IDENTIFYING LOW CARBON TECHNOLOGY FOR SUSTAINABLE ENERGY DEVELOPMENT IN INDONESIA

Identifikasi Teknologi Rendah Karbon Untuk Pengembangan Energi Berkelanjutan di Indonesia

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Abstrak
Sebagai negara berkembang , Indonesia secara sukarela berkomitmen untuk mengurangi emisi gas rumah kaca (GRK) sebesar 26 % dengan menggunakan biaya sendiri atau dengan menambahkan bantuan luar negeri sebesar 41 % pada tahun 2020. Target ini akan membawa dampak bagi Indonesia untuk membuat rencana kerja dan pada waktu yang sama untuk memilih teknologi karbon rendah (LCT) dalam mengurangi gas rumah kaca tersebut. Makalah ini akan fokus memperkenalkan LCTs untuk sektor energi di Indonesia . Pemilihan Teknologi rendah karbon (LCTs) untuk mengurangi emisi CO2 di Indonesia dianjurkan untuk sisi penyediaan dan permintaan energi. Teknologi untuk penyediaan energi diprioritaskan untuk batubara, geotermal, dan teknologi energi terbarukan meliputi teknologi untuk biomasa, air, angin dan matahari. Teknologi untuk permintaan energi diterapkan untuk efisiensi energi di sektor industri, perumahan dan bangunan komersial. Selain itu, soft technology seperti audit energi, energy rating dan pelabelan juga diusulkan. Untuk transportasi dan taxi, bahan bakar gas sebagai pengganti bahan bakar fosil atau gasolin sangat disarankan untuk digunakan. Manajemen permintaan transportasi juga diusulkan untuk ditingkatkan, seperti menggunakan intelligent transportation system (ITS) dan mass rapid transport system (MRTS).

***Kata kunci** : Gas rumah kaca, teknologi rendah karbon, penyediaan dan permintaan energi.*

Abstract
As a developing country, Indonesia has voluntarily committed to reduce its green-house gases (GHGs) emissions by 26% with its self-financing, or 41% with addition of foreign aids, by year 2020. This target will carry consequences for Indonesia to make an action plan and at the same time to choose which low carbon technologies (LCTs) are employed in reducing its GHGs. This paper will focus on introducing LCTs for energy sector of Indonesia. LCTs option for reducing CO_2 emission in Indonesia is suggested for both energy supply and energy demand sides. Energy technology for supply side is prioritized for clean coal, geothermal and renewable energy technologies including technologies for biomass, hydro, wind and solar. Prioritized energy technology for demand side is applied to energy efficiency for industries, residential and commercial buildings. Besides, soft technologies such as energy audit, energy rating and labeling are also proposed. For public bus transportation and taxi, a cleaner fuel of gas as a substitution to fossil fuel or gasoline is highly suggested to be used. Transport demand management is also proposed to be improved, like using intelligent transportation system (ITS) and mass rapid transport system (MRTS).

Keywords: greenhouse gases, low carbon technology, supply and demand side of energy.

1. INTRODUCTION

Indonesia, the world's largest archipelagic state and the world's fourth most populous country with more than 80% of its populations who live in agriculture and fishery sectors is highly susceptible to climate variability. High growth of economy in the last decades has led the growing demand of energy supply and utilization in the country. This growing energy demand goes in hand with increasing release of carbon (CO_2) emission [1,2].

Anthropogenic CO_2 is the main source of GHG accumulating in the atmosphere[2]. This source in particular has been due to the use of fossil fuel. In many cases, the use of technology such as fossil fuel combustion causes negative impact on the environment, in addition to the benefit given by it to the people. Carbon dioxide emission from fossil combustion technology that causes global warming is an example of its negative impact to the environment. Actually, both developed and developing countries at certain levels have employed technologies that contribute the increase of the CO_2 emission in the atmosphere [3].

Low carbon technology comes from processes or technologies that, at the point of generation release less carbon dioxide than the traditional means of power generation[4]. It includes zero carbon power generation sources, such as wind, solar, geothermal, nuclear power, as well as sources with slightly lower-level emissions than coal and oil, such as natural gas. Increase energy efficiency is also considered a low carbon technology since it generates less CO_2 emission [2,4].

2. ENERGY GENERATION AND USE

Total final energy consumption of Indonesia in 2006 was about 853.8 million BOE[5]. Its composition by sector was industry (37.14%), residential (36.65%), transportation (20.09%), commercial (2.57%), and others (3.55%); as shown in Figure 1.

