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ECONOMIC ANALYSIS OF CIKASO MINI HYDRO POWER PLANT AS A CDM PROJECT FOR INCREASING IRR

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Abstract

Renewable energy fueled power generations are few developed by private sector in Indonesia. High-cost investment and low electricity selling price to PT PLN as a single buyer is main barriers for private sector to involve in the development of renewable energy fueled power generations. In this project, the economic feasibility of Mini Hydro Power Plant of Cikaso with capacity of 5.3 MW, located at Sukabumi Regency, West Java province was assessed. This project utilized revenue generated from carbon market to increase the economic feasibility. Procedure to register the project to United Nation for Climate Change Convention (UNFCCC) as a Clean Development Mechanism project was explained in detail. Approved Consolidation Methodology (ACM) 0002 Version 12.3.0 was used to calculate grid emission factor in Jawa-Bali-Madura the grid electricity system. It was calculated that the grid emission factor is 0.833 (t-CO_2/MWh), and the carbon emission reduction generated for this project is 21,982 ton/year. From the analysis result, it can be proven that the additional revenue from carbon credit could increase the project IRR from 10.28% to 13.52%.

Key words: mini hydro power plant, Clean Development Mechanism, emission factor, IRR.

I. INTRODUCTION

A. Background

Renewable energy potential in Indonesia is quite large. Hydro energy potential in Indonesia is around 75 GW scattered over islands in Indonesia. Until now, only 4000 kW from the potential has been utilized as a power plant [1]. The utilization of mini hydro (over than 1 MW), micro hydro (10 kW – 1 MW) and pico hydro (below 10 kW) is suitable for remote areas and the area where PT Perusahaan Listrik Negara (hereinafter referred as to ”PLN”) Persero’s electric grid is not yet built. PLN is the state-owned electric power company, which has a role as a single buyer in the electricity business in Indonesia [2].

Indonesia government has targeted ratio of renewable energy to be 2.5% from all energy consumption in 2025. Regarding Green House Gas (hereinafter referred as to ”GHG”) Reduction, Indonesia’s government has planned to reduce 26% of GHGs in 2020 [3]. Despite policy and target for supporting renewable energy development have been implemented. Investors of renewable energy power plants still get a constrains on economic problems within the project. Unlike other countries, although the incentive for supporting renewable energy development has been implemented, however, the benefit still not be felt by investors. The incentive for renewable energy regarding electricity tariff for selling to PLN was determined by Regulation of Ministry of Energy and Mineral Resources in the year of 2002, 2006, and 2009 [4, 5, 6].

Despite the electricity tariff determined in 2009 relative closes to the economic price of the renewable energy project. However, it is not applicable to a hydro power plant project. Renewable energy based power plant is not economic. It is one reason why private sector is not interested to involve in it an investment in

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Indonesia. Development of the hydro power plants in remote areas needs high investment cost. Besides that the electricity selling price must compete with the electricity selling price of fossil fuel based power plant that gets a subsidy. This is another reason, why renewable energy based power plant is not a lot of built in Indonesia [7].

Clean Development Mechanism (hereinafter referred as to ”CDM”) is one of the mechanism of Kyoto Protocol as an attempt to reduce Green House Gasses [8] (hereinafter referred to as ”GHG”) such gas of CO_2, N_2O, CH_4, and so on. The reduction emission amount refers to the GHG amount generated by every country during a year of 1990. CDM has been implemented throughout the world since 1997, however, the implementation number in Indonesia is less compared to other countries in Asia such as India and China. Ratification of CDM by Indonesian government has been done in 2004, signed by the President of Republic of Indonesia.

Through CDM, developed countries (member of ANNEX I) collaborate with these countries to reduce GHGs emission. The benefit of CDM program for developing countries includes: (1) flow of the foreign fund which could help financial of a domestic project; (2) participation of foreign investors for the project which could minimize the risk to local developers; (3) possibility of transfer technology that could help domestic technology development in domestic; (4) loan rate from a foreign bank usually that has a lower rate compared to domestic bank rate. Among the benefits of CDM project above, lower bank loan rate is the most interesting factor for the local developers. For developed countries, CDM is the mechanism for reducing GHG with low cost compared to develop the project activity in their country.

