer period (6 or 12 months). It is thus urgently needed to develop or to modify climate prediction models under local specific conditions.

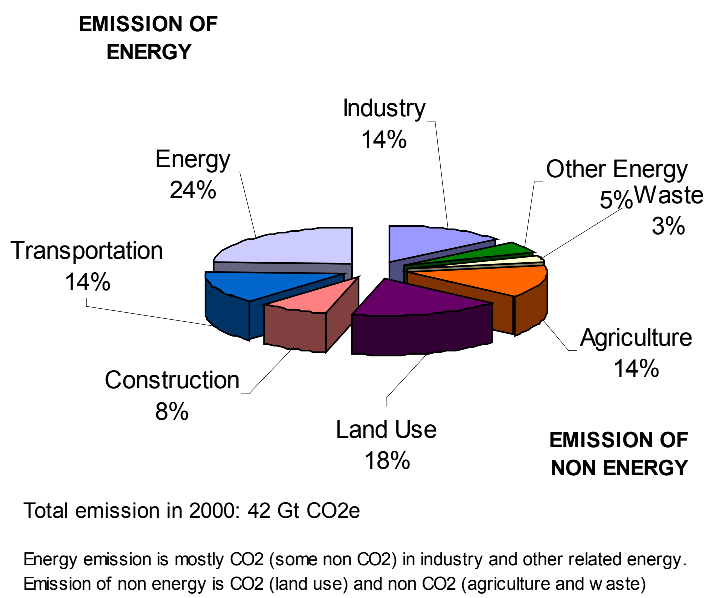
As far as the climate data are concerned, there is a gap of available data outside Java, since the weather station is relatively less dense compared to those over Java. Therefore, there is a need to develop weather-station networks outside Java and concurrently to maintain the stations in Java, especially in the central areas of food-crop plantations. Integration among the institutes, having the task to record climate data - such as BMG, the Ministry of Public Works and the Ministry of Agriculture - will be a focus of the climate-station network program.

2. REVIEW OF OPTIONS AND RESOURCES

2.1. Greenhouse Gas Emissions Inventory on National and Sectoral Level

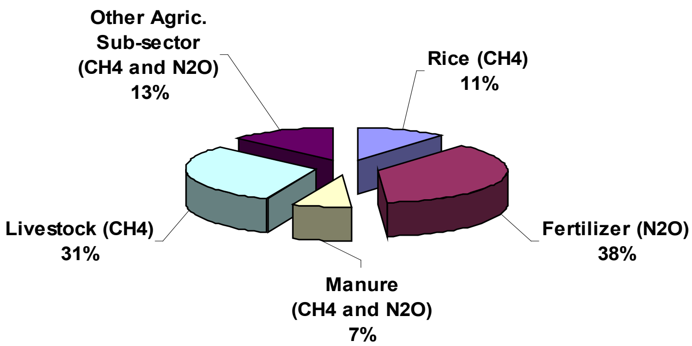
The inventory of greenhouse gas (GHG) emission in agriculture sector, compared to that in the energy sector, is limited. Inventories for estimating GHG emission from agriculture have noted that the agriculture sector has contributed about 14% of the total GHG emission of Indonesia (Figure 2.1). In Indonesia, the inventory of GHG emissions in 1990 showed that rice field was the highest GHG contributor among the major sources in the agriculture sector. As high as 3,649.2 Gg of CH_4 has been emitted from rice fields the burning of crop residues and livestock; 25.5 Gg of N_2O from the application of fertilizers and the burning of crop residues; 564.4 Gg of CO from burning crop residues; and 22.8 Gg of NO_x from burning crop residues (Table 2.1). These data are assumed to have increased over the past few years.

The World Resources Institute (2006) reported that various sources of emission of non- CO_2 has developed from the agriculture sector. Fertilizers contributed as high as 38% of N_2O, livestock as high as 31% of CH_4, rice as high as 11% of CH_4, manure 7% of CH_4 and N_2O, and other agriculture sub-sectors 13% of CH_4 and N_2O (Figure 2.2).



Source: (Stern, 2006)

Figure 2.1: GHG Emissions from Various Sectors, 2000



Source: (World Resource Institute, 2006)

Figure 2.2: Emission Sources of Non-CO2 Emissions from Agriculture, 2006

Table 2.1: GHG Emissions from Agriculture in Indonesia, 1990

(Gg)

Source	CH_4	N_2O	CO	NO_x
Rice field	2,758.0	-	-	-
Fertilizers	-	24.7	-	-
Burning of crops residues	26.8	0.6	564.4	22.8
Livestock	864.4	-	-	-
Total	3,649.2	25.5	564.4	22.8

Source: (State Ministry of Environment, 1996)

It has also been found that emissions from rice fields are influenced by rice varieties. It was reported that emissions from the Cisadane rice variety was 94.8 kg/ha, while that from the Way Apo variety was 58.9 kg/ha (Setyanto et al., 1997).

The animal-husbandry industry is also contributing to GHG emissions, especially CH_4 and CO_2. Globally, it is reported that about 300,000 Gg of CH_4 gas are released to the atmosphere annually, where about 30% comes from ruminant. The methane gas in animals is generated specifically from the food digestion system and the metabolism. In a farm animal, the internal digestion system together with methanogenic bacteria, helps the particular biochemical process and creates methane gas.

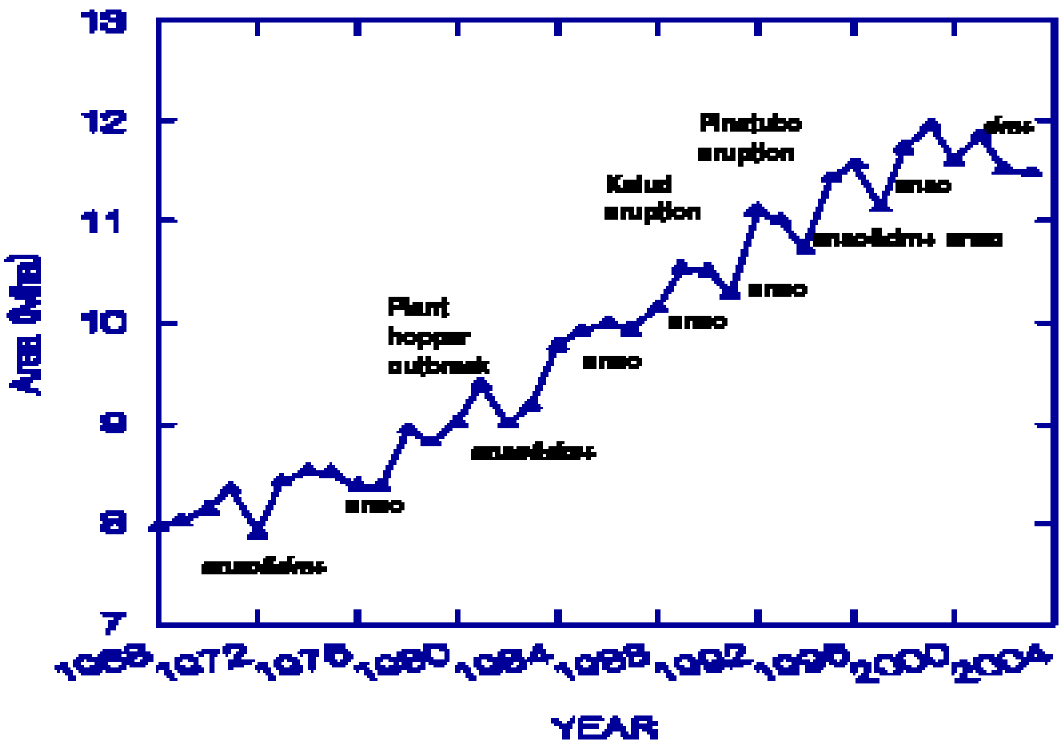
From the perennial crops point of view, waste of the palm-oil industry is also a potential of emission sources. Waste of this industry could be classified into two kinds: waste-water from the factory and solid waste from the field and factory. Waste-water has to be treated before being discharged into any body of usable water, while the solid waste consists of fruit peelings, leaves, trunks, fibers, shells, and stumps. The total amount of the palm-oil industry's solid waste in Indonesia was around 18,000 Gg in 2005 and the palm-oil wastewater was around 8,000 Gg (BPPT, 2007). Potential of GHG emissions from the palm-oil industrial waste is mainly the CH_4 emission.

2.2. Review of Vulnerability Studies

As extreme climate has frequently occurred with increased intensity, the pressure on agricultural production is growing in Southeast Asian countries, including Indonesia. On an annual basis, climatic variability, in the form of drought and flood (generally those are termed as El-Nino and La-Nina respectively), occurred more frequently and caused much damage to the ASEAN region. These phenomena have been well understood as the global phenomena which have been controlled by the dynamic flow of the Pacific Ocean (UCAR, 1994). In addition, seasonal variation has also occurred for rainfall, which is characterized by the variability in increasing and decreasing rainfall in the Indian and Pacific Oceans. The change in rainfall occurs within 30 to 60 days usually during a weak El-Nino and La-Nina (Amien *et al*, 2005). Agricultural areas are often affected by these phenomena leading to the production losses.

Since 1944, some 43 droughts have occurred in Indonesia, six of which resulted from ENSO phenomena (Boer dan Subbiah, 2003). This suggests that most of the droughts were due to the ENSO. In 1997, when a strong El-Nino occurred, 47,995 hectare (ha) of drought areas of rice were observed in Indramayu-West Java, which was much higher than that of 7,896 ha under a weak El-Nino in 2002/2003. During La-Nina, crop damage due to flood also happened, especially in areas with food crop-based cultivation. In Indramayu-West Java, it was observed that rice fields flooded during a strong La-Nina, reached an area of 50,478 ha, higher than during a weak La-Nina which reached an area of 25,644 ha. (Boer and Las, 2002).

A chart explaining agricultural vulnerability to extreme climate is projected in Figure 2.3, which illustrates the decrease of rice harvest areas during the extreme period. It is a fact that, due to innovations applied during the *green revolution* rice production increased. However, in the process of increasing production, there was a drop of rice yield due to the affects of the extreme climatic events of El-Nino, La-Nina or positive Indian Ocean Dipole Mode.



Source: Amien (2002)

Figure 2.3: Effect of Climate Anomalies on Rice Harvest Area in Indonesia, 1968 – 2004

Actions to mitigate those GHG emissions, through land and water management also include crop-varieties which have physiologically low GHG emissions. Attempts to adapt agriculture to climate change have also been introduced particularly in regard to flood and drought. The effect of change of temperature and humidity is also considered in areas of vulnerable agriculture.

2.3. National Planning

There are three major goals in the agricultural-sector development: (1) food security, (2) increase farmers' income, and (3) agribusiness development. These goals are described in the strategic planning of Ministry of Agriculture (2004-2009) and expanded in the details of development planning of the Directorate Generals and Agencies within a five-year planning program.

Food security is becoming a critical issue in the country to be covered in the development program to fulfill such needs as well as energy security. Five commodities have been set up in the planning program of food security, including (1) rice, (2) maize, (3) soybean, (4) sugar and (5) meat. Rice has been the major commodity developed intensively and achieved a major success in 1984, allowing the country to become self- sufficient in rice. Self-sufficiency in maize, soybean, sugar and meat will be reached in 2008, 2010 and 2012.
Since these commodities have been much affected by extreme climate adaptation options have been implemented. The Indonesian Agency for Agricultural Research and Development has directed the various researches working in the field of adaptation and, to some extent, mitigation. The options include crop varieties, tolerable and adaptable to extreme climate, water-harvesting and efficient water-use practices. For mitigation purposes, introduction of crops varieties with low emissions of GHG has also been initiated.

2.3.1. Greenhouse Gas Emissions Mitigation Potential

An estimation of the mitigation-potential from rice field has been made, by introducing a rice variety, which has relatively lower potential emissions. The mitigation potential, through technology, is based on the emission-reduction and the cost of mitigation. If Way Apo (lower emission potential) rice variety is introduced to change the Cisadane variety, the emission of CH_4 will be reduced by up to 37.8% (Setyanto et al., 1997), while the cost of mitigation was as high as 361,200 rupiahs per ha, or about US$ 40/ha.

Another approach, to mitigate emissions through soil and water management, may be also implemented. For rice-field management, the rice crop is often submerged under some 20 cm of standing water, with limited drainage during the irrigation cycle. This reduces land area and stimulates high CH_4 emissions. Intermittent irrigation, by which the water is drained during the irrigation cycle, eliminates the reduction potential and finally reduces the CH_4 emission by about 50-60% (Setyanto et al., 1997). Cost for implementation of this type of irrigation is about US$ 200-300 per ha., if irrigation channels and gates already exist, and about US$ 400-500 per ha., if there are none.

2.3.2. Key Sector Issues

Agriculture resources not only contribute to the food security, but also can be used as alternative sources of energy. Since limited oil resources are becoming a critical issue in the last decade, energy alternatives have to be created to fulfill the demand and an energy economy must be balanced vis-a-vis the increase of the energy demand. Unfortunately, the energy alternative from agriculture resources has to be created from food such as maize, cassava, etc. which might be inconsistent with the effort to support food security. The use of non-food crops should be the strategy to achieve both food and energy securities.

The use of manure for biogas production is one of the best alternatives to produce energy. This should be in line with the program of livestock development at the village level. Other materials such as crop residues, "jarak pagar", and other agriculture sources are also recommended. It would be unwise to produce energy from food crops, which are still relatively limited.

2.4. Existing Regulations and Policies

Crop management Decree (UU No. 12/1992 tentang Budidaya) is the principal regulation in the agricultural sector, which allows farmers to choose commodities in their farming. Water is required for the agricultural sector for crop production and livestock. Government regulations in managing irrigation is important Water Resource Decree no. 7/2004 governs the utilization of water resources for various need, including irrigation for agriculture. In addition, the agricultural sector faces problems of land conversion. which has reached a rate of more than 140,000 ha per year. To control this phenomenon, a "Lahan Abadi" (eternal land) decree has also been released.

Efforts to adapt agriculture to climate change have necessitated a policy to use water efficiently. Creating new crops varieties such as rice and other food crops was also conducted for adaptation and mitigation purposes.

2.5. Resources Potential and Utilization

2.5.1. Resources Potential

Indonesian agricultural resources are potentially used for sustaining human life. Energy (biogas, biofuel, biodiesel), conserving and sustaining the environment (compost, bio-fertilizer, bio-urine) and food security are priorities. Since food and energy become critical issues in a global perspective, the agricultural sector development has to accelerate to achieve these ends while maintaining a sound environmental condition.

Since technologies have been progressively developed in the agricultural sector, crop production and productivity have increased especially for food crops such as cereals, tubers, etc. However, the high price of oil in global market causes people to use other sources of energy. Food is one of the resources that have been converted for bio-fuels thus causing food crops to be used as food or fuel.

2.5.2. Resources Utilization

Agricultural resources can be utilized for many purposes related to adaptation to and mitigation of climate change. These resources include: (1) crops, (2) crop residues, and (3) manure. Crops are utilized for both adaptation and mitigation purposes through some varieties adapted for drought and submergence condition, early-maturing and highland-adaptable crop varieties. Crop residues and manure can be processed to produce organic fertilizers or compost which is very useful for improving land productivity and sustaining water availability for crops since organic matter improves soil water-holding capacity. Manure may also be potentially developed to produce biogas as an alternative energy reducing methane emissions.

Over-utilization of chemical fertilizer such as Urea, SP-36, KCl, limited drainage and other inappropriate management may increase GHG emissions. Production and application of slow-release N-fertilizers as well as implementing fertilizers are recommended.

3. TECHNOLOGY CRITERIA AND OPTIONS

3.1. Selection Criteria for Technology Assessment

Criteria used for technology selection includes general and sector-specific which are used to identify technologies for mitigation of, and adaptation to climate change. In general, technologies for mitigation and adaptation are selected, based on their potential reduction of GHG emissions and the characteristics of crops and animals which can be adapted to the environment influenced by the climate change. The specific criteria of the sector are based on the site and users of a particular mitigation and adaptation technology.

The criteria for selecting technologies for TNA of the agricultural sector are based on three considerations, which are:

1. The technologies should contribute to three important goals of realizing food security, increase farmers' income, and agribusiness development. The technologies should be economically beneficial, socially acceptable, and environmentally benign.
2. The technologies should address climate change mitigation which reduces GHG emissions (e.g. low emission of crops varieties, composting, etc.) and enhance carbon sink. The contribution to climate-change adaptation could involve an assessment of the degree to which climate change-related risks can be reduced by a particular technology, is also important.
3. The contribution to market potential which can involve an analysis of capital and operating costs relative to alternatives, the commercial availability of the technology, and the technology's replicability, applicability, adaptability, and potential scale of utilization.

Selected technologies are based on criteria and priority options of technology needs. Technology needs are country-specific, economically profitable, socially acceptable, and environmentally friendly. Technology selection process for mitigation using general and specific criteria is described in Table 3.3 and Table 3.4.

Table 3.1: General Criteria for Technology Selection

General Criteria	Sub-Criteria
General concern	• Reducing GHG emissions (RGHG) • Increasing adaptability of crops and livestock (ACL) • Promoting resource conservation (RC) • Promoting sustainable biodiversity (SB) • Promoting green energy (GE) • Sustaining food security (FS) • Promoting energy alternative (EA)

Table 3.2: Specific Criteria for Technology Selection

Specific Criteria	Sub-Criteria
General concern	• Promoting local technology for mitigation (LW) • Sustaining site-specific germ plasms (GP) • Promoting simple and cheap technology for poor farmers (SCT) • Promoting less water requirement crop varieties (LWRC) • Substituting an organic with organic fertilizers/compost (SOF) • Water-use efficiency in dry areas (WUE) • Reduce CH_4 emissions (RCHE)

3.2. Selection Process

The selection process of environmentally sound technology is carried out by applying general and specific criteria on the identified technology.

Table 3.3: Technology Selection Process for Mitigation using General Criteria

List of Technology	General Criteria							TP
	RGHG	ACL	RC	SB	GE	FS	EA	
Climate Prediction								
Climate database	NR	NR	M	NR	NR	NR	NR	3
Climate prediction model	L	M	M	L	NR	M	NR	11
Information technology of climate forecast	L	M	L	L	NR	M	NR	9
Rice/Horticulture								
Low methane emitter crops varieties	H	H	H	M	NR	M	NR	21
No tillage	H	L	L	L	NR	M	NR	11
Appropriate fertilizing	H	M	M	L	L	H	L	19
Intermittent irrigation	H	M	M	L	NR	M	NR	15
Perennial crops								
Low methane emitter crops varieties	H	H	H	M	NR	M	NR	21
No tillage	H	L	L	L	NR	L	NR	9
Appropriate fertilizing	H	M	M	L	L	M	M	19
Appropriate slash and burn	H	M	H	H	L	L	L	21
Biofuel	H	L	L	NR	H	NR	H	17
Livestock								
Composting manure	H	M	M	L	NR	M	H	20
Biogas production	H	M	L	NR	NR	M	H	17
Bio-urine production	H	M	L	NR	NR	H	M	17
Peat land								
Overcoming slash and burn	H	M	H	M	NR	M	L	20
Avoiding over drain	H	M	M	L	NR	M	L	19
Maintaining soil moisture	M	H	M	L	NR	H	L	18

Reducing GHG emission (RGHG), increasing adaptability of crops and livestock (ACL), promoting resource conservation (RC), promoting sustainable biodiversity (SB), promoting green energy (GE), sustaining food security (FS), promoting energy alternative (EA)

H: High value/ high relevant/high impact (score: 5);
M: Medium value/relevant/med impact (score: 3);
L: Low value/less relevant/less impact (score: 1);
NR: Nil – not relevant/no impact (score: 0);
TP: Total point

Table 3.4: Technology Selection Process for Mitigation using Specific Criteria

List of Technology	Specific Criteria							TP
	LW	GP	SCT	LWRC	SOF	WUE	RCHE	
Climate Prediction								
Climate database	NR	NR	M	NR	NR	NR	NR	3
Climate Prediction Model	L	M	M	L	NR	M	NR	11
Information technology of climate forecast	L	M	L	L	NR	M	NR	9
Rice/Horticulture								
Low methane emitter crops varieties	H	H	M	L	NR	L	H	20
No tillage	M	L	H	L	NR	M	L	14
Appropriate fertilizing	M	M	H	L	M	NR	H	20
Intermittent irrigation	L	L	M	M	NR	H	H	18
Perennial crops								
Low methane emitter crops varieties	H	H	M	M	NR	L	H	22
No tillage	M	M	H	M	NR	M	L	18
Appropriate fertilizing	M	M	H	L	H	L	H	23
Appropriate slash and burn	H	H	M	NR	NR	L	H	19
Biofuel	M	NR	M	NR	M	NR	H	14
Livestock								
Composting manure	H	NR	M	M	H	M	H	24
Biogas production	H	NR	M	L	H	L	H	20
Bio-urine production	H	NR	M	NR	H	NR	H	18
Peat land								
Overcoming slash and burn	H	H	M	L	M	NR	H	22
Avoiding over drain	M	L	H	M	NR	M	H	20
Maintaining soil moisture	M	L	H	M	NR	M	M	18

Promoting local wisdom technology for mitigation (LW), sustaining site specific germ plasma (GP), promoting simple and cheap technology for poor farmers (SCT), promoting less water requirement crop varieties (LWRC), substituting an-organic with organic fertilizers/compost (SOF), water use efficiency in dry area (WUE), reduce CH emission (RCHE)

4. TECHNOLOGY SELECTION

Adaptation of food crops to climate change can be done through various approaches and strategies. Options to adapt food production processes to climate change and to secure food are: (a) integrated crop management, and (b) water resources management. Priority of technologies for integrated crops management are: (a) appropriate cropping calendar, (b) introducing crops varieties tolerant to drought and flood and early mature crop varieties as well as dry seedling technology. Priority of water resources management technologies are: (a) water conservation technology, (b) water harvesting technology, (c) technology of modification of micro climate, (d) technology of efficient water use, and (d) intermittent irrigation for rice field. Water conservation technologies should be directed to increase infiltration and groundwater recharge and to reduce evaporation as well as to increase moisture content. Water harvesting technologies are addressed to collect water in the wet season and to use water especially in dry season. Micro-climate modification needs technologies of crops diversification. It should be an integration of water harvesting and irrigation application. Technologies of efficient water use are addressed for efficient irrigation. The intermittent irrigation technology is needed to reduce methane emissions from rice fields and increase the efficiency of water use.

Mitigation measures, through crop, management, with fertilizing and no tillage technology are also implemented, as a means of reducing GHG emissions from the agricultural sectors. Water resources management should also be considered, where intermittent irrigation, drainage to reduce CH_4 emissions and the introduction of rain-fed rice are priority technologies. Another priority could be the adaptation of livestock to areas affected by climate change, the introduction of the most-adaptable livestock such as cattle for dry or wet climate areas and the introduction of the technology of communal livestock as well as integrated livestock management.. Mitigation may also be introduced through biomass (manure) processing, as well as composting manure and converting it into biogas. Since peat soils are fragile, adaptation and mitigation technologies need to be implemented in appropriate ways. Through land and water management, several priority technologies will be implemented including minimum tillage, balanced fertilizing, appropriate soil amelioration, drainage and land-subsidence control, and peat dome area conservation (Table 4.1).

Table 4.1: Selected Technologies/ Measures for Mitigation

Agriculture sub-sector	Climate Prediction	Adaptation Technology	Mitigation Technology
Rice field/ Horticulture	a. Climate database Management b. Climate information technology c. Climate model development	a. Crops tolerant to drought and flood b. Early mature crops varieties c. Cropping calendar d. Water harvesting e. Efficient irrigation	a. Appropriate fertilizing b. No tillage c. Intermittent irrigation
Perennial crops		a. Introducing estate crops varieties tolerant to drought and flood b. Appropriate Crop sheltering c. Correct planting distance d. Optimum crops density	a. Appropriate Fertilizing b. No tillage c. Appropriate slash and burn d. Bio-fuel
Livestock		a. Adaptable cattle to dry and wet climate b. Communal livestock sheltering	a. Composting manure b. Biogas production
Peat Land		a. Minimum tillage b. Balance fertilizing c. Appropriate soil amelioration d. Drainage control e. Subsidence control	a. Overcoming slash and burn b. Avoiding over drain c. Maintaining soil moisture

Details of key technologies are also described in Appendix 1 at the end of this document. As far as climate prediction is concerned, especially for adaptation purposes, climate data collection is playing an important role. To do so, a representative distribution of climate stations within the country needs to be organized. Various agencies (institutes), responsible for data collection and management, should work in union and share the data needed by the agencies. Climate-prediction models and validation also need to be urgently developed. These are also important for the delivery of climate information to the user, through various channel and media, and the publication of periodical climatic forecasts.

Key technologies for mitigation include low emission crop varieties, appropriate fertilizing, no tillage, and intermittent irrigation for food crop as well as *slash and burn* technology for perennial crops. Composting and biogas development technologies will be focused on the livestock sub-sector. Technologies of minimum tillage, balanced fertilizer and appropriate amelioration combined with drainage control, as well as *slash and burn* technologies should be be focused on peat land.

5. IDENTIFICATION OF BARRIERS AND POLICY NEEDS

5.1. Institutional Barriers

Many institutions have mandates for dealing with mitigation and adaptation activities. In activities related to climate data-base development and prediction, several institutions have been involved. The Agency for Meteorology and Geophysics (BMG), the Ministry of Public Works (PU), the Agriculture Offices (Dinas Pertanian) and the Agency for Agriculture Research and Development (AARD) are responsible for climate data recording. Unfortunately, sometimes data have not been communicated and shared among related institutions. This is a principal barrier restricting the climate prediction model development being supported by a strong climate data-base. Regarding climate stations, their number and distribution are limited both quantitatively and qualitatively. Climate stations are quite well distributed around Java Island but not outside.

5.2. Policies needed to accelerate Technology Transfer

Several climate change mitigation and adaptation activities have been conducted by various institutions. Integrated activities have been classified as urgent. In order to prepare appropriate action programs the sectors Agriculture, Energy, Health, Industry, Transportation, Forestry, Ocean, and Waste must be analyzed. Coordination among the institutions is essential for the implementation of comprehensive action programs.

Since climate prediction is important, accurate and representative climate data has to be recorded. Installation of vast dense climate stations, especially outside Java, is urgently needed to cover more areas with an appropriate number of climate stations. Climate data-base systems should be improved to facilitate better climate prediction through development of model prediction and validation. The existing model offers a relatively little accuracy especially for a longer period of climate prediction. In addition, integrated programs on mitigation and adaptation have to be established to create comprehensive action programs. Barriers Assessment and Policy Needs in Agriculture Sector are presented in Table 5.1.

Table 5.1: Barriers and Policy & Action Needs

Barriers	Policy Needs
Climate Prediction	
• Less distributed climate stations outside Java	• Need of vast and dense climate station network especially outside Java
• Absence of network between climate station and users	• Improvement of users' access to climate data
• Limited accuracy of climate prediction model for longer period (> 6 months)	• Improvement of climate prediction model • Use model for prediction in shorter period (3 months), repeated for the subsequent 3 month period
• Lack of validation for climate prediction	• Improvement of model validation for different climate zone
Adaptation/ Mitigation	
• High time expenditure to produce crop varieties tolerant to drought and flood	• Improvement of crops breeding
• Adaptation technologies are not widely known to farmers	• Need of fare distributed dissemination technology
• Cost of adaptation technology implementation is relatively high for farmers	• Select simple and cheap adaptation technologies
• Limited knowledge of farmers	• Improvement of training
• Limited capital of farmers to implement adaptation technology	• Need for government support on financing adaptation technology implementation
• Expected benefit and beneficiaries	• Introducing high economic values of commodities
Dissemination	
• Limited awareness of farmers	• Improvement of awareness
• Limited knowledge of extension workers working on climate change, adaptation and mitigation	• Need for special training and on-the-job training
• Lack of proper information system for dissemination	• Need for information technology
• Gap of linkage between researchers and extension workers	• Need for an umbrella program of dissemination
Capacity Building	
• High cost of capacity building in adaptation and mitigation	• Need for government support in financing capacity building
• Limited knowledge of trainers	• Improvement of training of trainers (TOT)
• Lack of skilled professional in capacity building in adaptation and mitigation	• Need for special training
• Lack of personnel for introducing and implementing adaptation and mitigation technologies	• Need for recruitment of skilled professional personnel
• Gap of information technology for capacity building	• Improvement of information technology

5.3. Review of Resources

Technology Needs Assessment (TNA) has been conducted for rice field/ horticulture, livestock and peat land and the results are presented in Table 4.1. To develop climate- prediction models, several steps have to be taken including climate data-base development and information technology for climate forecasts. Potential barriers have been identified such as lack of dense weather-station networks. This is a constraint to producing accurate models and executing appropriate model validation. Human resource capacity in climate data recording is also a barrier which needs to be overcome. Training in development of climate-data management, operation and administration, technical assistance for administration and climate-record operations are modalities for the transfer of technology. The delivery of climate information from BMG to users, through various channels and media and the publication of periodical climatic forecasts are urgent.

6. CONCLUSION AND RECOMMENDATION

6.1. Definition, Determination and Selection of Options

Optional activities need to be defined to focus more in the program to combat climate change through mitigation and adaptation activities. The determination and selection of options are based on the communication among stakeholders and the feed-back from the existing technology-users, through the communication between the existing technology producers (research centers, etc.) and technology users (farmers, agriculture offices, etc.) technology needs can be assessed. Several options are selected as follows:

Mitigation

a. Crop varieties development: Rice varieties having lower potential CH_4 emissions have been developed. For example, Way Apo rice variety has a lower potential CH_4 emission than Cisadane rice variety.
b. Intermittent irrigation for rice fields: Standing water about 20 cm above soil surface is always provided by farmers in rice cultivation, putting the soil under reduced condition. This allows more CH4 emissions compared dry conditions. Intermittent irrigation is an alternative way to reduce CH4 emissions, because this irrigation technique may perform alternate dry and wet conditions, during the cycle of irrigation.
c. Drip and Sub-surface irrigation for estate crops: Controllable drip and sub-surface irrigation, at certain moisture conditions may provide circumstances that balance moisture and air in the soil, helping avoid frequent conditions of reduction in the soil and reduced CH4 emission.
d. Appropriate fertilizers and fertilize-management: Producing slow release N-fertilizer such as Sulphur-coated Urea, Urea tablet, Urea stick, etc. can be an alternative to N-fertilizer.
e. Composting manure and crop residues: Substantial amounts of manure are produced in community cattle management. Without processing this manure, GHG emissions will be relatively high. Composting is an alternative way to reduce emissions
f. Biogas production for energy use: Production of biogas means converting manure into gas that can be used as energy, also reducing emissions.
g. Biofuel production: Processing agricultural resources such as Jatropha, agro-industrial waste and other agricultural residues to produce bio-fuels.

Adaptation

Although adaptation is not the main focus of this TNA, adaptation measures are also important for the agricultural sector.

a. Climate prediction for an appropriate cropping calendar which provides information on an appropriate cropping season. This is arranged in different climate scenarios of La-Nina, Normal, or El-Nino. Climate prediction is needed to predict the future climate condition, whether it is La-Nina, Normal, or El-Nino.
b. Crops-sheltering for estate system: To avoid the high impact of an extreme drought climate, crop-sheltering may avoid high evaporation from the ground surface, reduce direct impact of sun and avoid wilting.
c. Water-harvesting and conservation: Water is essential for crops, but its availability is becoming scarce especially in dry areas and in the areas with worst impact to climate change. Waste-harvesting and conservation practices have to be implemented.
d. Drainage control for peat land: The impact of climate change on peat land can be subjected to the occurrence of subsidence, due to a drop in the ground-water level, and it may also allow high GHG emissions when reduced under submerged conditions. A drainage system has to be set up to control an appropriate ground-water level.

6.2. Conclusion

Efforts to mitigate GHG emissions from the agricultural sector and the adaptation of this sector to climate change needs urgent action through many activities including the farming-system development. Introduction of crop varieties, intermittent irrigation, application of appropriate fertilizer management, composting manure, gaining bio-fuel from crop residues, and biogas production can be conducted for mitigation purposes.

Adaptation to climate change can be realized through implementing climate predictions for an appropriate crop calendar, water-harvesting and conservation, and a correct drainage system. But adaptation is not dealt in detail in this report, which focuses on mitigation options.

6.3. Recommendation

- Appropriate planning of the cropping season and patterns can be implemented with regard to climate variability. Vast and dense climate station networks need to be organized to obtain reliable data for predictions and forecasts. Adaptation and mitigation technologies are required to support planning programs.
- Use of high-yielding crop varieties and cattle, adaptable to drought and flood and the introduction of early-mature varieties.
- Since irrigation water is scarce, efficient water use has to be implemented when dealing with irrigation management.
- The strengthening of water-management institutions (example: "Perkumpulan Petani Pemakai Air/P3A") is also valuable for water-resources management, in adapting agriculture to climate change.
- Accentuating the increasing incidence of water use and proportional water-sharing are other approaches since the number of water-users is increasing.
- Implementing water conservation and water-harvesting technologies.