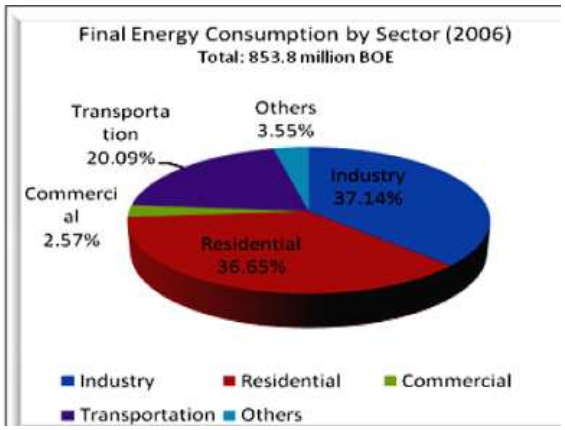

Figure 1. Final energy consumption by Sector 2006 (Source: Handbook of Energy & Economic Statistics of Indonesia (2006) taken from TNA, 2009).

Composition of Indonesia electricity production based on fuel types is shown in Table 1[6]. The total electricity production in 2012 was 202,387 GWh and in 2020 it is predicted to increase to 371,374 GWh. Its composition in 2012 by fuel is HSD (8.57%), MFO (2.38%), gas (21.09%), LNG (3.74%), coal (54.37%), hydro (5.5.4%), solar/ hybrid (0.002%), biomass (0.03%) and geothermal (4.27%).

The predicted fuel composition for electricity generation in 2020 will be HSD (0.7%), MFO (0.02%), gas (8.31%), LNG (8.49%), coal (64.2%), hydro (5.77%), solar/hybrid (0.002%), biomass (0.02%), geothermal (12.39%), and import (0.09%) [6].Figure 2 shows the resulted CO_2 emission if Indonesian electricity production is done with fuel mix as shown in Table 1. Figure 2 indicates that Indonesia CO_2 emission will increase from 141 Million Tons in 2011 to 276 Million Tons in 2020[6]. Of 276 Million Tons CO_2e emission, 245 Million Tons (89%) is contributed from coal combustion. Average grid emission factor for Indonesia in 2011 was 0.763 kg CO_2/kWh. It will slightly increase to 0.8 kg CO_2/kWh in 2013-2014 but it will go down back to 0.745 kg CO_2/kWh in 2020 due to operation of geothermal and hydro power [6].

In addition to energy generation and utilization, these low carbon technologies will also discuss energy use for transportation, industry and household. In the total final energy use in transportation, household and industry, the shares come from petroleum (65.9%), natural gas (12.7%), coal (7.4%), electricity (12.5%) and LPG (1.6%) [5].

Indonesian transportation, particularly road transportation consumes the biggest primary energy. About 88% of total primary energy consumption for all modes of transportation in the country is used by road transportation. The passenger cars dominate the energy consumption (38%), followed by trucks, buses, and motorcycles at 32%, 18%, and 12%; respectively [5]. Industrial sector produces GHG emissions from both its energy utilization and its production processes. The growth of industrial sector is parallel with the growth of national economy. Since the national economy of Indonesia increases the GHG emissions from the industry will consequently increase. The commercial final energy consumption is about 53% of the total national final energy consumption [5].

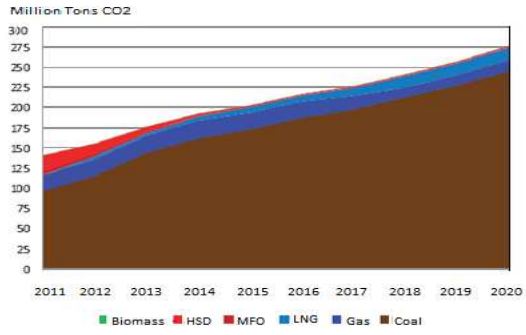

Figure 2. CO_2 emission per fuel type (compounded Indonesia) (Source: RUPTL-PLN 2011-2020)

Table 1. Composition of electricity production (GWh) based on total fuel types in 2012 and 2020. (Source: RUPTL-PLN 2011-2020)

Fuel Type	2012	%	2020	%
HSD	17,346	8.57	2,635	0.71
MFO	4,807	2.38	65	0.02
Gas	42,691	21.09	30,879	8.31
LNG	7,578	3.74	31,541	8.49
Coal	110,043	54.37	238,432	64.20
Hydro	11,204	5.54	21,429	5.77
Solar/ Hybrid	4	0.002	7	0.002
Biomass	63	0.03	63	0.02
Import			317	0.09
Geothermal	8,650	4.27	46,005	12.39
Total	202,386	100.00	371,373	100.00