CDM itself has procedures determined by United Frameworks for Convention Climate Change (hereinafter referred as to”UNFCCC”). The procedures should be conducted in order for approved officially by UNFCCC as an entity that provides a certificate for CDM project. Each step conducted in the CDM procedures may need a time more than one year. Basically, all procedures implemented on the project should be clarified whether the project can reduce GHG emission exactly and in line with the determined methodology. One of the conditions that a project can be implemented as CDM project, if the project economic can be increased using additional revenue from selling carbon credit. Project economic is a value of Internal Rate Return (hereinafter referred as to ”IRR”).

CDM is one of the mechanisms that can reduce unfeasible economic factors of the renewable power generation project. The renewable power generation is a project than can reduce carbon emission generated from fossil-fuel power generation plant connected by the grid electricity system in a certain area. Revenue from selling carbon credit can be extra revenue, and usually for hydro power plant the additional revenue increases IRR value around 1-2% more, and also grosses revenue around 10-20%.

PT Bumiloka Cikaso Energi has conducted the investigation of hydro power potential and found the hydro potential in Curug Luhur water fall in Cikaso River, in West Java Province. The investigation result concluded that the river in that area has a potential to generate electric power. This project utilizes potential energy generated from height differences between Cikaso River and Curug Luhur (Luhur Waterfall) (see Figure 1). After reaching the optimum head, the flow is returned to the Cikaso River from the river bank having height differences of 40 m with the Cikaso River. Using penstock the water flow is returned to the river through turbine. The potential energy is converted to mechanical energy by three units of turbines, and then it is converted to the electric energy by three units of generators.

Table 1 shows the specification of Cikaso Small Scale Hydro Power Plant (hereinafter referred to as ”SSHPP”). The lowest of turbine capacity of 0.8 MW is used especially in the dry season when the water flow decrease drastically. During the rainy season, all of three turbines can be operated at full capacity of 5.3 MW.

Rocky condition of the site leads to high investment cost, especially the cost for developing water channel toward to turbine became several times higher compared to the normal condition. Based on Feasibility Study

Figure 1. Site condition

Report that has been completed in 2009, it can be concluded that this project has IRR value of 10.28%. It is lower than a benchmark that determined based on the lowest rate of Working Capital rate of 12.22% issued by Bank of Indonesia in 2009. The project investment is Rp 122.2 billion funded by 100% owner equity.

In order to increase the feasibility level to the project, it is needed to add additional revenue through CDM mechanism for this project. For this purpose, this project activity would be submitted as CDM project and it was planned to be registered in UNFCCC. Certification of this project activity can be sold, and it can generate additional revenue besides the main revenue from selling electricity to PLN.

B. Purpose

This paper describes the grid emission factors (hereinafter referred as to ”EF”) calculation for Jawa-Bali-Madura grid electricity system (hereinafter referred as to ”JAMALI system”). Using the EF, the GHG reduction generated from this project activity can be calculated annually. The economy of Cikaso Small scale Hydro Power Plant (hereinafter referred as to ”SSHPP”) as the CDM project is calculated by considering the additional revenue from selling credit carbon. The economic condition with and without the additional revenue are compared. The economic feasibility of the project is compared using the conservative benchmark at that time.

II. Methodology

A. Green House Gas Calculation

Grid EF in this project activity is calculated using methodology determined by UNFCCC. Two methodologies are category of I-D:”grid connected renewable electricity generation” [8], ver. 16 and ACM (Approved Consolidation Methodology) 0002 version 12.3.0, “Consolidated methodology for grid-connected electricity generation from renewable sources” [9]. Using both methodologies, the electricity amount exported to the grid is converted to the emission reduction amount, and then based on the carbon market price, the additional revenue is calculated.

