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OPPORTUNITIES FOR CLIMATE CHANGE MITIGATIONS: A CASE STUDY OF INDONESIAN POWER SECTOR

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ABSTRACT

As an emerging economy, Indonesia's economy has been growing fast in recent years. The positive economic growth drives electricity consumption growth. However, the increase of electricity consumption contributes to the increase of greenhouse gasses (GHG) emissions. Energy sector is the second main contributors of the national GHG emission, hence, reducing GHG emission from power sector would contribute significantly to the national efforts of reducing GHG emission. This paper identifies opportunities for climate change mitigations in the Indonesia's power sector. The identification is based on literature review on power sector and climate change in Indonesia. It is observed that available renewable energy resources, government policies, climate finance, and low carbon technologies create opportunities for climate change mitigations in the Indonesia's power sector.

Keywords: Climate change, Electricity, Emission reduction, Indonesia, Mitigation.

INTRODUCTION

As an emerging economy, Indonesia's economy has been growing fast in recent years. Indonesia's economic growth is averagely 5.9% in last five years (BPS, 2014). The positive economic growth drives electricity consumption growth which recorded an annual average rate of 7.5% in 2008-2013 (PLN, 2013a). Despite the positive growth of electricity consumption, the national electrification ratio is only 77%, leaving around 15 million households without access to electricity (Ministry of Energy and Mineral Resources, 2013a). This implies that Government of Indonesia (GOI) still has homework to provide electricity to the non electrified households.

Figure 1 shows the electrification ratio in three different regions of the Indonesian archipelago (Ministry of Energy and Mineral Resources, 2013a). It can be seen from the Figure that eastern part of Indonesia has lower electrification ratio. Aiming at providing equal electricity supply for all regions in the country, the GOI announced its target to achieve 100% electrification ratio by year 2020 (Bloomberg TV Indonesia, 2014). In order to meet this target, the national electricity production is expected to increase significantly in the coming years

Figure 1. Fuel Mix of Indonesia's Power Sector in Year 2013 (PLN, 2013a)

The provision of electricity has been a great benefit to the society, but it also causes negative impacts to the environment. One of the impacts is the increase of CO concentration in the atmosphere that causes global warming. In Indonesia, 26.6% of emission from energy sector is attributed to electricity provision (Ministry of Environment Republic of Indonesia, 2010). This is because the power sector in Indonesia is highly dependent on fossil fuel. Figure 2 shows that fossil fuels contribute 91% of the national energy mix. Therefore, the expected increase of electricity production implies that GHG emission from power sector would increase in the coming years.

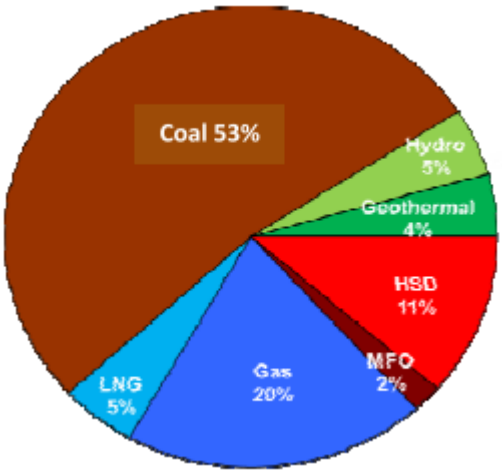

Figure 2. Fuel Mix of Indonesia's Power Sector in Year 2013 (PLN, 2013a)

Given the magnitude of C emissions from the power sector, the reduction of GHG emissions from the sector would contribute significantly to the national efforts of mitigating climate change.

METHODS

This paper is prepared with the following methodology:

1) Identify the status of power sector in Indonesia
   The status of power sector in Indonesia is identified trough literature review, mainly from MEMR and PLN publications.
2) Identify the sources and amount of GHG emissions from Indonesia's power sector
   Identification of GHG emissions from power sector is done through literature review.
3) Identify opportunities for GHG emission reduction
   Identification on opportunities for GHG emissions reduction is done trough literature review.

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POWER SECTOR IN INDONESIA

1. Status of Electricity Provision

The major provider of electrical energy in Indonesia is Perusahaan Listrik Negara (PLN) which is a national electricity company having business line in generation, transmission, and distribution of electricity. By end of 2013, the total generation capacity of PLN is 34.206 MW (PLN, 2014c) or about 73% of the total national power generation capacity (Ministry of Energy and Mineral Resources, 2013a).