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Appendix 1: Technology Needs Assessment for Adaptation to and Mitigation of Climate Change in Agriculture Sector

a. Rice Fields/ Horticulture:

Need and Opportunities	Urgency/Gap	Technology Options	Priority/Key Technology	Potential Barriers and Policy Needs	Modality for Transfer of Technology	Target Achievement
Climate Prediction	• High risk of harvesting failure prior to climate change • Accurate climate forecast will reduce risk of harvesting failure	• Climate database • Climate Prediction Model • Information technology of climate forecast	**Climate Database** • Well distributed climate stations exist in Java. But, limited distribution out side Java • Climate data are collected intensively in Lampung, West Java, Central Java, DI Yogyakarta, East Kalimantan, South-east Sulawesi, East Nusa Tenggara, but not in other area (Agency for Agriculture Research and Development) • Climate data are also collected from BMG and Min. of Public Work for other sites • Spatial data of predicted initial wet and dry seasons 2008 overlaid with distribution of sawahs in Java	• Need of vast and dense climate stations especially outside Java • Various Institutions (BMG, PU, AADR and others) are responsible to climate data recording • Absence of network between climate station and users • Need coordination among institutions	• Training on development of climate data management, operation and administration • Technical Assistance for farmers on climate data administration • Technical Assistance for farmers and extension workers on climate record operation	• Appropriate climate database system

Need and Opportunities	Urgency/Gap	Technology Options	Priority/Key Technology	Potential Barriers and Policy Needs	Modality for Transfer of Technology	Target Achievement
			Climate Prediction Model • Climate prediction using Filter Kalman Method, and/or other method • Model has been applied for Lampung, West Java, Central Java, DI Yogyakarta, East Kalimantan, South-east Sulawesi, East Nusa Tenggara **Model Validation** • Filter Kalman Model is more valid for areas with stationary rainfall pattern.	• Accuracy of the model needs to be improved • Possible new model is urgently to be developed. • Training is required	• Existing of climate data can be used for climate model validation • Training on appropriate local specific climate model • Technical assistance to develop climate model	• Validated climate prediction model
			Disemination of climate prediction. • Delivery of information of climate from BMG to user. • Delivery of informationof climate through various channel and media. • Publication of periodical climatic forecast	• Need inter ministerial collaboration: Public Works, Agriculture, BMG, Health • Climate data needs to be available on line to all districts	• Technical assistance to develop an effective climate data dissemination system	• Assessable climate data for public

Need and Opportunities	Urgency/Gap	Technology Options	Priority/Key Technology	Potential Barriers and Policy Needs	Modality for Transfer of Technology	Target Achievement
Adaptation to Climate Change	Productive capacity of food crops need to be maintained under climate variation	**Integrated Crop Management** Technologies: • Crops varieties tolerant to drought and flood • Early mature crops varieties • Cropping calendar • Dry seedling technology	• Introducing crops varieties tolerant to drought and flood • Introducing the early mature crops varieties • Appropriate cropping calendar • Dry seedling technology	• Need a long time to develop new varietes • Coordination of farming activities is difficult as involving community • Need acceleration of dissemination of new crops varieties	• Existing crops varieties tolerant to drought and flood can be introduced • Training and technical assistance on crop breeding • Enhancement of available technologies	• Implemented integrated crop management for adaptation • Introduction of crops varieties tolerant to drought may reduces fail harvest about 15% • Appropriate cropping calendar reduces lost of yields about 10-20%
		Water (Resources) Management Tachnologies: • “Embung” • Channel reservoir • Intermittent irrigation • Pressurized irrigation • Mulching • Slot mulch • Infiltration well	• Water conservation • Rain/water harvesting • Weather modification • Controlled groundwater exploitation • Efficient of water uses • Prioritize of water uses • Intermittent irrigation • Pressurized irrigation (particularly for horticulture)	• Various stake holders engage in water sector • Eventhough there is water law available, it is still required Government regulation on IWRM to accelerate implementation	• Technical assistance on water conservation and river basin management • Technical assistance on development the climate modification technology	• Implemented water resources management for adaptation

Need and Opportunities	Urgency/Gap	Technology Options	Priority/Key Technology	Potential Barriers and Policy Needs	Modality for Transfer of Technology	Target Achievement
Mitigation of climate change	Need to valuate contribution of agriculture sector to GHG emission	**Soil and Crop Management** Technologies: • Low methane emitter crops varieties • No tillage • Appropriate Fertilizing • Intermittent irrigation	• Appropriate Fertilizing • No tillage • Intermittent irrigation	• Need a longer time to develop new varietes • Coordination of farming activities is difficult as involving community	• Technology transfer for no tillage equipment development	• Implemented soil and crop management for mitigation • Introduction of low emitter crops varieties may reduce emision by about 35%. Cost of introduction of rice varieties can be as high as US$ 40/ha • Intermittent irrigation reduces emission about 10-15% • Appropriate fertilizers reduces about 20%
Monitoring	No data on GHG emission from agriculture sector	**Periodical Monitoring**	• Monitoring of frequency and intensity of GHG emission from paddy rice field with intensive fertilizer application • Monitoring of frequency and intensity of GHG emission from paddy rice field with various water management practices	No equipment and instrument are available	Need technical assistance and technology transfer for GHG emission	Periodic GHG emission data

Need and Opportunities	Urgency/Gap	Technology Options	Priority/Key Technology	Potential Barriers and Policy Needs	Modality for Transfer of Technology	Target Achievement
Dissemination of mainstreaming of Global Climate Change	No adequate understanding on impact of agriculture to climate change among stake holder such as local government and farmer	**Awareness Program**	• Awareness campaign on global climate change in agriculture sector • Formulation guidelines and modules and extension materials of adaptation strategies for Sawahs • Other dissemination methods	Despite target area is country-wide, campaign reach might be limited		Increase of public awareness
Capacity Building	Most of stakeholders do not have capacity to cope with climate change	**Public Campaign/ Extension**	• Training and capacity building for local government for mainstreaming Global Climate Change in agriculture policy • farmer field school (Climate field school, Integrated Crop Management field school , etc) • Institutional building and strengthening for climate change mainstreaming	Need great number of facilitators		Increase capacity of local goverment to cope with climate change

b. Perennial, trees, and estate crops:

Need and Opportunities	Urgency/Gap	Technology Options	Priority/Key Technology	Potential Barriers and Policy Needs	Modality for Transfer of Technology	Target Achievement
Climate Prediction	• High risk of reducing estate crops production prior to climate change • Accurate climate forecast will reduce risk of reducing estate crops production	• Climate database • Climate Prediction Model • Information technology of climate forecast	**Climate Database** • Well distributed climate stations exist in Java. But, limited distribution out side Java • Climate data are collected intensively in Lampung, West Java, Central Java, DI Yogyakarta, East Kalimantan, South-east Sulawesi, East Nusa Tenggara, but not in other area (Agency for Agriculture Research and Development) • Climate data are also collected from BMG and Min.of Public Work for other sites • Spatial data of predicted initial wet and dry seasons 2008 overlaid with distribution of estate crops	• Need of vast and dense climate stations especially outside Java • Various Institutions (BMG, PU, AADR and others) are responsible to climate data recording • Absence of network between climate station and users • Need coordination among institutions	• Training on development of climate data management, operation and administration • Technical Assistance on climate data administration • Technical Assistance on climate record operation	• Appropriate climate database system

Need and Opportunities	Urgency/Gap	Technology Options	Priority/Key Technology	Potential Barriers and Policy Needs	Modality for Transfer of Technology	Target Achievement
			Climate Prediction Model • Climate prediction using Filter Kalman Method, and/or other method • Model has been applied for Lampung, West Java, Central Java, DI Yogyakarta, East Kalimantan, South-east Sulawesi, East Nusa Tenggara **Model Validation** • Filter Kalman Model is more valid for areas with stationary rainfall pattern	• Accuracy of the model needs to be improved • Possible new model is urgently to be developed. • Training is required	• Existing of climate data can be used for climate model validation • Training on appropriate local specific climate model • Technical assistance to develop climate model	• Validated climate prediction model
			Disemination of climate prediction. • Delivery of information of climate from BMG to user • Delivery of informationof climate through various channel and media • Publication of periodical climatic forecast	• Needs inter ministerial collaboration: Public Works, Agriculture, BMG, Health • Climate data needs to be available on line to all districts	• Technical assistance to develop an effective climate data dissemination system	• Assessable climate data for public
Adaptation to Climate Change	• Maintaining potential estate crops productivity under extreme climate is urgent • Avoiding estate crops damage due to extreme climate	**Integrated Crop Management** Technologies: • Estate crops tolerance varieties to drought and flood • Crop shading (sheltering) • Planting distance • Crop density	• Introducing estate crops varieties tolerant to drought and flood • Appropriate Crop sheltering • Correct planting distance • Optimum crop density	• Needs a long time to develop new estate crops varietes • Coordination of farming activities is difficult as involving community • Need acceleration of dissemination of new estate crops varieties	• Existing estate crops varieties tolerant to drought and flood can be introduced • Training and technical assistance on estate crops breeding • Enhancement of available technologies	• Implemented integrated crop management for adaptation

Need and Opportunities	Urgency/Gap	Technology Options	Priority/Key Technology	Potential Barriers and Policy Needs	Modality for Transfer of Technology	Target Achievement
		Water (Resources) Management Technologies: • “Embung” • Channel reservoir • Drip irrigation • Sub-surface irrigation • Mulching • Slot mulch • Infiltration well • Drainage system	• Water conservation • Rain/water harvesting • Weather modification • Controlled groundwater exploitation • Efficient of water uses • Prioritize of water uses • Drip irrigation • Sub-surface irrigation	• Various stake holders engage on water sector • ALthough there is water law available, it is still required Government regulation on IWRM to accelerate implementation	• Technical assistance on water conservation and river basin management • Technical assistance on development of the climate modification technology	• Implemented water resources management for adaptation

Need and Opportunities	Urgency/Gap	Technology Options	Priority/Key Technology	Potential Barriers and Policy Needs	Modality for Transfer of Technology	Target Achievement
Mitigation of climate change	• Valuation of GHG emission under different estate crops • Valuation of carbon sequestration under different estate crops age, and above and below ground sequestration • Control of slash and burn system	**Soil and Crop Management** Technologies: • Low methane emitter estate crops varieties • No tillage • Appropriate Fertilizing • Correct slash and burn technology • Agro-forestry	• Appropriate Fertilizing • No tillage • Appropriate slash and burn	• Need a longer time to develop new estate crops varietes • Coordination of estate crops management activities is difficult as involving community • Difficult to control corect slash and burn	• Technology transfer on no tillage equipment development • Potential resources to develop agro-forestry	• Implemented soil and crop management for mitigation
Monitoring	No data on GHG emission from estate crops	**Periodical Monitoring**	• Monitoring of frequency and intensity of GHG emission from estate crops with intensive fertilizer application • Monitoring of frequency and intensity of GHG emission from estate crops with varies water management practices	Limites equipments and instrument are available	Needs technical assistance and technology transfer for GHG emmission	Periodic GHG emission data
Dissemination of mainstreaming of Global Climate Change	No adequate understanding on impact of estate crops to climate change among stake holder such as local government and farmer	**Awareness Program**	• Awareness campaign on global climate change in estate crops • Formulation guidelines and modules and extension materials of adaptation strategies for estate crops • Other dissemination methods	Despite target area is country-wide, campaign reach might be limited		Increase of public awareness

Need and Opportunities	Urgency/Gap	Technology Options	Priority/Key Technology	Potential Barriers and Policy Needs	Modality for Transfer of Technology	Target Achievement
Capacity Building	Most of stakeholders do not have capacity to cope with climate change	**Public Campaign/ Extension**	• Training and capacity building for local government for mainstreaming Global Climate Change in estate crops • Farmer field school (Climate field school, Integrated Estate crop Management field school, etc) • Institutional building and strengthening for climate change mainstreaming	Need great number of facilitators		Increase capacity of local goverment to cope with climate change

c. Livestock

Need and Opportunities	Urgency/Gap	Technology Options	Priority/Key Technology	Potential Barriers and Policy Needs	Modality of Technology Transfer	Target Achievement
Climate Prediction	• Livestock will face problems under climatic variation due to risk of harvesting failure of forage crop • Accurate climate forecast will help farmer to maintain livestock health	• Climate database • Climate Prediction Model • Information technology of climate forecast	**Climate Database** • Well-distributed climate station in Java. Limited distribution out side Java • Climate data are collected intensively in Lampung, West Java, Central Java, DI Yogyakarta, East Kalimantan, South-east Sulawesi, East Nusa Tenggara (Agency for Agriculture Research and Development) • Climate data are also collected from BMG for other sites	• Need of vast and dense climate stations especially outside Java • Various Institutions (BMG, PU, AADR and others) are responsible to climate data recording • Absence of network between climate station and users • Need coordination among institutions	• Note: similar training and technical assistance to farming activities is applicable as well for livestock	Appropriate climate database system
			Climate Prediction Model • Climate prediction of BMG is used • Climate prediction for Sawahs is to some extend can be used **Model Validation** • Model has not been validated for livestock • Validated model for Sawahs to some extend can be used **Model Application** • Model has not been applied for livestock			Validated climate prediction model

Adaptation to Climate Change		Livestock Management Technologies: • Communal sheltering • Sanitation technology • Fodder technology • Insemination technology	• Introduce most adaptable livestock for dry or wet climate areas • Communal Livestock Sheltering • Integrated Crop Livestock Management	Policy to allow inter island livestock transport	• Technical assistance and training on livestock breeding • Guideline development for integrated crop livestock management	Implemented livestock management technology for adaptation
		Water (Resources) Management Technology • “Embung”	• Water conservation and utilization for fodder and cattle drinking water	• Various stake holders engange on water sector. • New water law is not enough. Need Regulation on Integrated Water Resource Management	• Technical assistance for pastoral management in eastern and semi arid region of Indonesia	Implemented water resources management technology for adaptation
Mitigation of climate change	Agriculture sector also emits GHG	Biomass Processing Technologies • Bio-gas • Bio-urine • Composting	• Composting of manure (manure emitted 40-60 percent lower compared with fresh rice straw) • Biogas reactor	• Need Coordination of farming activities	• Technical assistance on bio energy (biogas) management • Technical assistance for bio-fertilizer production	Implemented biomass processing tchnologies for mitigation
Monitoring			• Monitoring of frequency and intensity of GHG emission from cattle’s manure		Note: similar training and technical assistance to farming activities is applicable as well for livestock	Periodic GHG emission data

Dissemination for Global Climate Change mainstreaming	No adequate understanding on impact of livestock sub sector to climate change among stakeholder such as local government and farmers		• Introduction to climate change • Climate field school • Establishment of module and extension material • Disseminating the guideline of adaptation strategies for livestock • Other dissemination methods	Target area is country-wide, campaign reach might be limited		Increase of public awareness
Capacity Building	Most of stakeholders do not have capacity to cope with Global Climatic Change	Mass Education/ Extension	Capacity building for local government on the impact of global climate change on livestock			Increase capacity of local government to cope with climate change

d. Peat land

Need and Opportunities	Urgency/Gap	Technology Options	Priority/Key Technology	Potential Barriers and Policy Needs	Modality for Transfer of Technology	Target Achievement
Climate prediction	• Peat soils claimed as one of the biggest GHG emission sources • Mitigation is urgent	• Climate prediction for areas with peat land • Hydrological model for peat land • Need database on local climate and hydrology of peat land	**Climate Database** • Limited climate data in swampy (tidal and non tidal) areas • Data are from BMG and Min.of Public Work	• Development of climate network has high cost	• Use of existing climate stations is suggested • Use of available climate data from reports of various previous projects is valuable • Technical assistance to climate model development	Appropriate climate database system

Need and Opportunities	Urgency/Gap	Technology Options	Priority/Key Technology	Potential Barriers and Policy Needs	Modality for Transfer of Technology	Target Achievement
			Climate Prediction Model • Climate prediction of BMG is used			Validated climate prediction model
			Model Validation • Model has not been validated for areas with peat or swampy areas			
			Model Application • Model has not been applied for areas with peat or swampy areas			
Adaptation to climate change	While, the peat soils support livelihood of many poor farmer, the area is relevant for adaptation program	**Land management** Technologies • Minimum tillage • Balance fertilizing • Appropriate soil amelioration	• Minimum tillage • Balance fertilizing • Appropriate soil amelioration	• Peat soils are problem soils • The soils are fragile, without a proper management soils will be severely degraded • Usually poor farmers are living in peat lands except in peat land with developed estate (such as oil palm estate)	• Technical assistance on appropriate land use management in areas with peat or swampy areas • Technical assistance to characterize peat soil	Implemented land management technology for adaptation in peat land
		Water (Resources) Management Technologies • Appropriate drainage to control subsidence • Peat dome conservation • Appropriate irrigation to control soil moisture	• Drainage control • Land subsidence control • Irrigation for areas with C and D tidal types • Peat dome area conservation	• High cost for development • Poor infrastructure in areas with peat soils	• Technical assistance to drainage and water management in peat soil area	Implemented water resources management technologies for adaptation purpose in peat land

Need and Opportunities	Urgency/Gap	Technology Options	Priority/Key Technology	Potential Barriers and Policy Needs	Modality for Transfer of Technology	Target Achievement
Mitigation of climate change	GHG emission from peat soils should to be reduced	**Land Management** Technologies • Appropriate slash and burn techniques • Minimum tillage	• Overcoming slash and burn system on peat land with sustainable farming	• Other alternatives for people's income are limited	• Technical assistance for sustainable farming in peat soils area • Technical assistance to swamp forrest management	Implemented land management technologies for mitigation in peat land
		Water Management Technologies • Drainage control technology for avoiding subsidence • Drainage control for avoiding peat fire	• Avoiding the over drain in peat land to overcome subsidence and further acidification (generally peat soils are underlined by acid sulphate soils) • Maintaining optimum drainage level to overcome burning of peat (peat fire)	• Drainage/irrigation infrastructures are limited • Most existing canals and gates are not functioning	• Available drainage/ irrigation infrastructures can be maintained • Technical assistance to drainage and water management in peat soil area	Implemented water management technologies for mitigation in peat land
Monitoring		**Research Emission Modeling/Forecasting**	• Monitoring of frequency and intensity of GHG emission from peat and tidal swampy land	• Accessibility is limited • Equipments are limited • Limited of capable human resources for monitoring of GHG emission from peat land	Note: similar training and technical assistance to farming activities is applicable as well for the case of peat soil	Periodic GHG emission data

Need and Opportunities	Urgency/Gap	Technology Options	Priority/Key Technology	Potential Barriers and Policy Needs	Modality for Transfer of Technology	Target Achievement
Dissemination	Swamp and peat area are also claimed as one of primary GHG emitter. There is no adequate understanding on character of peat soil impact on CC among stake holder such as local government and farmer	**Mass extension/Public awareness**	• Awareness campaign on GCC in agriculture sector • Formulation guideline and module and extension material • adaptation strategies for swampy land and peat			Increase of public awareness in peat areas
Capacity building			• Training and capacity building for local government			Increase capacity of local government

CHAPTER - VI

OCEAN SECTOR

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1. BACKGROUND

1.1. Aims

Indonesia ratified the United Nations Framework of Climate Change Convention (UNFCCC) through Act No. 6, in 1994 and the Kyoto Protocol through Act No. 17, in 2004. "*...Article 4.5 of the Convention defines technology needs assessments (TNAs) as, a set of country-driven activities that identify and determine the mitigation and adaptation technology priorities of Parties. They involve different stakeholders in a consultative process to identify the barriers to technology transfer and measures to address these barriers through sectoral analyses. These activities may address soft and hard technologies, such as mitigation and adaptation technologies, identify regulatory options and develop fiscal and financial incentives and capacity-building."* [UNFCCC: Technology Transfer Framework] Stakeholders are governments, private sector entities, financial institutions, NGOs and research/education institutions. The aims of Indonesia's TNA can be itemized as follows:

- Contribute to the global effort towards sustainable development and, in particular, the protection of the climate system;
- Communicate Indonesia's needs for environmentally sound technologies (EST) to the UNFCCC Conference of the Parties (COP) and the global community;
- Resource documents to identify and prioritize EST needed by Indonesia and mark those, which require support and co-operation from developed countries;
- Set the foundation for a database for EST.

1.2. Objectives

- Identify, analyze and prioritize technologies, which could form the basis for a portfolio of Technology Transfer programmes aiming greenhouse gas (GHG) emissions mitigation;
- Identify human and institutional capacity needs that ensure the smooth development, transfer and acquisition of environmentally sound technologies;
- Enlist interest and commitments from key stakeholders and partnerships to support investment or barrier removal actions for enhancing the commercialization and diffusion of high priority technologies.

This document will be focused on a Technology Need Assessment for mitigation in the ocean sector only, while adaptation will be analyzed in the next document.

The assessment of technology options will be focused on the utilization of coastal and marine resources, which can be classified as follow:

a. Natural resources
    - Marine plankton

  - Marine fisheries
  - Aquaculture (seaweed, fish, etc.)

b. Renewable energy (tide current, wave, thermal gradient, solar, wind, marine algae)

c. Coastal and marine protection, conservation, and rehabilitation
  - Seagrass
  - Mangrove and other coastal vegetation
  - Coral reefs

d. Ocean and coastal observation

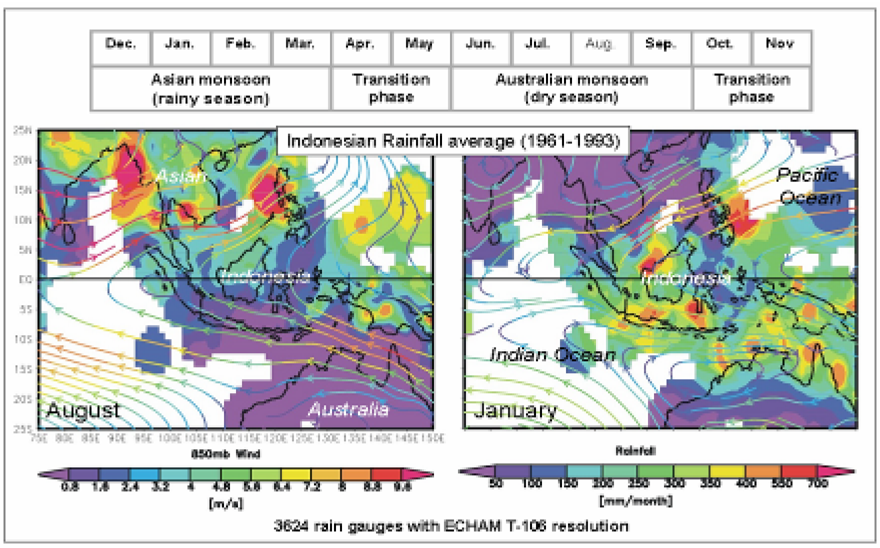
2. REVIEW OF OPTIONS AND RESOURCES

2.1. Introduction: Oceanic Phenomena of Indonesian Seas

Indonesia is the largest archipelagic state in the world. There are estimated to be a total of 17,504 islands according to the Indonesian Naval Hydro-Oceanographic Office, of which only about 6,000 are inhabited, stretching at the equator for 5,150 km (3,200 miles). The Indonesian archipelago is on a crossroads between two oceans, the Pacific and the Indian oceans, and bridges two continents, Asia and Australia. The territory of the Republic of Indonesia stretches from 6°08' north latitude to 11°015' South Latitude, and from 94°45' to 141°05' East Longitude.

The relationship between wind systems and surface ocean circulation in Indonesian waters was traced during its annual cycle. These referred to the temporal variation due to the monsoon. Indonesian waters are characterized by an interaction of waters from the Pacific Ocean and the Indian Ocean. Sea surface temperatures typically range from about 25° to 32°C, while the water temperature of the Pacific is higher than that of the Indian Ocean.

The Indonesian archipelago is characterized by strong seasonal variations in the upper oceanic circulation influenced by monsoonal winds. The seasonal solar heating over the continents of Asia and Australian drives the monsoons, which change wind direction twice a year. In the southern hemisphere of Indonesian water, the southeast (SE) and northwest (NW) monsoons induce the occurrence of different dynamic processes. The NW monsoon is recognized by higher intensity of rainfall, since this monsoon transports moist air from the Pacific Ocean. The transition phase from the NW to the SE monsoon is characterized by decreasing rain intensity (in April–May). The inverse condition occurs during the transition from the SE to the NW monsoon (October-November).



Source: Aldrian (2000) and Vose et al. (1992) in Hendiarti (2003)

Figure 2-1: The Climatological Condition of the Indonesian Archipelago Comparing the Precipitation and Wind Pattern (850mb) in January and August

Ocean dynamic in the Southeast Asian region is very influential to the Indian Ocean. The Western of Indian Ocean has strong responses of ocean circulation to atmospheric forcing by the monsoon and characterized by a prominent semi-annual cycle. The Eastern of Indian Ocean is dominated by an annual cycle and important to Indonesian Through Flow (ITF). The phase differences in the tropical Indian Ocean between its western and eastern region makes the east-west dipole structure in the tropical Indian Ocean.

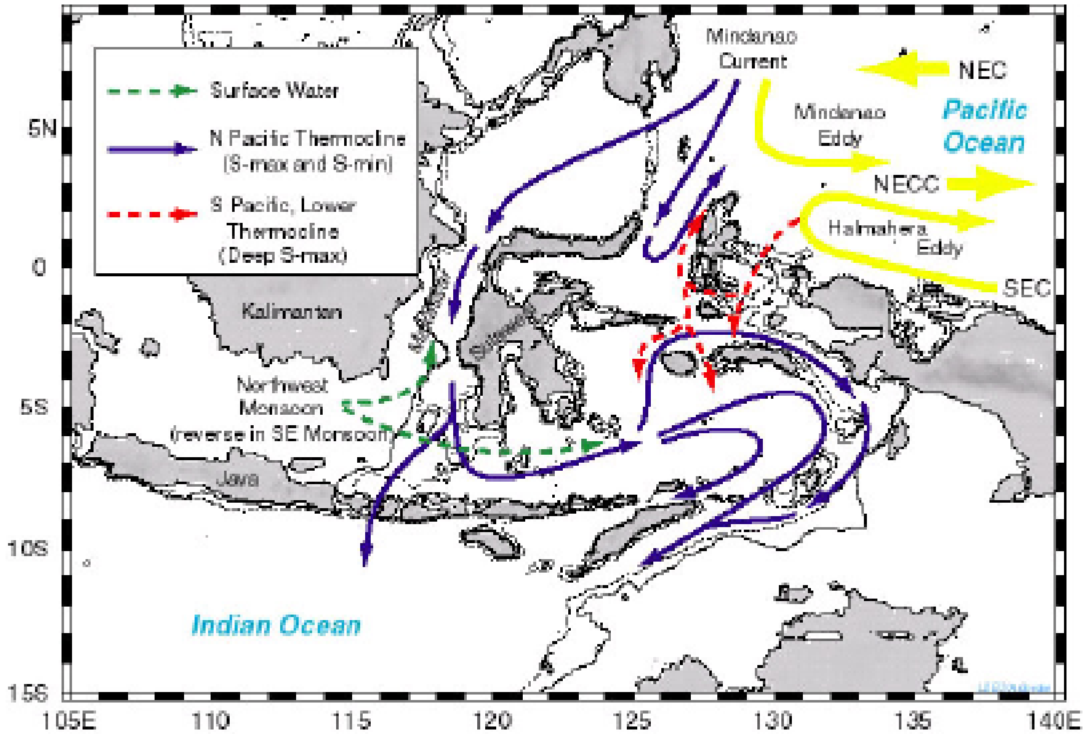


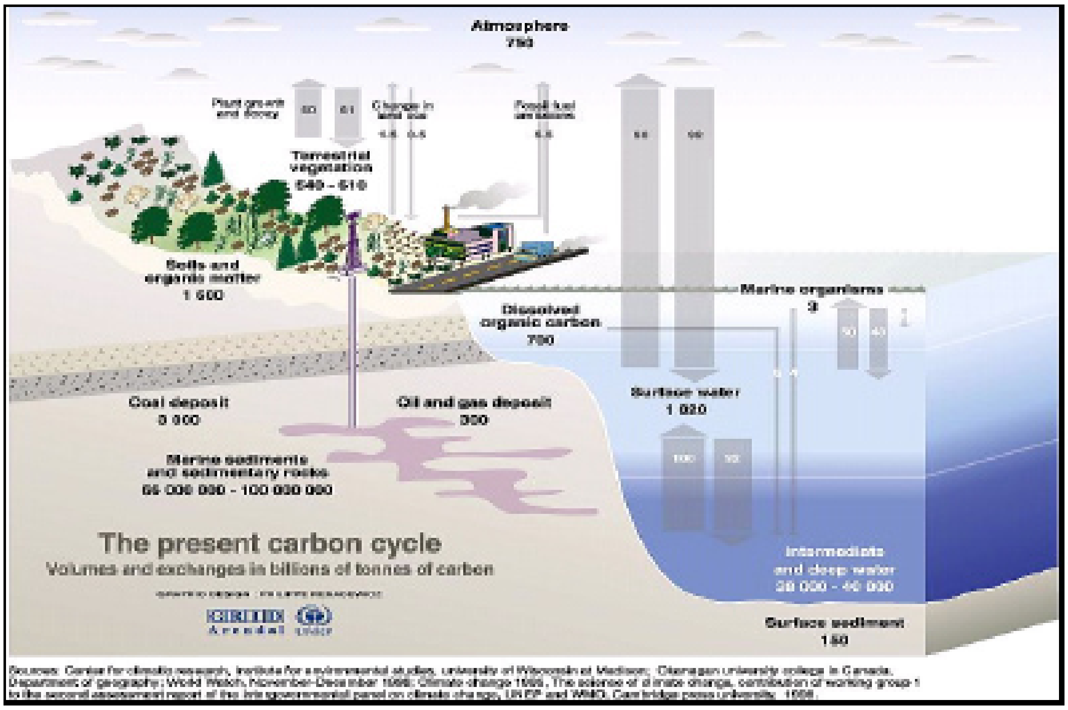
Figure 2-2: Indonesian Through Flow

3. INITIAL REVIEW OF OPTIONS AND RESOURCES

3.1. Greenhouse Gas Inventory of Indonesian Ocean Sector

The Indonesian sea area is four times greater than its land area. The sea area is about 7.9 million sq km (including the exclusive economic zone, EEZ) and constitutes about 81% of the total area of the country. Five main islands and 30 smaller archipelagos are home to the majority of the population. Around 140 millions Indonesian are living along 60 km of the coasts, mostly within the large coastal cities that occupy a predominant position in the national economy.

GHG in ocean sector can be produced from several aspects. These aspects can be seen in the figure below



Source: (UNEP, 1995)

Figure 3-1: Present Carbon Cycle from Several Aspects

a. Marine organism

Referring to UNEP and WMO assessment in 1995 (figure above), marine organism potentially utilize 3 billions tonnes CO_2/year. Throughout Indonesia archipelago, sea grasses cover at least 30,000 km^2, and it can potentially absorb 56.3 million tonnes CO_2/year (BRKP, 2007).

b. Sea surface water

Sea surface water in Indonesia can potentially absorb 40.4 millions tonnes CO_2/year (BRKP, 2007). This study is based on daily satellite monitoring of chlorophyll abundance distribution over Indonesia Seas.

c. Fisheries activities

GHG emissions, which were released from fishery activity, were related to the amount of fishing vessels operated in Indonesia. Most of these fishing vessels were using fossil fuel for their fisheries activity, which will release GHG to the open air. In the period of 2005 – 2007, the amount of fishing vessel in Indonesia has increased 0.05%, from 555.581 units in 2005 to 556.090 units in 2007. Since the calculation of fishing vessel fuel consumption is part of the number of fuel consumption for sea transportation activities, than

CO_2 release calculation will be taken into account in the transportation sector report.

d. Mangrove

Even though mangroves belong to the coastal resources, they will be discussed in the forestry sector report.

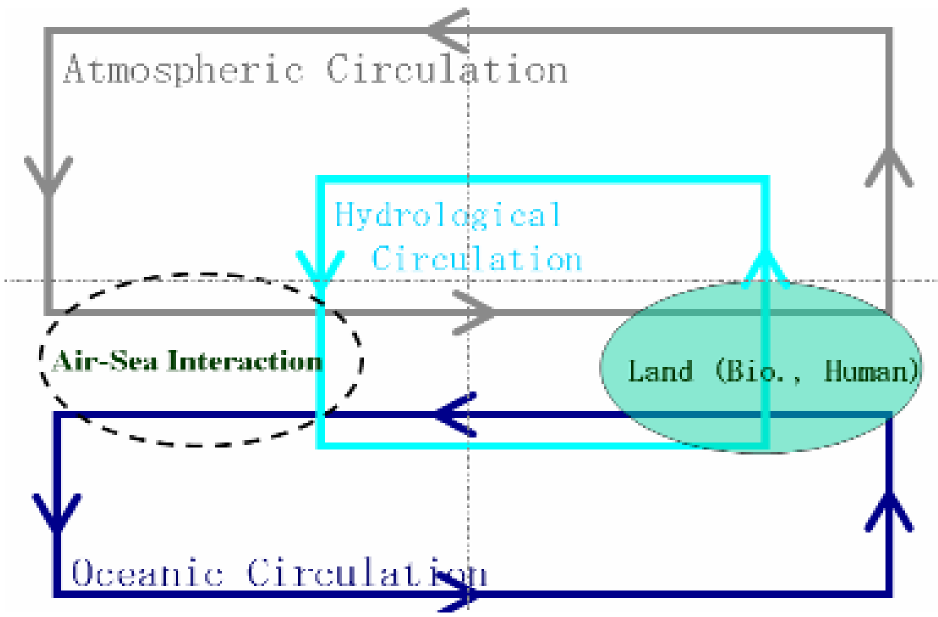
e. Sea transportation

Sea transportation will be discussed in the TNA transportation sector report.

3.2. Vulnerability of Indonesian Coastal Zone

Indonesian marine waters consist of various marine resources potentials, both living and nonliving resources, which have long been used in the country's industries, e.g.; shipping, transportation, oil and gas production, fisheries, aquaculture, and tourism, and employ approximately 15% of Indonesia's workforce. As an archipelagic state, Indonesia is particularly vulnerable to the impacts of climate change.

The global climate change is believed not only as the result of atmospheric dynamics, but also by ocean, land, and atmosphere interactions. One astounding fact pertaining this is that the interaction between ocean and atmosphere is uninterruptible in motion, in time and space. The simplification of the interrelation can be described as follows:



Source: (Yamanaka, M., 2003)

Figure 3-2: Scheme of Air-Sea Interaction

One of the simplest interactions is the heating of ocean surface. This heating produces an upward air mass movement that results in air circulation.

The climate change will give impacts to the coastal and marine resources, particularly related with:

- Sea level rise;
- Change on sea surface temperature;
- Change on water acidity;
- Increase of the frequency and intensity of extreme events such as tropical storm and high waves.