Project boundary is determined based on the methodology as illustrated in Figure 2 [8]. This figure indicates that the emission reduction activity is limited to the activities related to the Cikaso SSHPP only. In this project activity, small part of generated electricity is utilized for auxiliary equipments and the remaining is

Table 1.
Cikaso SSHPP specification

Item	Unit	Value
Installed total capacity	MW	5.3
Installed capacity each unit	MW	2 x 2.25 1 x 0.8
Average of exported energy to the grid annually	MWh	26,390
Capacity factor	%	58
Head	m	40
Water flow	m^3/s	16.5
Unit number	-	3
Turbine type	-	Horizontal Francis

exported to the grid owned by PLN of West Java region. The difference between both electricity amounts is net electricity that used in the in the emission reduction calculation.

The data used during the determination of EF is all electricity generated by all power plants connected by the JAMALI system and all fuel consumption used in the all power plant during 2001-2005 [10-15]. Based on ACM 0002 [9], EF value is calculated by average value of the latest three years of data used during the determination of EF, 2003-2005 [12-15]. JAMALI system is the interconnection electricity system in Jawa, Madura and Bali Island.

Based on AMS-I.D [8], Baseline Emission, BE_y, is obtained by multiplying net of electricity, EG_y, by the grid emission factor within the system, EF_y. Equation of BE is indicated in Equation (1).

$$BE_y = EG_y \ x \ EF_y \quad (1)$$

where BE_y is baseline emission ($tCO_2 e$) in year y, EG_y is quantity of net electricity generation that is produced and fed through the system as a result of the implementation of the CDM project

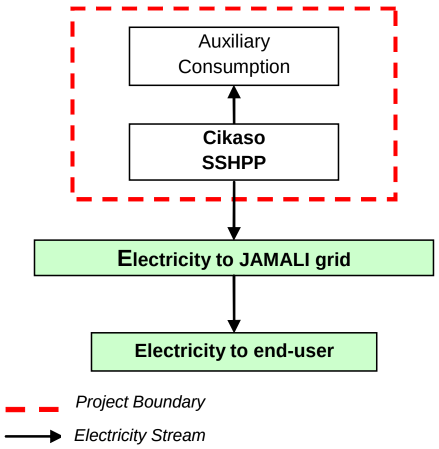

Figure 2. Project boundary

activity in the year y, and EF_y is Emision factor (tCO_2 e). Prior BE_y calculation, parameters used in the steps below should be determined [16].

1) Step 1; Determination of Operating Margin Emission Factor

Simple Operating (OM) is selected for the emission factor calculation with the reason as follows.

- Dispatch data analysis emission factor is unable to be implemented, because required data cannot be published
- Number of plants which includes the category of “Low-Cost and Must-Run/LCMR” power generation plan is below of 50% compared to total of power generations connected to JAMALI system during five years (2005-2009).

In this case, numbers of LCMR power plants are five units of power plant in 2005 and 2006, six units of power plant in 2007 and 2008, and seven units of power plant in 2009.

Calculation of simple operating margin ($EF_{OM,y}$) uses Equation (2) as follows.

$$EF_{OM,average,y}\left(\frac{tCO_2}{MWh}\right) = \frac{\sum_m (EG_{m,y}\ x\ EF_{EL,m,y})}{\sum_m EG_{m,y}} \qquad (2)$$

where $EG_{m,y,}$ is net quantity of electricity generated and delivered to the grid by power unit m in the year y (MWh), $EF_{EL,m,y}$is CO_2 emission factor of power unit m in the year y (tCO_2/MWh), m is power unit included in the operated margin, and y is most recent historical years for which power generation data is available.

2) Step 2; Calculation of Build Margin Emission Factor

Build Margin Emission Factor ($EF_{BM,y}$) calculation indicates an amount of CO_2 reductions in the absence of fossil fuel based power plant or on the delay to the development.

In the $EF_{BM,y}$, calculation, the most recently developed a set of power plant having the highest electricity production annually is selected according to the following procedures.