Indonesia is an archipelagic country, thus electricity could not be distributed through a single power grid. Therefore, a number of power grids are scattered throughout Indonesian archipelago. The Java-Madura-Bali Islands account for 78% of the national generation capacity in the country (PLN, 2012a). All large generation units are installed on Java Island and are connected to JAMALI interconnection system. The load is concentrated in this location because it is the most developed island in the country. Meanwhile, electricity system outside JAMALI system comprises of many regional grids such as Sumatera grid, Kalimantan grid, Sulawesi grid, and others.

By end of 2012, the national installed capacity of electricity generation plants in Indonesia is 45,254 MW (Ministry of Energy and Mineral Resources, 2013a). This is composed by steam power plants (44%), gas combined cycle power plants (2 l%), gas turbine and gas engine power plants (l 0%), diesel power plant, (13%), hydro power plant (9%), geothermal power plant (3%).

While electricity production in year 2012 reached 200,317 GWh which supplied almost 50 million customers, there are still 23% of Indonesian households still do not have access to electricity. Indonesia has the largest number of non-electrified population in ASEAN (Schweinfurth, 2012). Achieving 100% electrification ratio remains a challenge for Indonesia considering the fact that Indonesia consists of thousands islands with many rural and remote areas. However, there were improvement of electrification ratio in year 2011 and 2012 as can be seen in Table 1.

Table 1. Electrification Ratio of Indonesia (Ministry of Energy and Mineral Resources, 2013a).

Year	2008	2009	2010	2011	2012
Electrification Ratio (%)	67	66	67	73	77

2. Future Electricity Provision

Future electricity provision can be identified through published electricity business plans. The MEMR prepares Electricity Business Plan up to 20 years. The long term electricity provision plan is developed based on national energy policy. Meanwhile PLN prepares more specific plan covering shorter period i.e. 10 years so called RUPTL. The RU PTL is endorsed by MEMR and it covers power expansion plans of both PLN and IPPs. The preparation of RUPTL is taking into account a number of factors including but not limited to: national energy policy; electricity demand projection; availability of local primary energy sources; and economic analysis (P LN, 2013a).

According to RUPTL year 2013-2022, 60 GW of new power plants are planned to be commissioned up to 2022. Within ten years, oil fuel consumption will decrease gradually and will only contribute 1.7% of national electricity mix by year 2022 as can be seen in Figure 3. However, fossil fuels (coal and gas) will remain the major contributors of future electricity fuel mix.

GHG EMISSION FROM POWER SECTOR

1. Sources of GHG Emission

In this paper GHG emission from the power sector defines as the amount of GHG emission as result of burning of fossil fuels for electricity generation. Sources of GHG emission includes coal fired power plants, gas power plant and diesel power plants. Meanwhile, renewable energy power plants are considered as zero emission power plants.

2. Emission Factor

The National Council of Climate Change (NCCC) has announced emission factor for 8 electricity interconnection systems (electricity grids) in Indonesia. The grid emission factors were calculated by MEMR in accordance with UNFCCC methodology to calculate emission factor for an electricity system. Data for emission factor calculation are sourced from PLN and independent power producers (IPPs). Table 2 shows the emission factor of 8 electricity grids in Indonesia for year 2012.

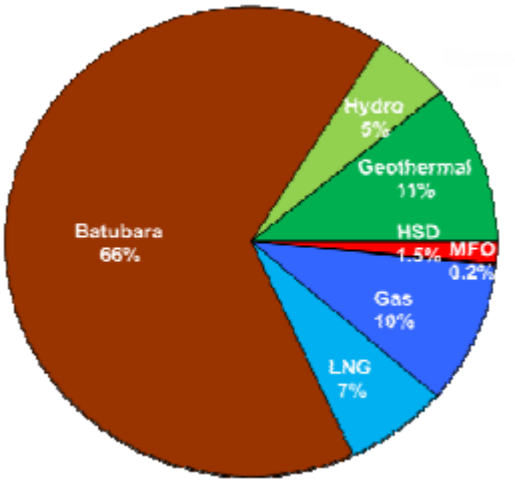

Figure 3. Energy Mix of Indonesia's Power Sector in Year 2022 (PLN, 2013a)

Table 2. Grid Emission Factors (National Council on Climate Change, 2014)

Interconnection System	Emission Factor of year 2012 ($kgCO_2/kWh$)	
	Ex-ante	Ex-post
Jawa-Madura-Bali	0.814	0.823
Sumatera	0.686	0.687
West Kalimantan	0.730	0.732
South and Central Kalimantan	0.900	0.900
East Kalimantan	1.030	1.069
North Sulawesi	0.532	0.600
South and West Sulawesi	0.710	0.746

The value of Indonesian grid emission factor can also be found in the RUPTL. While the NCCC calculates the actual grid emission factor, the RUPTL calculates future grid emission factors. The RUPTL calculation is based on estimated amount of consumed fuel and default emission factor for each fuel type which is published by Intergovernmental Panel on Climate Change (IPCC). According to the RUPTL 2013-2022 Indonesia's average grid emission factor in year 2013 is 0,766 $kgCO_2/kWh$. This means that 766 g of CO_2 is emitted to the atmosphere for every kilo watt hour of electricity produced.