The continuation impacts are damage and loss of economic assets and infrastructure, increase of erosion and damage to the fisheries and aquaculture sites in coastal areas, and degradation of coastal and marine biodiversity, and threat of low lying islands, including outer small islands, having function as reference point of the Republic of Indonesia territory.

3.3. National Plans and Policy for Ocean Sector

It is a concern that development conducted by the government will be hampered by the impacts of climate change. The poor are the most vulnerable group to the impacts of climate change, and they are also the most impacted group due to the obstruction of national development. Therefore, any response to climate change should include poverty alleviation. The three main directions of the national marine development, the triple track strategy, which is pro-growth strategy (economic growth), pro-job strategy (unemployment reduction), and pro-poor strategy (poverty eradication) should become an integral part of the national strategy to address climate change. To ensure the sustainability of natural resource development, this triple track strategy should be expanded with the fourth track, namely pro-environment, which based on the sustainable development concept and principles.

Related to climate change mitigation, Indonesia government has already arranged national plan for ocean sectors i.e.:

- Fisheries sector focus only on developing 3 main commodities: Seaweed, Tuna, and Shrimp (Revitalization of Fisheries Sector Program);
- International Cooperation on combating IUU (Illegal, Unreported, Unregulated) Fishing, referred to Code of Conduct for Responsible Fisheries (CCRF) – FAO;
- Surveillance and Control of Marine Ecosystem Degradation;
- Surveillance and Control of Coral Utilization;
- Member of Regional Fisheries Management Organization (RFMO), such as IOTC (Indian Ocean Tuna Commission).

A significant number of national GHG emission factors related to the Ocean Sector i.e. coastal and fisheries activities need to be developed to ensure their suitability for use when preparing more precise mitigation proposal.

4. TECHNOLOGY CRITERIA AND OPTIONS

4.1. Selection Criteria of Technology Assessment

Technology Needs Assessment in the ocean sector for mitigation of climate change is determined by technology choices based on resources as carbon sink and emission reduction potential, current ocean environment and climate-friendly technology options that can reduce GHG emission.

Among others, the national program on climate change mitigation includes ocean sector related plans, which are targeted by the Ministry of Marine Affairs and Fisheries and directed to increase the coastal and small island capacity in absorbing carbon.

4.1.1. General Criteria

Two sets of criteria are determined for technology selection: general criteria and specific criteria. The general criteria are based on national-wide interests and priorities.

Table 4-1: General Criteria for Technology Selection

General criteria	Sub-Criteria
a. Conformity with national regulation and policy	• Food security (FS) • Natural resource security (NR) • Energy security (ES) • Incentive for participation (IP)
b. Institutional and human development	• Capacity building (production & know how) (CB)
c. Technology effectiveness	• Mature degree of technology • Advanced degree of technology • Reliability of technology (RT) • Applicability of technology • Easiness of wider use of technology, including local contribution support of technology application (ET)
d. Environmental effectiveness	• Greenhouse gas emissions reduction (GR) • Improvement of local environmental quality (LE)
e. Economic efficiency and cost effectiveness	• Capital and operational costs relative to alternatives (COC) • Commercial availability (market) (CA)

4.1.2. Specific Criteria

The specific criteria for selecting the mitigation measures and set technology priorities in the ocean sector are used for a discrete Multi Criteria Analysis (MCA) method. The process involves scoring and Analytical Hierarchy Process (AHP). AHP is a mathematical technique for multi-criteria decision making [Saaty 1980, 1990, 1994] and is used for relative critical weighting of indicators and relative critical weighting of evaluators.

Table 4-2: Specific Criteria for Technology Selection

Specific criteria	Sub-Criteria
a. Development benefits	• Security and legality • GDP growth, income equity, job creation • Coastal and small island community development • Capacity building
b. Environmental protection	• Sustainable fisheries and aquaculture • Marine resources protection, conservation, rehabilitation
c. Market potential	• Business scale development • Added value of marine & fishery products • Development & intensification • Marketing (commercial readiness)

Besides the priority technology for climate change mitigation and general/ specific criteria, there will be third level used for this AHP model. The third level (bottom level) is the technology choices based on the resources for climate change mitigation. Eight choices are presented as follows:

1. Marine Plankton;
2. Seaweed;
3. Seagrass;
4. Mangrove and coastal vegetation;
5. Coral reefs;
6. Ocean and coastal renewable energy;
7. Indonesian ocean observing system;
8. Marine fisheries.

The selected technologies must pass the MCA and AHP selection processes by involving stakeholders of the ocean sectors.

4.2. Resources and Technology Options Review

The TNA ocean sector has identified the existing and future mitigation technologies and measures, which are suitable for assessment. The identified technologies and measures for each resource are listed below:

Table 4-3: Technology Options for Greenhouse Gas Emissions Mitigation in the Ocean Sector

Present Condition	Technology Options	
	Carbon Sink Potential	GHG Emission Reduction Potential
A. Marine Plankton		
Problem on euthropication and algal blooms in large river delta	Satellite Remote sensing technology for estimation of net primary production (NPP) and total carbon sink	
Large differences in abundance between shallow and deep sea	Numerical modeling of oceanography parameters for measuring ocean primary productivity	
	In-situ and laboratory measurements to find out the absorption effectiveness	
	Ecological modeling for marine plankton as carbon source or sink	
	Identification of potential plankton species to absorbs carbon	
	Phytoplankton culture in photo bioreactor	
B. Marine Fisheries		
		Development of low energy fishing vessels with bio fuels and other energy alternative such as ocean renewable energy (solar cell, wind-power, etc.)
		Implementation of technology and fishing supporting device that consume low energy (such as set-net, electronic fish aggregating device/ EFAD, under water light/LACUBA, etc.)
C. Seaweed		
Grow very well at Indonesian coastal waters	Detailed mapping of potential areas for seaweed culture development	Generation of non-conventional energy from seaweed processing waste.
Short cultivation time	Seaweed culture management	
Big market opportunity for seaweed and its end products	In-situ and laboratory measurements on carbon sink potential of seaweed culture areas	
Applicable from SME to large industry	Development of potential areas for seaweed cultivation	
D. Seagrass		

Present Condition	Technology Options	
	Carbon Sink Potential	GHG Emission Reduction Potential
Distributed along Indonesian coastal water	In-situ and laboratory measurements on carbon sink potential of seagrass beds	Generation of non-conventional energy from seagrass
Threat of seagrass beds loss due to human activities	Seagrass cultivation and rehabilitation	
E. Mangrove		
Distributed along Indonesian coastal areas	In-situ and laboratory measurements on carbon sink potential	
Even though mangrove can be described as one of coastal resources, but this resource will be discuss deeply in the forestry report	Mangrove cultivation and rehabilitation	
	Modeling of carrying capacity for mangrove cultivation and rehabilitation, silvofishery	
	Identification of supporting data of environmental parameters including substrate, oceanography, water quality, etc.	
F. Coral Reefs		
Problem on coral damage	Coral replanting and transplantation	
High diversity and spatial coverage 14% of world total coral reef	Remote sensing for estimation of net primary production (NPP) and total carbon sink (including mapping of high and low bleaching risk regions)	
	In-situ and laboratory measurements on carbon sink potential	
	Modeling of carrying capacity for technology implementation	
	Identification of supporting data of environmental parameters including oceanography, water quality, etc.	
	Coral reefs transplantation	
G. Ocean and coastal based renewable energy		
Rapid deployment of sustainable energy production and efficient end-use technologies, systems and practices is essential		Development of utilization technology for ocean and coastal based renewable energy potential: • Tidal current • Wave • Ocean thermal gradient • Solar • Wind
H. Indonesia Ocean Observing System (INAGOOS)		

Present Condition	Technology Options	
	Carbon Sink Potential	GHG Emission Reduction Potential
The INAGOOS has been launched by Minister of Marine Affairs & Fisheries, Republic of Indonesia in August 2005	Monitoring marine environment condition by using remote sensing technologies and in-situ measurements	
	Establishment of ocean and coastal stations to observe Indonesian waters	
	Operational Ocean Observing System, establishing data & information centre in at least three locations throughout Indonesia (west, central, east)	
	Study on water mass transport in related to oceanic carbon budget	

4.2.1. Marine Plankton

Ocean dynamics in Indonesia are observed within available technology as follows:

a. Satellite observation:
   - Sea surface condition: sea surface temperature (SST), sea surface height anomaly (SSHA), sea surface current (SSC), ocean colour (OC), and sea surface salinity (in the near future);
   - Distribution and concentration of chlorophyll-a.

b. Coastal observation and in-situ measurement:
   - Monitoring through coastal station: observation of tides, observation of water column in shallow water (CATS - Coastal Acoustic Tomography System);
   - In-situ measurement: CTD, drifters, surface buoy, underwater moorings.

Remote sensing technology has been used as primary data sources in national marine observation system, considering its temporal and spatial scale capability to cover the entire Indonesian territory regularly. Space observations of Indonesian waters reveal that characteristic of the plankton distribution also contain variation due to seasonal change.

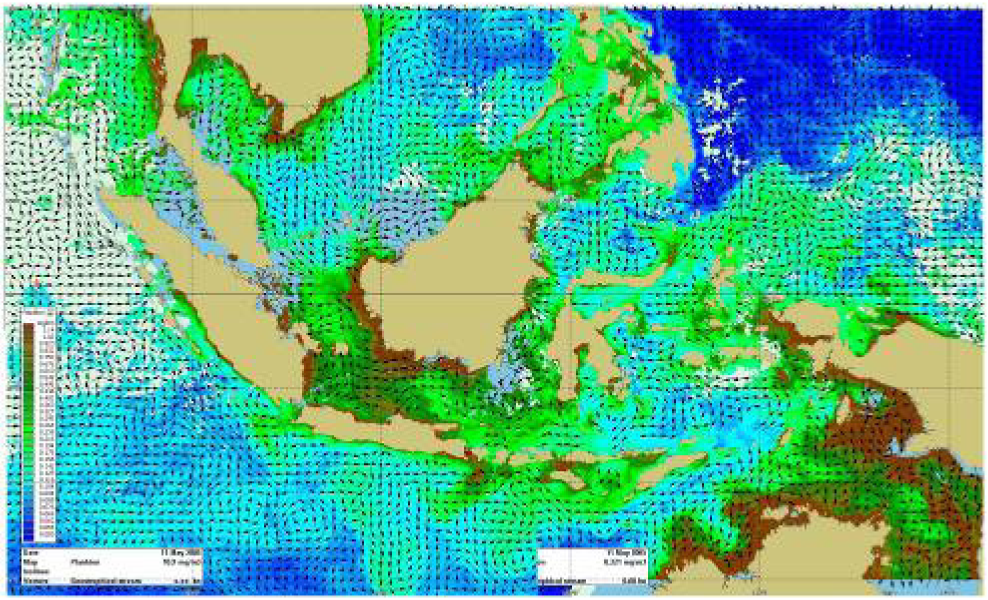


Figure 4-1: Plankton Distributions on 11-May-2005

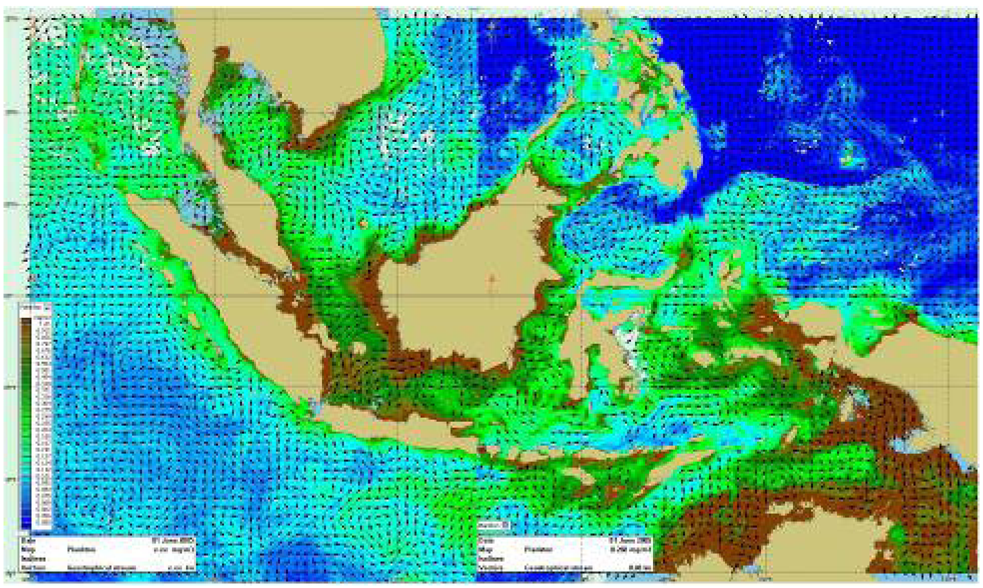


Figure 4-2: Plankton Distributions on 01-June-2005

Image of plankton distribution during May – June 2005 shows dominancy in Java and Arafura Sea, also in Makassar Strait. There are quite numbers of high plankton concentration situated in south of Bali Island and Nusa Tenggara (shown in green colour). The Pacific Ocean is shown to have low concentration with the blue colour. Brown indicates concentration of plankton with organic content from sediment.

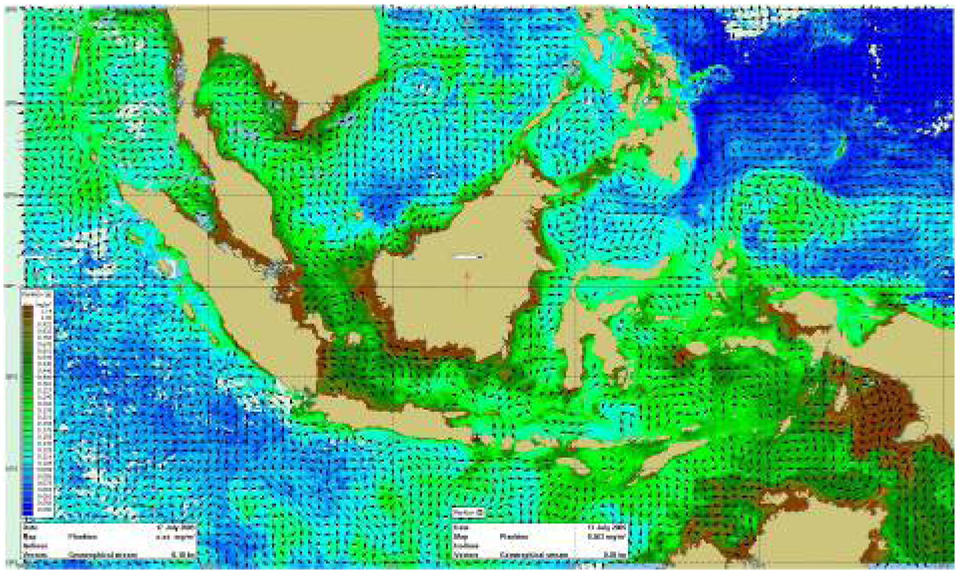


Figure 4-3: Plankton Distributions on 17-July-2005

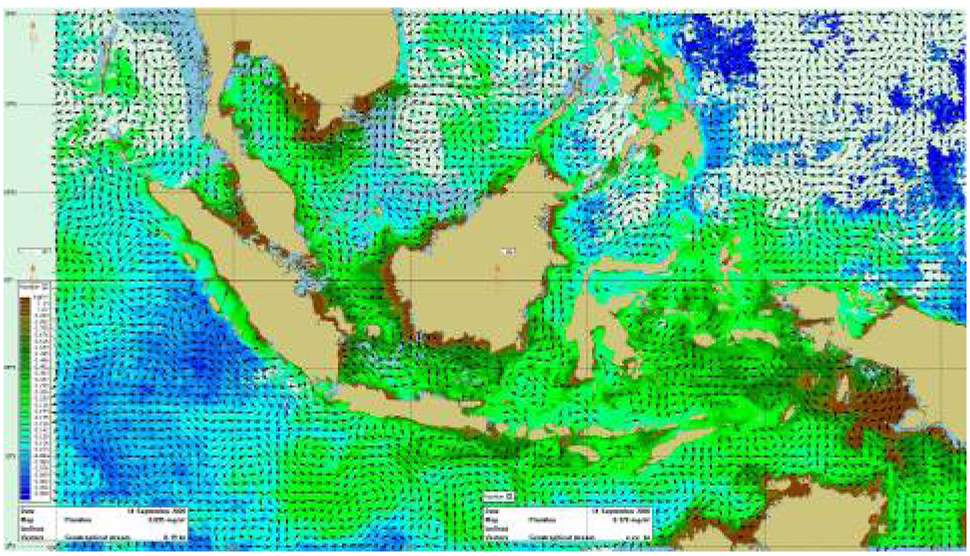


Figure 4-4: Plankton Distributions on 14-September-2005

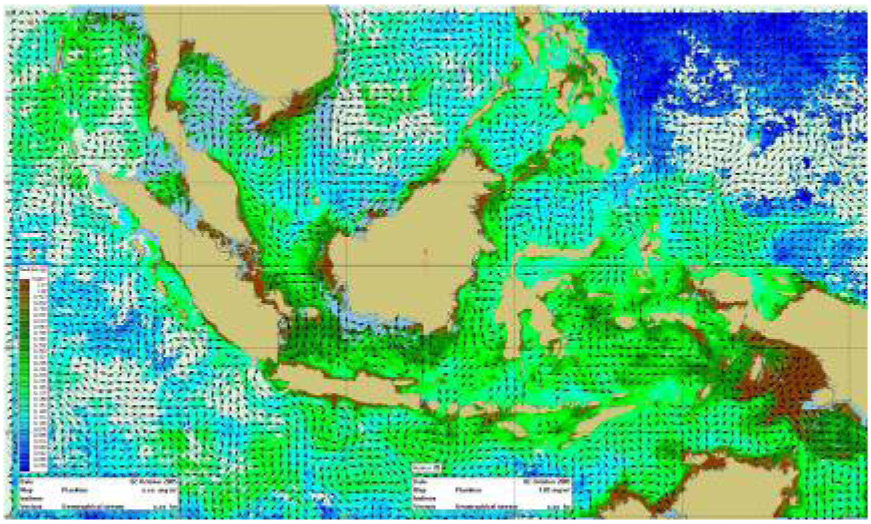


Figure 4-5: Plankton Distributions on 04-October-2005

In general, Plankton distribution is shown to be dominant in several areas, such as Malacca Strait, Kalimantan waters, and Arafura Sea, where almost the entire year are shown with high plankton concentration. Distribution variation is shown in Banda Sea, Pacific Ocean: north of Papua, and Indian Ocean. There are areas indicated with continuous plankton concentration due to the Indonesian through flow as shown in the Straits of Bali, Lombok, and Timor.

Plankton concentration in Indonesian water varies from 0.01 mg/m^3 to 1.8 mg/m^3 and distributed specifically due to several parameters that are interfering each other, such as current, up welling, sun radiation, etc.

Up welling phenomenon that trigger blooming or drastic plankton growth may be identified through multitemporal images, which show the concentration change. Through multitemporal data, the duration of an up welling may also be identified, from the current or from food chain processes occurring in that area.

Ocean phytoplankton (chlorophyll a) as retrieved from ocean colour data is important for Indonesian waters, since there is no seasonal heating of water, which obliterates the temperature contrasts in the imagery. However, the high percentage of cloud cover in tropical waters and the information restricted to the near surface waters are limitations for the application of satellite remote sensing data.

The methodological investigations focused on the validation of existing algorithm of suspended sediment and chlorophyll with in-situ measurement. To obtain a suitable atmospheric correction procedure for Indonesian waters, the validation of derived chlorophyll concentrations was performed in two steps. The first step was a qualitative check of various SeaDAS atmospheric correction algorithms because of an overestimation of atmospheric effects in deriving water-leaving radiances. Secondly, detailed investigations using in situ measurements were performed to find the best atmospheric correction algorithm for Indonesian waters and to obtain information about the precision of the derived chlorophyll concentrations. These investigations represent the first systematic study of the use of satellite ocean colour for chlorophyll estimations in Indonesian waters.

4.2.1.1. Validation of satellite derived chlorophyll

The validation of satellite derived chlorophyll in Indonesian waters was realized in two steps.
The first step was the check of various atmospheric correction algorithms. This is because the atmospheric influence varies strongly with the aerosol content depending on its origin, e.g. maritime or continental. An overestimation of atmospheric effects in the correction method caused negative values of water-leaving radiances. Secondly, in situ chlorophyll measurements were compared with satellite derived chlorophyll. Diagram of detailed validation using in situ data is shown in Figure 4-6.

Match-up analyses were performed for each field campaign. The images were selected based on the cloud-free pixels during the field observation period. It should be noted that in situ chlorophyll was measured at a single position; while SeaWiFS derived chlorophyll was estimated for a single pixel for 1 km^2 coverage. OC4 algorithm based on the ratio of radiance in blue and green spectral bands were used to calculate chlorophyll-a concentration. The in situ measurements were not conducted at the same time as the satellite-passing period. The following table shows the different results of turbid coastal areas and the ocean. The regression analyses delivered correlation coefficients of higher than 0.653 for the Indian Ocean and the Sunda Strait with maximum of 0.806, and of less than 0.432 for the turbid water (East Lampung, upwelling area and Pelabuhan Ratu Bay) with minimum of 0.260. The results show that mean values and standard deviation of chlorophyll in situ and satellite derived are within an order of magnitude of each other, and the coefficients of determinations R^2 for ocean water types are higher than for turbid waters (East Lampung and Pelabuhan Ratu Bay), except for upwelling may be because the limited number of the matched stations.

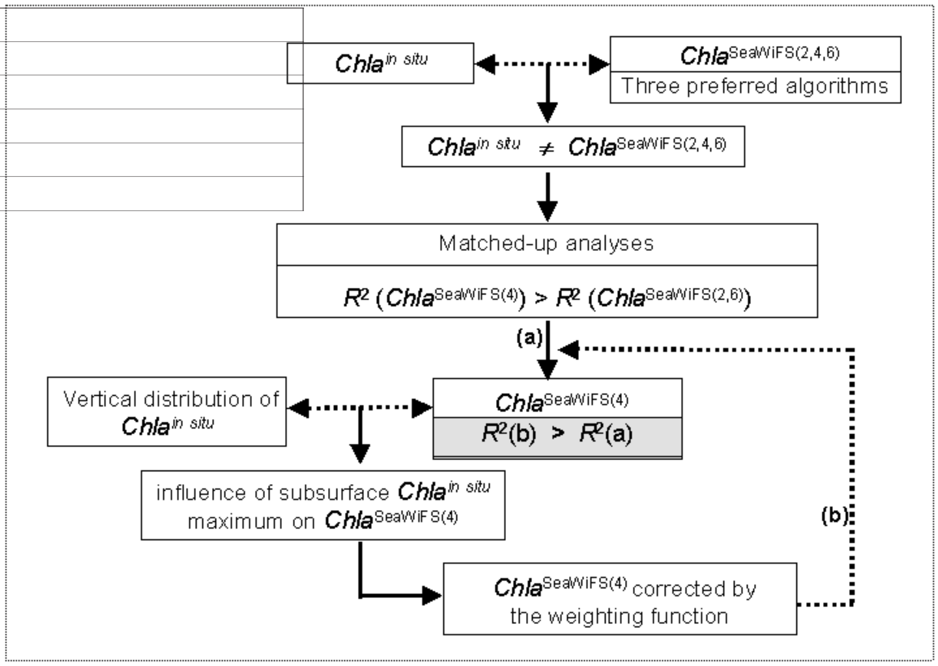
Table 4-4: Correlation between Seawifs Derived Chlorophyll using Default Procedure and In-Situ Chlorophyll Concentrations

Areas		Indian Ocean	Up-welling	Sunda Strait – Indian Ocean	Sunda Strait	East Lampung	Pelabuhan Ratu Bay
Chi-a mean values ($mg.m^{-3}$) and standard deviation	In-situ	0.27 ± 0.14	0.95 ± 0.16	0.41 ± 0.17	0.48 ± 0.29	3.64 ± 0.56	0.54 ± 0.17
	Satellite	0.29 ± 0.08	1.07 ± 0.06	0.37 ± 0.20	0.57 ± 0.23	3.04 ± 1.40	0.77 ± 0.30
Station Number (N)		13	4	10	15	10	4
Correlation (R^2)		**0.72**	**0.40**	**0.65**	**0.81**	**0.26**	**0.43**

Note: Mean value and standard deviation of chlorophyll concentrations were calculated from each cruise.

Differences in chlorophyll concentrations between satellite derived and *in situ* surface values were explained as follows. In the Sunda Strait, three different water types were distinguished during the cruise in July 2001: inner water, mixed water from the Java Sea and Indian Ocean and outer water. The investigations in upwelling areas and in the Indian Ocean were performed using *in situ* measurements during two cruises in August and in October-November 2000. The differences in chlorophyll concentrations observed in the mixed region of the Sunda Strait (0.2 mg/m^3) were slightly higher compared to the differences in other regions, upwelling area (0.18 mg/m^3) pure ocean waters (0.04 mg/m^3). These satellite-derived concentrations are higher than *in situ* surface values since the radiance received by satellite sensor contains contributions from subsurface chlorophyll depending on the signal depth. Subsurface chlorophyll maximum may increase the concentrations derived from SeaWiFS data.

To consider this condition, a weighted surface concentration was calculated on the basis of concentration and depth of subsurface chlorophyll maximum, and of the vertical attenuation coefficient. The weighting procedure increased the precision of the SeaWiFS derived chlorophyll concentrations by about 2% in the Sunda Strait and 6% in Indian Ocean including upwelling regions.



Note: The diagram of the detailed validation, which was performed using *in situ* measurements. $Chla^{SeaWiFS}$ is chlorophyll concentrations estimated from SeaWiFS and produced by the default (2), 670/865 NIR (4) and fixed model (6) algorithms. $Chla^{in\ situ}$ is *in situ* chlorophyll *a* as measured in the surface water.

Figure 4-6: Detailed Validation Diagram

Below are some researches which have not been conducted and need to be done as soon as possible in Indonesia:

- In-situ and laboratory measurements to find out the absorption effectiveness;
- Ecological modelling for marine plankton as carbon source or sink;
- Identification of potential plankton species to absorbs carbon;
- Phytoplankton culture in photo bioreactor.

4.2.2. Marine Fisheries

Indonesia marine fisheries mitigation activities goals are as stated below:

1. Development of low energy fishing vessels with biofuels and other energy alternative such as ocean renewable energy (solar cell, wind-power, etc.).
   Research Centre for Marine Technology (RCMT) in the year 2006 – 2007 has developed a new Biodiesel derived from *jatropha sp* and tested on fishing vessels. In the year 2006, RCMT tested a mix of 10% of *jatropha sp* biodiesel and 90% HSD (High Speed Diesel) fuels, continued in 2007 by using 100% of *jatropha sp* biodesel on the fishing vessels. The research shows a better machine performance by using *jatropha sp* biodiesel. The following two figures show a performance comparison between *jatropha sp* biodiesel and HSD fuels.

Figure a: Comparison of Machine Performance using a Mix of 10% *Jatropha sp* Biodiesel and 90% HSD Fuel

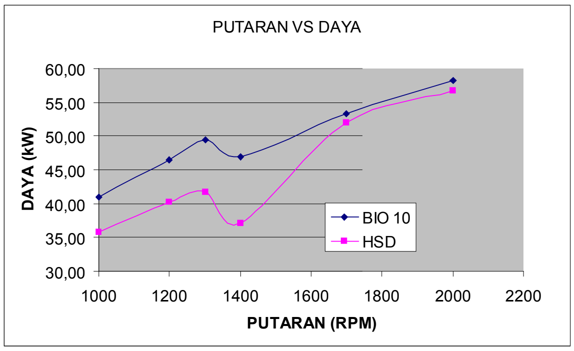


Figure b: Comparison of Machine Performance using a 100% *Jatropha sp* Biodiesel

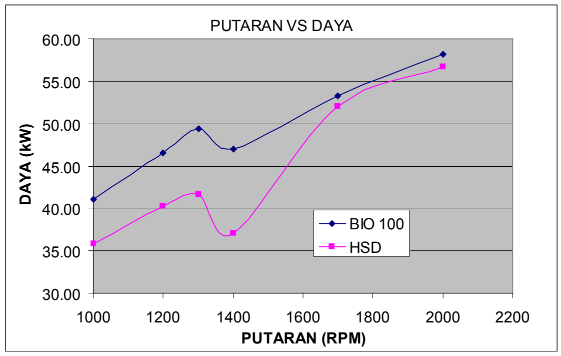


Figure 4-7: Machine Performance using different Jatropha Biodiesel Mixes

Figure a: Comparison of Specific Fuels Consumption using a Mix of 10% *Jatropha sp* Biodiesel and 90% HSD Fuel

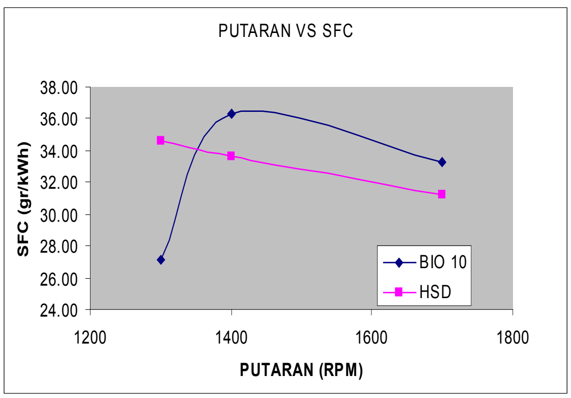


Figure b: Comparison of Specific Fuels Consumption using a 100% *Jatropha sp* Biodiesel

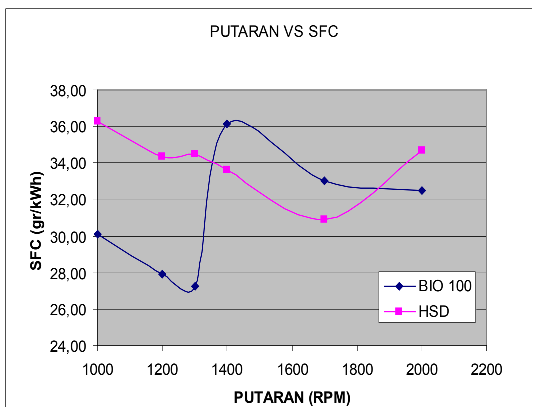


Figure 4-8: Specific Fuel Consumption using different Mixes of Jatropha Biodiesel

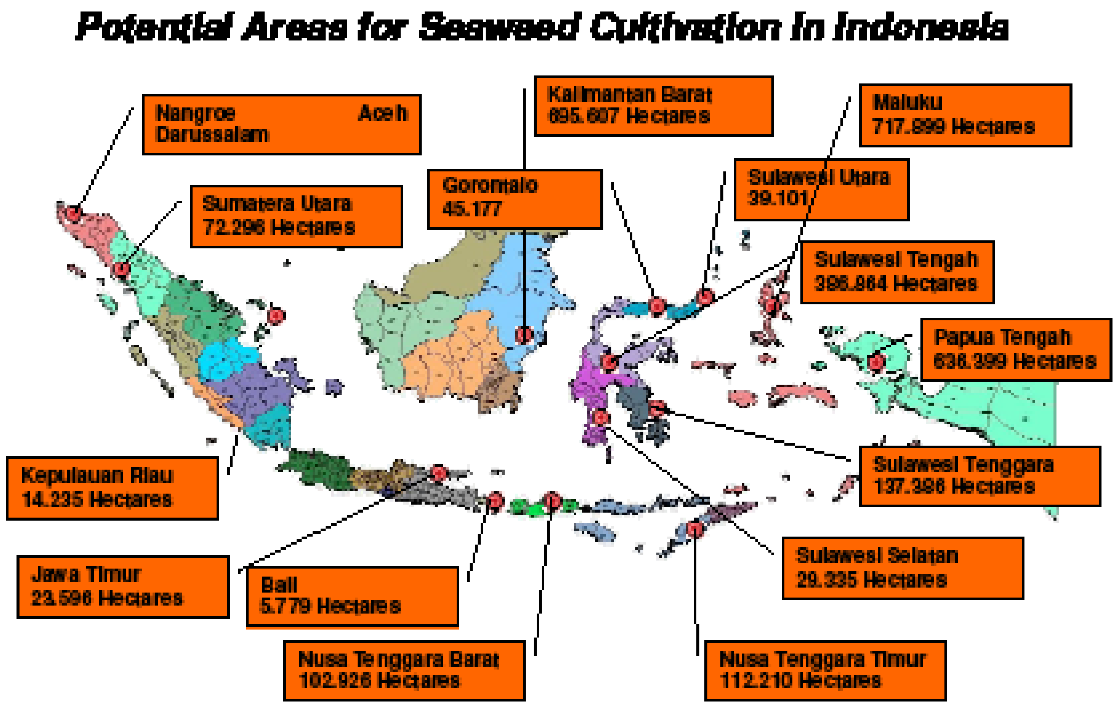
In the near future, RCMT planned to have a research on fishing vessels using wave as the energy source.

2. Implementation of technology and fishing supporting device that consume low energy (such as Electronic Fish Aggregating Device (EFAD), Under Water Light (LACUBA), etc.)
   Electronic Fish Aggregating Device (EFAD) is an instrument that has a function to attract fish using sound attractor and light attractor integrated with electronics component. This instrument goal is to gather fishes near the light and sound attractor which has specific sensors to attract specific species. EFAD was developed by Research Centre for Marine Technology (2007) cooperate with other institution based on several research that have been done before such as Fish Attracter (develop by Airlangga University), Fish Attracter Phone (develop by SMK BPPT Lamongan, East Java), and Under Water Light or LACUBA (develop by PT LEN Industry).

4.2.3. Seaweed

At the moment Indonesia is one of the biggest seaweed producers in the world. Anggadiredja (2008) mentioned that Indonesia is targeting to be the biggest seaweed producers in the world in 2010 and ready to step to become the leading industrial country for this commodity.