- The set of five power units that have been built most recently, or
- The set of power capacity additions to the electricity system that comprise 20% of the system generation (in MWh) and that have been built most recently.

The set of power units that comprises the larger annual generation is selected, and then Build Margin Emission Factor is calculated using the following Equation (3).

$$EF_{BM,y}\left(\frac{tCO_2}{MWh}\right) = \frac{\sum_{i,m} F_{i,m,y} \cdot COEF_{i,m}}{\sum_m GEN_{m,y}} \qquad (3)$$

where $F_{i,m,y}$, $COEF_{i,m}$ and $GEN_{m,y}$can be analogous as the same parameters which are used throughout the operating margin emission factor calculation for a set of power units, m.

3) Step 3; Calculation of Baseline Emission Factor

Combined Margin Emission Factor (EF_y) is using Equation (4).

$$EF_y = w_{OM}\ x\ EF_{OM,y} + w_{BM}\ x\ EF_{BM,y} \qquad (4)$$

where the ratio for w_{OM} and w_{BM}, is 50% respectively (w_{OM}= w_{BM}= 0,5).

4) Step 4. Calculation of Baseline Emission

Baseline emission (BE_y) is calculated using Equation (5):

$$BE_y = EG_y\ x\ EF_y \qquad (5)$$

Where EG_y is quantity of net electricity generation and EF_y is Emision factor.

5) Step 5. Calculation of Emission Reduction

Calculation of Emission Reduction (ER_y) is using Equation (6):

$$ER_y = BE_y - PE_y - L_y \qquad (6)$$

This project activity is a renewable energy based power generation. Therefore, there is no leakage, L_y=0, and Project Emission, PE_y=0.

B. Economic Analysis

The aim to submit the project activity as CDM project is to increase the economic feasibility of the project. The Internal Rate Return (hereinafter referred as to ”IRR”) is used as an economic parameter. The value is lower than the selected benchmark. The lowest bank loan rate over the year of 2009 is taken as the benchmark. The feasibility study was completed in 2009. Sensitivity analysis is calculated using ±10% of change of the following parameters,

- Investment cost
- Electricity selling prive
- General administration and O&M cost

The change of ±10% is considered can be represented the changes due to inflation, increase over the prices, change of water debit and other parameters that able to change parameter of (i) investment cost, (ii) selling electricity price and (iii) generation administration cost and O&M cost.

The IRR project is re-calculated using the additional revenue generated from selling carbon credit and then the economic feasibility of the project is re-analyzed.

III. RESULTS AND DISCUSSIONS

A. Green Houses Gasses Emission

Green houses gasses emitted from power generation plant activity is Carbon Dioxide (hereinafter referred as to ”CO_2”), mainly. The amount of the GHG in JAMALI system rises year by year along with the increase of the coal-fired power plant number as a result of implementation of the Crash Program I.

The increase of CO_2 is shown in Figure 3. Figure 3 indicates that CO_2 rose sharply in 2006. The increase is caused by Cilacap and Tanjung Jati B coal-fired power plants started to operate in that year.

Even, there is no new power plant operated. The consumption of coal increased gradually that resulted CO_2 emissions increased, in the following years. According to the methodology [8], emission factor shall be calculated using the average of the last three years of 2007, 2008 and 2009.

B. Calculation of Emission Factor

EF of JAMALI system is calculated using Equations (1), (2) and (3). Coefficient Emission calculation (COEF) of CO_2 for each fuel is shown in Table 2. The total amount of generated electricity within five years in the system is indicated in Table 3.