3. GHG Emissions

The actual amount of GHG emissions from the power sector is calculated based on fuel consumption. In year 2013, GHG emission from PLN's power plants is 127.5 million ton C eq. This value is increased from 118.3 ton C 2eq in the previous year. (PLN, 2014). Meanwhile, there is no record regarding the actual amount of GHG emissions from IPPs. However, the RUPTL provide estimations of GHG emissions from both PLN and IPPs from year 2013 until 2022, as can be seen in Figure 4.

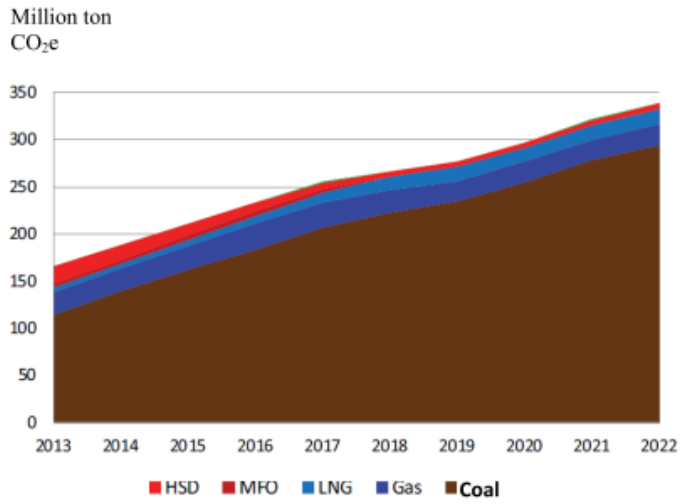

Figure 4. CO Emission from Different Fuel Type (PLN, 2013a)

From figure 4 it can be seen that estimated CO emission from power sector in 2013 is about 160 million ton. This value is estimated to be doubled within ten years.

REDUCING GHG EMISSION FROM THE POWER SECTOR

1. Climate Change Mitigation in the RUPTL

The RUPTL 2013-2022 incorporates climate change mitigations in its planning. The RUPTL policies regarding climate change mitigation are as follow (PLN, 2013a):

a. Prioritizing local primary energy sources especially renewable energies;
b. Geothermal and hydro power are prioritized regardless of the cost;
c. Diesel power generator is no longer considered (except hybrid with renewable energy);
d. Improving power generation's efficiency (retrofitting);
e. Development of new large scale CFPPs will be using supercritical or ultra supercritical boiler (lower emission boiler);

Concerning the above policies, it can be concluded that from the view point of climate change mitigation, RUPTL is not a business as usual plan. The RUPTL climate change policies yield the following outputs (PLN, 2013a):

a. Share of Geothermal and hydro power increase from 9% in 2013 to 16% in 2022
b. Emission factor dropped from 0,846 $kgCO_2$/kWh in year 2017 to 0.773 $kgCO_2$/kWh in year 2022

2. Opportunities for Further Mitigation

Although the RUPTL has incorporated climate change mitigation policies, there are opportunities for further mitigation of climate change in the power sector. Four opportunities are identified i.e. national policies, availability of renewable energy resources, climate finance, and technology development.

National Policies

A number of new national policies can create opportunities for climate change mitigations in the power sector. The new policies are:

a. Draft of New National Energy Policies

Draft of new National Energy Policy (Draft KEN) has been approved by the Legislative to replace the current National Energy Policy. The objective of the draft is to improve national energy security as well as to support sustainable development.

It is observed that the draft KEN intends to maximize the use of renewable energy by taking into account its economic level. Furthermore, the draft KEN points out the intention to minimize the use of oil as well as to optimize the utilization of natural gas and new energy. Yet, coal is considered to be the main option to secure the national energy supply.