Based on ecological requirements for seaweed growth, Indonesian coastal zone is suitable for seaweed culture development. According to Anggadiredja and Zatnika (2008) and Sunaryanto (2008), Indonesian coastal zone provide large development areas for seaweed culture with various species diversity potential. The following two figures show potential areas for seaweed culture development based on location and commercial species, respectively.



Source : Directorate of Production, Ministry of Marine Affairs and Fisheries. 2008

Figure 4-9: Potential Areas for Seaweed Culture in Indonesia

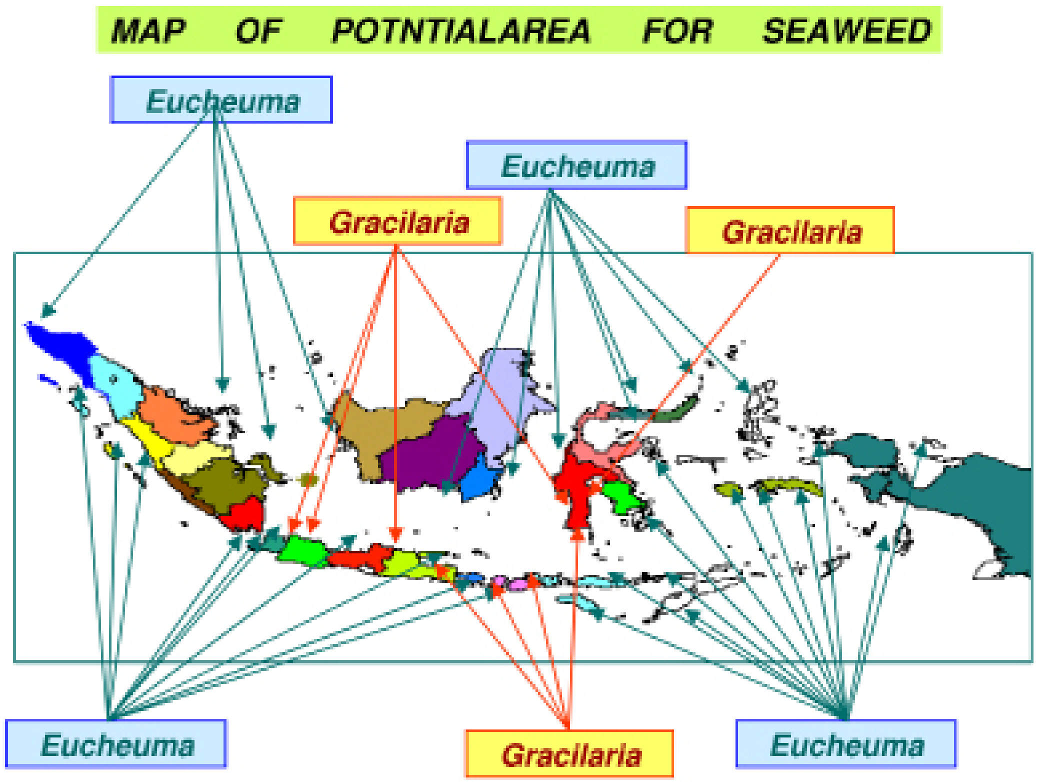


Figure 4-10: Potential Areas for Seaweed Culture in Indonesia based on Ecological Requirements for Commercial Seaweed Species

Seaweed culture development in Indonesia is also creating job opportunities, economic growth and community welfare for Indonesian coastal communities. In 2006, Indonesia produced 1,341,141 tonnes of seaweed from cultivation and in the same year Indonesia exported 95,588 tonnes of seaweed to around 22 countries worldwide (Ministry of Marine Affairs and Fisheries, 2007).

In the tropics areas where day length is quite long with about 10+ or –2 hours throughout the year, net photosynthesis that removes CO_2 from the atmosphere is expected to dominate than respiration that dominates in winter and releases CO_2 in the atmosphere. Utilization of CO_2 as an industrial by-product for seaweed production holds great promise not only in acting as a significant sink, but also in meeting to some extent global food, fodder, fuel and pharmaceutical requirements, particularly in the tropics.

CO_2 can be utilized for stimulating the wild growth of seaweed in the sea or in culture on the shore. However, no such scientific studies have been done to evaluate this and to quantify the degree of stimulation of growth and enhanced productivity through anthropogenic CO_2. It is important to note that 3.5 tonnes of alga production utilizes 1.27 tonnes of carbon and about 0.22 tonnes of nitrogen and 0.03 tonnes of phosphorus (Sinha & Fraley, 2008).

Thus, significant increase in the production of the seaweed, especially in Asia and the Pacific, reflects the growing importance of seaweeds as marine biological resources, not only as an important primary producers in the shallow-water marine ecosystem, but are directly utilized as human food, as components of animal feeds and as organic fertilizer. Biological products derived from them, such as agars, alginates, furcellaran and carrageenans, have and will continue to have diverse applications in the food, chemical, pharmaceutical and other industries (Trono 1986 in Sinha & Fraley, 2008).

At the moment there is not enough annual production data for primary producers including seaweed. Future studies are needed to improve our understanding of the amount of carbon absorption by marine plants including seaweed. There was the estimation of the annual net production of marine plants and the amount of carbon absorption of marine plant beds along the coasts of Japan in 1991. Based on the total area of seaweed plant beds on the coasts of Japan was 2,012 km^2, thus using the total areas of each type of seaweed, the estimation of the total annual carbon absorption to be about 2,700,000 tonnes of carbon a year. But there is little data about how much of the total quantity of production of marine plant become deposition. To know the quantitative significance of marine plants including seaweed on a global long-term carbon sink is to understand the role and position of marine plant ecosystems in the global carbon sink with accuracy (Muraoka, 2004).

4.2.4. Seagrass

The calculation of global seagrass habitat area is very important and useful for an asessment of the role of seagrasses in global processes, particularly in global carbon budgets, and also in assessing historical and future loss of seagrass and in priority setting and management of natural resources for activities such as fisheries and conservation (Green & Short, 2003).

The greatest seagrass species diversity in single-climate countries occurs in the tropics. The Philippines and Papua New Guinea, together with Indonesia are considered to be the center of global seagrass biodiversity. Seagrasses cover at least 30,000 km^2 throughout the Indonesian Archipelago , from Pulau Weh in Aceh to Merauke, Papua. The diversity of seagrass in Indonesia is among the highest in the world. Seven genera and 12 species of seagrasses currently occur in Indonesian waters (Green & Short, 2003).

Worldwide, seagrass occupies about 600,000 km^2 of the continental shelf, contributing 12% of the total carbon storage in the ocean (Duarte & Cebrian, 1996 in UNEP, 2004). According to Dierssen & Zimmerman (2003) Seagrass ecosystems in carbonate sediment banks represent a natural sink for atmospheric CO_2 – a shallow water "biological pump" – and may be responsible for as much as 10% of the ocean's annual net CO_2 uptake. Seagrass meadows are sites of intense organic and inorganic carbon fluxes. Unfortunately, these fluxes are seldom examined in concert so that carbon budget of seagrass meadows, and their potential role as carbon sinks or sources, remains poorly constrained (Barro et al, 2006). We need to conduct further activities to examine the potential role of seagrass in Indonesian marine waters as carbon sink.

4.2.5. Mangrove

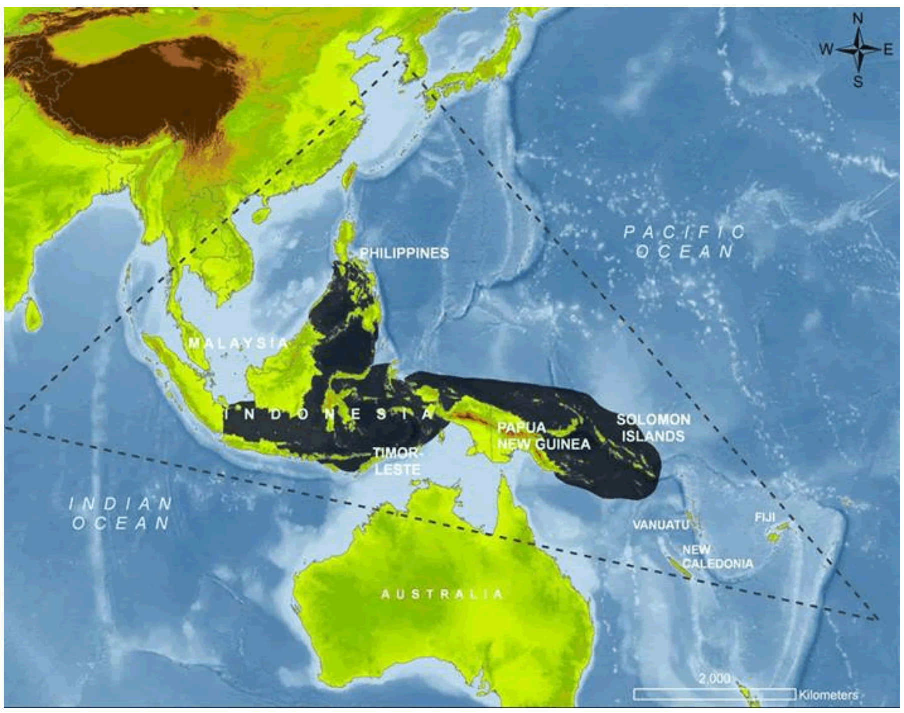
Even though mangroves belong to the coastal resources, they will be discussed in the forestry sector report.

4.2.6. Coral Reefs

Coral reef is one of the richest ecosystems in terms of biodiversity. Coral reef plays an important role in human life, particularly in relation to economic capability and environmental protection. Even though coral reef looks massive and strong, but in fact it is weak against environmental changes. Apart from its economic value, coral reef is a unique natural laboratory in which various researches can be done leading to new findings that may be of great value to mankind. For example, some of coral associated sponges species are believed to produce bioactive substance that has a high potency to be further developed for cancer treatment. Similarly, the carbonate skeleton of coral colony has been used in osteotherapy. The fringing reef physically protects the coastline from adverse effects of waves and currents.

Coral reefs fringe the coasts of almost 100 countries in the world, covering some 600,000 km^2. Indonesia has highest diversity of coral reef and largest world coverage of coral reef (approximately 75,000 km^2) in the world, but only about 6.20% is still in good condition. Coral reef in Indonesia spread from Aceh at the western end to Papua at the eastern end. The figure below shows the map of the world's coral triangle, which covers large areas of Indonesian marine waters.

Almost 100 millions people live along the Indonesian coast, meaning that despite being an important living resource, coral reef will face or even is under heavy anthropogenic threat. The Indonesian coral reef is currently undergoing serious degradation, as reflected by decreasing catch from the reef in terms of quantity, quality and catch per unit effort. The increasing part of the population, which is dependent on coastal resources, will heighten the stress to coral reef ecosystem. Since the 1990s, scientists and professionals launched the issue on worldwide decreasing of coral reef's, which is also happening in Indonesia. Presently about 10% of world coral reef is under serious devastation even though not unrecoverable. If there is no effort to take action on rehabilitation and implement sustainable management system for coral reef, it could be in 20 years; about 30% of the rest world's coral reef will be threatened into serious unrecoverable damage.



Source: assets.panda.org/.../coral_triangle_map.gif

Figure 4-11: Map of the World's Coral Triangle covering large Areas of Indonesia

4.2.7. Ocean and Coastal Renewable Energy

Having geographical position along the equator and between two oceans (Pacific Ocean and Indian Ocean), Indonesia has a big potential of ocean energy. Ocean energy is defined by energy conversion from mechanical forces, potential forces, and the difference of ocean temperature between sea surface and certain depths (temperature > 20^0C), to become electricity. Based on energy sources, ocean energy can be classified into: tidal energy, wave energy, current energy, and ocean thermal energy, while solar and wind energy can also be used as an alternative energy sources for coastal community in Indonesia.

Utilization of Indonesia's ocean energy can also take into account to be installed in isolated or remote coastal area and small islands, due to lack of national electrical transmission network. So, an individual power plant with capacity around 500 watts is important to be developed.

Table 4-5: Indonesia's Renewable Energy Potential

Resources	Potential (MW)	Installed (MW)	Expected Investment (USD/kW)	Expected Energy Cost (USD/kWh)
Hydro (big scale)	75,764	4,200	1,500 – 2,000	0.035 – 0.045
Mini/ Micro Hydro	459	32	1,000 – 2,000	0.025 – 0.069
Geothermal	27,000	800	910 – 1,500	0.030 – 0.050
Biomass	49,810	302	1,200 – 1,500	0.040 – 0.060
Solar	4.0 – 6.5 kWh/m2/day	5	4,000 – 6,000	0.500 – 0.900
Wind	> 8 m/s	0.5	1,000 – 1,500	0.050 – 0.060
Marine (Coastal)	35 kW/m coastal line	None	500 – 1,000	0.045 – 0.090

4.2.7.1. Tidal Current Energy

The research activities in using tidal current energy in Indonesia have been doing progressively by Institute for Hydrodynamics Research (BPPH), Agency for the Assessment and Application Technology (BPPT) and Bandung Institute of Technology (ITB) since 2006.

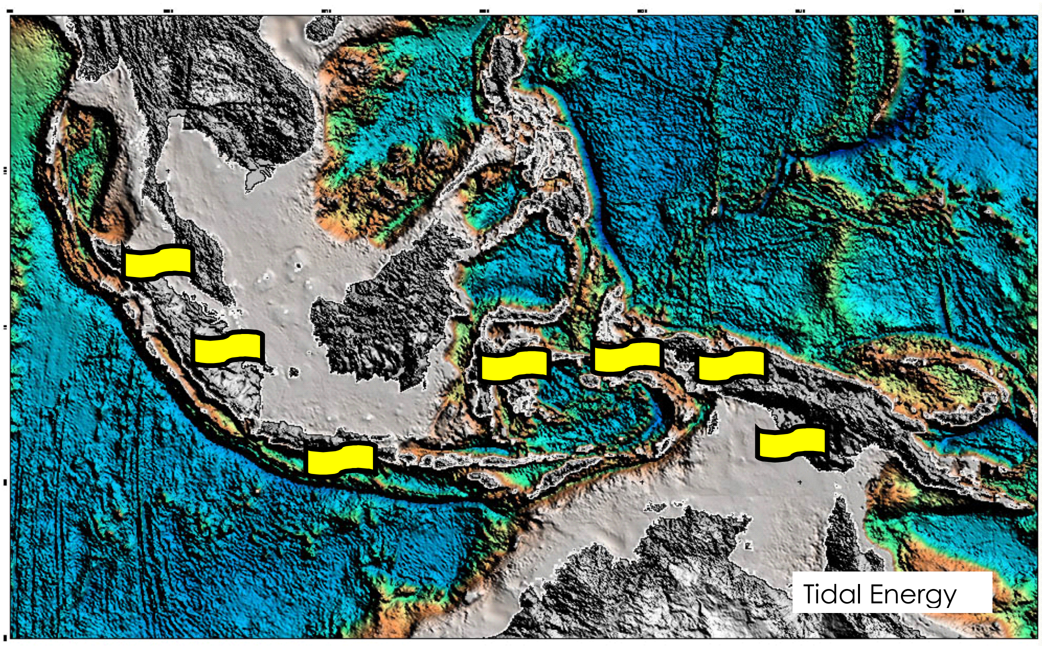
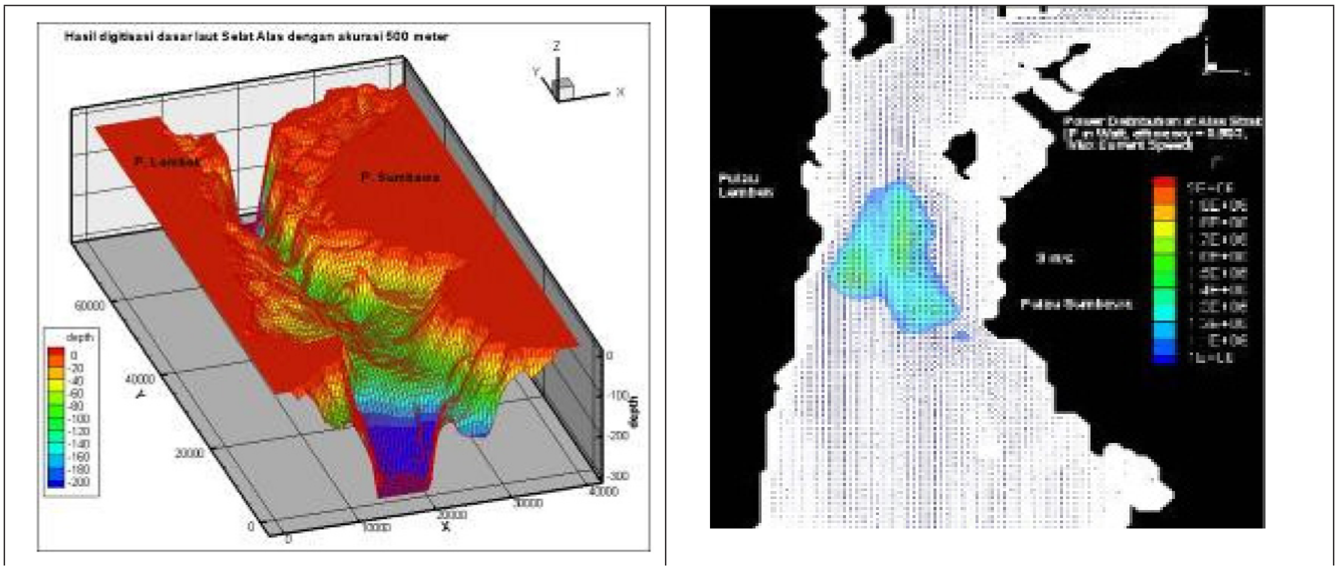


Figure 4-12: Tidal Energy Potential in Indonesia

Exploitation of marine current energy has some advantages such as:

- Renewable and sustainable energy supply;
- High energy densities at low velocities;
- Predictable, marine currents are primarily driven by the tide.

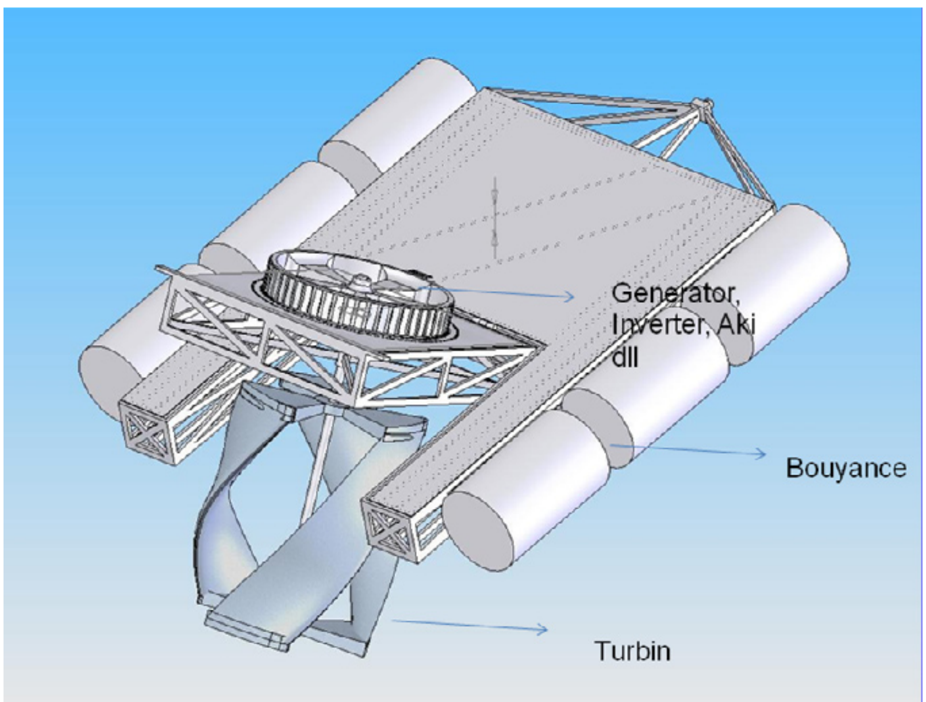
BPPT's study on electricity generation by tidal current in Alas Strait (between Lombok and Sumbawa islands) revealed that ocean current speed can achieve 2.19 m/s in certain points. 1 kW current turbine already tested in laboratory, and it will be deployed by 2009 in this strait.



Source: Courtesy of Erwandi, BPPH – BPPT, 2006

Figure 4-13: Simulated Power Distribution at Atlas Strait

Another research was conducted by some young researchers at ITB. They fabricated a turbine marine current by adopting Gorlov turbine. This kind of turbine can be used for low marine current like in Indonesia. The principle of Gorlov turbine is similar like Darrius turbine. But the Gorlov turbine has higher power coefficient in low marine current. It can be worked with current speed starting at 0.5 m/s. This turbine marine current is claimed can produce 1 kW. And they plan to sell it at price of 100 millions Rp. for one structure (exclude transportation and installation costs).



Source: (ITB, 2008)

Figure 4-14: Turbine Marine Current fabricated by ITB

4.2.7.2. Wave energy

Wave energy potency can be found mostly in Eastern Indian Ocean and in South Java Island, with wave energy rated between 15 – 20kW/m. 1 km wave can generate electricity as big as 20 – 70 MW, and in 50% efficiency and it will produce 10 – 35 MW of electricity.

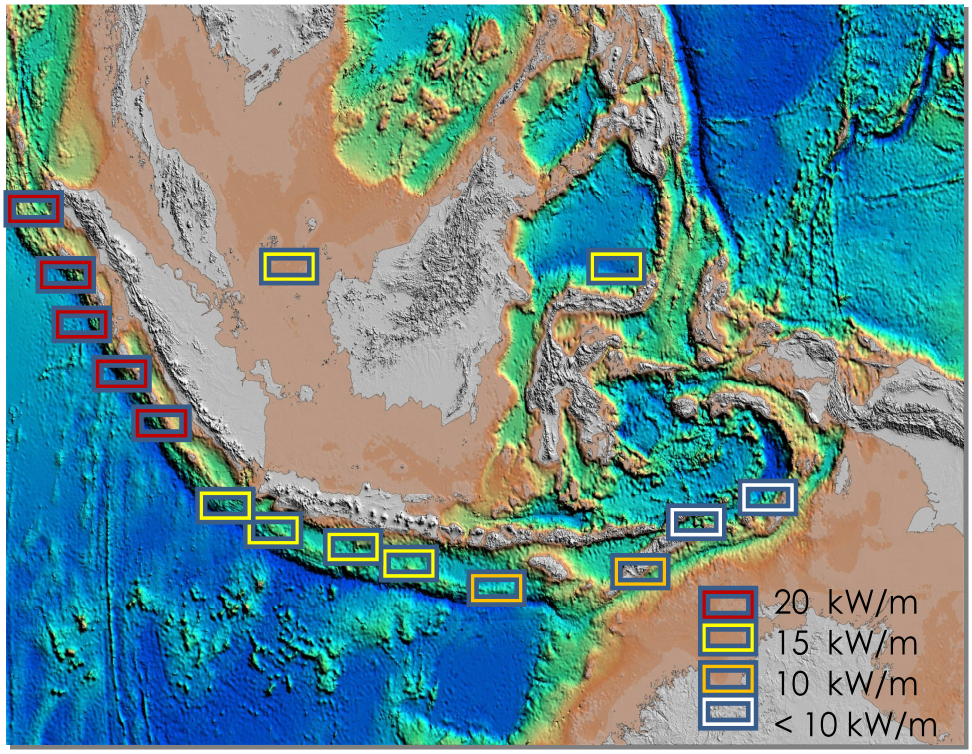


Figure 4-15: Wave Energy Potential in Indonesia

Since 2003, BPPT has been developing coastal wave energy electrical generation by using Oscillating Water Column in Parang Racuk, Yogyakarta (southern part of Central Java). But this joint activity with Norway is still on going research phase.

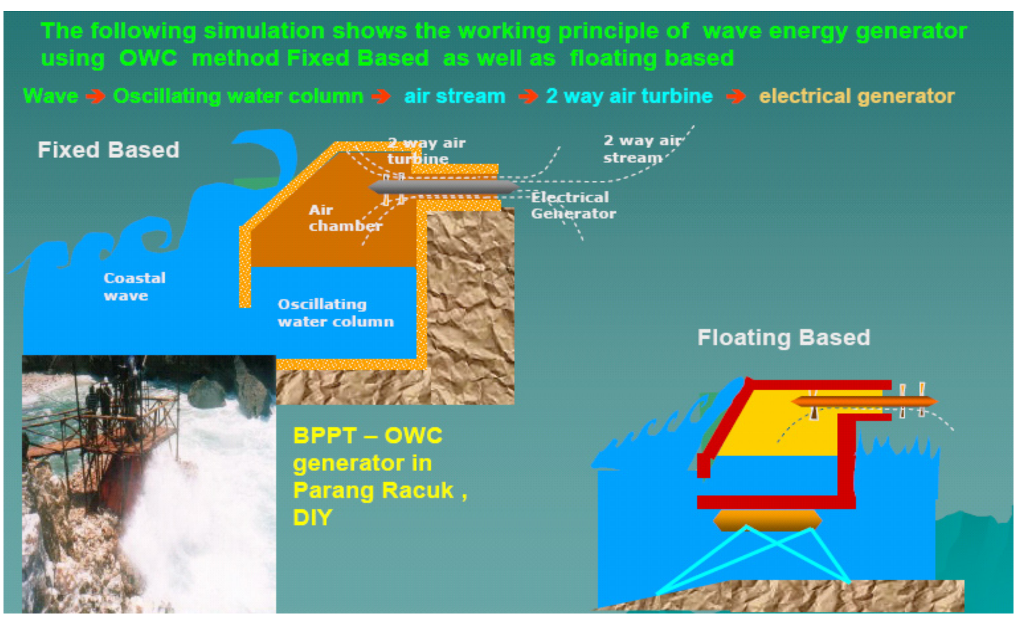


Figure 4-16: BPPT's OWC System Design in Parang Racuk

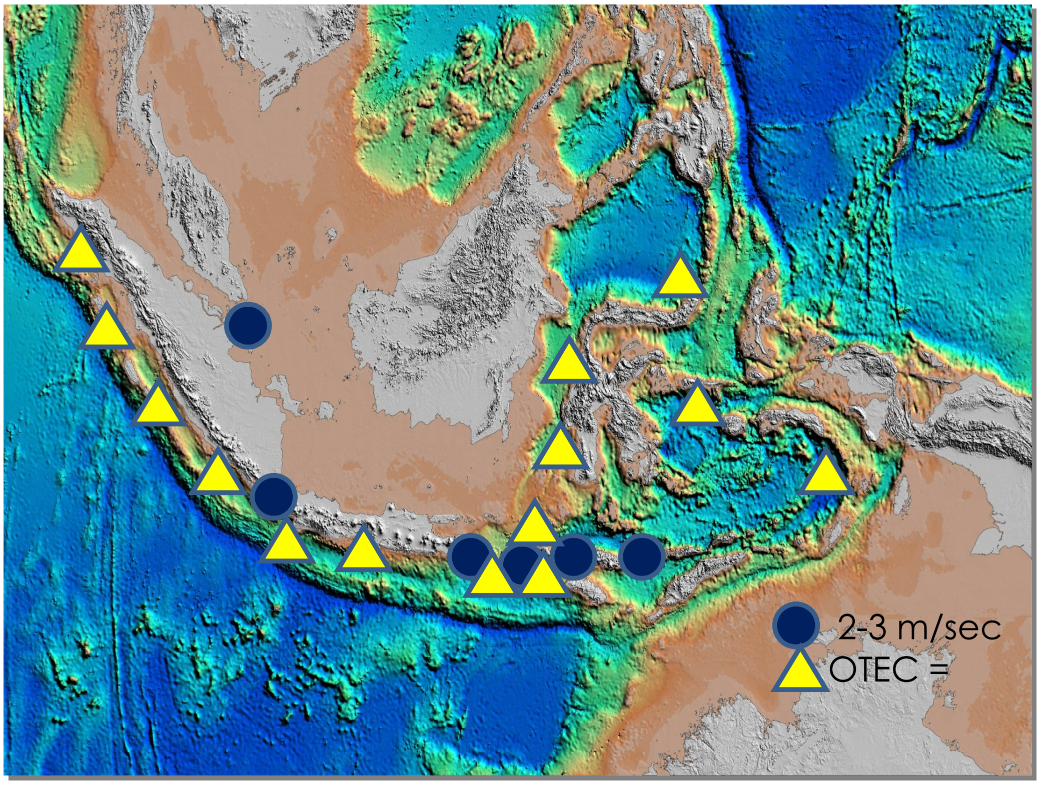


Figure 4-17: Ocean Thermal Gradients and Current Energy Potential in Indonesia

4.2.7.3. Ocean Thermal Gradient Energy

Some research activities have been done in attempts to explore the ocean thermal energy in Indonesia. The first assessment of OTEC implementation in Indonesia conducted in 1982 collaborated with Holland Betons Group of Netherlands. The pilot project of 100 kW OTEC was planned to be installed in Lombok Strait. Unfortunately, this project never realized at full scale implementation. In the year 2000, BPPT continued to inventory the potency of OTEC in Indonesia, with some supports of Kanematsu Corporation and University of Saga – Japan. The last activity of OTEC research was the completion of the system design and feasibility study for the Tulamben site in Bali. The financial aspect is the main constraint for ocean thermal energy exploitation in Indonesia.

4.2.7.4. Solar and Wind Energy

As tropical country, Indonesia has a big potential in solar energy, which is 4.8 kWh/m^2/day. This potency can be described as follows:

- East part of Indonesia has 5.1 kWh/m^2/day solar potential with 9% monthly variation.
- West part of Indonesia has 4.5 kWh/m^2/day solar potential with 10% monthly variation.

Common wind speed in Indonesia is only 3 – 5 m/s, which is very small to converse into energy. But in some areas, such as: Nusa Tenggara Timur (NTT), Nusa Tenggara Barat (NTB), Sulawesi Selatan and Sulawesi Tenggara, wind speed can reach up to > 5 m/s. With wind speed > 5 m/s, in 1 km^2 area, one can produce 6 – 7 MW of electricity.

4.2.8. Indonesia's Ocean Observing System (INAGOOS)

The sustainable development of Indonesia coastal areas, the management of water (the integrated atmosphere-ocean water cycle), marine resources (off-shore activities and fisheries) and the overall management of open sea and land deriving pollution is a serious concern. Millions of people lives depend upon the continuous assessment of the state of the system so that prevention actions against pollution, overexploitation of fish stocks, loss of water resources and marine ecosystem habitat loss can be organized in a timely fashion, together with adaptation and mitigation measures.

Due to the large natural variability and the human induced changes, the Indonesian archipelago water resources and coastal areas sustainable development need to be continuously monitored, analyzed and predicted following the practice of operational oceanography.

Operational oceanography in the Indonesian archipelago is close to be a reality and not only connected to physical environmental variables. It is clear that the practices and methodologies of operational oceanography could be of benefit to sustainable development issues related to marine coastal areas, water and marine resources management. In particular, the practice of real time monitoring and modelling together with field estimation needs to be exported to the other environmental aspects of sustainable development of marine areas.

The Indonesia Ocean Observing System program has been launched by the Minister of Marine Affairs and Fisheries of the Republic of Indonesia in August 2005. Actually, the INAGOOS is still in research and pilot project phases. The overall INAGOOS goals are as follows:

1. Scientific: to explore, model and quantify the potential predictability of the marine ecosystem from the overall basin to the coastal areas
2. Operational: to initiate the operational observational/ modelling system in the Indonesian archipelago

The INAGOOS goals will be achieved only if we will develop a research and technology strategy for each of the four environmental system methodological blocks:

1. Monitor in Real Time the hydrodynamics, biochemical fluxes (e.g. nutrients), contaminants levels (oil in the open sea and other contaminants in the coastal areas) and fishery from the basin to the shelf/coastal scale;
2. Improve the capability to model the hydrodynamics and the biochemical fluxes and food webs (coupled models, downscaling, up-scaling, process nesting, ensemble forecasting) from the basin scales to the coastal areas, including the connection with the surface and underground water input to the coastal areas, the contaminants fate and impact on the environment and the connections between fishery and environment;
3. Improve data assimilation tools in order to consider all the relevant real time measurements for hydrology and biogeochemical parameters;
4. Develop the information management system for the Indonesian archipelago that will disseminate in real time both observed and model estimates of the state of the system and develop interfaces to make available this information to policy makers.

Due to complex topography and dynamic oceanography in the Indonesian Seas, the regionalization for monitoring system in Indonesia at minimum need can be divided into 3 zones, based on the eco-regions (Sunda shelf, Sahul shelf, and transition zone), they are:

- International Exclusive Economic Zone (IEEZ) and open oceans: These regions cover the Pacific and Indian Oceans which very closely with the issues of regional climate changes of ENSO (El Niño and La Niña) and Indian Ocean Dipole (IOD). The ongoing monitoring systems of TRITON buoys arrays have been installed by JAMSTEC (Japan) in cooperation with NOAA (USA) and BPPT (Indonesia) along the equatorial Pacific and eastern Indian Oceans.