Tabel2.Emission reduction target of each sector in NAP-GHGs
(Source: Presidential RegulationNo. 61 of 2011)

No	Sector	26% Emission Reduction (in Giga ton CO2e)	41% Emission Reduction (in Giga ton CO2e)
1	Agriculture	0.008	0.011
2	Forestry and peat-land	0.672	1.039
3	Energy and Transportation	0.038	0.056
4	Industry	0.001	0.005
5	Waste management	0.048	0.078
Total		0.767	1.189

Table 3. Electricity generation needed for Java-Bali (Source: RUPTL-PLN 2011-2020)

No	Year	2011	2012	2013	2014	2015	2016		2018	2019	2020	Total
1	Steam	3,880	4,095	1,050	1,040	2,320	3,520	3,860	1,200	600	1,000	22,565
2	Geothermal	-	-	60	-	385	325	270	815	855	165	2,875
3	Gas-Steam	594	743	-	-	-	-	-	-	750	750	2,837
4	Gas	-	-	-	150	-	-	-	400	-	400	950
5	Minihydro	9	4	68	18	-	-	-	-	-	-	99
6	Hydro	-	-	-	-	257	62	37	-	-	18	374
7	Solar	-	-	-	-	-	1,010	-	-	450	950	2,440
8	Gas-Wind	-	-	-	3	3	-	-	-	-	-	6
	Total	4,483	4,842	1,178	1,211	2,965	4,917	4,167	2,415	2,655	3,283	32,116

3. INDONESIAN GHG'S REDUCTION PLAN

By 2020, Indonesia has voluntarily declared to reduce its GHGs emissions by 26% with selffinancing or 41% with additional foreign aids [7]. This target has become a reference in designing and planning all technologies needed to reduce GHG emissions in each sector.

4. IDENTIFYING LOW CARBON TECHNOLOGIES FOR ENERGY SECTOR

Beside a climate change reason on emission reduction targets, the low carbon technology can be as a determining factor in next economic era that leads to low carbon economy. There is currently however no clear or agreed definition of what constitutes a low carbon technology (LCT). Wikipedia[4] states that lowcarbon power comes from processes or technologies that, at the point of generation, release less carbon dioxide than the traditional means of power generation. In general term, low carbon power can be assumed as low carbon technology (LCT). It includes zero carbon power sources, such as wind power, solarpower, geothermal power and including fuel preparation and decommissioning, nuclear power, as well as sources with slightly lower-level emissions than coal, such as natural gas [2,4].

For the case of Indonesia, clean coal technology is also considered to be low carbon technology. These powergeneration techniques emit significantly less carbon dioxide than a traditional fossil fuel power plant [7].

Low carbon technologies for targeted sectors in terms of reducing GHG emission in Indonesia have actually been established by the Government via President Regulation No. 61 year 2011[7].

4.1 LCT for Energy Generation and Transportation

For energy and transportation sector, targeted reduction of GHG emission by 2020 based on 26% CO_2e reduction scenario is about 0.038 G.Ton CO_2e and based on 41% CO_2e reduction scenario is about 0.056 G.Ton CO_2e[7]. They will be done through (1) increase of energy conservation, (2) clean fuel switching, (3) increase of new and renewable energy resources, (4) use of clean technology, and (5) sustainable low carbon development of national mass transportation.

The following action plans [7] for examples were formulated : (1) implementation of energy management for intensive energy users (10,16 MT CO_2e); (2) implementation of energy conservation partnership (2,11 MT CO_2e); (3) increase household appliances' efficiency (9,82 MT CO_2e); (4) accessibility and management of new and renewable energy and energy conservation such as development of micro-hydro, minihydro, solar, wind and biomass (4.4 MT CO2e); (5) biogas utilization (0.13 MT CO_2e); (6) natural gas utilization for rural transportation (3.09 MT CO_2e); (7) household gas transmission (0.15 MT CO2e); (8) development of intelligent transport system (1.77 MT CO_2e); parking management (1.07 MT CO_2e); (9) reformation of bus rapid transit (0.69 MT CO_2e);(10) renewal of public transportation (0.36 MT CO_2e); and others.