Although coal is still dominant, the draft KEN lifts the target of renewable energy contribution in the national energy mix as can be seen in Figure S. By doing so, the draft KEN reduces GHG emission from business as usual scenario as much as 94.2 million ton C e as can be seen from Figure 6 (Ministry of Energy and Mineral Resources, 2013b)

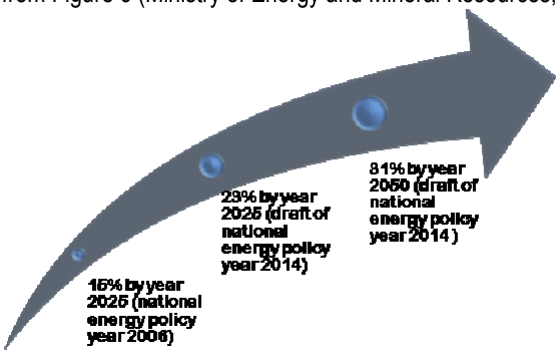

Figure 5. Target of Renewable Energy in the National Energy Mix

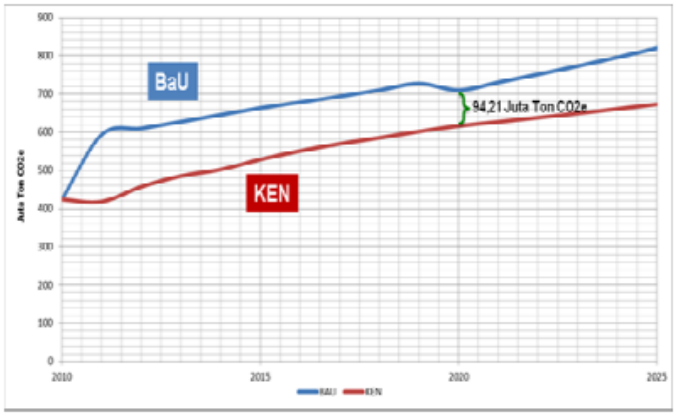

Figure 6. Projection of GHG Emission from Energy Sector (Ministry of Energy and Mineral Resources, 2013b)

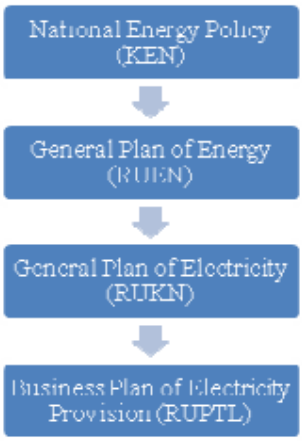

Figure 6. Policy Basis for the RUPTL

The National Energy Policy (KEN) becomes the basis for National General Plan of Energy (RUEN) and National General Plan of Electricity (RUKN) (Ministry of Energy and Mineral Resources, 2013). Meanwhile, the RUKN becomes the basis for RUPTL as can be seen in Figure S. Therefore, the new National Energy Policy is expected to enhance renewable energy utilization in the power sector.

b. Feed-in Tariff

In order to accelerate the development of renewable energy, the Government of Indonesia obliges PLN to purchase power from IPP and sets prices for purchasing power from renewable energy so called feed-in tariff. The regulations on feed-in tariff are expected to increase

attractiveness of renewable energy projects and thus encourage more investors to develop renewable energy projects.

(i). Geothermal

MEMR Regulation No. 17/2014 sets ceiling price ranging from 11.8 to 29.2 cent USD/kWh, depends on location and commercial operation date as can be seen from Table 3.

Table 3. Ceiling Prices for Geothermal Power according to MEMR Regulation No. 17/2004

Commercial Operation Date (COD)	Ceiling Prices		
	Region I	Region II	Region III
2015	11.8	17.0	25.4
2016	12.2	176	25.8
2017	12.6	18.2	26.2
2018	13.0	18.8	26.6
2019	13.4	19.4	27.0
2020	13.8	20.0	27.4
2021	14.2	20.6	27.8
2022	14.6	21.3	28.3
2023	15.0	21.9	28.7
2024	15.5	22.6	29.2
2025	15.9	23.3	29.6