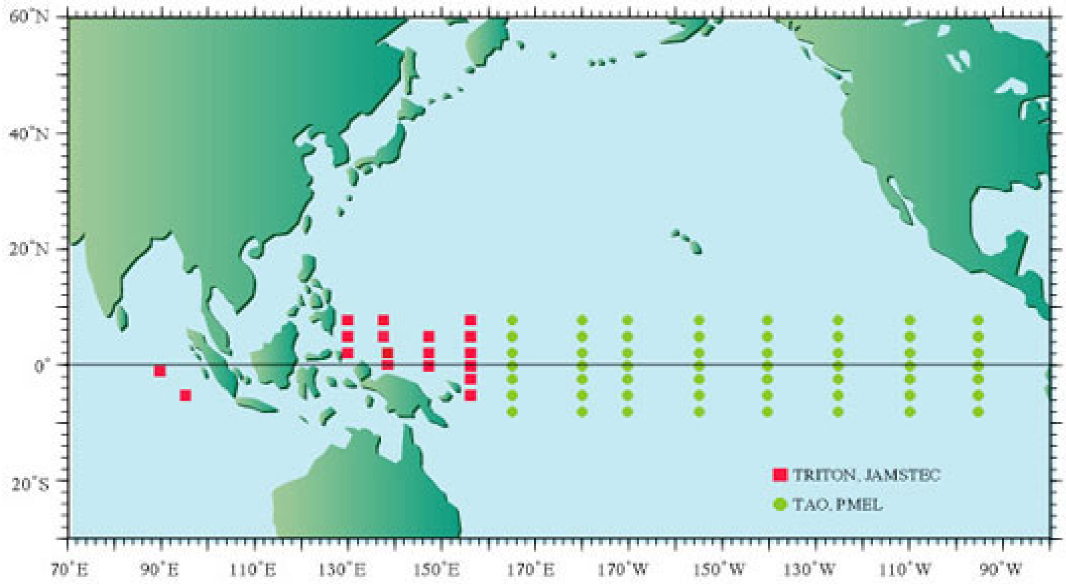


Figure 4-18: Tropical Moored Buoys Network

- Semi enclosed and marginal seas: These regions importantly correspond with regional economic cooperation in the South China Sea, Arafura and Timor Seas, Sulawesi and Sulu Seas, and Malacca Strait under cooperation among countries of Indonesia, Singapore, Malaysia, China, Papua New Guinea, Timor Leste, and Australia. Proposed monitoring system of tide gauges arrays along the coastal regions surrounded by the South China Sea is still in discussion between Indonesia and China. Some moored current meters have been deployed in the Sulawesi Sea to monitor Indonesian Through Flow (ITF) under joint cooperation between Indonesia and JAMSTEC, Japan. In the near future, we are going to use ARGO floats to monitor these regions.
- Internal Indonesian seas: The regions significantly affect on the societal aspects along the cities surrounded by the Straits (Malacca, Ombai, etc.) and Bays (Tomini, Bone, etc.). Under national programs, we have conducted small scale oceanographic surveys to identify the characteristics of important Bays in the internal Indonesian Seas and under international programs we put several moored current meter arrays in the several important passages in the Makasar, Lombok, Lifamatola, and Ombai Straits to monitor the Indonesian Through Flow. All those measurements could be useful information for setting up monitoring programs in these regions.

Based on the description of marine zones above, then there is a need to build several INAGOOS centres, which function as regular and sustainable data collection stations and analysis of the Indonesian ocean conditions. Several locations identified to build the INAGOOS centres, among others are:

3. Bali Island. As has been mentioned before, BRKP-DKP (Agency for Marine and Fisheries Research - Ministry of Marine Affairs and Fisheries) has built an institute for ocean observation research (SEACORM – Southeast Asia Centre for Ocean Research and Monitoring) in Perancak-Bali. SEACORM is anticipated to be the data processing and information centre of the future INAGOOS stations. Moreover, SEACORM has the best location for monitoring and prediction of oceanographic condition of the Indian Ocean, south of the Indonesian archipelago.
4. North western part of West Papua. ENSO phenomena and several monitoring that are done thus far in the Western Pacific still need the data of local scale. This data is needed to downscale the global ocean modelling to understand the regional ocean phenomena. The possible location for developing a coastal station in this area by reason of infrastructure availability is at Biak Island.
5. Padang-West Sumatra Province. Padang is a very strategic city for the location for marine phenomena observation of the Eastern Indian Ocean. Several natural phenomena that are of important issue in the Eastern Indian Ocean are the Indian Ocean Dipole Mode (IOD), tsunami, deep sea resources, and fisheries. Padang is located close to the equator and presently has already

several facilities that will be beneficial in understanding the atmospheric condition, sea surface, air-sea interaction, and tsunami impact to the coastal area. The facilities and infrastructure already available are: maritime continent radar in Koto Padang, the new international airport, the harbour in Teluk Bayur, the fishing port (Pelabuhan Perikanan Samudera) in Bungus, the local tsunami mitigation centre, and local universities.

Nevertheless, there are several constraints still facing the setting up of an operational system in the Indonesian and its adjacent seas due to the large areas that should be covered, compared to the minimal oceanographic knowledge in these regions, and the lack of instruments (buoys and moored current meter arrays, etc.) that has been installed in the internal Indonesian Seas. We also face with the lack of interest of community to cooperatively maintain the operational monitoring system installed in their regions. Cannibalism of the instruments in the seas is one of the major drawbacks that need to be solved by effective socialization programs. Besides, data sharing among the Indonesian institutions are not easy to organize. Development of national marine data and information centre must be put into priority. Finally, we must take into consideration to the constraints above in order to optimize the setting up of operational monitoring systems in the Indonesian Seas.

5. TECHNOLOGY SELECTION

Based on priorities and criteria set for selecting and implementing various technologies for climate change mitigation in the ocean sector, the following preferred technology options have been selected; seaweed; mangrove and coastal vegetation; coral reefs; Indonesian ocean observing system; marine fisheries; ocean and coastal renewable energy; sea grass and marine plankton. The technologies are selected based on the AHP analysis and barriers and policy needs.

Table 5-1: Results of Weighting the Criteria

Criteria		Relative Weights
a. Development Benefits		
1	Security and legality	20.42%
2	GDP growth, income equity, job creation	19.90%
3	Coastal and small island community development	6.35%
4	Capacity building	5.72%
b. Environmental Protection		
5	Sustainable fisheries and aquaculture	12.12%
6	Marine resources protection, conservation, rehabilitation	15.65%
c. Market Potential		
7	Business scale development	4.40%
8	Added value of marine & fisheries product	5.23%
9	Development & intensification	5.82%
10	Marketing (commercial readiness)	4.39%
	Total	**100%**

Table 5-2: Weighting Results for each Resource's Technology Choice

Technology Choices based on Resources	Relative Weights (%)									
	1	2	3	4	5	6	7	8	9	10
Marine plankton	2.50	2.30	2.64	2.30	5.51	3.96	2.36	2.00	1.97	2.14
Marine fisheries	10.35	8.39	7.39	11.37	3.75	3.07	17.23	25.37	12.44	24.23
Seaweed	22.63	29.47	28.60	29.79	19.24	18.12	30.26	28.43	39.75	30.24
Sea grass	4.37	3.59	4.01	3.50	5.53	6.58	2.93	3.19	3.07	3.59
Mangrove & other coastal vegetation	20.54	23.67	21.51	17.26	23.50	25.17	10.14	7.45	12.18	7.68
Coral reefs	18.12	17.32	19.48	17.08	22.64	28.60	6.25	13.13	14.61	8.38
Ocean & coastal renewable energy	11.94	8.67	8.45	11.66	6.60	2.71	10.09	7.63	6.04	6.47
Indonesian ocean observing system	9.54	6.59	7.92	7.04	13.22	11.79	20.74	12.81	9.95	17.27
Total	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**100**

Table 5-3: Ranking of Mitigation Technologies/ Measures according to Resources

No	Mitigation Technologies / Measures according to Resource	Composite Weight
1	Seaweed	25.63%
2	Mangrove and coastal vegetation	19.93%
3	Coral reefs	18.76%
4	Indonesian ocean observing system	10.53%
5	Marine fisheries	9.71%
6	Ocean and coastal renewable energy	8.07%
7	Seagrass	4.40%
8	Marine plankton	2.97%
	Total	**100%**

5.1. IMPLEMENTATION PLAN FOR TECHNOLOGY TRANSFER

Implementation plan discuss in this document was based on the AHP analysis and barriers and policy needs as in the previous chapter. In this project year 2009 is the starting year (year 1) and all project hopefully will be completed in the year 2015 (year 7). The Implementation plans needs to be adapted are explains as below:

Rank 1. Seaweed

1. Development of potential areas for seaweed cultivation
   The project is still at study stage and still need some development. It planned to be carried out by 2009 – 2015 (Year 1 – year 7).
2. Seaweed culture management
   The Seaweed Culture Management project has already been performed and the official starting project is year 2009, this project will be completed in the year 2015 (Year 1 – year 7).
3. In-situ and laboratory measurements on carbon sink potential of seaweed culture areas
   The project is still at planning stage and will be done after all preparation ready, it planned to be performed in the year 2010 – 2012 (Year 2 – year 4).
4. Detailed mapping of potential areas for seaweed culture development
   The project is still at planning stage and will be carried out along with the In-situ and laboratory measurements on carbon sink potential of seaweed culture areas project in the year 2010 – 2012 (Year 2 – Year 4).

Rank 2. Mangrove And Coastal Vegetation

As mention above in this document, mangrove will be discussed in the forestry sector report.

Rank 3. Coral Reefs

1. Identification of supporting data of environmental parameters including oceanography, water quality, etc.
   This project has been done in the last couples of year by various institution, nevertheless Indonesia are still lacking in complete coral data and needs to be integrated. The plan is carried out the project in the year 2009 – 2015 (Year 1 – Year 7).
2. Coral replanting and transplantation
   Coral replanting and transplantation project will be carried out along with the Identification of

supporting data of environmental parameters including oceanography, water quality project in the year 2009– 2015 (Year 1 – Year 7).

3. Remote sensing for estimation of net primary production (NPP) and total carbon sink (including mapping of high and low bleaching risk regions)
   The project is still at planning stage and needs some development of satellite data processing algorithm related with Net Primary Production (NPP) and total carbon sink. Afterwards the project will be carried out in the year 2010 – 2011 (Year 2 – Year 3).
4. Modelling of carrying capacity for technology implementation
   The next phase of the project is conducting modelling of carrying capacity for technology implementation and since this project connected with the third project, modelling project will start on the year 2010 and completed in the year 2011 (Year 2 – year 3).
5. In-situ and laboratory measurements on carbon sink potential
   The last phase is conducting in-situ and laboratory measurements on carbon sink potential for the completion of the whole coral reefs project. This particular phase will start in the year 2011 and be completed in the year 2013 (Year 3 – Year 5).

Rank 4. Indonesian Ocean Observing System

1. Monitoring marine environment condition by using remote sensing technologies and in-situ measurements
   This project has been carrying out by various institutions but integration from the entire project should be done in order to make integrated information of marine environment condition. This project phase will be started in the year 2009 and be completed in the year 2015 (Year 1 – year 7).
2. Establishment of ocean and coastal stations to observe Indonesian waters
   To gain more completed data and more comprehensive ocean observations, Indonesia needs to establish ocean and coastal stations in several important spots. This project phase planned to be carried out in the year 2009 – 2015 (year 1 – Year 7).
3. Operational Ocean Observing System, establishing data and information centre in at least three locations throughout Indonesia (west, central, and east).
   The operational of Ocean Observing System, establishing data and information centre as the most important project stage will be performed in the year 2010 – 2015 (Year 2 – year 7).
4. Study on water mass transport in related to oceanic carbon budget.
   The last stage is to have study on water mass transport in related to oceanic carbon budget will be performed in the year 2012 – 2015 (Year 4 – year 6).

Rank 5. Marine Fisheries

1. Development of low energy fishing vessels with bio fuels and other energy alternative such as ocean renewable energy (solar cell, wind-power, etc.).
   The project is still at study stage and still need some development. It planned to be carried out by 2010 – 2015 (Year 2 – year 7).
2. Implementation of technology and fishing supporting device that consume low energy (such as set-net, Electronic Fish Aggregating Device/EFAD, under water light/LACUBA, etc.)
   EFAD technology has been develop but still need some development and has planned to be carried out in the year 2009 (Year 1) until year 2011 (Year 3). While set net technology is still in the study stage and it was planned to carried out in year 2010 – 2015 (Year 2 – year 7).

Rank 6. Ocean And Coastal Renewable Energy

Development of utilization technology for ocean and coastal based renewable energy potential:

1. Tidal current
   Renewable energy project based on tidal current has started to develop but still need development and planned to be performed in year 2009 – 2015 (Year 1 – year 7).
2. Wave

Renewable energy project based on wave also has started to develop. This project will be started in year 2009 and be completed in year 2015 (Year 1 – year 7).

3. Ocean thermal gradient
   Ocean thermal gradient for renewable energy is still in the study stage. This project needs more cooperation between institutions to develop grand design of its utilization. This project has received some initial assessment from private institution and planned to start in year 2015 – onward.
4. Solar
   Renewable energy project based on solar energy has been implemented since early 2000 by various government projects and for coastal and small islands communities have been introduced by the Ministry of Marine Affairs and Fisheries in 2001. The next stage of its implementation will be trying to design and fabricate solar cells by local company instead of importing from abroad. This development is planned to be conducted in year 2009 – 2015 (Year 1 – year 7).
5. Wind power
   The utilization of wind power has been carried out in some areas prone to high content of wind energy namely south of Java, East Nusa Tenggara (NTT) and it has proven to be good source of energy especially when it is combined with solar and micro hydro power.
   The next stage of the development on wind power technology is planned to be conducted in year 2009 – 2015 (Year 1 – year 7).

Rank 7. Seagrass

1. In-situ and laboratory measurements on carbon sink potential of seagrass beds
   The in-situ and laboratory measurements on carbon sink potential of seagrass beds project is the first step and first phase to support another project of seagrass development. This project is planned to be carried out in year 2012 – 2015 (Year 4 – year 7).
2. Seagrass cultivation and rehabilitation
   Seagrass cultivation and rehabilitation project is based on in-situ and laboratory assessment on carbon sink potential of seagrass beds. This is a second phase of the seaweed development project and planned to be completed from year 6 – onward.
3. Generation of non-conventional energy from seagrass
   Project of non-conventional energy generation from seagrass is still in the study stage and open for mutual cooperation among several institutions. This project is planned to be started on year 2014 – onward (Year 6 – onward).

Rank 8. Marine Plankton

1. Satellite remote sensing technology for estimation of net primary production (NPP) and total carbon sink
   Project of remote sensing technology for estimation of net primary production (NPP) has already been performed by various institutions but still need some improvement and cooperation to make integrated information of NPP. Meanwhile project of remote sensing technology for estimate total carbon sink is still in the study stage and need further development. This project will be continued to develop in year 2009 – 2011 (Year 1 – year 3).
2. Numerical modelling of oceanography parameters for measuring ocean primary productivity
   Development of numerical modelling of oceanography parameters for measuring ocean primary productivity also has already been performed by various institutions. Development and improvement methods of numerical modelling will be continued in year 2009 – 2011 (Year 1 – year 3).
3. In-situ and laboratory measurements to find out the absorption effectiveness
   This project is very important to develop in order to support remote sensing and numerical modelling project to estimate NPP and total carbon sink. This project will be performed in year 2011 – 2015 (Year 3 – year 7).
4. Ecological modelling for marine plankton as carbon source or sink
   Ecological modelling for marine plankton as carbon source or sink project can be integrated with in-situ and laboratory measurements project. This project is still in study stage and need more supporting

data to validate the numerical model result. This project will be performed in year 2011 – 2015 (Year 3 – year 7).

5. Identification of potential plankton species to absorbs carbon
   This project is still in study stage and need some supporting data from in-situ and laboratory measurements. This project can be integrated with ecological modelling for marine plankton as carbon source or sink project that will be performed in year 2011 – 2015 (Year 3 – year 7).
6. Phytoplankton culture in photo bioreactor.
   Phytoplankton culture in photo bioreactor project needs some integration from various institutions. This project could be supported by previous project that mention above and planned to be preformed in year 2011 – 2015 (Year 3 – year 7).

Table 5-4: Selected Technologies/ Measures

No	Technology Priority selection	Priority of action plan	Period of action
1	Seaweed	Development of potential areas for seaweed cultivation	2009 – 2015
		Seaweed culture management	2009 – 2015
		In-situ and laboratory measurements on carbon sink potential of seaweed culture	2010 – 2012
		Detailed mapping of potential areas for seaweed culture development	2010 – 2012
2	Mangrove and coastal vegetation	Topic will be covered by the Forestry Sector TNA	-
3	Coral reefs	Identification stage	2009 – 2015
		Coral replanting and transplantation	2009– 2015
		Remote sensing for estimation of net primary production (NPP) and total carbon sink	2010 – 2011
		Modeling of carrying capacity for technology implementation	2010 – 2011
		In-situ and laboratory measurements on carbon sink potential	2011 – 2013
4	Indonesian ocean observing system	Monitoring marine environment condition	2009 – 2015
		Establishment of ocean and coastal stations to observe Indonesian waters	2009 – 2015
		Operational Ocean Observing System	2010 – 2015
		Study on water mass transport in related to oceanic carbon budget	2012 – 2015
5	Marine fisheries	Development of low energy fishing vessels with bio fuels and other energy alternative	2010 – 2015
		Implementation of technology and fishing supporting device that consume low energy	2009 – 2015

No	Technology Priority selection	Priority of action plan	Period of action
6	Ocean and coastal renewable energy	Tidal current	2009 – 2015
		Wave	2009 – 2015
		Ocean thermal gradient	2015 – onward
		Solar	2009 – 2015
		Wind power	2009 – 2015
7	Sea grass	In-situ and laboratory measurements on carbon sink potential of sea grass beds	2012 – 2015
		Sea grass cultivation and rehabilitation	2014 – onward
		Generation of non-conventional energy from sea grass	2014 – onward
8	Marine Plankton	Satellite remote sensing technology for estimation of net primary production (NPP) and total carbon sink	2009 – 2011
		Numerical modeling of oceanography parameters for measuring ocean primary productivity	2009 – 2011
		In-situ and laboratory measurements to find out the absorption effectiveness	2011 – 2015
		Ecological modeling for marine plankton as carbon source or sink	2011 – 2015
		Identification of potential plankton species to absorbs carbon	2011 – 2015
		Phytoplankton culture in photo bioreactor	2011 – 2015

6. IDENTIFICATION OF BARRIERS AND POLICY NEEDS

The ocean sector identified barriers and policy needs as follow:

Barriers	Policy Needs
Technological	
√ Limited technical data on mitigation measures/ technologies in ocean sector. √ Limited data and advanced research on ocean carbon budget, marine and coastal resources as carbon sinks – emission reduction potential. √ Limited in-situ/field observation over Indonesian marine waters. o Lack of quantitative data on marine plankton in Indones ian waters as oceanic carbon sink potential. o Lack of data on the role of marine plankton in Indonesian water in the ocean carbon budget. o Lacks of data on seaweed species and seaweed culture areas as carbon sink potential. o Limited data on ecology and distribution of seagrass in Indonesian coastal waters o Lack of data on seagrass species and seagrass beds as carbon sink potential. o Lack of data on the role of coral reef as coastal carbon sink or source. o Limited data on renewable ocean and coastal based energy resources potential in Indonesia o Indonesia is in the early stage of research and development of low emission power generation from ocean and coastal based energy potential.	√ Promoting applied research activities on technology of mitigation measures, measurement of ocean carbon budget, and utilization of marine and coastal resources as carbon sink – emission reduction potential. √ Implementing national plan for conducting in-situ/field observation over Indonesian marine waters (sea-territory/ EEZ). o R&D on measurement of marine plankton as oceanic carbon sink potential. o R&D on measurement of ocean carbon budget. o R&D on phytoplankton culture to absorbs CO_2. o Enhancement of research on seaweed culture technology and measurement of seaweed as carbon sink potential o Strengthen and implement the national policy on seaweed culture development as one program of fisheries revitalization. o Enhancement of research on seagrass ecology and distribution and measurement of seagrass as carbon sink potential. o Strengthening and implementing the national policy and strategy on seagrass beds conservation and management. o R&D on measurement of coral reefs as coastal carbon sink potential. o Detailed mapping on distribution of renewable ocean and coastal-based energy potential throughout Indonesia marine and coastal areas. o Enhancement of R&D on low emission power generation from ocean and coastal-based energy potential.
Institutional	
√ Limited trained professionals in technical aspect of mitigation measures/technologies.	√ Institutional and human capacity buildings in technical aspect of mitigation measures/technologies.
Socio-Economic	
√ Limited financial resources.	√ Financial support for ocean climate change-related research activities and program implementation.
Policy/ Regulatory	
√ Weak coordination and collaboration among stakeholders. o Require more effort on integrated mangrove conservation and management among stakeholders.	√ Strengthening coordination and collaboration among stakeholders. o Strengthening the integrated mangrove conservation and management.
Information	
√ Limited of integrated data exchange and management.	√ Improvement of integrated national data exchange and management mechanism.

7. CONCLUSION

1. Indonesian marine and coastal areas are vulnerable to the impacts of climate change, needs mitigation technology support and measures of climate change.

2. Indonesia needs to promote applied research activities and implement policy on the utilization of technology of mitigation measures, particularly technology for measurement of ocean carbon budget, and technology for utilization of marine coastal resources as carbon sink – emission reduction potential.

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CHAPTER - VII

WASTE SECTOR

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CHAPTER VII - WASTE SECTOR

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1. BACKGROUND

1.1. Aims

Indonesia ratified the United Nations Framework of Climate Change Convention (UNFCCC) through Act No. 6, in 1994 and the Kyoto Protocol through Act No. 17, in 2004. "*...Article 4.5 of the Convention defines technology needs assessments (TNAs) as, a set of country-driven activities that identify and determine the mitigation and adaptation technology priorities of Parties. They involve different stakeholders in a consultative process to identify the barriers to technology transfer and measures to address these barriers through sectoral analyses. These activities may address soft and hard technologies, such as mitigation and adaptation technologies, identify regulatory options and develop fiscal and financial incentives and capacity-building."* [UNFCCC: Technology Transfer Framework] Stakeholders are governments, private sector entities, financial institutions, NGOs and research/education institutions. The aims of Indonesia's TNA can be itemized as follows:

- Contribute to the global effort towards sustainable development and, in particular, the protection of the climate system
- Communicate Indonesia's needs for environmentally sound technologies (EST) to the UNFCCC Conference of the Parties (COP) and the global community
- Resource documents to identify and prioritize EST needed by Indonesia and mark those, which require support and co-operation from developed countries
- Set the foundation for a database for EST

The development of the TNA in the Indonesian waste sector has the objective to identify various technologies, which are suitable for Indonesian's conditions and capacities with regard to reducing the greenhouse gas (GHG) emissions in the sub sector of municipal solid waste (MSW), wastewater, and waste from agro industry, specifically palm oil, tapioca and livestock waste. This TNA is expected to be a baseline or guidance for the transfer of technology needs.

1.2. Objectives

Principal objectives of the TNA are:

- Identify, analyze and prioritize technologies, which could form the basis for a portfolio of Technology Transfer programmes aiming GHG emissions mitigation;
- Identify human and institutional capacity needs that ensure the smooth development, transfer and acquisition of environmentally sound technologies;
- Enlist interest and commitments from key stakeholders and partnerships to support investment or barrier removal actions for enhancing the commercialization and diffusion of high priority technologies.

1.3. Stakeholders Participation Process

The priority selection of ESTs for each sub sector of the waste sector is based on the discussions and agreements between the related stakeholders. This TNA waste sector document is developed in cooperation with some related institutions, such as the Department of Public Works (PU), the Ministry of Environment (MoE), the Agency for Assessment and Application of Technology (BPPT), the Bandung Institute of Technology (ITB), the Pelangi Foundation (Non-Governmental Organization), and PT. Gikoko (private company). The process of developing the TNA waste sector has been completed by conducting a series of discussions between stakeholders, a series of workshops between all sectors to collect some input and to evaluate the overlapping issues. In every workshop, all experts of all sectors were invited to give their comments.

In the first stage of discussions among the stakeholders, the priorities of the sub- sectors, which will be adopted in the TNA were identified and determined. The municipality solid waste was identified because this sub-sector has a large potential for reducing the GHG emissions. Currently there are more than 400 Final Disposal Sites (TPA), locations where municipal solid waste is accumulated. Also, because the new Solid Waste Act no. 18/2008 is now available, national intention is directed to this issue. Wastewater is also identified because of its potential in the CH_4 and N_2O emissions and because of its large quantity in Indonesia. From the total wastewater production in Indonesia, almost 80% comes from households and the rest comes from industries (BPPT, 2007). Development of municipal solid waste and wastewater infrastructure is the r responsibility of the Department of Public Works.

On n the other hand waste from agro industries - both wastewater and solid waste are included in the document because of its large waste production and its large potential in reducing emissions, if the appropriate mitigation technology is adopted. The suggestion to include the waste from the agro industry in the TNA waste document came from the Ministry of Environment and the suggestion was accepted by the team. From the research conducted by BPPT in 2007, three agro sub-sectors, which have a large potential in contributing to the GHG emissions, are palm oil, tapioca, and livestock waste.

In the second stage of discussions, all stakeholders gave the data contribution that is needed for developing the TNA document, specifically the verification of the emission quantity (baseline) and its scenario, waste management planning in the future such as a the Strategic Plan, or the Millennium Development Goals (MGD) target. All data received from the stakeholders were processed and put in the TNA document, which is based on the UNDP format. After that, the TNA document, still in the draft format, was presented in the workshop for finalization. There were two workshops conducted in the waste sector. The revised document after the workshop was then sent to the international reviewer for evaluation and comment. This TNA document is the final draft document after all consultations and the finalization by stakeholders.

For solid waste and wastewater the technology selection was done by calculating the weighted factors, which were given by the stakeholder, based on the general criteria. The highest-weighted technologies were then selected.

2. EXISTING CONDITION IN INDONESIA

2.1. Resources Potential

2.1.1. Municipal Solid Waste

Indonesia actually produced 48.8 Mt/year of Municipal Solid Waste (MSW), from a population of 218.8 million and the rate of waste generation of 0.61 kg/cap/day. Most of MSW (40%) is transported to the Solid Waste Disposal Sites (SWDS/'landfill'; the rest is illegally dumped (8%), composted and recycled (2%), open burned (35%) and treated in other ways (15%) (*National Action Plan, 2003*). Illegal dumping means, that waste is buried individually. Commonly it is practiced by community villagers in their own yard.

In the municipal solid waste (MSW) management issues, Indonesia is facing many problems such as:

- Most cities have no consistent master plan on managing solid waste, because management of municipal waste is still not formalized;
- MSW management has not been given an appropriate priority in local government policy, hence the budget planned for solid waste management (SWM) is limited;
- Facilities for waste collection, transportation, and disposal are limited;
- Almost all of the final disposals are open dumping sites that are causing water pollution, gases, smoke emissions and a bad stench.

Landfills are a very important issue in the solid waste management (SWM) because, recently, there are no landfill sites in Indonesia that are managed properly. The new problem regarding the landfill area selection exists because nobody wants his/her area to be selected as a new landfill site. A solution to the problem is to improve the landfill management from open dumping to sanitary landfill. The landfill site, which is unmanaged will become a source of the GHG emissions, mainly methane (CH_4). According to The World Bank (2005), Indonesia's landfill sites in major urban areas (17 cities) receive nearly 10 million tonnes of waste/year.

It is predicted that, by the year 2020, solid waste generation will double, compared to now. Based on a population of 218,868,791 in 2005 (SUPAS, 2005), the total MSW generated in Indonesia was approximately 48.8 Mt/year. The calculation is based on the Indonesian MSW generation rate of 0.61 kg/cap/day (national average in rural & urban areas). The following table shows the distribution of the solid waste in several big cities in Indonesia.

Table 2-1: Municipal Solid Waste Production in Different Cities

No	City	Population	Solid waste (t/yr)
1	Jakarta	7,512,323	2,083,918
2	Surabaya	2,740,490	760,212
3	Bandung	2,453,302	680,546
4	Medan	2,068,400	573,774
5	Semarang	1,419,734	393,834
6	Palembang	1,520,199	421,703
7	Makassar	1,179,024	327,061
8	Bekasi	1,914,316	531,031
9	Depok	1,373,860	381,109
10	Tangerang	1,354,226	375,662

Source: Central Bureau of Statistics (for Population), and BPPT calculation (for number of SW)

The waste composition in Indonesia is quite different from that of other developed countries as organic waste comprises the largest part in Indonesian municipal solid waste. The following table shows the composition of municipal solid waste in several cities. There were no data available for rural waste compositions.

Table 2-2: Composition of Municipal Solid Waste in Different Cities

Materials	5 Cities[1)]	Bandung[2)]	Yogyakarta[3)]	Average
	(%)	(%)	(%)	(%)
Food waste	59.47	54.97	16.37	43.6
Garden & park	6.92	5.26	49.46	20.5
Paper & cardboard	12.85	3.03	4.07	6.7
Wood	0.75	0.84	0.95	0.8
Textile	0.81	0.89	1.45	1.0
Nappies	-	-	3.10	3.1
Rubber & leather	-	-	0.79	0.8
Plastic	10.71	1.54	12.43	7.3
Metals	1.77	0.25	0.12	0.6
Glass	1.33	1.13	0.93	1.0
Others	6.21	32.08	10.34	14.4

Source: 1) KLH – Status Lingkungan Hidup Indonesia 2004 (the cities are Jakarta, Surabaya, Medan, Makassar, Bandung), 2) Prihartini, I. W, Departemen Teknik Lingkungan , ITB (2007), 3) BPPT, Studi Neraca GRK di Indonesia, Laporan Akhir (2008)

2.1.2. Wastewater

The domestic wastewater issues are proportional to the number of population and the increase of population automatically increases fresh water consumption. It means that amount of water discharged will increase too. Domestic wastewater in Indonesia is a big part constitutes 80% of total wastewater. The smaller part of 5% emanates from office and commercial waste and another 15% from industry.. The wastewater, which is not treated correctly, will pollute the water body and/or the land. Wastewater can be a source of methane (CH_4) when treated or anaerobically disposed. It can also be a source of nitrous oxide (N_2O) emissions. Carbon dioxide (CO_2) emissions from wastewater are not considered in the IPCC Guidelines, because these are of biogenic origin and should not be included in national total emissions.

The principal factor in determining the CH_4 generation potential of wastewater is the amount of the degradable organic material in the water. Nitrogen oxide (N_2O) is associated with the degradation of nitrogen components in the water e.g., urea, nitrate and protein. Direct emissions of N_2O may be generated during both nitrification and de-nitrification of the nitrogen present. Both processes can occur in the wastewater treatment plant and in the water body receiving the effluents.

However, the condition of the infrastructure for attending to the state of domestic wastewater in Indonesia is still very poor. At the national level, the wastewater services in cities with off-site sanitation (sewerage systems) cover only 2.33% of the total domestic wastewater that should be treated, and the proportion of septic tank (individual & communal) treatment is 46.60%. In the rural area, on-site sanitation for private and communal septic tanks share is around 49.33% for on-site sanitation. Off-site sanitation is not yet

available (SUSENAS, 2004).
Domestic wastewater in Indonesia is still a national problem, due to the fact l only 12 cities have off-site sanitation. While the treatment facilities are not yet capable of reaching the technical standards. The quantity of the domestic wastewater will increase correspondingly parallel to the increase of population. The following table shows the potential of domestic wastewater generated in several big cities in Indonesia. This calculation is based on the assumption that the fresh water demand in big cities in Indonesia is 150 l/cap/day, and the wastewater generated is 80% from the fresh water utilization (Department of Public Work).

Table 2-3: Domestic Wastewater Production in Different Cities

No.	City	Population	Wastewater ('000 m^3/yr)
1	Jakarta	7,512,323	548,399
2	Surabaya	2,740,490	200,055
3	Bandung	2,453,302	179,091
4	Medan	2,068,400	150,993
5	Semarang	1,419,734	103,640
6	Palembang	1,520,199	110,974
7	Makassar	1,179,024	86,068
8	Bekasi	1,914,316	139,745
9	Depok	1,373,860	125,364
10	Tangerang	1,354,226	98,858

Source: Central Bureau of Statistics (BPS) (for Population), and BPPT calculation (Wastewater generation)

Besides the domestic wastewater, GHG emissions are also generated from the industrial wastewater treatment plants are equipped with the lagoon system or anaerobic ponds. For many big cities in Indonesia, river and open channel pollution is commonly caused by 80% domestic wastewater, 15% industrial wastewater, and 5% from commercial areas. Because of lack of detailed data in industry and commercial activities, for calculating the amount of CH_4 generation from industrial wastewater, it is assumed that the amount of industrial wastewater is 15% of the total and wastewater from commercial areas is 5% of the total.

2.1.3. Agro-Industrial Waste

The agro industry sector has a strategic and important role in the national development. It contributes to the prosperity and community welfare, foreign exchange income, labor extension fields, added value gains and competition, domestic consumption needs and the optimization of sustainable resources.
Nevertheless, the significant source of GHG emissions come from the agro-industrial waste, such as palm oil, tapioca, sugar cane and the pulp & paper industry waste, mainly from wastewater generation. Other agro industries such as coffee, tea and cacao processing use dry process, so there are not so many liquid wastes discharged. In Indonesia, it becomes a national problem when the agro-industry waste is not managed and treated in a proper way, especially for the palm oil estate.

2.1.3.1. Palm Oil Industry

In 2005, Indonesia was the second largest palm oil exporter in the world, after Malaysia,, and right now there are 320 units of palm oil factories with total average capacities, during 2000 – 2005 of 9,816,393 tonnes of fresh fruit bunch (FFB) and six seed producers with total capacities of 124 million seeds per year.

Palm oil industry waste could be classified into two kinds of waste, wastewater from the factory and solid waste coming from the field and the factory. Wastewater has to be treated before being discharged into the water body, while the solid waste consists of empty fruit- bunch, leaves, tree trunks, fibers, shells and stumps.

Table 2-4: Palm Oil Production, 2000 – 2005

No.	Year	Production FFB (t)
1	2000	6,270,871
2	2001	8,378,472
3	2002	9,622,344
4	2003	10,368,186
5	2004	11,806,549
6	2005	12,451,937
Average		9,816,393

Source: Central Bureau of Statistics (BPS)

The liquid waste originates from the factory process in sterilization, decanter, separation, oil purifier, vacuum dryer and in hydrocyclone unit. The processing of palm oil can be described as follow: first the fresh fruit bunches are sterilized, stripped, digested and pressed. After that, the mixed liquid goes to the screening, settling tank, oil purifier, vacuum dryer, oil pump and storage tank unit, while the solid waste goes to the percarper. The fiber goes to the burner and the nut goes to the silo drier and nutcrackers. The cracked nut is blown to the hydrocyclone, then it goes to the kernel dryer and finally to the kernel storage. Empty fruit bunches are not brought back to the field, but are directly disposed of in open areas near the factory. It is very rarely managed for EFB to become a compost, but now some factories are trying to make compost from EFB to get accreditation for the CDM project.