Table 4 shows the ratio number between Low Cost Must Run (hereinafter referred as to ”LCMR”) [16] power plants and total power plant connected with the system. In the table, it is indicated that within five years (2001-2005) consecutive, the ratio of LCMR power plant is lower than 50%. Therefore, according to the tool, the calculation of EF_{OM} shall use a simple OM [16]. Table 5 shows the loss generated from own consumption and generated from sub stations. The lost data used is only for 2005 and 2006, because in the following years, a net electricity production of each power plant was published. The net electricity production is an amount of

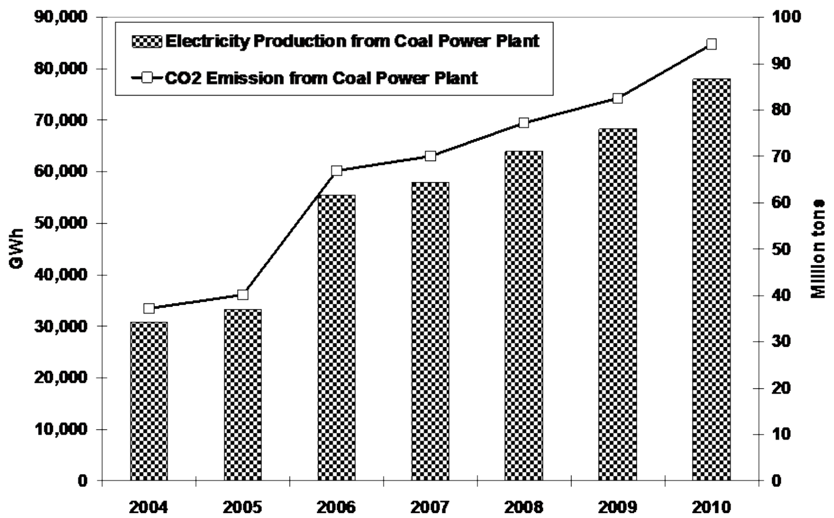

Figure 3. CO_2 Emitted from coal fired power plant in JAMALI system during 2004-2010 [17]

Table 2.
Fuel specification

Fuel Type	**(A)**			**(B)**	**(C)**	**(D)**	**(E)**	**(F)**	**(G)**
	Calorie Value			**Carbon Content Standard**	**Oxidized Carbon Factor Standard**	**Carbon**	**Emissin, CO_2**	**Specific Gravity**	**Emission CO_2**
						(A)x(B)x(C)	**(D) x 44/12**		**(E) x (F)**
	TJ/kt fuel			**(tC/TJ)**	**-**	**tC/kt fuel**	**tCO_2/kt fuel**	**kt/k l**	**tCO_2/kl fuel**
Sources	Pertamina	MEM	IPCC	IPCC	IPCC	-	-	-	
MFO	41.02			21.1	1	865.50	3,173.51	0.00099	3.142
HSD	42.73			20.2	1	863.12	3,164.77	0.000845	2.674
Coal		24.03		26.20	1	629.61	2,308.56		
Natural Gas			48.00	15.30	1	734.40	2,692.80		

Note. : *HSD: High Diesel Speed, MFO: Marine Fuel Oil, IPCC: Intergovernmental Panel on Climate Change; PERTAMINA: Perusahaan Pertambangan Minyak dan Gas Bumi Negara/State-Owned Oil Company of Indonesia,* kt fuel: kilo tonne fuel; tC: tonne carbon, TJ: Terra Joule, kl fuel : kilo litre fuel electricity generated deducted by the loss generated from own consumption and generated from sub stations.

Fuel consumption of each power plant during five years, 2005-2009 is shown in Table 6. Amount of GHG emitted from each kind of fuel is shown in Table 7. Table 8 shows $EF_{simpleOM}$ derived from the amount of CO_2 emission and total amount of electricity generated during the last three years, 2007, 2008, and 2009. The value of $EF_{simpleOM}$ was calculated using Equation (4), and the result is 0.9583 (tCO_2/MWh).