In line with the government policy to utilize new and renewable energy resources as documented in the President Regulation Number 5 year 2006 regarding National Energy Policy[8], National Electric State Owned Company (PLN) has set up policy to prioritize geothermal and hydro power[6]. PLN has also received the task from the government to electrify rural communities that have not yet received electricity.

From this policy, PLN plans to develop geothermal with very big capacity, hydro power with large, medium and small capacity, and small scale of new and renewable energy like solar power, wind power, biomass, bio-fuel and coal gasification.

PLN also support research and development of other new and renewable energy sources such as thermal solar power, sea water current, ocean thermal energy conversion (OTEC) and fuel cell. Special for solar power system, PLN makes a policy to develop centralized PVs at large scale to electrify remote area communities a far from the grid and underdeveloped area, and front end islands next to neighboring countries[6].

Geothermal power is considered to be sustainable because the heat extraction is small compared to the Earth's heat content. The emission intensity of existing geothermal electric plants is about 122 kg of CO_2 per megawatt-hour (MWh); a small fraction of that conventional fossil is fuel plants[2,4]. Geothermal technology is selected by Indonesia because the resources are abundant and its utilization is still low. It is planned to enhance geothermal development up to 2,875 MW in the next 10 yearsin Java – Bali system (see Table 2)[6]. Deployment of advanced geothermal technology such as binary cycle might be suitable for some areas of Indonesia[9].

Hydroelectric plants have the advantage of being long-lived as many existing plants have operated for more than 100 years. Hydropower is also an extremely flexible technology from the perspective of power grid operation. Large hydropower provides one of the lowest cost options in today's energy market, even compared to fossil fuels and there are no harmful emissions associated with plant operation.Hydroelectric power is currently the world's largest installed renewable source based electricity, supplying

Tabel 4.Identified low carbon technology for supply side
(Source: TNA 2009 Study of Indonesia)

Identified technology	Present situation	Technology input	Emission reduction potential
Advanced thermal power technology/ clean coal technology	Pulverized Coal Power Plant; Thermal efficiency: 33%, 1 ton CO2/MWh	Subcritical Pulverized Coal Power Plant, 36% eff.	0.70 ton CO2/MWh (w/o CO2 capture) 0.830 ton CO2/MWh (w/ CO2 capture)
		Supercritical and Ultra Supercritical Pulverized Coal Power Plant, 40-46 % efficiency	0.170 ton CO2/MWh (w/o CO2 capture) 0,891 ton CO2/MWh (w/ CO2 capture)
		Cogeneration	0.325 ton CO2/MWh
		IGCC, 38 – 41% eff.	0.168 ton CO2/MWh w/ Pre-combustion 0.898 ton CO2/MWh, w/ CO2 capture
		Coal upgrading	Vary depending on quality of coal; 5% emission reduction of conventional PC
		Improve efficiency.	1% increase of eff. will reduce 2-2.5% CO2 emission
Fuel switching	Combine Cycle Gas Turbine to Replace HSD Generator	Gas to replace HSD	N.A
		Coal to Gas (50%)	0.5 ton CO2/MWh
Utilization of renewable energy technology	More than 95 % of primary energy uses oil, coal and gas.	Biomass Power – Co-firing	15-20 % of emission reduction depends on the main fuel.
	Government set a target to reduce oil but increase new and renewable energy up to 15 % of total primary energy mix,	Biomass power-gasification	Avoid CO2 emission from coal combustion.
		Geothermal - Flash Steam	0.9 – 1 ton CO2/MWh (depend on type of PP replaced)
		Geothermal - Binary Cycle	
		Geothermal- Hot Dry Rock	
		Photovoltaic – Single Crystal/Mono	idem
		Wind turbine	idem
		Micro and Mini Hydro	idem
		Advanced Hydro Power	idem
		Nuclear Power : PWR/BWR 2ndGeneneration	0.85 – 0.9 ton CO2/MWh (depend on type of power plant replaced)
		Nuclear Power PWR/BWR 3/3+ generation	idem

about 17% of total electricity in 2005[4]. China is the world's largest producer of hydroelectricity, followed by Canada [4].

Hydroelectric power is one of renewable energy technologies selected by Indonesia. Its water resources are abundant however its utilization is still very low due to a huge budget to use it, in addition to social and environmental constraints.

Indonesia will initiate the use of wind power combined with the gas power forabout 6 MW of energy output in the next 10 years for Java-Bali system. Technology chosen is improved efficiency and reliability of low-speed wind turbine, light material for blade, control system and motor and other main parts[6].