Indonesia has a significant potential as a generator of the palm oil industry waste due to the big production of the product. The following table shows the amount of waste generated from the palm oil industries for the years (2000 – 2005).

Table 2-5: Agro-Industrial Waste from Palm Oil Production, 2000 – 2005

No.	Description	Average[1]	Waste conversion	Total waste
		(t/yr)	(%)	(t/yr)
1	Palm oil production (FFB)	9,816,393		
2	Part of waste			
	- Empty bunch (t/yr)		23	2,257,770
	- Shell (t/yr)		8	785,311
	- Fiber (t/yr)		12	1,177,967
	- Wastewater (m^3)		0,66 m^3/t FFB	6,478,819

Source: 1) Central Bureau of Statistics (BPS)

The total number of palm oil industry solid waste in Indonesia was around 4,221,048 tonnes an average from 2000 – 2005 and palm oil wastewater is around 6,478,819 m^3. The potential of GHG emissions from palm oil industrial waste consists mainly of the CH_4 emissions, that are generated from wastewater without treatment and the empty fruit bunch, that is disposed of and left to decay.

2.1.3.2. Tapioca Industry

Cassava based industries are spread all over the provinces in Indonesia which is the third largest cassava producer in the world, after Brazil and Thailand. On the national level, Lampung province is the largest producer with a production capacity of 5 million tonnes/year. Currently, cassava is not only considered as a national consumption but it is also exported for the national income. One problem in Indonesia is the low productivity level, which is around 20 - 30 tonnes/ha. Cassava is processed into various products, such as dried cassava (*gaplek*), cassava flour, and tapioca starch, while small numbers are used for bio-ethanol. The deployment of the cassava based industry for food and energy is also producing waste as a non-product output from processing.

Wastewater in the tapioca industry originates from the sedimentation process, while other wastes, which are solid, waste, come from the separation process after crushing/milling. Usually this solid waste is used for animal feed A big part of tapioca industries do not treat their wastewater correctly. Only bigger industries with high production capacities, undertake the treatment. Some industries are already equipped with a wastewater treatment plant (anaerobic- aerobic treatment) as a standard technology. Under anaerobic conditions, CH_4 will be produced and in case where it is not burned or used, it will produce GHG emissions. There are no fixed data for the tapioca industry available, but the potential is high for the release of GHG emissions, when the solid or liquid waste are not correctly treated. The cassava production in Indonesia currently is around 19 million tonnes/year, 5 million produced in Lampung province. Almost 90% of the tapioca factories in Lampung have a production capacity of 750 – 1,000 tonnes/day and need 17 – 20 m^3 fresh water/tonne tapioca produced. The wastewater generated from the tapioca industry in Indonesia is around 20 – 25 m^3/tonnes of tapioca produced. Commonly, the wastewater from the tapioca industry has a BOD characteristic of 10,000 – 20,000 ppm and COD characteristics of 18,000 – 25,000 ppm. From the research it is concluded that the tapioca industry will generate CH_4 of around 25 – 44 kg/tonne cassava used (Hasanudin, 2008).

2.1.3.3. Livestock

Livestock waste is a waste generated from the animal farm activities and mainly comes from the animal husbandry industry (dairy farm) activities. Another major source of this waste comes from big farm stables and some little part comes from the pasture, especially in the Nusa Tenggara area where the waste is discharged into the environment. Livestock contributes to methane emissions through the digestion process of ruminant animals (e.g. cattle, sheep, goats, buffalos etc.). These animals digest feed in their fore-stomach or rumenand some of this methane is exhaled or eructed, on a purely energy basis, considered as feed conversion inefficiency. Feed energy converted to methane cannot be used by animals for maintenance, growth or production. The total livestock population in Indonesia is shown in the following table.

Table 2-6: Animal Population by Type of Animal

No.	Animal Types	Number of Animals*
1.	Beef Cattle	8,121,691
2.	Dairy Cattle	265,744
3.	Buffalo	1,766,248
4.	Sheep	7,414,965
5.	Goat	12,613,108
6.	Pig	5,247,200
7.	Horse	412,919
8.	Poultry:	
	Native Chicken	261,132,020
	Broiler	534,810,990
	Layer	69,702,890
	Duck	29,674,120

The livestock population is concentrated in the provinces of Java Island, particularly West Java, Central Java, and East Java. In the other islands, the significant part of livestock population is concentrated in North Sumatra, South Sulawesi, Lampung, NAD, West Sumatra and Bali. Based on the numbers of each kind of livestock, the total livestock waste can be calculated. For these calculations, native chicken, layer, broiler and duck are to be considered as poultry. Some animals like slaughtering and dairy cow, pig, chicken layer or broiler stay in the stable and have the potential to generate GHG, if the waste are dumped and not treated. However, some farms have already treated their solid wastes in an appropriate manner.

If livestock manure is kept under anaerobic (absence of air) condition and with temperature higher then about 15oC methanogenic bacteria will produce methane. At this stage, a controlled fermentation of manure can be started. Methane emission from anaerobic digestion/fermentation constitutes an energy resource that can be then recovered. Manure management and recovery techniques enable methane to be collected. This recovered methane (biogas) can be either flared (combusted) or used for energy generation (heat and/or electricity) for on farm purposes or for sale. The flaring process decreases up to 95% of the harmful atmospheric effect of recovered methane if this gas was actually emitted. The final stabilized product produced by anaerobic digestion can be utilized as a feed and aquaculture supplements in fish farming or as a crop fertilizer.

If livestock manure is kept under aerobic conditions (by turning the manure regularly or by forced ventilation), aerobic transformation of the product will take place, replacing methane emissions by CO2 emissions. That process will lead to stabilized compost, which can then be used as a crop fertilizer. Clearly in this process, energy resources and benefits of biogas are lost, but its main advantage stays in the replacement of powerful greenhouse gases by weak ones, which leads to a drastic reduction (up to 95%) of the Global Warming Potential (GWP).

2.1.3.4. Sugar Cane Industry

Sugar cane industry has a long history in Indonesia, since the time of colonialism. In 2002, Indonesian sugar production had reached 1.7 million tonnes and it was increased to 2.3 million tonnes in 2006. It is predicted that sugar production in 2009 will reach 3.3 million tonnes. Climate and weather conditions are suitable for sugar cane plantation. Indonesia is also considered as a rich source of the sugar cane genetic (*saccharum officinarum*) and believed to be the world's original source of sugar cane (Papua). However, the big potential of this sugar cane faces some problems, as many factories are obsolete, running inefficiently or are under mismanagement. Currently there are 59 sugar cane factories in Indonesia but some 68% of them are factories older than ge 75 years and 80% of them are concentrated in Java. . Sugar cane industry and its derivatives are also producing solid waste that results from the crushing process and gas emissions released from burner equipment, partly in the form of GHG, that produce energy. Yet, the liquid byproduct molasses still can be used in the ethanol industry, as raw material
In the sugar cane industry although there are no fixed data. the potential for GHG emissions is very low, because there is nearly zero waste produced. Bagasse, as a solid waste, is used as raw material in boilers and to produce the electricity to run the plant. Therefore, the GHG will come from the electricity use and it will thus be reported in the energy sector.

As already mentioned, the sugar cane industry in Indonesia faces some problems regarding the big number of the existing old and inefficient factories. Another inefficiency can be seen from the Indonesian theoretical sucrose content in the sugar cane, that is supposed to be 14-15%, but currently only reaches a figure of 6 - 8%. The Indonesian National Sugar Committee (*Dewan Gula Nasional*) has mentioned, that in r 2004, total sugar cane plantation area was 344,791 ha.. With a sucrose content of 7.67%, and a sugar cane productivity of 77.6 tonnes/ha, the sugar production reached 2.05 million tonnes. In 2007, it was projected that the sugar cane plantation area would reach 380,775 ha with a the sucrose content of 7.82%, a sugar cane productivity of 100 tonnes/ha and would result in sugar production of 2.98 million tonnes.

Commonly, the sugar industry will generate 0.3 to 0.4 m^3 wastewater/tonnes of raw materials. The COD number is in a range of 1,921 – 3,600 mg/l (or ppm) and the methane emissions in the range of 0.2 – 0.5 m^3/tonnes of raw materials resp. 0.14 – 0.35 kg CH_4 per tonne of raw material input.

2.1.3.5. Pulp & Paper Mills

Indonesian pulp and paper industry has comparative advantages with the availability of forest land totaling 120 million hectares that could be transformed into industrial forest plantations (*Hutan Tanaman Industri/HTI*) to guarantee supply of tree basic materials in the future. In addition, trees grow three times faster in tropical countries than in non-tropical countries. The production cost are also cheaper in tropical countries like Indonesia. In the past 5 years, the country's production of pulp has increased by 3.75% annually – from 4.67 million tonnes in 2001 to 5.47 million tonnes in 2005. Paper production also rose by 4.5% annually from 6.95 million tonnes in 2001 to 8.21 million tonnes in 2005. Exports have increased in volume. Based on the official data at the Indonesian Association of Pulp and Paper (APKI), pulp exports increased from 1.7 million tonnes in 2001 to 2.43 million tonnes total in 2005. The increase showed that Indonesia is still quite competitive in the world pulp market.

The largest problem in the pulp industry is related with the forest as a raw material and also as a carbon sink. If we need a number of 4.5 m^3 pulpwood to produce 1 tonne pulp, it means that in the year 2001, pulp industries in Indonesia would need in total a number of 21 million m^3 pulpwood. With the assumption, that the average pulpwood potential productivity related to the forest area is 80 m^3/ha, so to cover the needs of the pulp industry raw material, an amount of 260,000 ha natural forest will be needed. As a non-product output from the pulp industry, GHG are produced from the process industry. These GHG emission come from the fossil fuel burning in the process and unmanaged anaerobic process of the organic wastewater produced.

The current national production capacity of pulp is 6.3 million tonnes/year and paper is 10 million tonnes/year. The data shows that the paper consumption in Indonesia is 26 kg/capita (APKI, 2005). Indonesian Trading Department's data shows that Indonesia is the 9th largest pulp producer in the world (2.4% from the world total production which is 179.4 million tonnes/year). And in the paper industry, Indonesia is the 12th largest paper producer in the world (2.2% from the world total production which is 318.2 million tonnes/year). Currently there are 34 pulp and paper producers in Indonesia. The largest producer is Sinar Mas Group with 42% of national total capacity, and the second largest producer is PT. Riau Andalan Pulp & Paper with 35% of national total capacity.

2.2. Resources Use and Utilization

2.2.1. Municipal Solid Waste

Generally, solid waste management (SWM) in Indonesia really depends on the existence of landfill or final disposal sites (Tempat Pembuangan Akhir/TPA). An intermediate treatment plant was developed as an effort to reduce the amount of solid waste that is disposed to the landfill site. Until nowadays, there is no ideal Intermediate Treatment Plant (large scale) that is managed professionally in Indonesia. Community Scale Treatment Center (3R) was developed as a solution to reduce the amount of solid waste, that is transported to the landfill. This centre acts as an intermediate treatment plant. Nationally, the total number of solid waste, which that is managed through the intermediate treatment plant is still below 2%. The MSW management in each city in Indonesia is commonly based on the principle of collect-transport-move-dispose on the final disposal area/ landfill site. The consequence of this principle is, that the management of MSW in Indonesia really depends on the availability of the final disposal area. In the rural area, currently 40 – 50% of the total solid waste is disposed to the final disposal area and only 2% from the total solid waste is composted. The rest are illegally dumped and/or burned by an open burning method.

Through a 3R (reduce, reuse, and recycle) principle campaign, some big cities such as Jakarta, Bandung, Surabaya, Medan, Semarang and Yogyakarta are now starting to develop an intermediate treatment plant by composting the organic waste component and recycling inorganic waste in order to reduce the volume of MSW, that is disposed on the final disposal area (TPA). The problem faced in Indonesia in the composting issue is the small amount of compost due to the difficulties in the marketing of the output (organic compost fertilizer). The price of compost from producer is around Rp 300 – Rp. 400 / kg, compared with the price of inorganic fertilizer, which is lower. Inorganic waste recycling activities are practiced by scavengers and collectors. From an economical view, inorganic waste business is beneficial and exists in every city in Indonesia.

Generally, plastic is taken directly by scavenger from household waste while cardboard or old newspaper can be sold directly to the collector. All goods from the collector (lapak) are generally collected by a bigger collector (bandar). After sorting the goods are sold to an agent. There are agents, that wash and crush all goods, but there are also agents, that only wash and resale the goods to bigger plastic industries. For illustration, the business value magnitude in the inorganic solid waste recycling process in Bandung city is measured by Endah Juwendah (2003) as follows:

Table 2-7: Economic Benefit of Inorganic Municipal Solid Waste in Bandung City, 2003

No.	Rubbish Type	Volume	Selling Price	Economic Benefit
		(t)	(Rp./kg)	(Rp.)
1	Paper	221.08	700	154,756,000
2	Glass/ Bottles	30.76	200	6,152,000
3	Plastics	119.65	800	95,720,000
4	Rubber	87.41	200	17,482,000
5	Metal	20.16	500	10,080,000
Total		**479.06**		**284,190,000**

Source : Padjadjaran University, 2003

The survey by BPPT on October 2007 found, that the price of the waste goods changes. It could be concluded that the price of waste materials, especially plastic, is increasing every year.

2.2.2. Wastewater

The increasing population certainly will increase the demand for fresh water. It means, that the discharge water will be increased too. Commonly for the big cities in Indonesia, like Jakarta, Surabaya and Semarang, the composition of the wastewater is 80% from the domestic, 15% from the industry and around 5% from the commercial areas. On the national level wastewater services in cities with off-site sanitation (sewerage system) reach 2.33% of the population while by septic tank (individual & communal) 46.6% is reached. In the rural area, where the on-site sanitation as private septic tank and as a communal tank is adopted, the figure is 49.33% and off-site sanitation is not yet built (see the following table). On the national level, the national target for services on the city wastewater treatment facility is, that in the year 2015 a total of 80% from the community will receive services for the wastewater treatment facility (see Table 2-9). The current service for the wastewater treatment facility can be seen in the profile of off-site sanitation system in several cities data (please see the following table).

Table 2-8: Profiles of Off-Site Sanitation Systems in Different Cities

<table>
<tr><th>No.</th><th>City</th><th>Capacity (m3/day)</th><th>Type of Technology</th><th>Location</th><th>Service Area (ha)</th><th>Service Area (%)</th></tr>
<tr><td rowspan="2">1</td><td rowspan="2">Jakarta</td><td>43,000</td><td>Aerated Lagoon</td><td>Setabudi</td><td>1,800</td><td rowspan="2">2.8</td></tr>
<tr><td>400</td><td>RBC</td><td>Duren Sawit</td><td>25</td></tr>
<tr><td>2</td><td>Bandung</td><td>243,000</td><td>Stabilization pond</td><td>Bojongsoang</td><td>2,817</td><td>40.0</td></tr>
<tr><td>3</td><td>Yogyakarta</td><td>15,500</td><td>Aerated Lagoon</td><td>Bantul</td><td>1,330</td><td>5.0</td></tr>
<tr><td rowspan="2">4</td><td rowspan="2">Surakarta</td><td>2,592</td><td rowspan="2">Aerated Lagoon</td><td>Semanggi</td><td rowspan="2"></td><td rowspan="2">10.6</td></tr>
<tr><td>2,074</td><td>Mojosongo</td></tr>
<tr><td rowspan="4">5</td><td rowspan="4">Cirebon</td><td rowspan="4">13,500</td><td rowspan="4">Stabilization pond</td><td>Ade Irma S</td><td>248,980</td><td rowspan="4">15.0</td></tr>
<tr><td>Kesenden</td><td>83,890</td></tr>
<tr><td>Perumnas S</td><td>174,840</td></tr>
<tr><td>Perumnas U</td><td>53,580</td></tr>
</table>

No.	City	Capacity (m3/day)	Type of Technology	Location	Service Area (ha)	Service Area (%)
6	Tangerang	5,500	Oxydation ditch	Sukasari	83,000	0.3
		117	Oxydation ditch	Perumnas		
7	Malang		UASB	Ciptomulyo		0.4
			UASB	Mergosono		
8	Balikpapan	800	Extended aeration	Pasar Inpres		0.3
9	Banjarmasin	1,000	RBC	Kota		
10	Medan	30,000	UASB	Pulau Bayan	823,000	10.0
11	Prapat	2,010	Aerated Lagoon	Kec. Aji Batu		
12	Denpasar	51,000	Aerated Lagoon	Suwung		
		10,000	Aerated Lagoon	Nusa dua		

Source:Dit. PLP-Departemen PU (2007)

Table 2-9: Service Area Scenario for Wastewater Treatment

Item	2005	2009	2015
Urban			
Population ('000,000)	102.30	113.50	130.70
AccesTarget (%)	70.35	73.74	78.82
Population Target ('000,000)	71.97	83.99	103.02
Rural			
Population ('000,000)	120.60	119.45	114.90
AccesTarget (%)	59.95	64.52	71.39
Population Target ('000,000)	72.29	77.07	82.03
National			
Population ('000,000)	222.90	233.35	245.60
AccesTarget (%)	64.72	69.02	75.34
Population Target ('000,000)	144.26	161.06	185.04
Acces Realisation	62.62*)		

Source: Susenas Data, 2004

2.2.3. Agro-industrial waste

2.2.3.1. Palm Oil Waste

The solid waste from palm oil industry consists of empty fruit bunch, leaves and trunk, fiber, shell and stump. Fibers and shells are used as fuel for boiler and sometimes empty bunch fruit is burnt or it is composted and it is utilized as fertilizer. One of the strategies to treat solid waste of palm oil is by improving the value of the solid waste and make such a product, that use fiber material from the solid waste, for example. There is no detailed data available on the national level to show the quantity of the palm oil waste that is composted and/or utilized as an improved product.

Commonly, wastewater from the palm oil industry is treated in a wastewater treatment plant (WWTP). The employment of the WWTP is an obligation for a factory to run the production process and the quality of the wastewater output should be controlled. There are opportunities to produce biogas from the wastewater. The treated wastewater can be utilized in a solid waste composting process to watering the compost heap. According to the experiences of BPPT, the oil produced in palm oil industry can be used as raw material for biodiesel as well.

2.2.3.2. Tapioca Industry Waste

The tapioca industry process will generate wastewater, solid wastes and gas emissions. The solid waste is in the form of cassava's skin and cut, while the wastewater is normally generated from the washing process. Also the tapioca starch process generates pulp and wastewater. By the drying process, cassava pulp will become fiber (*onggok*). The fiber contains protein less than 5%, so it can be fermented and utilized as cattle feed. For every tonne cassava processed, 250 kg tapioca starch is produced and 114 kg cassava fiber is generated. Wastewater from the washing and starch process is commonly treated in a WWTP, which consists of several units such as screening unit, sedimentation unit, facultative anaerobic unit, aerobic unit and in the end, a fish cultivation pond is used before the treated wastewater is disposed to the irrigation system. Usually CH_4 is produced in the anaerobic process. When the methane is not used or burned, then the GHG emission will be generated.

2.2.3.3. Livestock Waste

Big parts of livestock population consist of dairy cow, cow for slaughtering, buffalo and horse, while lambs and pigs are of small population. Animal husbandry waste is waste that comes from farm and the slaughterhouse. Slaughterhouse in Indonesia has the function also as cow/buffalo market, where the livestock stays more than 4 days. The wastes generated are wastewater, solid waste and others. Until nowadays compost, fertilizer and liquid fertilizer are output from the processing of solid wastes. Some times, the solid waste is processed to become an additional energy in rural area and is used as fuel. The wastewater and solid waste is treated biologically or physically and if it is treated biologically, methane is generated and can be used as fuel substitute.

There is no detailed data in the national livestock waste utilization and treatment available. But it is quite sure, that most of the livestock waste is composted and treated anaerobically and the gas generated from the anaerobic process can be utilized as energy.

2.2.3.4. Sugar Cane Industry Waste

From the sugar cane plants, there are 3 parts that can be utilized, which are bud leaf as a cattle feed, the residue for the fuel/energy in the factory and the trunk, which is processed for sugar. From the process of making sugar from the sugar cane trunk, only 8% from the total volume will become sugar, the rest are residue (35%), drops (4.5%), filter cake/*blothong* (4%) and water (33.5%). The residue can be utilized as fuel (23%), fungi media and for paper (5%) and brake canvas (2%) production. The filter cake/*blothong* can be further processed for compost and molasses can be used as raw material to make monosodium glutamate or alcohol/bio-ethanol. The water is commonly recycled (not discharged). There are no fixed data for sugar cane available, but is estimated, that the GHG emissions from this industry are very limited.

2.2.3.5. Pulp & Paper Mills Waste

Pulp and paper are manufactured from raw materials containing cellulose fibers, generally wood, recycled paper and agricultural residues. The significant environmental impacts of the manufacture of pulp and paper are resulting from the pulping and bleaching processes. In some processes sulfur compounds and nitrogen oxides are emitted to the air, and chlorinated and organic compounds, nutrients, and metals are discharged to the wastewater. Wastewater is discharged at a rate of 20 to 250 m^3/t of air-dried pulp (ADP, air-dried pulp is defined as 90% bone-dry fiber and 10% water). Wastewater is high in BOD, relating to figures of 10 – 40 kg/t of ADP or approximately 10,000 to 40,000 ppm BOD. The value for TSS (= total suspended solids) is 10 – 50 kg/t of ADP and for COD the value is 20 – 200 kg/t or approximately 20,000 to 200,000 ppm of ADP.
The major concern of solid wastes includes wastewater treatment sludge (50 – 150 kg/t of ADP). Solid materials that can be reused include waste paper, which can be recycled, and bark, which can be used as fuel. Lime sludge and ash may need to be disposed off in an appropriate landfill. This industry has also no data available, but has a big potential to generate GHG emission when the wastewater is not treated in proper way.

2.3. Existing Regulations and Policies

The solid waste, wastewater and emission gas waste management from the domestic and industrial source is carried out in order to increase the public health, prevent environmental pollution and protect the fresh water resources as stated in the National Act for Environmental Management number 23/1997 (UU no 23/1997 tentang Pengelolaan Lingkungan Hidup) and in the Solid Waste Act (UU no. 18/2008), the Water Resource Act (UU no 7/2004) and in Government Regulation (PP no 16/2005).

The National Policy of Solid Waste Management (SWM) is based on the Ministry of Public Works Decree no 21/PRT/M/2006. It is focusing on reducing the amount of waste at source (3R), improvement of landfill quality and regional landfill development, strengthening the institutional capability, improvement of related stakeholders as a partner of SWM and improvement of investment sources. The national policy is still in line with the solid waste management act focusing on reducing of the amount of waste from sources, open dumping closure by 2015 and improvement of disposal site as a final treatment (including LFG = land fill gas utilization).

The target of national policy on SWM are:

1. To support the level of service towards 60% in the year 2010
2. To support reducing amount of waste up to 20% in year 2010
3. To improve landfill quality:
    - Controlled Landfill (CLF) for medium and small cities
    - Sanitary Landfill (SLF) for metropolitan and big cities
    - Open Dumping Closure
4. To support the institution performance and regional cooperation

Currently, on local level the implementation of SWM is based on the local government regulation related to SWM organization, retribution fee and solid waste handling from source to landfill site. The biggest problem is on law enforcement, which is very weak in implementation.
On the other hand, some related regulations regarding the wastewater issue are available. The National Water Resources Management Act number 7/2004 point out that the wastewater management is very important to support the fresh water resources conservation. The water resources management system is in more detail controlled under the regulation number 16/2005 about the drinking water supply system development. Besides that, government regulation number 82/2001 (PP no 82/2001) controls the industry

to follow the maximum standard of quality of the industrial wastewater before it is discharged into the river. For the hazardous waste, regulation number 74/2001 (PP no. 74/2001) is available to control the issues.

2.4. National plan

Based on the 2004 National Action Plan on Solid Waste, there are two policies regarding the domestic waste issue. First policy mentions, that the domestic solid waste should be reduced as much as possible,, reused and recycled (3R) before disposed in the SWDS. The second policy mentions, that the domestic waste management is carried out by integrating the community participation. These two policies are used as a basic principle of the domestic waste management as described in the Solid Waste Act. The principle of waste management will be the management from “cradle to grave” and the disposal area (*Tempat Pembuangan Akhir/TPA*) will not be considered as final disposal site but it will be considered as final processing site. In the meanwhile, active participation of the community in reducing, reusing, and recycling of waste will be started on the household level by changing the habit towards a clean and healthy lifestyle. Also the industrial participation will be carried out by supporting the Extended Producer Responsibility (EPR) principle for the hazardous waste producer and importer.

In the wastewater management issue, future development will focus on increasing the availability for the wastewater treatment facility for urban and rural areas. Currently the low degree of services has resulted in a high number of waterborne diseases in the urban and rural areas and has also lowered the quality of the ground water and surface water as a drinking water resource. The national target is, that Indonesia will not have any open defecation by the end of 2009 and that 50% of the community will have access to the wastewater treatment as stated in the MDG target by the end of 2015.

The national plan for plantation estate in Indonesia is protected by the Agricultural Ministry and according to the Agricultural Ministry, there is a law for plantation estate no. 18 year 2004 and its contents are as follow:
Plantation estate has strategic and important role in national picture, especially for improving the prosperity and welfare of people, devisal acceptance, job creation, added value gain and competition, domestic consumption needs, domestic industries raw material and also for optimizing the sustainable resources.

The development of plantation estate is done based on the technical culture of plant estate in the term of management that has economical benefit to sustainable resources. The sustainability of plant estate will give benefit to the improvement of prosperity and people welfare through the chance of getting access to resources, information, foundation, technology and management.

Plant estate activities are usually less affected by the monetary crises in Indonesia. Therefore, the plant estate should be protected, opened, managed and utilized through a good integrated planning. The professional should have responsibility for improving peoples economic situation, as well as impacting on national and country level. In a geographic territory, which produces specific plant estate product, the sustainability must be protected by geographic indication. The territory then is prohibited for use for another interest.

To prevent disturbances and avoid environmental damage, therefore every plant estate company has an obligation to perform and implement an environmental impact analysis and an environmental management risk assessment. Environmental friendly operation of plant estate can be done if it is supported by knowledge and appropriate technology and also equipped with the professional skill of human resources.

Research and development of plant estate could be done by personal, government research institution or private institution. Research institution can cooperate with companies or with commodity and/or foreign researcher. Government, province, district or city and plant estate entrepreneur could serve facilities to support research institution.

Improvement of human resources of plant estate could be done through education and training, information and/or development of methodology by giving attention to plant estates needs and the community cultural background, which is matched with knowledge and technology.

Financial aid is needed to support plant estate. The financial support could be assured from the domestic or foreign finance institution, from community, from private enterprises and government and from provinces/district/city. Therefore, government is to push and facilitate the financial institution, which is suitable for the needs and characteristics of plant estate.

According to the points as mentioned above, the law has the aim to give basic laws for the plant estate executor. In this case palm oil estate is also following the law of Plant Estate no. 18 year 2004.

In the future, palm oil growth will give a good prospect in view of price, export and product development aspects. Furthermore, palm oil products are processed as conventional products like CPO etc, but also as renewable energy for replacing dwindling fossil fuel reserves.

Government's policies for supporting palm oil development are: (1) to increase productivity and quality of palm oil, (2) to increase product development and to add value, (3) to integrate palm oil industries and (4) to facilitate support funds. Other agro industries or plantations such as tapioca, sugar cane, cacao are also getting support by the government.

3. INITIAL REVIEW OF OPTIONS AND RESOURCES

3.1. Greenhouse Gas Inventory of Indonesian Waste Sector

3.1.1. Municipal Solid Waste

The GHG emission from the MSW sector are commonly Methane (CH_4) generated from the Solid Waste Disposal Site (SWDS) and composting and CO_2 which is generated from the open burning practice. Emissions from the open burning are more difficult to control than the emissions from the final disposal site (*Tempat Pembuangan Akhir/TPA*). The figure for the Indonesian population is 218,868,791 inhabitants (in 2005). With the MSW generation rate of 0.61 kg/cap/day, Indonesia generates about 48.7 Mt/yr of MSW.

Most of the Indonesian MSW in urban area is transported to SWDS (40%), other parts are dumped, composted and recycled or open burned. In total (urban and rural area), only 18% from the total MSW is transported to the SWDS (BPS, KLH, 2005). According to that data, using the Methane Correction Factor (MCF) of 0.8 (*2006 IPCC Guidelines for National GHG Inventory*), the population growth of 1.3% per year and the waste production of 0.61 kg/cap/day, the total emission from SWDS in the year 2006 from SWDS is 76 Gg CH_4 for that year. For getting an indication on the total volume of methane being produced in the SWDS sector, we also have to assess the emissions from the previous waste volumes put into SWDS in the different years. MSW would emit methane after the disposal for nearly 20 years with a descending intensity. By using a simplified approach (smaller population in the previous years, 5% decline in percentage of waste being deposed in SWDS) one can assume a total of 350 – 400 Gg CH_4 being emitted in the year 2006.

For the case of open burning and/or natural decomposition of waste we can also assume that the portion of biodegradable waste would be quite high. As this process is combustion or aerobical decay only CO_2 from the process and no other GHG are released. As most of the CO_2 is not regarded as contribution to GHG (biomass based), the impact on the GHG balance of Indonesia is limited. As also stated above, the figures for waste utilization are not available in detail.

3.1.2. Wastewater

Wastewater can be a source of methane (CH_4) when treated or disposed anaerobically. The CO_2 emission from wastewater is not counted according to the IPCC guidelines, because it is classified as a source of ‘biogenic origin’ so it is not totally a part of greenhouse gas emission. By observing the existing percentage, the largest part of the wastewater in Indonesia is domestic wastewater.

The domestic wastewater commonly is the mix of black water (from toilet) and grey water (from kitchen). In every city, black water generally is processed by a septic tank (on-site sanitation). Meanwhile, grey water is only flowing to the ditch. Centralized services are only offered by some cities and generally consist of lagoon type aerated system, rotating biological contractor (RBC), UASB or oxidation ditch. The processing of this different methods generally will generate sludge, that need to be processed before it is disposed to the environment.

The GHG emission potential from domestic wastewater sector in Indonesia can be estimated from the number of population and the BOD weight per capita per day. For calculating the amount of CH_4 generation from domestic wastewater, for the population increase 1.3% per year is used as assumption and a BOD weight number of 40 g/cap/day with the methane generation potential is 0.6 kg CH_4 per kg of BOD wastewater is set as standard. Besides that, by using the IPCC model method, it is also assumed that the urbanization fraction for Indonesia is rural (0.54), urban high (0.12) and urban low (0.34), while on the other hand, the conversion to the sludge fraction based on the WWTP data in the Department of Public Work is 24.48%.

By using those data based on the population number in 2005, the number of the CH_4 potential generation from domestic wastewater is around 340 Gg CH_4/year. In each city, the potential CH_4 emission is Jakarta with 11.7 Gg CH_4/year, Surabaya with 4.3 Gg CH_4/year, Bandung with 3.8 Gg CH_4/year, Medan with 3.2 Gg CH_4/year and Semarang with 2.2 Gg CH_4/year. The total potential emission from domestic wastewater in the 10 major cities as described in Table 2-1 is 36.5 Gg CH_4/year.

3.1.3. Agro-Industry Waste

GHG emission originate from the raw material, the waste product and the manure, exhaust gas from the industrial process and also from the wastewater treatment. There is a methodology approach, which helps to calculate emissions from different sources (methodology of UNFCC). The amount of emission is different for different industries and depends on its production process, waste characteristic and waste management system. Another major source is from the farm waste, when it is treated in anaerobic conditions or it is discharged to the environment. For converting CH_4 emissions into the equivalent amount of CO_2 emissions, a conversion factor of 21 has to be applied. The latter expresses the higher Global Warming Potential of CH_4.

3.1.3.1. Palm Oil Industry

Based on the findings in the previous chapters the total amount of GHG, which could be produced by solid waste and the wastewater generated through the production of palm oil in the palm oil plantation and the milling industry, can be assessed. The summary results are displayed in the following table. The methane emissions are expressed as CO_2 equivalents in the last row according to the conversion factor of 21. The largest contribution to GHG emission is from the wastewater with some 1.3 million tonnes of CO_{2e} followed by the portion by empty fruit bunch and smaller amounts for the shells and fibers.