Table 3.
Electricity generated in JAMALI system based on the fuel type (MWh nett)

Source of plant	Operation year	2005	2006	2007	2008	2009
	fuel	GWh				
Hydro		7,023	5,309	5,930	6,251	6,635
Diesel	Oil	128	101	87	173	121
Gas Turbine	Gas	2,603	2,038	2,126	3,073	4,688
	Oil	2,547	2,087	1,958	2,191	3,275
Geothermal		6,185	6,183	6,672	7,337	8,188
Steam	Coal	45,477	51,826	57,206	54,140	56,965
	Gas	646	669	941	690	563
	Oil	6,673	7,171	7,685	8,274	7,301
Combined Cycle	Gas	16,559	6,193	17,929	18,953	20,301
	Oil	8,980	8,444	7,192	10,505	7,527
Total Net Production		96,821	100,021	107,726	111,586	115,564

Tabel 4.
Ratio of low cost and must run power of power plant in the last 5 years (2005 - 2009)

Item	Units	2005	2006	2007	2008	2009
Total Generation Net	GWh (net)	83,436	88,351	95,124	97,999	100,741
Low Cost and Must-run generation	GWh (net)	13,385	11,670	12,603	13,588	14,823
Low Cost and Must-Run Generation/ Total Generation	%	16%	13%	13%	14%	15%

Table 5.
Lost ratio

Year	2005	2006
Average losses in Java-Bali system due to own consumption	3.94%	4.21%

Table 6.
Fuel consumption in the grid during 2005-2009

Fuel Type	unit	2005	2006	2007	2008	2009
HSD	kilo litre	4,406,883	3,623,332	3,498,197	4,031,017	2,781,649
MFO	kilo litre	1,944,142	2,054,365	2,225,317	2,374,577	2,150,386
IDO	kilo litre	4,074	2,343	2,306	4,401	-
Gas	MMBTU	136,744,924	141,147,996	145,991,700	167,844,288	219,008,065
Coal	ton	24,524,261	26,860,205	29,584,714	28,353,988	29,409,721

Table 7.
CO_2 emission in JAMALI grid system during 2005-2009

Year	2005	2006	2007	2008	2009
Fuel type	t-CO2				
HSD	11,785,015	9,689,620	9,354,980	10,779,863	7,438,768
MFO	6,108,049	6,454,344	6,991,436	7,460,377	6,756,020
IDO	11,142	6,408	6,307	12,037	-
Gas	8,093,881	8,354,497	8,641,195	9,934,641	63,006
Coal	6,615,701	62,008,365	68,298,053	65,456,849	67,524,209
TOTAL	82,613,788	6,513,234	93,291,971	93,643,767	94,682,002

Table 8.
Operating margin emission factor during in the last three years (2007-2009)

Item	Unit	2007	2008	2009	TOTAL
Total Emissions	tCO_2 e	93,291,971	93,643,767	94,682,002	281,617,740
Total Generation	MWH (net)	95,123,861	97,998,684	100,741,000	293,863,545
EF_{OM}	tCO_2 e/MWh				0.958

Table 9.
Two groups of power plant using to determine build margin emission factor

Sample group (m) Classification	"The five power plants that have been built recently" (GWh)	"The power plants capacity addition to the electricity system that comprises 20% of system generation (in GWh) and that have been built most recently"	Comments
Electricity quantity	12,578.0	25,660	Total generation is 115,564 (GWh) in JAMALI grid
Proportion (ratio to total generation in JAMALI grid)	10.88%	22.20%	
Selected group		O	

EF_{BM} calculation is conducted after determined the most recently developed a set of power plant having the highest electricity generated annually. Two groups of power plants were determined according to step 2. The first group consisted of five units the most recently developed power plant, and the second group consisted of power plant generating electricity with the amount ratio of 20% from total electricity generated within the system. The highest electricity generated from both groups that consist of power plants producing electricity in amount of 20% from the total in 2009 was selected, as shown in Table 9.

Table 10 to Table 12 indicates electricity generated and fuel consumption in 2009 from a group of power plants having electricity generated of 20% from total electricity generated inside the system. Using Equation (2), EF_{BM} is 0.7075 (t-CO_2/MWh). Using Equation (3), EF_{2005} is 0.833 (t-CO_2/MWh).

C. Emission Reduction, (ERy)

ER in this project activity is calculated using Equation (4) and Equation (5). L_y=P_{ey}=0, and then emission reduction of CO_2 resulted from operation of Cikaso SSHPP is 21,982 tCO_2/yr.