Indonesia will also build solar power system of about 2,440 MW in the next 10 years in Java-Bali system.

As seenin Table 3 the total additional capacity of electricity for the next 10 years in Java-Bali system will be 32,1 MW or around 3,1 GW per year[6]. Steam coal combustion will still dominate the generation (22,5 GW or 70%) while steam gas generation will be the second (2.8 MW or 8.8%), followed by renewable energy such as geothermal (2.9 GW or 8.9%) and hydro/ minihydro/solar power (2.9 GW or 9.1%), and finally gas power (1 GW or 3%).

Biomass is another source of energy for Indonesia, namely agriculture waste, agriculture biomass, palm oil, other bio-fuels, and industrial waste. Several biomass conversion technologies such as direct combustion and co-firing technology can help utilization of the potential resources[5]. In the last 15 years, several biomass plant projects such as biomass power generation using rice husk or straw have been introduced but the result was poor due to the continuity of the feedstock. Therefore, in addition to the deployment of biomass conversion technology, there is a need to develop data base of biomass resources potential in Indonesia which can be updated regularly.

Study on low carbon technologies in energy generation in the purpose of technology transfer was conducted[5] and part of the result can be seen in the following **Table4.**

Low carbon technology to reduce CO_2 emission from transportation includes adoption of advanced vehicle technologies with less or no CO_2 emission. Improvement of transportation management system, including advanced transportation control and development of mass rapid transit system is another option. It is also suggested to reduce the GHG's by using alternative fuel technology (bio-fuel and gaseous based fuels) for the vehicles. Other less greenhouse gases emission technologies such as hybrid gasoline/diesel -electric powered and bi-fueled (CNG) vehicles are also suggested[5]. The application of low GHGs emission technologies should be encouraged by the government through strategic measures anactions and involving all stakeholders (incding private, public and society). Measures are needed by the government to undertake the "Zero Growth Vehicles" policy in major cities of Indonesia. The development of mass rapid transit system especially in the metropolitan cities in Indonesia should be prioritized by the Central Government and Regional Government, as it is potentially reducing the greenhouse gaseous emission.

Table 5 shows the vehicle low carbon technology based upon the rate of fuel saving and Table 6 shows the vehicle LCT based upon selected alternative fuel [5].

Table 5. Selected vehicle technology(Source: TNA 2009 Study of Indonesia)

No	Technology	Potential CO_2 reduction to BAU (%)
2.	Cellulosic ethanol	≈ 90
3.	Biodiesel fuel	≈ 70
4.	Ethanol	≈ 60
5.	CNG	≈ 30
6.	LNG	≈ 20
7.	LPG	≈ 20

Table 6.Selected alternative fuel technology. (Source: TNA 2009 Study of Indonesia)

For industrial sector targeted reduction of

No	Technology	% Fuel Saving
	Gasoline direct injection	3-4
	Six-speed automatic transmission	4-5
	Continuously variable transmission	≈ 7
	No Torque converter	3-4
	Hybrid vehicle w/o Torque converter	30-40

GHG emission by 2020 based on 26% reduction scenario is about 0.001 G Ton CO_2e and based on 41% reduction scenario is about 0.005 G.Ton CO_2e[7]. They will be done through optimization

of energy utilization. The action plans have been formulated and those are (1) the implementation of technology and process modification (2.75 MT CO_2e); (2) energy audit and conservation (4.81 MT CO_2e); and (3) passing out ozone depleting substances (1.5 MT CO_2e).

Table 7 shows more detailed information on energy efficiency for demand side suggested by TNA Study (2009) [5] (Source: TNA 2009 Study of Indonesia)

No	Technology	Efficiency measure	Result
1	CFL (Compact Fluorescent Lamp)	Replacement of incandescent bulb with CFL	Reduction up to 80% of energy use
2	Solar water heater	Solar water heater for hot water.	Electricity reduction up to 50%
3	Electronic Ballast	Magnetic w/ electronic ballast.	20 % reduction of energy use
4	High Efficiency AC	Replacement of standard AC with high efficiency AC	Reducing energy cons up to 50 %
5	HC Refrigerant	CFC with HC refrigerant	Electricity saving up to 20 %
6	BAS (Building Automatic System)	Application of BAS to monitor lightning and energy use in building	Electricity saving 10 – 20 %.
7	High Efficiency Chiller	Normal chiller with high efficiency chiller	COP normal chiller = 4,0 COP high efficiency chiller = 5,0 for Comm.& industry
8	High Efficiency Electric Motor	Replacement of normal electric motor with high efficiency electric motor	High efficiency can reduce energy consumption up tp 25 % for Industry.