Table 3-1: CH_4 Emissions from Waste by Type of Palm Oil Production Waste

No	Description	Average[2]	Waste Conversion	Total Waste	Emission CH_4	Emission CO_2e [3]
		(t/yr)	(%)	(t/yr)	(t/yr)	(t/yr)
1	Palm oil production (FFB)	9,816,393				
2	Part of waste					
	- Empty bunch (t/yr)		23	2,257,770	27,093	568,958
	- Shell (t/yr)		8	785,311	9,423	197,898
	- Fiber (t/yr)		12	1,177,967	14,135	296,847
	- Wastewater (m^3)		0,66 m^3/t FFB	6,478,819	61,224	1,285,721

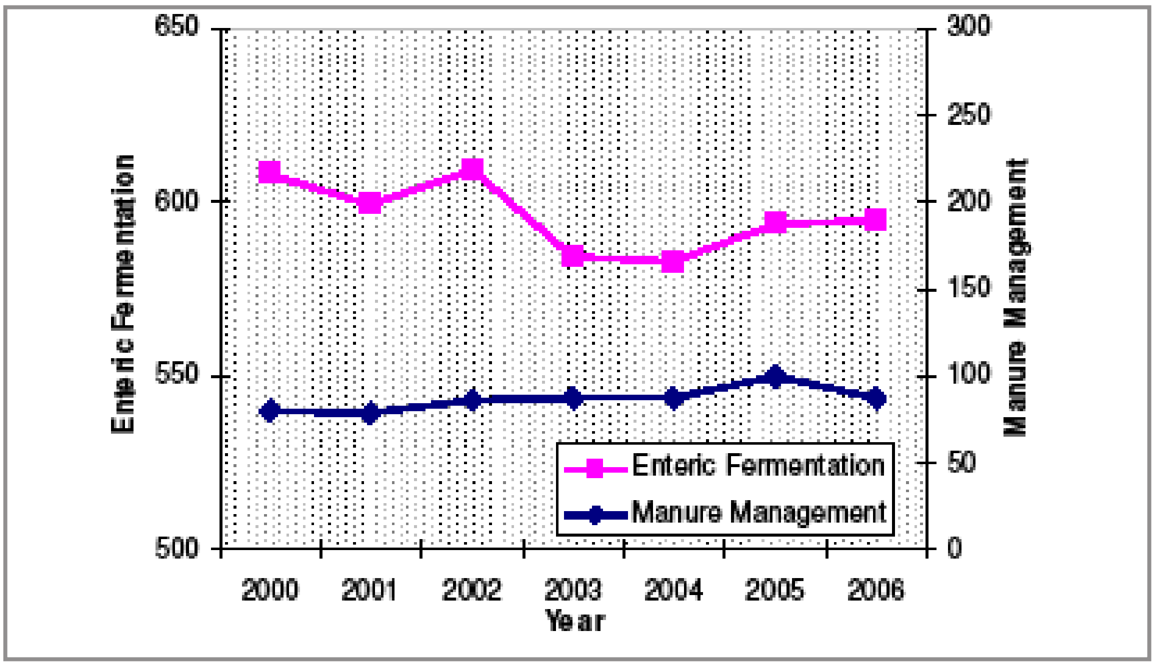
Source: 2) Central Bureau of Statistics (BPS), 3) IPCC 1996 Revised Guidelines for National Greenhouse Gas Inventories

3.1.3.2. Tapioca Industry

The waste streams and the potential GHG emissions from the different parts in the tapioca industry have been explained before. Taking the different ranges and sources into account and calculating an average GHG emission with some assumption, the final generation of methane from that sector is assessed to 288.57 Gg CH_4/year.

3.1.3.3. Livestock industry

By counting the amount of the farm animal population, the waste amount and the potential methane gas emission, the total of methane gas generated from the farm sector in the national level can been seen in the following table.
Indonesian methane emission from livestock during 2000 – 2006 is presented in the following figure as well. The average total emission by enteric fermentation of the country during 2000 – 2006 was 596.07 Gg CH_4. Emission from enteric fermentation decreased slightly from 607.89 Gg CH_4 in 2000 to 594.83 Gg CH_4 in 2006. In term of total methane emission from livestock, enteric fermentation contributed 89%.



Source: Second National Communication,KLH, 2008

Figure 3-1: Actual CH_4 Emissions from Livestock in Gg CH_4/year, 2000 – 2006

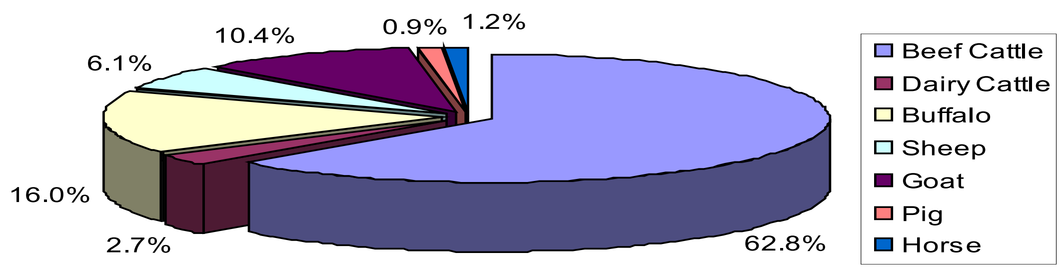
Enteric fermentation was the most important source methane emission. Distribution of methane emissions by animal's types is shown in the following table. Methane emission from enteric fermentation was largely dominated by beef cattle with more than 11 million AU contributing 62.8%. The second largest amount of emissions came from buffaloes (16.0%), and the third from goats (10.4%; see also Figure 3-2).

Methane emission from manure management in 2002 reached 79.67 Gg CH_4. Methane emission from manure management was small compared to enteric fermentation. It was 12% of the total emission from livestock. Methane emission from manure management was dominated by pig contributing 46.1%, followed by dairy cattle (10.3%) and beef cattle contributed the third largest emission (10.2%; see also the following table). The potential GHG emission from livestock comes from animal which is stay in a stable such as diary cow, cattle beef and chicken broiler. While other live stocks such as buffalo, horse or duck have difficulties in collecting their wastes.

Table 3-2: CH_4 Emissions from Livestock by Animal Type

No.	Animal Types	Number of Animals*	CH_4 Emissions from Enteric Fermentation	CH_4 Emissions from Manure Management	Total
			(Gg CH_4/yr)	(Gg CH_4/yr)	(Gg CH_4/yr)
1.	Beef Cattle	8,121,691	381.72	8.12	**389.84**
2.	Dairy Cattle	265,744	16.21	8.24	**24.45**
3.	Buffalo	1,766,248	97.14	3.53	**100.68**
4.	Sheep	7,414,965	37.07	1.48	**38.56**
5.	Goat	12,613,108	63.07	2.77	**65.84**
6.	Pig	5,247,200	5.25	36.73	**41.98**
7.	Horse	412,919	7.43	0.90	**8.34**
8.	Poultry:				
	Native Chicken	261,132,020	-	5.22	**5.22**
	Broiler	534,810,990	-	10.70	**10.70**
	Layer	69,702,890	-	1.39	**1.39**
	Duck	29,674,120	-	0.59	**0.59**
	Total		**607.89**	**79.69**	**687.58**

*The population number of beef cattle, dairy cattle and buffalo are expressed in Animal Unit; the other animals are expressed in 'head'
Source: Second National Communication, KLH, 2008



Distribution of methan emission from enteric fermentation (Gg CH4) by species type

Source: 2nd National Communication, MoE, 2008

Figure 3-2: Contributors to CH_4 Emissions from Enteric Fermentation

3.1.3.4. Sugar cane industry

Most of the waste and byproducts in the sugar industry is used in the production process (e.g. the bagasse in producing steam and electricity). On a smaller scale only wastewater is produced which would have a potential for GHG. Based on the present production figures the amount of GHG is assessed to 356 tonnes CH_4/year.

3.1.3.5. Pulp & Paper Industry

As mentioned before information on details in the pulp and paper industry is not sufficient to come to a final conclusion. However, the total potential for GHG emissions from untreated or not properly treated wastewater would be smaller as in the other identified main sectors.

3.1.3.6. Summary of GHG emissions in the sectors

The following table summarizes all the findings from the assessment of the different sectors.

Table 3-3: CH_4 Emissions by Type of Waste

Waste Type and Origin	CH_4 emission (t/yr)	CO_2e emission (t/yr)
Solid waste		
- from 1 reference year	76,000	1,596,000
- estimated for all disposed waste to date	350,000 to 400,000	7,350,000 to 8,400,000
Wastewater sector on average	340,000	7,140,000
Palm Oil		
- Empty bunch	27,093	568,953
- Shell	9,423	197,883
- Fiber	14,135	296,835
- Wastewater	61,224	1,285,704
Tapioca/Cassava	288,572	6,060,012
Livestock waste	687,580	14,439,180
Sugar cane waste	356	7,476
Pulp & Paper	n/a	n/a

As can be seen in Table 3-1, the highest GHG emissions are from livestock. But some 90% of livestock emissions is enteric, so actually there is a lack of real technical solution to mitigate emissions from that sector. Next important in total emission then is the contribution by MSW being deposited in landfill and the emissions from the wastewater treatment in residential, industrial and commercial areas. From the group of agro-industries the tapioca wastewater and then the wastewater in palm oil mill are important emission sources for GHG. In a conclusion, it remains that the three main areas should be solid waste management, wastewater treatment improvement and proper wastewater treatment in agro-industry and here especially in tapioca and palm oil.

3.2. Mitigation Potential

Mitigation of GHG emissions can be done after the identification of the emission potential and its source is done. Commonly mitigation of the GHG emissions can be done in the place where the waste is collected (accumulated) in the big volume and under anaerobic condition. For the municipal solid waste, landfills are the most significant GHG emitter. And for domestic wastewater sector, GHG emissions are generated from latrine, septic tank, and centralized off-site plant. For the industrial wastewater, GHG emissions are generated from the WWTP.

Based on the Indonesian population in 2005 (Supas 2005), using FOD IPCC Tier-2 Method, CH_4 generated from MSW sector (landfill only) in 2005 is 76 Gg CH_4 and will be increased up to 313 Gg CH_4 in 2010, 577 Gg CH_4 in 2015 and 862 Gg CH_4 in 2020 (detailed calculation in Annex 1) The increase number of this CH_4 emission is caused by the increase of population number that will increase the waste production and also increase the volume waste that is collected in the disposal area. The increase of service of waste collection in the disposal area will increase the methane emission if the management of disposal area is not parallel improved. This calculation is based on the unavailability of technology intervention and waste management model/business as usual (BAU).

The future scenario by referring to the national strategic plan, which is developed by the Public Work Department, is that the waste should be reduced from the source, so the total volume will be reduced by 20% in 2010. In 2015, referring to the MDG target, 80% of the MSW in urban area and 50% of the MSW in rural area should be transported to the final disposal site. As stated in Solid Waste Management Act No 18/2008 and in accordance with the fresh water protection, improvement of landfill quality from open dumping to sanitary landfill or controlled landfill and development of regional landfill are the priority programs with national financial support as an initial investment.

Beside that, nowadays, there are some efforts to recover LFG from the open dumping site (existing) in the scheme of CDM. It is also contributing to the GHG emissions reduction in the sub-sector landfill (in the Fig. 3, the term is CDM-OD).

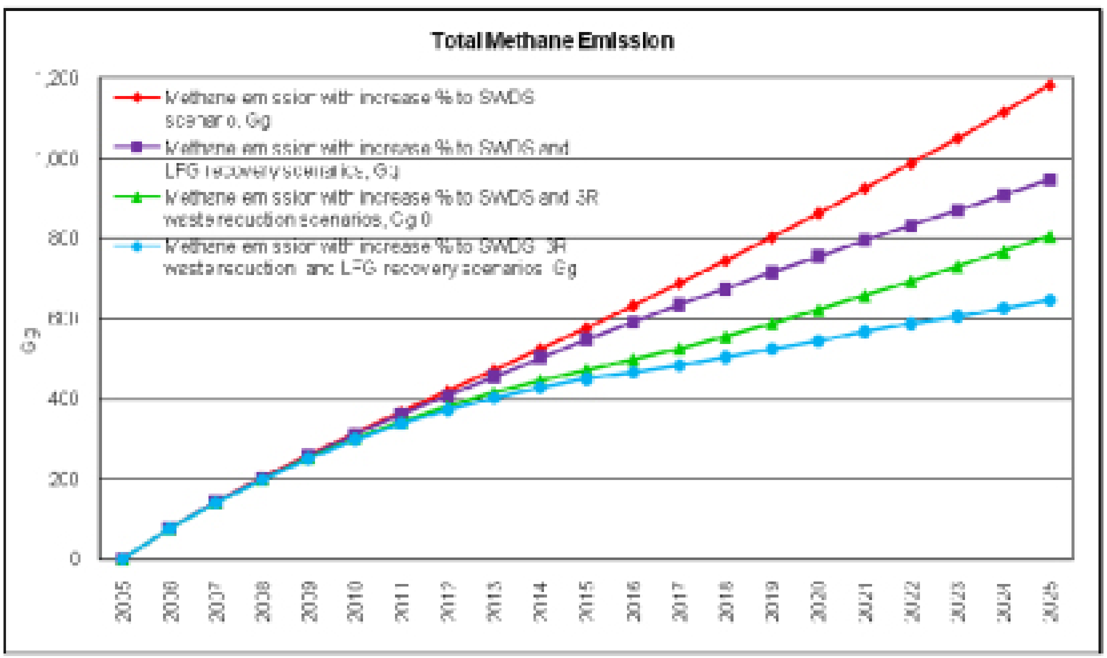


Figure 3-3: Projected CH4 Emissions from Waste, 2010-2025 (Municipal Solid Waste Scenario)

I in every year, the LFG in one open dumping site is recovered, we can assume that the GHG emissions will be reduced by 5% in 2025. The efforts to reduce the waste in the final disposal site by 3R techniques will also reduce the GHG emissions by around 5%. The significant reductions of GHG emissions will be achieved by closing the open dumping landfills and develop sanitary landfills with LFG recovery technology. Based on the Solid Waste Act, all open dumping sites should be closed by 2015, it is predicted that 50% GHG emissions will be reduced from the landfill sector. This scenario was developed by also including the level of services as MDG target. However, there is also uncertainties factor in this prediction. Figure 3-3 shows that scenario.

For the domestic wastewater, using the year 2005 data, the calculated methane emission is 340 Gg CH_4 /year. With business as usual (BAU) and the population rate of 1.3% per year, the methane emission in 2010 will be 364 Gg CH_4 and it will increase to 390 Gg CH_4 in 2015 and finally 419 CH_4 Gg in 2020. The increased number of individual and or collective septic tank would not automatically decrease the amount of emissions because it really depends on the control of the generated gas. Controlling the methane gas capture will not be effective for individual septic tank; therefore GHG emissions mitigation will be effective only in the centralized WWTP. However, the public service for centralized WWTP is still very low.

The expected scenario is the implementation of GHG emissions recovery in communal wastewater plant and industry. The methane emission reduction cannot be done in the individual/households septic tank. It can only be done in the available sewerage treatment plant by increasing the number of services. If GHG emissions can be consistently reduced by 1%, the emission in the year 2020 will be 20% lower from the emission level in 2005. The following figure shows the scenario.

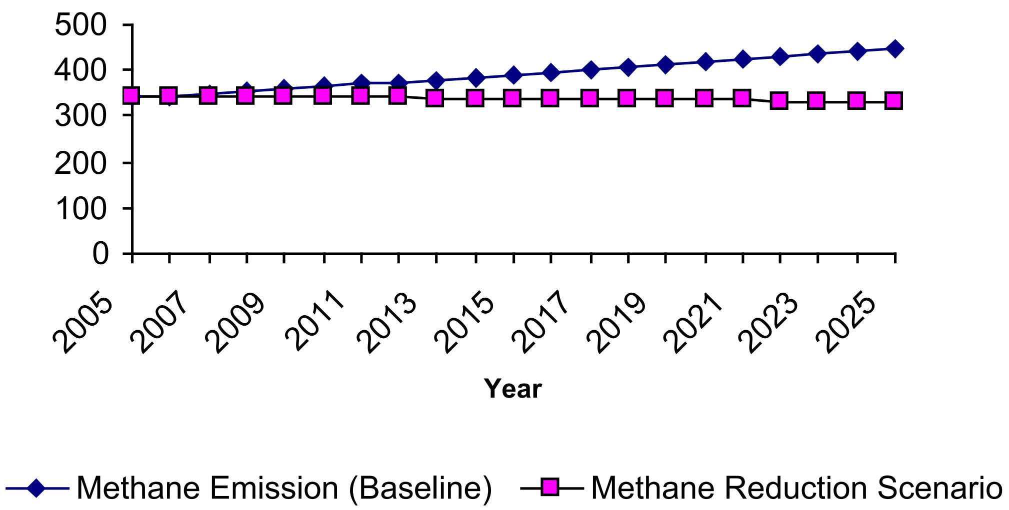


Figure 3-4: Projected CH_4 Emissions from Waste, 2000-2025 (Wastewater Scenario)

The scenario of agro industry especially for palm oil is until up to 2012, where according to production and consumption balance in the world, vegetable oil production will grow to 108,512,000 tonnes and it is assumed that 30,8% of them comes from palm oil sector. On the other hand, vegetable oil consumption will reach 132,234,000 tonnes. However, we are just able to develop 450,000 ha which consist of new planting of 350,000 ha and plant rehabilitation (replanting) of 100,000 ha. When all the waste of palm oil is treated well as raw material for energy, there will be no waste anymore and the palm oil industry will discharge GHG emission, which comes only from the burner and electricity used.

3.3. Key Sector Issues

Policy issues (regulation) as an umbrella for all activities regarding the waste management particularly the domestic solid waste management in Indonesia is focusing to the new Solid Waste Act. Since it is legitimated, the domestic waste management in each city in Indonesia should follow the Solid Waste Act. According to the act, the domestic waste management activity is a domain of public service by the local government, where the management principle is 3R (Reduce, Reuse, and Recycle) and supporting the producer and importer to do EPR (Extended Producer Responsibility).

Other key issue that is included in the Solid Waste Act is that the regulation for local government (*kabupaten/kota*) to close the open dumping final disposal site (*TPA open dumping*) and replace with the controlled landfill for small and medium city and with sanitary landfill for big and metropolitan city by 2015 and local government should do monitoring and control for the closed final disposal site up to 20 years.

Financial issue commonly related with the reality that the local government budget allocated for the domestic waste management (< 3%), it shows that the SWM development is not the priority. In the future, it is hoped that the waste management in Indonesia will be based on the 'self financing' initiative, such as local sanitary enterprise or *Badan Layanan Umum* (BLU). Beside that, the financial issue is also related with the proportion of the yearly national budget compare with the yearly local budget allocated for the domestic waste management, and with the amount of retribution collected from the community for the domestic waste management. This is because of the local government has responsibility in the waste management and the central government just has task for support, except in the interlocal government development or issues.

Organizational and management aspect is one of the important issues for the city domestic waste management. Currently, there are various organizational forms for the domestic waste management in the local level, such as sanitary sector under Public Works Office (*Dinas Pekerjaan Umum*), local technical implementation unit (*Unit Pelaksana Teknis Daerah*), Cleansing department, and local sanitary enterprise. The organizational format is developed based on the city scale, service area and also the waste problem and complexity. Since the local sanitary enterprise is not subsidized by the local government the effectively collected retribution from community for the domestic waste management is really important. And since the Solid Waste Act and Government Regulation No 41/2007 are legitimated, every city (*kota/kabupaten*) should be changed properly.

Technological and operational aspect in the waste management is related with the reduction technique from the source, technique of collection, technique of transporting, and technique of the waste final treatment or sanitary landfill. One important issue in the 3R (reduce, reuse, and recycle) program is campaign support which have to be done effective and regularly,. For the final disposal technology choices, some cities have showed enthusiasm to develop a waste to energy incinerator as one of the treatment choices. Based on the Solid Waste Act, the most important technology that should be developed soon is the sanitary landfill technology with the LFG recovery. In the wastewater issue, the technological aspect is related with the development of the communal scale waste waster treatment (WWTP) or decentralized treatment system.

From all issues described above, the most important issue is the social aspect which is community participation. Without the community participation, all planned activities related with the waste management program will be hindered. The significant approach to the community should be made to help the government program regarding the waste management issue. Other social aspect that should be considered is the community lifestyle that should support the waste management program.

In the wastewater sector, the priority issue is the low number of the coverage service in the rural and urban area. It turns into a high amount of the water borne diseases and a low quality of the ground water and surface water as drink waster sources. Besides that, the key issue is in relation with the MDG target in the wastewater sector, where open defecation free will be realized in 2009 and 50% of the community will receive the wastewater treatment service in 2015. For the livestock waste, the key issue is the low quality of the environmental hygiene in the animal husbandry, and the low number of the waste utilization to energy, fertilizer and other products. In agro industrial sector, the key issue is the low presence of the efficient process levels and the proper energy utilization. This fact would cause the big quantity of the produced waste.

4. TECHNOLOGY CRITERIA AND OPTIONS

4.1. Selection Criteria of Technology Assessment

4.1.1. General Criteria

In accordance with national interests and policies general criteria are set for national technology transfer priorities in the waste sector as follow:

Table 4.1: General Criteria for Technology Selection

General criteria	Sub-Criteria
a. Conformity with national regulation and policy	• Food security (FS) • Natural resource security (NR) • Energy security (ES) • Incentive for participation (IP)
b. Institutional and human development	• Capacity building (production & know how) (CB)
c. Technology effectiveness	• Reliability of technology (RT) • Easiness of wider use of technology, including local contribution support of technology application (ET)
d. Environmental effectiveness	• Greenhouse gas emissions reduction (GR) • Improvement of local environmental quality (LE)
e. Economic efficiency and cost effectiveness	• Capital and operational costs relative to alternatives (COC) • Commercial availability (market) (CA)

4.1.2. Specific Criteria

In the technology application regarding the waste treatment, some specific criteria, which are related with the area and social culture aspect where the technology will be implemented should be considered to support the sustainability.

For example, the composting technology implementation should consider the location of the farming area near the composting plant. It is related to the marketing issue, where the cost of compost fertilizer as the output of the composting process, really depends on the transportation cost. If the target user is located near the composting plant, then the cost will be minimized and the user will be motivated to use the compost as fertilizer rather than the anorganic fertilizer.

Regarding the implementation of the Municipal Solid Waste technology, one criterion that should be considered is the management of the scavengers. The technology that is chosen should solve the problem of the scavengers in Indonesia. For example in the sanitary landfill site, the scavengers should be located on the recycling unit part. The scavengers are really much related to the high figure of unemployment in Indonesia.

The social and culture aspect is also should be considered in the implementation of the domestic wastewater technology specifically in the communal scale level. In Indonesia, each region has specific characteristic in how they treat or dispose their black wastewater.

In the short brief, the additional criteria of the specific criteria for waste sector are:

Table 4.2: Specific Criteria for Technology Selection

Specific Criteria	Sub-Criteria
General concern	• Close connection to the local market (solid waste) • Support of sustainability • Alignment with regulations • Accommodation for scavenger (solid waste) • Alignment with traditional characteristics (wastewater)

On the implementation level, some other criteria should be followed. For example, selection of the final disposal site (TPA) must be in line with the regulation (SNI No. 03-3241-1994). And also for the implementation of incinerator, the community condition near the location should be considered. And for the 3R application, the motivation of the community, composition and the characteristic of waste are very important to be considered. For the Intermediate Treatment Centre, in which the 3R would be applied, it should be differentiated between big, medium and small cities. Specific criteria for agro industry waste is, that generated waste has to be as long as possible be used as raw material for another product, so the waste of agro industry will be something valuable such as raw material for energy, compost for fertilizer, particle board and so on. Nowadays, agro industry waste is not treated well yet, so it is still to be waste.

4.2. Resources and Technology Options Review

4.2.1. Municipal Solid Waste

4.2.1.1. Sanitary Landfill with LFG recovery

The disposal of MSW produces significant amounts of methane (CH_4) and carbon dioxide ($CO_{2)}$. Methane produced at SWDS contributes approximately 3 – 4% to the annual global anthropogenic greenhouse gas emissions (IPCC, 2001).

Globally landfill gas (LFG) recovery has become a more common technology to reduce CH_4 emissions from SWDS. In Indonesia the transfer of LFG recovery technology and its methodology is still needed. Such LFG recovery technology should be suitable for CH_4 recovery both in open dumpsites and sanitary landfills. Although some research institutes together with foreign partners have tried to explore the potential of CH_4 recovery, Indonesia's experience is still limited.

The country also needs sanitary landfill technology, which is suitable for Indonesian conditions and can replace the currently used open dumpsites. The replacement of open dumpsites by sanitary landfills will not directly reduce GHG emissions, but it can improve the overall environmental conditions, obedient to Indonesia's Solid Waste Act. A reduction of GHG emissions from sanitary landfills can be achieved by adding an LFG recovery system.
Based on the experiences of sanitary landfill development in Bangli and Gorontalo and on other research results, the application of sanitary landfill technology in remote areas (inland areas) need a budget of 300,000US$/ha – 500,000US$/ha (1US$ = 9,300Rp.). In coastal areas a budget of 400,000US$/ha – 600,000US$/ha has to be calculated. The difference originates from a different ground lining work factor. The budget has included the LFG recovery system. The benefit will be gained by deciding the tipping fee to 6 to 10USD/tonne MSW with 6,000 tonnes/day and the minimal tolerance waste input is 800 tonnes/day. The operational and maintenance budget is around 3 to 4USD/tonne MSW.

4.2.1.2. Composting

Composting is an aerobic process, where a large fraction of the degradable organic carbon (DOC) in the waste material is converted into CO_2 and compost. CH_4 is formed in anaerobic sections of the compost, but is oxidized to a large extent in the aerobic section of compost. The estimated CH_4 released into the atmosphere is only less than 1% of the initial carbon content in the material (IPCC, 2006). It means that composting can avoid the methane production from MSW.

The low-tech system of composting is widely used in several Indonesian cities using windrow composting systems. If an open windrow system is treated in the proper way, it will generate a high quality compost. Such system is operated manually involving the support of scavengers to segregate the waste. A composting technology, which can produce high quality of compost is needed, because of the high demand for compost (organic fertilizer) for organic agriculture. There are several composting technologies that can produce high quality compost under tight controlled conditions such as the mechanical windrow system.

Based on best practice of composting, an application of low-end composting technology needs an upfront investment of 10,000US$ – 20,000US$/tonne cap/day. The associated costs for maintenance and operations are calculated with 20US$/tonne – 40US$/tonne. High-end composting technology requires an upfront investment of 25,000US$ – 50,000US$/tonne cap/day with associated costs for maintenance and operations of 30US$/tonne – 50USD$/tonne MSW.

4.2.1.3. Anaerobic Digestion

Anaerobic digestion of organic waste expedites the natural decomposition of organic material without oxygen by maintaining the temperature, moisture content and pH close to their optimum values. It produces CH_4 that can be used for producing heat and/or electricity. The other gas, CO_2 emission, is of biogenic origin. N_2O emissions from the process are assumed to be negligible.

Anaerobic digestion is also a common method in Indonesia. But it is only popular for treating wastewater from small or big scale livestock. Unfortunately, the experience of anaerobic digestion for treating solid material of MSW is limited. Technologies involve low-solid anaerobic digestion, high-solid anaerobic digestion and combined high-solid anaerobic digestion/ aerobic composting. The transfer of these specific technologies to Indonesia is still needed. Based on the reference of countries, which have already applied the technology, the investment cost for anaerobic digestion lays between 900US$/$m^3$ – 1000US$/$m^3$ waste.

4.2.1.4. Mechanical-Biological Treatment (MBT)

Mechanical-biological treatment (MBT) of waste is becoming popular in Europe. During MBT, the waste material is processed in a series of mechanical and biological operations with the aim to reduce its volume, as well as to stabilize it. GHG emissions from the final disposal site can be reduced that way.

The operation varies in application. Typically, the mechanical operation separates the waste material into fractions that will undergo further treatment (composting, anaerobic digestion, incinerating, recycling). This may include separation, shredding and crushing of the material. The biological operation includes composting and anaerobic digestion. The composting can take place in heaps or in composting facilities with optimization of the conditions of the process as well as filtering of the produced gas. The possibilities to reduce the amount of organic material to be disposed at landfill are large (40 – 60%).

Due to the reduction of the amount of the material, the organic content and the biological activity, the MBT will produce up to 95% less CH_4 than untreated waste when disposed to SWDS. The practical reductions have been smaller and depend on the type of MBT. CH_4 and N_2O emission during the different phase of the MBT depend on the specific operations and the duration of the biological treatment (IPCC, 2006). Indonesian experiences of MBT are still limited. This kind of technology needs to be improved in Indonesia.

The application of low-mechanical intensity MBT technology needs an upfront investment of 10,000US$ – 20,000US$/tonne cap/day and maintenance and operations costs of 20US$/tonne – 40US$/tonne. For high-mechanical intensity MBT technology investment costs are calculated with 25,000US$ – 50,000US$/ tonne cap/day and cost for maintenance and operations with 30US$/tonne – 50US$/tonne.

4.2.1.5. Incineration

Waste incineration is defined as the combustion of solid and liquid waste in controlled incineration facilities. Modern refuse combustors have specially designed combustion chamber, which provide high combustion temperatures, long residence times and efficient waste agitation for more complete combustion. Incinerations are the source of GHG emissions of i.e. CO_2, CH_4 and N_2O. The flue gas treatment is very important in applying the incineration in order to clean the emitted pollutants, such as CH_4 and N_2O but usually not for CO_2.

Big capacity incinerators or incinerator flue gas treatment has not been implemented in Indonesia yet. Such system can potentially be applied in metropolitan cities like Jakarta, Surabaya and Medan. If incinerators are planned to be used for burning MSW, they must be chosen considering their efficiency of combustion and a low concentration of resulting pollutants. Incineration systems are combustion (stoichiometric air) such as mass-fired, RDF-fired, fluidized bed; gasification (substoichiometric air) such as vertical fixed bed, horizontal fixed bed, fluidized bed; and pyrolysis (no air) such as fluidized bed system. The erection of mass burn fields or the application of modular technology need an upfront investment of 80,000US$ – 120,000US$/tonne cap/day. Maintenance and operations costs are calculated with 40US$/ tonne – 80US$/tonne.

4.2.2. Wastewater

GHG emissions from wastewater can be decreased by realizing the national service degree target and implementing technologies, which are sufficient for either on-site or off-site sanitation. According to the national target at least 60% of the community will be able to access wastewater processing services in 2015. This increasing access can be realized if the finance, the suitable technology, and the consumer society preparedness are available. Some cities in Indonesia have some experiences with the 'off-site sanitation' technologies such as aerated lagoon, stabilization pond, oxidation ditch, rotating biological contractor (RBC) and UASB (see also the following table).

Concerning the population density at this moment in every city of Indonesia is different; therefore some strategies are necessary to be developed, such as:

- For cities or provinces that have low population density, the cities are obliged to its citizen to make on site treatment that is suitable with standard, so that the effluent from the on site treatment will not pollute the environment. On site treatment can be done individually or communally. The example system of on site treatment is a septic tank that is modified by added biofilter and aeration.
- For cities or provinces with medium population density, the 'on-site communal' treatment system is very encouraged. The examples of the 'on-site communal' technology are UASB, RBC or biofilter anaerob-aerob.
- For cities or provinces with high population density and also with difficulties to find land in its house district, therefore on city scale off site technology becomes a very necessity.

A complete wastewater processing system consist of chemical physic (primary treatment), biological processing (secondary treatment) and if it's needed tertiary treatment. Chemical physic processing commonly can only reduce pollutant parameter to around 50 – 60%. Using biological processing to treat wastewater can reduce pollutants by up to 90% as shown in the table below.

Table 4-1: BOD Removal Efficiency of Biologically Treatment Systems for Wastewater

No.	Type of Treatment	BOD Removal efficiency (%)
1	Activated sludge (standard)	85 – 95
2	Step aeration	85 – 95
3	Modified aeration	60 – 75
4	Contact stabilization	80 – 90
5	High rate aeration	75 – 90
6	Pure oxygen process	85 – 95
7	Oxidation ditch	75 – 95
8	Trickling filter	80 – 95
9	Rotating Biological Contactor	80 – 95
10	Contact aeration process	80 – 95
11	Biofilter Anaerobic	65 – 85
12	Stabilization ponds	60 – 80

Based on best practice, the cost of wastewater treatment varies and depends on the respective technology as described below:

Table 4.4: Cost of Wastewater Treatment Systems

No.	Type of Treatment	Cost (US$/$m^3$)
1	Aerated Lagoon	800 – 900
2	UASB	900 – 1,000
3	RBC	925 – 1,000
4	Oxidation ditch	400 – 750
5	Stabilization ponds	400 – 550
6	Communal decentralized	200 – 300

Source: BPPT

The investment costs for off-site systems lay between 685US$/$m^3$ (68US$/capita) and 840US$/m^3 (84US$/capita) according to the Department of Public Work.

4.2.3. Agro-Industrial Waste

4.2.3.1. Palm Oil Waste

Basically, the technology applied to treat the wastewater based agro-industrial waste is similar to the technology applied for livestock waste treatment. And for the agro-industrial solid waste treatment, the technology choices are similar to the Municipal Solid Waste treatment. Some of the technologies, which can be used to treat the waste of palm oil production are composting, incineration/ gasification, particle board making and anaerobic- or aerobic biological system to treat the waste water. Such technology can reduce CH_4 emission by up to 80%.