D. Economic Analysis

The calculation results of sensivity analysis are shown in Figure 4. X-axis and Y-axis indicates the amount of parameter change and IRR value. In the Figure, benchmark line of 12.22%, selling electricity price, investment cost, and general administration cost and O&M cost is indicated by symbol of (X), (■), (◆) and (▲), respectively. The selected benchmark used throughout the calculation is the conservative bank loan rate in 2009 when the Feasibility Study completed. Change of three parameters within the amount of ±10% shows IRR is still below than the benchmark value. It can be concluded that the

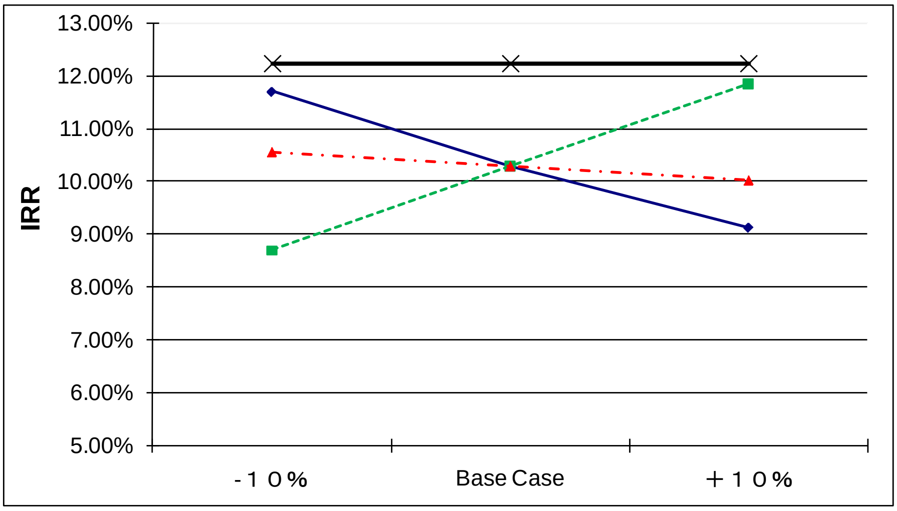

Figure 4. IRR project and the benchmark

Table 10.
Sample group power plant for build margin calculation (part 1)

No.	Power Plant		Fuel type	Operation year	Capacity	Generated Power		Thermal Eff.
						Actual Data	Calculation data	
					MW	MWh		Gj/GW/h
	Owner	Power Plant			A	C	C=AxBx 8760/1000	D
1	PT Java Power	Paiton II #6	Steam-Coal	2000	1220	4541.7		0.00
2	PT Geo Dipa Energi	Dieng	Geothermal	2002	50	93.0		0.00
3	PT Cikarang Listrindo Power	Cikarang	GT-Gas	2003	150	1043.0		9119.04
4	PT Krakatau Daya Listrik	Krakatau	Steam-Coal	2003	0	2.0		9235.95
5	Muara Tawar	Block 3 & 4	GT-Gas	2004	840	3555.0		9119.04
6		Block 3 & 4	GT-Oil	2004	840	351.0		9119.04
7	PT Sumberenergi Sakti Prima	Cilacap #1	Steam-Coal	2006	562	3496.0		9235.95
8		Cilacap #2	Steam-Coal	2006	562	3496.0		0.00
9	Tanjung Jati B	unit #1	Steam-Coal	2006	660	8226.0		9235.95
10		unit #2	Steam-Coal	2006	660	8226.0		0.00
11	Cilegon	Cilegon	CCGT-Gas	2006	740	3916.0		6003.37
12	Indorama	Indorama	Steam-Coal	2007	50	0.0		9235.95
13	PLN	Labuhan	Steam-Coal	2009	300	436.0		9235.95
	TOTAL						25,659.7	

Table 11.
Sample group power plant for build margin calculation (part 2)