Table 4. Ceiling Prices for Hydro Power according to MEMR Regulation No.12/2014

No	Voltage of Electricity Network (Plant Installed Capacity)	Location /Region	Purchase Price Rp/kWh		F Factor
			Year 1 to 8	Year 9 to 20	
1	Medium voltage (up to 10 MW)	Java, Bali and Madura	1075 x F	750 x F	1.00
2		Sumatera	1075 x F	750 x F	1.10
3		Kalimantan and Sulawesi	1075 x F	750 x F	1.20
4		NTB & NTT	1075 x F	750 x F	1.25
5		Maluku and Maluku Utara	1075 x F	750 x F	1.30
6		Papua and Papua Barat	1075 x F	750 x F	1.60
7	Low voltage (up to 250 kW)	Java, Bali and Madura	1270 x F	770 x F	1.00
8		Sumatera	1270 x F	770 x F	1.10
9		Kalimantan and Sulawesi	1270 x F	770 x F	1.20
10		NTB & NTT	1270 x F	770 x F	1.25
11		Maluku and Maluku Utara	1270 x F	770 x F	1.30
12		Papua and Papua Barat	1270 x F	770 x F	1.60

(ii). Hydro

MEMR Regulation No. 12/2014 sets the purchase price of hydro power (up to 10 MW) based on location, capacity and stage of operation, as shown in Table 4.

(iii) Solar Photovoltaic

MEMR regulation No. 17/2013 sets ceiling price at 25 cents USD/kWh. Ceiling price becomes higher i.e. 30 cents USD/kWh if the project is employing at least 40% of domestic components.

(iv) Municipal waste

MEMR regulation No. 19/2013 sets purchase price based on technology being used and network capacity as can be seen in Table 5.

Table 5. Purchase Prices of Power Generated from Municipal Waste according to MEMR Regulation No.19/2013

No.	Voltage of Electricity Network (Capacity)	Purchase Prices Rp/kWh	
		Zero Waste Technology	Sanitary Landfill Technology
1.	Medium voltage (up to 10 MW)	1,450	1250
2.	Low voltage (up to 10 MW)	1,798	1598

(v) Biomass and Biogas

According to MEMR regulation No. 4/2012, PLN is obliged to purchase power or excess power generated from biomass and biogas up to 10 MW capacities. The regulation also sets the purchase price based on locations and capacity ranging from 975 to 1,987.5 Rp/kWh as can be seen in Table 6.

Table 6. Purchase Prices of Power Generated from Biomass and Biogas

No.	Voltage of Electricity Network (Capacity)	Location/Region	Purchase Prices Rp/kWh	F Factor
1.	Medium voltage (up to 10 MW)	Java and Bali	656 x F	1.0
2.		Sumatera and Sulawesi	656 x F	1.2
3.		Kalimantan, NTB and NTT	656 x F	1.3
4.		Maluku and Papua	656 x F	1.5
5.	Low voltage (up to 10 MW)	Java and Bali	1004 x F	1.0
6.		Sumatera and Sulawesi	1004 x F	1.2
7.		Kalimantan, NTB and NTT	1004 x F	1.3
8.		Maluku and Papua	1004 x F	1.5

c. Draft of New Geothermal Law

Geothermal Law year 2003 set target to develop 6,000 MW of geothermal up to 2020 and allowed participation of private sectors. However, it fails to accelerate geothermal development due to the following reasons (Polycarp, Brown, & Fu-Bertaux, 2013):

- Delay on establishment of implementing regulations
- Unfavorable pricing structure
- Limited capacity of regional government
- Insufficient information on resource potential

In August 2014, draft of new Geothermal Law passed the legislative review and is expected to accelerate geothermal development (Okezone, 2012). The draft revises the Geothermal Law No. 27 Year 2003.

The draft of new Geothermal Law includes centralization and integration of geothermal field permissions and thus expected to speed up the permit process. This is because the permit process does not have to go through local governments. This will also ease the local governments' work considering the fact that they do not have enough human resource capacity with regard to geothermal. Furthermore, the new Law gives more benefits to the local governments as they will receive income from production bonus (KOMPAS.com, 2014).

The draft of new Geothermal Law also opens possibility for geothermal development within conservation forests because according to the draft, geothermal field is not considered as mining and thus it is possible to be developed in conservation forests (KOMPAS.com, 2014).

d. Regulations on GHG Emission Reduction

Government of Indonesia has issued a number of regulations related to GHG emission reduction as follow:

(i). Presidential Regulation No.61/2011 regarding The National Action Plan for GHG Reduction

This regulation manages action plans to achieve the national target to reduce GHG emission as much as 26% by 2020. The target is distributed through a number of sectors including energy sector.

Renewable energy becomes one of measures to achieve the national target on reducing GHG emission. MEMR reveals that out of 32.3 million ton of GHG emission reduction target from energy sector, 26.8 million tone reductions (83% of the energy sector target) are expected to be achieved through activities under new and renewable energy sub sector i.e. through development of mini hydro power plants, solar PV, biomass power plants and wind power plants (Ministry of Energy and Mineral Resources, 2013b) .