Table 4-2: Technologies for CH_4 Emissions Reduction from Palm Oil Production Waste

No	Waste	Estimation of GHG Emissions/ GWP*			Technology input	Potential Reduct.
		(t CH_4/yr)	(t CO_{2e}/yr)	(t CO_2/yr)		
1.	Empty Bunches 2,257,770 t/yr	27,093	568,958	455,166	- Composting - Advanced/ Efficient Power Generation Technology - Particle board - Mulch	80%
2.	Shell 785,311 t/yr	9,423	197,898	158,318	- Advanced/ Efficient Power Generation Technology - Mulch	80%
3.	Fiber 1,177,967 t/yr	14,135	296,847	237,477	- Advanced/ Efficient Power Generation Technology	80%
4.	Wastewater 6,478,819 m^3/yr	61,224	1,285,721	1,028,577	- Anaerobic Treatment producing Biogas - Aerobic Treatment - Covered Lagoon	80%

* Global Warming Potential (GWP)

4.2.4. Composting

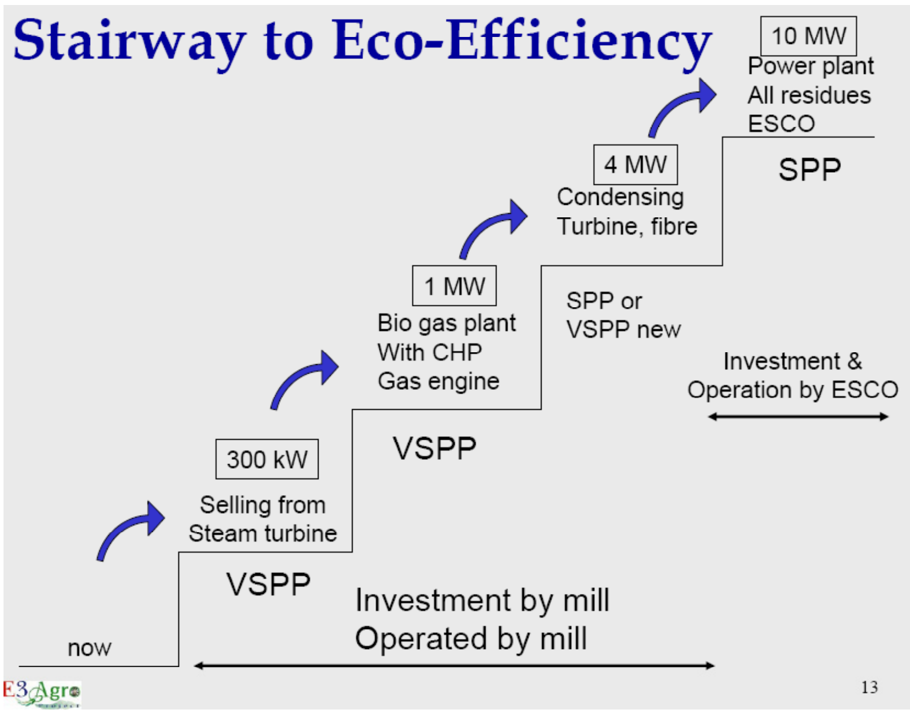
Composting is an aerobic process where the waste material is converted to CO_2 and compost. The low-tech composting system still tries to be applied in some palm oil plant. There is demand of a special crushing technology of empty fruit bunches and a need to accelerate the composting process. The implementation of low-end composting technology needs an upfront investment of 10,000US$ – 20,000US$/tonne cap/day. The associated maintenance and operations costs (O&M) lay between 20US$/tonne – 40US$/tonne. Composting in palm oil industry might be either more expensive or cheaper, depending on the technology and the distance of the composting plants to the fields.

4.2.5. Advanced and Efficient Power Generation

Palm oil based empty fruit bunches usually are burned in the open burning system without controlling the temperature and without flue gas treatment. The fiber and parts of palm 0il shell is being used by CPO plant for steam and electricity generation for their internal purpose and usually the industry still uses the

standard combustion technology (low efficient technology).
Right now the gasification/combustion system is being developed for treatment of the waste and recovering heat potential used to convert to electricity. But the application of the big capacity of combustion units for commercial use supplying electricity to the grid is not yet in existence in Indonesia. These systems can be combustion (stoichiometric air) such as mass-fired, RDF-fired or fluidized bed; gasification (substoichiometric air) such as vertical fixed bed, horizontal fixed bed or fluidized bed and pyrolysis (no air) such as fluidized bed system. The implementation of field-erected or modular mass burning technology requires an upfront investment of 50.000USD per tonne/day and cost for maintenance and operation of 40 – 80USD/tonne.

The most urgent need for reducing GHG emissions from palm oil solid waste in Indonesia is the implementation of advanced, efficient and integrated technology for steam and power generation. It can be used for internal consumption in crude palm oil (CPO) plant or send to the grid. According to the study of the E3 Agro Project in Thailand, “Biomass Energy, Possibilities in Palm Oil Industries”, CPO plants with a capacity of 45tonnes fresh fruit bunch/ hour can generate 10MW electricity from production residues using advanced, very efficient technology (see also the following figure).



Source: E3 Agro, Thailand

Figure 4-1: Integrated Power Generation using Waste of Crude Palm Oil Production

4.2.6. Particle Board

Empty bunch and fiber from palm oil fruits can be used for particle board- or material based fiber production.

4.2.6.1. Tapioca Industry waste

Wastewater and cassava fiber are wastes from the tapioca industry, which have a high priority for the treatment. Currently, many tapioca industries treat their wastewater in the treatment lagoon without any further control and innovation, a lot of industries use this treatment because it is cheap and easy to

maintain. One example for improvements is to do additional effort to recover the biogas generated in anaerob reactors or treatment facilities. Some existing anaerobic technologies are:
Low load technology, which can be applied for the wastewater with characteristic of TCOD less than 2 kg/m^3 day. Some low load technologies are natural cover lagoon and synthetic covered lagoon and plug flow (PF). These technologies are known as a basic technology in anaerobic system. The economical cost of the low load technology really depends on the availability of the local material.

Medium load technology, which can be applied for the wastewater with the characteristic of TCOD between 2-5 kg/m^3 day. Some choices for the medium load technology are Contact Process (ANCP) and Sequencing Batch Reactor (SBR).

High load technology, which can be applied to the wastewater with characteristic of TCOD between 5-20 kg/m^3 day. They are Up Flow Anaerobic Sludge Blanket (UASB) and Anaerobic Hybrids. The economic cost for the UASB is between 900 – 1000USD/m^3 waste (BPPT source, based on calculation of existing condition in Indonesia). Nowadays, the pretreatment technology such as Anaerobic Fixed Film Reactor (AFFR) is developed to treat the wastewater before the lagoon treatment. The benefit of AFFR technology is that the methane can be extracted from the treatment and can substitute the existing fuel used for the heating process in the tapioca industry. The economic cost for AFFR is between 900 – 1000USD/m^3 waste.

The very advanced technology is applied to the wastewater with characteristic of TCOD higher than 20 kg/m^3 day. Currently there are limited choices of the very high technology. Cassava fiber is the byproduct from the tapioca industry with the protein content of less than 5%. The utilization of this cassava fiber as a raw material for the cattle feed is still very limited, especially for the monogastric animals By using the bio technology process, the quality of the cassava fiber can be increased and the protein content can be reached to 18% and if it really used as cattle feed it will help to reduce the impact of GHG emissions. The rest of tapioca solid waste is still high in volume, so it needs more knowledge for application. When the waste is not treated well, it will have an impact to GHG emission.

4.2.6.2. Livestock Waste

There is a possibility for reducing methane production especially for that portion in the sector, that come from animals in stable, so the waste can be collected and treated in proper way. Consequently a reduction of the greenhouse effect is possible. Therefore, it is important to evolve in different ways when reducing methane production from ruminants. The two tables below summarize the technical aspects and the effectiveness of the options of livestock waste treatment to reduce greenhouse gas emissions. Some considerations for their application in Indonesia are also described regarding technology costs, strengths, weaknesses and the relevant research available in Indonesia.

Under that condition, the processing of wastewater and recovery of methane gas can be applied. Methane, that had been collected generally can be burned (flared) or it's used as energy source for heat and electricity. Other efforts in processing farm waste is the composting option, where the ditches are turned around periodically so that aerobic process is happening and by this replacing the methane emission to be CO_2 emissions only.

The upfront investment and O&M costs of composting are 10,000US$/tonne – 20,000US$/tonne and 20US$/tonne – 40US$/tonne respectively. The investment cost for anaerobic digestion lays between 900US$/$m^3$ – 1,000US$/$m^3$ of waste.

Table 4-3: Technologies for CH_4 Emissions Reduction from Livestock Waste

Option	CH_4 Emissions Reduction (%)	Consideration for application in Indonesia		
		Cost	Strength	Weakness
1.Covered Lagoons	80	Cheap	Simple	Environmental hazard
2.Digester	70	Expensive	Double benefit	Need investment
3.Spread on pasture and rangeland	100	cheap	Simple	No energy recovered

Table 4-4: Appropriate Technologies for CH_4 Emissions Reduction from Waste developed in Indonesia

Techniques Available	Status	CH_4 Emissions Reduction	Cost	Strength	Weakness
1. Compost production	Advanced research	Decrease	cheap	Easy to apply, low methane emission	No energy used
2. Direct spread as fertilizer	Advanced research	Decrease	cheap	Increase soil fertility, no methane emission	Depend on slope of land, limited manure utility
3. Small scale digester	Advanced research	Decrease	expensive	Double benefit, energy used	Need investment, complicated application
4. Integrated farming system	Advanced research	Decrease	cheap	Multiple benefit, zero waste, decomposition quickly, effective	Time and skills of the farmer limited, CH_4 emission can be measured

4.2.6.3. Sugarcane Industry Waste

Currently there are 54 sugarcane industries in Indonesia. Sugarcane industry is one of the highest potential industries that are able to recycle their waste to become other products. This effort can minimize the environmental impact by reducing the GHG emissions and also can give an additional income to the industry. The wastes from the sugarcane industry are filter cake (*blothong*), furnace ash, bagasse and wastewater. Some technologies are needed to process filter cakes to become organic fertilizers or briskets, to convert furnace ash into paving blocks, and to convert the bagasse into particle board, boiler's fuel or brake canvas. The needs for technology in sugarcane industrial waste is improving the existing technology for the utilization of blothong and furnace ash. There is also a need for the improvement and application of advanced technology to generate steam and electricity using bagasse and wastewater.

4.2.6.4. E. Pulp & Paper Mills

Wastewater treatment in the pulp and paper mills industry, typically includes (a) neutralization, screening, sedimentation, and floatation/hydrocyclone, to remove suspended solids and (b) biological/secondary treatment to reduce organic content in wastewater and destroy toxic organics. Chemical precipitation is also used to remove certain substances. Fibers collected in primary treatment should be recovered and

recycled. A mechanical clarifier or a settling pond is used in primary treatment. Flocculation, to assist in the removal of suspended solids, is also sometimes necessary.
Biological treatment systems, such as Activated Sludge, Aerated Lagoons and Anaerobic Fermentation can reduce BOD by over 99% and achieve a COD reduction of from 50% to 90%. Tertiary treatment may be performed to reduce toxicity, suspended solids and color.

Solid waste treatment steps include de-watering of sludge and combustion in an incinerator, bark boiler or fossil-fuel-fired boiler. Sludge from a clarifier is de-watered and may be incinerated; otherwise assigned to land fill..

5. TECHNOLOGY SELECTION

5.1. Selection Process

The technology choice for the priority list is an important aspect in this TNA. From the various technologies that already have been described above, the assessment was done by all stakeholders to determine the technology priorities that are suitable and can be applied. Each technology is weighted, based on the 11 general criteria which are (1) food security, (2) natural response security, (3) energy security, (4) incentive for participation, (5) capacity building, (6) reliability of technology, (7) ease of wider use of technology, (8) GHG emissions reductions, (9) improvement of local environment quality, (10) capital & operational costs relative to alternatives and (11) commercial availability.

All stakeholders should agree to give a value with a number between 0 and 1 for each technology in relation to each general criteria and calculated. All 11 general criteria are shown in the assessment matrix. The specific criteria just apply for the high priority technology or the high possibility of the technology to apply.

5.1.1. Solid Waste Management

As already described in the general and specific criteria, the technology selection for the waste treatment should be based on these criteria and also support Indonesian development (for example, a balanced match between energy and food security). The criteria's priorities for MSW management, can be seen in the following table.

Table 5-1: Priority List of MSW Technology

No.	Technology	1	2	3	4	5	6	7	8	9	10	11
1.	Intermediate Treatment											
	- Composting		1	1	1	¾	1	1	1	1	1	1
	- MBT		1	1	¾	1	½	¾	1	1	1	¾
	- W to E Incineration		½	½	½	1	¾	¾	¾	¾	1	1
	- Anaerobic Digestion		½	1	¾	½	½	½	¾	¾	1	1
2.	Final Treatment											
	- Sanitary Landfill		1	1	1	1	1	½	1	1	1	1

Note: Number 1-11 are the 11 general criteria described above

Based on the table above, the assessment is made and the priority lists for Intermediate Treatment Facilities (ITF) are as follows:

1. Composting (improve in the mechanical approach
2. Mechanical-Biological Treatment (MBT)
3. Waste to energy incinerator
4. Anaerobic digestion

Technology priority for final treatment systems is Sanitary Landfill with LFG recovery.

The technology for the general ITF can be developed by Indonesia itself; nevertheless, the technology is not disseminated widely, due to some problems. For example, composting technology, particularly the open windrow system, is already developed in Indonesia. To increase the capacity and the effectiveness of the composting system, a mechanical windrow system should be developed, under joint research. Besides that, anaerobic digestion technology has already been introduced. Innovation in the optimization of the process and the gas quality still can be implemented.

Regarding the Mechanical Biological Treatment technology and 'waste to energy' incineration, joint research can be undertaken, because those technologies have not been developed in Indonesia. As for the final disposal site technology, the sanitary landfill has already been introduced in Indonesia. Unfortunately, the operational system was not working properly and the final disposal site intended to be a sanitary landfill, became an open dumping system. But since the Solid Waste Act is legitimate, it is necessary for the cities to manage and control the disposal sites with the sanitary landfill system. The LFG recovery technology is really needed for the existing SWDS and, in the future, also for the developed landfill.

The sanitary landfill technique will make the methane and carbon dioxide generated, easy to collect. The sanitary landfill with an LFG recovery system can reduce the emissions of methane and other gases, by almost 90%. Composting technology and anaerobic digestion can reduce CH_4 and CO_2 to between 80 – 90% depending on the operational condition. The Mechanical Biological Treatment can reduce CH_4, CO_2 and other gases by up to 90%.

5.1.2. Wastewater

Based on the general criteria, the evaluation result from stakeholders is as follows:

Table 5-2: Priority List of Wastewater Treatment Technology

No.	Technology	1	2	3	4	5	6	7	8	9	10	11
1	Off-site Centralized System											
	Stabilization ponds		1	1	1	1	1	1	1	1	1	1
	Aerated Lagoon		1	½	1	1	1	1	1	1	¾	1
	Oxidation Ditch		1	¾	1	1	1	½	1	1	1	½
	UASB + DHS		1	¾	1	1	1	¾	1	1	¾	1
	RBC		1	½	1	1	1	¾	1	1	¾	¾
2	On-site System											
	Communal Biofilter		1	¾	1	1	1	1	1	1	1	1
	Communal UASB		1	½	1	1	1	¾	1	1	1	¾
	Modified Ind. Septic Tank		½	1		1	1	1	1	1	1	1

Note: Number 1-11 are the 11 general criteria described above

Technology priority list for off-site /centralized treatment system:

1. Stabilization ponds
2. Aerated Lagoon
3. Oxidation ditch

4. UASB + DHS
5. Rotating Biological Contactor (RBC)

Technology priority list for on-site/decentralized treatment system
1. Communal Biofilter System
2. Communal UASB treatment system
3. Modified Septic tank +filtration

For domestic wastewater, selection of the technology is based on the criteria listed and also based on the demography characteristic, social culture and the operational system that is easy to handle. For the cities, the technology selection is focused on the off-site/centralized treatment system. Indonesia has a capability to develop most of the treatment technologies (self capability). Nevertheless, a joint research is still needed to optimize the process including the energy utilization.
Technology priority list for 'off-site /centralized treatment' system are:
1. Stabilization ponds
2. Aerated Lagoon
3. Oxidation ditch
4. UASB + DHS
5. Rotating Biological Contactor (RBC)

Technology priority list for 'on-site/decentralized treatment' system are:
1. Communal-Biofilter System
2. Communal-UASB treatment system
3. Modified Septic tank + filtration

The application of the stabilization ponds, oxidation ditch, and aerated lagoon technology can reduce the CH_4 generated by up to 80%. The application of the UASB and biofilter technology can reduce the CH_4 emissions by up to 90%.

5.1.3. Agro Industrial Waste

The technology to reduce the GHG emissions from the agro industrial waste is nowadays related to the effort to introduce alternative energy (biogas). Liquid waste from palm oil, tapioca, sugarcane, and the pulp & paper industry is organic waste with different values for BOD and COD quality. The technology application for those industries is different in the pretreatment technology, which is done to reduce the specific material, before it enters the primary treatment unit. For agroindustrial waste treatment technology, the assessment to determine technology priority was not done by the stakeholder judgment, as was the case with the MSW and domestic wastewater. The determination of the priority technology was based on the best practices that have been applied by Indonesian industries. Besides that, the technologies, that are listed, are only for the primary treatment of agro-industrial waste, with priority areas listed as below:

Technology priority list of palm oil liquid waste are:
1. Anaerobic filter, the technology is the same as biogas technology but the bio digester uses support material for bacteria fixation;
2. Aerobic system;
3. Stabilization ponds;
4. Aerated lagoon.

Technology priority list of palm oil solid waste are:

1. Composting;
2. Combustion for steam and electricity.

Technology priority list of tapioca liquid waste are:
1. Facultative Anaerobic (or combination with aerobic);
2. AFFR (+ aerated lagoon);
3. Aerated Lagoon system.

Technology priority list of tapioca solid waste (cassava fiber) is:
1. Fermented cassava fiber (cattle feed).

Technology priority list of livestock liquid are:
1. Anaerobic filter technology is the same as biogas technology. But the biodigester uses support material for bacteria fixation;
2. Aerobic system (or Anaerob-Aerob Combination);
3. Stabilization ponds.

Technology priority list of livestock solid waste is:
1. Composting windrow system.

For livestock waste, the anaerobic filter technology can reduce the CH_4 emission up to 90% compared to wastewater from ethanol or the palm oil industry. The combination of the anaerobic-aerobic technology can increase the pollutant reduction efficiency up to 95%. And the composting technology can reduce CH_4 emission up to 90%.

Technology priority list of sugarcane liquid waste is:
1. Water recycle system.

Technology priority list of sugarcane solid waste is:
1. Residue/*bagasse* utilization;
2. Furnace ash utilization.

Technology priority list of pulp & paper liquid waste is:
1. Aerated lagoons;
2. Anaerobic fermentation.

Technology priority list of pulp & paper solid waste is:
1. Dewatering & incineration;
2. Dedicated landfill.

The technologies, which are listed for the waste sector are supporting the national development, particularly the energy and food sector. Solid waste treatment,, which has an output as organic fertilizer or as cattle feed, is also supporting the food security. Beside that, the chosen anaerobic process can produce the biogas as an alternative energy source. Overall, the technologies listed in this TNA for the waste sector are available either nationally and/or in the international arena.

6. IDENTIFICATION OF BARRIERS AND POLICY NEEDS

6.1. Institutional Barriers decelerating Technology Transfer

It is a fact that the SWM institution in Indonesia is handled by various organizations, with differing tasks and responsibilities. At the city (*kota/kabupaten*) level, almost 95% of SWM is taken care by the local government in the form of Sanitary Sub Department (*Dinas Kebersihan*) (60%), Environmental and Cleansing Department (*Dinas Kebersihan dan Lingkungan*) (10%), Cleansing and Parks Department (*Dinas Kebersihan dan Pertamanan*) (8%), Public Work Department (7%), and local company or community organization (15%). Nevertheless, financial issues in the SWM sector are not yet a priority in each city (*kota/kabupaten*). For example, Bandung (capital city in West Java Province) has tried to establish a local cleansing enterprise (*PD Kebersihan*). This is still unstable compared to the private enterprise business. In the future, it is hoped that the private enterprise business can be more active as an operator and the government institution as a regulator (Government Regulation No 41/2007). <u>The most important aspect in this issue is how to increase the private contribution in the SWM (Solid waste as a beneficial commodity) and set the achievable retribution fee collected from the community</u>.

As is known, the "Solid Waste Act" is focused on how to reduce the waste from its source, meaning that composting and inorganic waste recycle technology is very important. There are many 3R (reduce, reuse, and recycle) methods developed in some cities since 1980. These include Waste Industrial Estate (*Kawasan Industri Sampah*), Recycling Business (*Usaha Daur Ulang*), Composting Production or an Integrated Waste Management Centre in Final/Temporary Disposal Area. However, most of these methods are not sustainable and the unsustainability of the concept is caused by the unreadiness of the parties. Beside that, the ways of thinking on waste management issues, particularly from the city governments and local sanitary department sides, should be changed. Some of the cities, which succeeded in applying the 3R system, are Surabaya, Sidoarjo and Cimahi.

It is the right time for the local government to develop the strategy, policy organization and/or institutions to manage the Municipal Solid Waste based on the recycling method. The waste generator should be positioned as an important component in the Municipal SWM cycle. The most important aspect in the SWM, is the support of the local government, which should be formally stated and, if possible, translated into incentives such as a reduction of the amount of retribution that should be paid by the community. The local government should be ready to find a market for compost products that are produced, in order to finance part of the city waste management cost (or can be bought by the government for city garden fertilizer, etc. Currently, support from the local government is still not forthcoming or clear.

<u>In conclusion, the important issue is to change the ways of thinking of the local government and waste management organization to support the recycle idea in the SWM.</u>

For domestic wastewater, most of the communities have built the individual septic tank for the wastewater treatment. The problem is that a good standard of good septic tank that is not widely available yet. On the national level, the development of communal wastewater treatment is the responsibility of the Public Works Department in coordination with the Ministries of Health and the Environment. It is different with the fresh water supply institution (*Perusahaan Daerah Air Minum*) with has an established organization, readily- available in each city (kabupaten/kota), while there are only limited independent institutions available for domestic wastewater management, for example, PD PAL in Jakarta.

<u>In conclusion, the most important aspect for the domestic wastewater issue is how to increase the number of domestic wastewater treatment institutions in order to increase the level of service.</u>

To manage and treat industrial wastewater (including the agro industrial wastewater), is one of industry's responsibilities. The effluent of the treated wastewater should comply with the effluent quality standards before it is released into the environment (river). This issue is controlled under the Government Regulation (*Peraturan Pemerintah*) number 82, 2001 concerning , Water Quality Management and Water Pollution Management. On this subject, the government should be responsible for monitoring and identifying the pollutant source and the control of water quality. This responsibility should be that of the Ministry of Environment at the national level and *Bapedalda* oat the local level. There are two government programmes that are related to this issue, the Clean River Programme (*Prokasih*) and performance ranking (*Proper*). The most important strategic issue is how to increase the control of wastewater disposal into the environment.

6.2. Institutional Policies accelerating Technology Transfer

In Agenda Item 21 article 34, the technology transfer issue, specifically the environmental technology issues between developed and developing countries, is described. The explicit objectives for the developing countries in this, are:

1. Obtain easy access to information including "state of the art technology".
2. Promotion, facilitation, and financial support to the access and technology transfer (incl. Intellectual Property Right).
3. Facilitation of maintenance and indigenous environmentally sound technology promotion.
4. Capacity development indigenously so the developing countries are able to research, adopt and apply environmentally -sound technology through:
    a. Human resource capacity development;
    b. Organizational capacity for R&D implementation;
    c. Integration of technology needs research, to comply with the national development plan.
5. Promotion on the sustainable technological cooperation for the partners, who cooperate with the potential users.

The most intensely discussed issues, when talking about technology transfer, are the patent problem, fees and access to information. Aspects regarding social structure, organizational and cultural issues and capacity development of local people get less attention. Condemnation of local communities happens in this context. The technological process research has not completely been finished yet for developing the best applicable technology, which is also inline with the condition, potential and needs of the local communities.

Beside that, the technology transfer process, specifically the Research & Development (R&D) activities, faces many problems:

- Prohibition of activities in the R&D sector using a multi-year budget;
- The intra institution sector approach and inter institution approach are too rigid;
- A critical mass research could not been achieved yet;
- The import substitution activities have resulted in industrial relocation only, so the technological shift is not eventuating;
- The relations between the real sector and the R&D sector are not yet organized.

In order to fasten the process of technology transfer, some supported policies are needed, for example:

- A communication forum between all technology users, R&D institutions and the technology provider needs to be formed.
- Multi-year financing policy is required for an effective technology transfer program.
- Cooperation and coordination between all development sectors has to be ensured.
- The incentives for science and technology equipment tax have to be discussed.

7. CONCLUSION AND RECOMMENDATION

7.1. Definition, Determination and Selection of Options

As already described before, the MSW is one of the major sources of GHG emissions from the waste sector. The accumulation of emissions from the MSW will be concomitant with the number of locations of the Solid Waste Disposal Sites (SWDS) where the waste is collected and undergoing the anaerobic decomposition process. From the selection of the priority technology, followed by discussions between stakeholders and by considering the institutional analysis result, some choices to be implemented in the future can be made. Also in line with the Solid Waste act are:

- Reduce as much as possible the waste that will be transported to the final disposal site, by implementing: reduce, reuse, and recycle (composting is included) technologies. Composting technology should be easy to implement, especially by the community and it should be low budget technology. Local institutions e.g. the Sanitation Department should support the 3R implementation efforts of the community e.g. by buying compost products and/or providing technical assistance.
- In the metropolitan areas and big cities, the implementation of 3R could also include private companies, where the composting system quality on the mechanical and biological side can be increased.
- The new final disposal site development should implement the sanitary landfill techniques with LFG recovery. On the other hand, existing open dumping final disposal sites should be closed. Planning for this should be prepared, including the gas product utilization. At present, the LFG recovery system in several SWDS exists, but generally uses the flaring system for burning the biogas collected.
- Implementation of the small-scale incinerator is not expected before the result of such research is available. The implementation of an incinerator should follow the air pollution control regulations.

The GHG emission reduction potential is large in the domestic wastewater sub-sector. But the GHG emission source is dispersed due to the large number of individual septic tanks. GHG emissions could be reduced significantly, when controlling domestic wastewater via off-site systems (centralized treatment plants). The available options are to increase the technology potential for methane recovery in the centralized Wastewater Treatment Plant (WWTP) and to increase the number of community services via the WWTP, specifically in the big cities. For other cities, having special demographic conditions, the decentralized WWTP of the communal-scale WWTP can be developed. As a result of the stakeholder discussions, some options to be implemented in the future are proposed such as:

- In big cities, due to the limited space available, communal treatment plant systems can be built for example by using bio-filters or UASB technology. If space is available, the best option would be to build the centralized WWTP
- In rural areas septic tanks shall be implemented, which meet the standards set by the Department of Public Work.
- Regarding industrial waste, the implemented technology should depend on the waste characteristics. In the future, biological based processes are expected to be developed, which will help to process the waste in such way, that the increasing energy price can be handled.
- For the agro-industry, especially palm oil production, it is suitable to implement waste-to-energy technology. For example by converting solid waste to compost - or using the solid waste as fuel to generate electricity from biomass. The latter, based on examples in Thailand for palm oil mill processing, could be implemented assuming the following approximate values: capacity 45 tonnes of FFB/h will produce power of 10.6 MW total, biogas 1 MW, EFB 2.3 MW, Shells 2.7 MW and fiber 4.6 MW.

For the wastewater from the industry (including agro industry), currently there are still many industries that do not treat wastewater in the WWTP but discharge it directly into the environment. For industries, that already treat the wastewater in WWTP, they should increase the efficiency and increase the recovery potential of the gas thus formed (methane). The impact of monitoring the industries, regarding their WWTP operations is seen as a primary issue in Indonesia.

7.2. Conclusions

The waste sector is one of the main contributors to GHG emissions especially from the accumulated MSW in SWDS, from the domestic & industrial wastewater sectors, from MSW uncontrolled combustion and also from the wastewater that is discharged into the water body under anaerobic conditions. The mitigation effort that can be done is to apply the technology for the waste minimization, reuse and recycle technology, and also the technology that can directly recover the GHG emissions. Currently, on the national level, there are many technologies that already have been developed in Indonesia and still need to be disseminated at the local level. But there are also some technologies that require more development under joint research with developed countries, for application and implementation in Indonesia.

The success of waste management, specifically for MSW, does not depend on the technological aspect only. The MSW management is a o system that needs a "systematic approach". Beside the technical aspects, waste management depends also on legal/regulation aspect, organizational/management,, economical and human resource aspects as well as on community participation.

Recommendation for implementation action:

- In the implementation of composting technology and to reduce the waste that is disposed to the final disposal areas, policy support and technical assistance from the local government are needed. The composting technology is very important and needs to be further developed, since more than 60% of the total waste in Indonesia is organic waste.
- Private companies should be included in the waste management, especially in the big cities; for example in the development of intermediate treatment plans.
- As stated in the Solid Waste Act, by 2015, all open dumping sites must be closed and be replaced with sanitary landfill & controlled landfill. Starting from now, post-closure plans for the sites should be prepared.
- Since it is becoming more difficult to locate final disposal sites, all areas should be supported in building final disposal site areas.
- In all waste management technology implementation, the possibility of the "waste to energy" principle should be optimized.
- For domestic wastewater, improvement in public services should be undertaken.. For big cities, the WWTP with control emissions technology should be built. For rural areas, the existing technical standard for septic tank should be improved. And in the village areas, biogas plan with input from domestic and livestock waste, should be considered.
- For industrial waste, including agro industrial waste, some technology that is available in the market can be implemented. Social moves for zero waste or cleaner production principals should be encouraged.
- Specifically, for waste from the palm oil industry, there is a big potential to implement the waste to energy principal. Since there are a large number of palm oil industries in Indonesia, the effective management of palm oil waste, can help to reduce the GHG emissions at the national level.,
- Wastewater treatment in agro-industries could reduce the GHG emissions by the anaerobic treatment method. By collecting methane already savings on global emissions are possible. In using the biogas for heat and/or power, more benefits could be reached with that strategy.

Table 7-1: Selected Technologies/ Measures - Waste Sector

Type and Amount of Waste	Estimation of CH_4 Emission	Existing Condition	Technology Input	Cost		Estimation of Reduced CH_4 Emission by Input Technology (2025)
				Investment	O&M	
Type: Municipal Solid Waste (MSW)	76,000t/yr		<u>Composting/ MBT</u> • Low tech • High tech	10,000 – 20,000 USD/t cap/day 25,000 – 50,000 USD/t cap/day	20 – 40USD/t 30 – 50USD/t	In composting as well as in the MBT process: DOC is converted to CO_2 and small amount of N_2O, CH_4 CH_4 emission reduced almost 90% compared with anaerob condition.
	The emission is just calculation from SWDS in one year	Urban Area : ▪ Disposed to SWDS 40% ▪ Illegal dumped 7.5% ▪ Composted and recycled 1.6% ▪ Open burned 35.5% ▪ Others 15.3%	<u>Incineration</u> • MSW burning	80,000 – 120,000 USD/t cap/day	40 – 80USD/t	In incineration process: Waste is converted to CO_2, NO, and small amount of N_2O, CH_4 CH_4 emission reduced almost 90%
Amounts: 48,800,000t /yr	Estimation and projection for accumulation of waste and adjusted emissions		<u>Landfilling</u>			In land filling process: DOC is converted to CO_2 and CH_4 and small amount of N_2O, CH_4 emission reduced by almost 90% if to be recovery type
			• Comingled waste	300,000 – 400,000 USD/ha	3 – 4 USD/t MSW	
			• <u>Sanitary landfill</u> • <u>CH_4 gas flaring</u> • <u>CH_4 gas combustion for electricity generation</u>			
Type: Domestic wastewater Amounts: 9,586 M m^3/ yr	340,000t/yr 36,500t/yr from 10 biggest cities	▪ On-site sanitation 63% (urban), 27% (rural) ▪ Off-site sanitation 1.25% (urban)	• Aerated lagoon • UASB • RBC • Oxydation ditch • Stabilizationponds	800USD/m3 900USD/m3 925USD/m3 400USD/m3 300USD/m3	- - - - -	CH_4 emission reduced almost 80 – 90% compared to no treatment

Type and Amount of Waste	Estimation of CH_4 Emission	Existing Condition	Technology Input	Cost		Estimation of Reduced CH_4 Emission by Input Technology (2025)
				Investment	O&M	
Type: Agroindustrial Palm Oil Amount FFB: 9,816,393t/yr (2000 – 2005)	EFB 27,000t/yr Shell 9,400t/yr Fiber 14,000t/yr Wastewater 61,000t/yr	EFB ▪ Disposed to plantation 85% ▪ Mulch 10% ▪ Burned 5% Shell ▪ 5 – 10% burned as steam and power generation for internal CPO consumption, low efficiency Fiber ▪ Burned as steam and power generation for internal CPO consumption, low efficiency	Composting • Low tech • High tech	10,000 – 20,000 USD/t cap/day 25,000 – 50,000 USD/t cap/day	20 – 40USD/t 30 – 50USD/t	In composting process: DOC is converted to CO_2 and small amount of N_2O, CH_4 CH_4 emission reduced almost 90% compared to without treatment
			Incineration/ Combustion Techn. ▪ Advanced, Efficient, Integrated Power Generation Tech.	80,000 – 120,000 USD/t cap/day	40 – 80USD/t	In Combustion process : Waste is converted to CO_2, NO and small amount of N_2O, CH_4 CH_4 emission reduced almost 90%
			Could produce electricity from biogas 1MW, EFB 2.3MW, Shells 2.7MW, Fibers 4.6MW Total: 10.6 MW (from mills with capacity FFB 45 t/h)			
Type: Tapioca Ind. waste Amount: 15.2 Mt /yr (solids) 100 M m^3/yr (liquid)	288,000t/yr	▪ WWTP 50% ▪ Cattle feed 25% ▪ Others 25%	▪ Aerated lagoon ▪ An & aerob filter ▪ AFFR + lagoon	800USD/m^3 700USD/m^3 900USD/m^3		CH_4 emission reduced almost 80% to 90% for all anaerobic tretament system

Type and Amount of Waste	Estimation of CH_4 Emission	Existing Condition	Technology Input	Cost		Estimation of Reduced CH_4 Emission by Input Technology (2025)
				Investment	O&M	
Type: Livestock waste	688,000t/yr	▪ Disposed or dumped to become compost	▪ Composting ▪ Direct spread to land ▪ Anaerobic digestion	10,000 – 20,000 USD/t cap/day 900 – 1000 USD/m^3	20 – 40 USD/t	CH_4 emission reduced almost 90% Mostly converted to CO_2 CH_4 reduced by utilisation or flaring
Type: Sugar cane waste Amount: 8,500,000t/yr	356t/yr	▪ Water recycled 80% ▪ SW utilization 5% ▪ Others 10% ▪ Bagasse for steam and electricity generation	▪ Water recycling ▪ Bagasse & ash utilization using advanced and efficient and power generation Technology	5,000USD/m^3		Generally 'Cleaner Production' approach in sugar cane factory, can reduce GHG emissions.
Type: Pulp & paper waste Amount: no data			Liquid waste: ▪ Aerated lagoon ▪ Anaerob ferment. ▪ Activated sludge Solids			

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