No.	Power Plant		NCV		Fuel Consumption			Unit
			GJ/k t fuel	GJ/k ltr fuel	Actual data	calculation data		
	Owner	Power Plant	E		F	G= CxD/E	G= 1000x CxD/E	
1	PT Java Power	Paiton II #6	24,031	-	-	-	-	-
2	PT Geo Dipa Energi	Dieng	-	-	-	9,014,689	-	MMBTU
3	PT Cikarang Listrindo Power	Cikarang	-	-	-	-	769	ton
4	PT Krakatau Daya Listrik	Krakatau	24,031	-	-	30,726,000	-	MMBTU
5	Muara Tawar	Block 3 & 4	-	41	-	-	78,820	kltr
6		Block 3 & 4	-	-	1,899,271	-	-	ton
7	PT Sumberenergi Sakti Prima	Cilacap #1	24,031	-	-	-	-	-
8		Cilacap #2	-	-	3,620,231	-	-	ton
9	Tanjung Jati B	unit #1	24,031	-	-	-	-	-
10		unit #2	-	-	-	22,282,040	-	MMBTU
11	Cilegon	Cilegon	-	-	-	-	-	ton
12	Indorama	Indorama	24,031	-	-	-	-	ton
13	PLN	Labuhan	24,031	-	-	-	-	-
	TOTAL							

change of three parameters doesn’t give an effect to the feasibility of the project to be unfeasible.

The assumption of CER (Certified Emission Reduction) is 13 Euro/t-CO_2 for 30 years. The calculation results considered the additional revenue from CER shows IRR increased 3.24%, from 10.28% to 13.52% as shown in Table 13. The additional revenue increased the value of IRR of 13.52%. It becomes higher than the benchmark value of 12.22%.

IV. CONCLUSION

According to the calculation result of economic feasibility of the project, it can be proven that the additional revenue generated from carbon credit could increase the project IRR

Table 12.
Sample group power plant for build margin calculation (part 3)

No.	Power Plant		Fuel type	Operation year	Effective CO2 emission factor	Emission Reduction	
					(t- CO2/GJ)	t-CO2	
	Owner	Power Plant			H	G= (ExF)xH/1000	G= ExGxH
1	PT Java Power	Paiton II #6	Steam-Coal	2000	-	4,968,464	-
2	PT Geo Dipa Energi	Dieng	Geothermal	2002	0	-	-
3	PT Cikarang Listrindo Power	Cikarang	GT-Gas	2003	0	-	533,576
4	PT Krakatau Daya Listrik	Krakatau	Steam-Coal	2003	0	1,775	-
5	Muara Tawar	Block 3 & 4	GT-Gas	2004	0	-	1,818,661
6		Block 3 & 4	GT-Oil	2004	0	237	-
7	PT Sumber Energi Sakti Prima	Cilacap #1	Steam-Coal	2006	-	4,384,579	-
8		Cilacap #2	Steam-Coal	2006	0	-	-
9	Tanjung Jati B	unit #1	Steam-Coal	2006	-	8,357,517	-
10		unit #2	Steam-Coal	2006	0	-	-
11	Cilegon	Cilegon	CCGT-Gas	2006	0	-	1,318,866
12	Indorama	Indorama	Steam-Coal	2007	0	-	-
13	PLN	Labuhan	Steam-Coal	2009	-	386,848	-
	TOTAL					-	**21,770,522**

Table 13.
IRR calculation with and without the additional revenue

	without additional revenue	**with additional revenue**
Investment cost	Rp 122.2 Billion	
Benchmark	12.22%	
Life Time	30 years	
IRR Project	10.28%	13.52%

from 10.28% to 13.52%. The additional revenue from carbon credit can increase the economic feasibility of a renewable energy.

This mechanism is suitable for Indonesian condition that still doesn't have incentives to renewable energy power generation development. The other benefit for implementing CDM, the project can be known internationally as the project that contributes in emission reduction of GHG. It can increase the project image as a green project which contributes in GHG emission reduction.

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