(ii). Presidential Regulation No. 71/2011 regarding National GHG Inventory

The objectives of national GHG inventory activities are to provide periodic information on level, status, and trend of GHG emissions and carbon sink as well as to provide information on climate change mitigation activities.

According to this regulation, industries are obliged to identify their sources of GHG emissions, measures, report, as well as to verify their GHG inventories.

(iii). MOE Regulation No. 15/2013 regarding Measurement, Reporting and Verification (MRV) of Climate Change Mitigation Action

This regulation set guidelines for measurement, reporting, and verification of climate change mitigation actions. The National MRV Commission will award certificates for successful mitigation actions and register the certified mitigation actions into the National Registration System.

The above regulations regarding GHG emission reduction are expected to encourage climate change mitigations in the power sector.

Availability of renewable energy resources

Indonesia is blessed with abundant renewable energy resources which include geothermal, hydro and solar. Unfortunately, the utilization of renewable energy in Indonesia is still low. Total portion of renewable energy is merely 4.7% of the national energy mix (Sumiarso, 2011). Therefore, the availability of renewable energy has been a great opportunities for climate change mitigation in the power sector.

a. Geothermal

The world's largest geothermal reserve lies in Indonesia and it is equal to 28.9 Giga Watt electricity (National Geographic Indonesia, 2012). Meanwhile, the current installed capacity of geothermal power plants is only 1 .3 GW. Out of the 28.9 GW potential, 9.5 GW are confirmed feasible to be developed until 2025 (West Japan Engineering Consultants, Inc., 2007). This means that there are opportunities for further development of geothermal power.

b. Hydro

World Bank study in year 1983 identified 1,275 hydro power potential sites in Indonesia (Nippon Koei.,Ltd., 2011) which will be able to generate 75 GW power capacity (Ministry of Energy and Mineral Resources, 2013b). However, due to a number of obstacles hydro potentials that are feasible to be developed is 23 GW. Meanwhile, the current installed capacity of hydropower is 6.8 GW (Ministry of Energy and Mineral Resources, 2013b). This implies that there is 16.2 GW of hydro potential can be developed as climate change mitigation options.

c. Solar

Solar radiation in Indonesia is 4.8 kWh/m2/day or equivalent to 4,035 TWh per years (Agency for The Assessment and Application of Technology, 2012). Meanwhile, current installed capacity of solar power is 27 MW or approximately 0.028 TWh per year[1] (Ministry of Energy and Mineral Resources, 2013b). Hence, there are opportunities for further development of solar power.

Climate Finance

According to RUPTL 2013-2022, investment required for power plant expansion until 2022 is 91.3 billion USD. Sources for financing are generally from PLN budget, government budget, investors (IPP) and international funding institutions (development banks, export credit, etc). It is observed that development banks are interested to low carbon projects. For instance, German Development Bank (KfW) considers environmental and climate protection as one of its main field of attention. KfW allocated 23 billion Euro in the area of energy efficiency and renewable energy (Thies, 2011). KfW have been supporting PLN to conduct feasibility study for a number of hydro power projects (Khairunnas, 2014).

Asian Development Bank is also eager to support the development of low carbon projets. For instance, ADB is currently providing technical assistance to PLN for preparation of hydro power development with total capacity of 184 MW (Asian Development Bank, 2013).

The World Bank has been implementing a program that aims to support implementation of the geothermal law using the Global Environment Facility fund. Meanwhile readiness support for further resource assessments, feasibility studies, environmental and social impact assessments, and institutional strengthening have been provided by several other international partners which includes Japan's International Cooperation Agency (JICA), the Asian Development Bank (ADB), the German Development Bank (KfW), the Netherlands, and New Zealand (Polycarp, Brown, & Fu-Bertaux, 2013).

Other opportunity for climate finance comes from bilateral agreement between Indonesia and Japan on Joint Crediting Mechanism (JCM). The agreement has been established in year 2013. There are 2 renewable energy projects of PLN that are currently developed under JCM scheme.

CONCLUSION

1. Up to 2022, power sector will remain dependent on fossil fuel, however the share of renewable energy is expected to be increased from 9% in 2013 to 16% in 2022.
2. GHG emission will increase gradually up to 2022, however the grid emission factor will drop after renewable energy projects go online.
3. There are opportunities for further mitigations of climate change in the power sector due to more favorable national policies, renewable energy availability, climate finance opportunities and the development of low carbon technology.

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