The reduction of GHG emission from the industries is carried out by improving the process and energy utilization according to cleaner production mechanisms. These activities range from changing or retrofitting the equipment and materials that are not efficient anymore to optimizing the use of the waste for energy.

Grand strategy of energy conservation and CO_2 emission reduction in industrial sector, 2010–2020 has been proposed[10]. This grand strategy shows that the way to reduce CO_2 emission from targeted industries in order to share about 2% of 41% National CO_2e reduction is as follows.

The phase 1 implementation is energy conservation and CO_2 emission reduction in industrial sector in 2011. It was done an energy audit for 35 steel industries and 15 pulp and paper industries.

Following technology audit, some recommendations were made with the following categories [10]:

No Cost and Low Cost, such as improvement of monitoring system and energy management; recuperating maintenance, heat waste utilization, insulation and coverage of steam pipe leaks.

Medium Cost, such as recuperating installation, bank capacitor improvement, dust collector inverter installation, blow-down heat recovery installation, flash tank equipment addition.

High Cost, such as new incinerator addition, variable speed driver addition, and recuperating change with the more efficient one.

Realization of these recommendations, their implementation strongly depends on capability of the industry and therefore it needs stimulation from the government.

In cement industry, LCT is used for energy efficiency because high contribution on CO_2 emission from cement industry is due to coal fuel and electricity. Calcination of calcium carbonate is also a source of CO_2 emission. Therefore the area of LCT for cement industry is :[10]

Fuel consumption reduction is done through for example burner modification, alternative fuel, heat waste recovery, use of high efficiency motor, and compressed air system optimization. Alternative raw material utilization such as limestone with low CaCO3, fly ash, bottom ash, etc.

Increase of grinding efficiency; Maintenance of general measures such as preventive maintenance, efficient lighting, automatic process control system and energy management.

4. CONCLUSIONS

There is a policy for low carbon technology

established by the government of Indonesia through President Regulation No. 61 Year 2011 regarding National Action Plan on GHG reduction. The policy and strategy as well as the activities and targets have been formulated. The related sectors have also implemented those related action plans.

To reduce greenhouse gases for energy and transportation sectors and industrial sector, low carbon technology scenario is dedicated to reduce the GHG emission via pre-fossil combustion to avoid much more use of fossil energy, such as efficient energy technologies (high efficiency light, efficient appliances, etc.); renewable energytechnologies (geothermal, hydro, solar, wind, etc.); and fossil pre-treatment (coal upgrading). The reduction of GHG emission is also be done during fossil fuel combustion process, such asby using efficient technologies of combustors (co-generators), low carbon electric generation (high efficiency and low emission, IGCC, etc.), and clean fuel technology (fuel switching). At last, a post fossil combustion to mitigate emitted GHG from existing sources is also important to be conducted, such as through carbon capture and storage technologies and utilization of $CO_2$for biofuel and other products.

REFERENCES

1. Ministry of Environment and UNIDO. (2009). Indonesia Second National Communication Under the United Nation Framework Convention on Climate Change (UNFCCC).
2. Quanchning, V. (2010). Renewable Energy and Climate Change, HedyJourdan (Translator), A John Weley and Sons, Ltd, Publication.
3. IPCC. (2010). Special Report on Renewable Energy Sources and Climate Change Mitigation, in Press.
4. http://en.wikipedia.org/wiki/Low-carbon_power,Accessed on 16 August 2012.
5. Ministry of Environment, BPPT and GTZ. (2010). Indonesia's Technology Needs Assessment on Climate Change Mitigation of 2009.
6. Rencana Usaha PenyediaanTenagaListrik (RUPTL), PT. PLN (Persero) 2011-2020, DiterbitkanolehSekretariat PT. PLN.
7. President Regulation No. 5 Year 2006 regarding National Energy Policy.
8. President Regulation No. 16 Year 2011 concerning National Action Plan on Green House Gases Reduction.
9. Agency for the Assessment and Application of Technology, 2012. "Energy Outlook 2012".
10. Ministry of Industry. (2012). Program of Industrial Revitalization and the Important of Incentive for Industries in order to Implement Clean and Efficient Energy Technology, Center for Green Industry and Environmental Assessment, Agency for the Assessment of Industrial Climate and Quality, presented on the workshop in Bogor, July 2012.