A Proposed Scheme and Future Development for Carbon Trading System in Indonesia based on Case Study in Muaratawar Add-On Power Plant

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Abstract. The growth of electricity demand in Indonesia has enforced the government to develop several large-scale power plants to electrify some region. Due to economical and operational aspects, mostly majority of plants are build based on coal-fired plant, where it can give bad impact to environment. Furthermore, some mitigation has been taken into account in attempt to reduce the GHC emissions. One of the options is by evaluating on a case in Muaratawar add-on project (Block 2, 3 and 4). The addition of HRSG at the plant is expected to reduce the GHG emissions to 0.48 Tons of CO₂/MWh with a potential carbon reduction of 3,599.410.69 Tons of CO₂/year. This paper concern on proposed business scheme for carbon trading through a comprehensive evaluation based on historical recorded data and baseline along with weighting and scoring method to select the best carbon trading system.

1. Introduction

Along with the growth of global economies and also technology development, environmental issues, such as global warming and air pollution, have rapidly rocketed in recent years. Over the past ten years, greenhouse gas (GHG) emission has gradually increased about 2.7% annually [1]. Countries in the world have given a quick response in attempt to reducing the GHG emission through a declaration in Kyoto [2] and followed in Paris Agreement [3] by setting the energy development plans to deal with those commitments [4]. Through those meetings, it has been proposed the average global temperature increase by GHG emission should not be exceeded by 2°C annually [5]. By 2050, it is expected the GHG emission could be likely lowered at least 50% of their current values. Several sectors have been examined as a suspect in exhausting GHG emission, particularly from power sector.

Most of technology used for power plant, especially in developed country are depends on fossil fuels (i.e coal, oil, and diesel). Fossil fuels power plants are still being considered as the fastest, easiest and cheapest way to generate the electricity, locking up it is as the one of the main sources of GHG emission. Yet, due to its bad impact to environment, some countries have set specific efforts in attempt to reduce GHG emission, such increasing the use of renewable energy sources (RES) technology, promoting energy conservation and efficiency and also more approach named carbon trading.

As one of global countries, Indonesia has ratified the agreement and submitted its commitment through a proposal of Nationally Development Contribution (NDC). It is submitted that Indonesia commit to reduce emission up to 29% on their own and to 41% with the support of international cooperation from conditions without action (Business As Usual (BAU)) by 2030 as shown in Table 1 [6].
Table 1. Contribution of GHG Emission Reduction Achievement to the 29% Target in 2030 (in Mton CO2e)

| Parameter              | Target 2030 | 2010   | 2011   | 2012   | 2013   | 2014   | 2015   | 2016   | 2017   |
|------------------------|-------------|--------|--------|--------|--------|--------|--------|--------|--------|
| Actual Emission Level  |             | 1,116  | 1,354  | 1,478  | 1,349  | 1,767  | 2,372  | 1,457  | 1,154  |
| BAU NDC                | 2,869       | 1,334  | 1,521  | 1,570  | 1,610  | 1,703  | 1,703  | 1,768  | 1,860  |
| Emission Reduction     | 834         | 218    | 167    | 92     | 261    | -97    | -669   | 311    | 706    |
| Contribution of        |              | 29     | 7.6    | 5.8    | 3.2    | 9.1    | -3.4   | -23.3  | 10.8   |
| realisation (100%)     |             | 24.5   | 100    | 100    | 100    | 100    | 100    | 100    | 100    |

Source: Directorate General of Climate Change Control 2018.

Table 2. Contribution of GHG Emission Reduction in Energy Sector (in Mton CO2e)

| Source of GHG Emission | 2010   | 2011   | 2012   | 2013   | 2014   | 2015   | 2016   | 2017   |
|------------------------|--------|--------|--------|--------|--------|--------|--------|--------|
| Industry               | 146,703 | 162,076 | 155,355 | 104,638 | 110,964 | 122,563 | 103,413 | 102,344 |
| Power Generation       | 130,886 | 160,771 | 174,873 | 177,294 | 208,671 | 211,916 | 231,370 | 243,629 |
| Transportation         | 108,264 | 117,570 | 139,271 | 143,243 | 141,520 | 129,187 | 136,405 | 147,230 |
| Residential            | 28,264  | 28,674  | 29,663  | 31,313  | 32,303  | 32,720  | 33,164  | 34,863  |
| Commercial             | 3,793   | 3,462   | 4,306   | 4,103   | 3,834   | 4,413   | 2,918   | 3,182   |
| Others                 | 35,291  | 34,803  | 36,950  | 35,439  | 33,851  | 35,508  | 30,754  | 30,996  |
| Total Emission by      | 453,235 | 507,357 | 540,419 | 496,030 | 531,142 | 536,306 | 538,025 | 562,244 |
| Energy Sector          |         |         |         |         |         |         |         |         |

Source: Directorate General of Climate Change Control 2018.

Energy sector, particularly power plant emission has dominated the total emission. In 2017, the energy sector has contributed up to 49% or 562,244 GgCO2e to national GHG emissions. Of 49% GHG emissions produced in 2017 by the energy sector, 43% of it is produced from power generation as shown in Table 2. Yet ironically, the government of Indonesia has launched 35 GW megaproject of power plant – especially in Java-Bali area where it has more than 70% of the electricity demand – through the 2019-2028 General Business Plan for Electricity Supply (Rencana Umum Penyediaan Tenaga Listrik, known as RUPTL) [7, 8].

One of projects, which is recently under construction, Combined cycle gas turbine (add-on) at Muara Tawar power plant complex. The project is about 650 MW in total capacity and expected to start synchronizing by 2021 to support for Greater Jakarta power grid system. At the same time, this project is also projected to reduce exhausted emission.

As power plant industry sector is giving high contribution to GHG emission, this paper concern on designing a carbon trading scheme with some intriguing stimulation through market and also reducing cost, will promote power industry sector to provide a reliable basis to develop carbon trading market. The scheme will be based on Muaratawar Add-on project, due to this project is expected to have commercial operation date (COD) within next year and it has mature system on emission measurement based on existing plant.

2. Overview of Carbon Trading
Carbon trading or emission trading (ET) is designed worldwide to reduce GHG emissions through market mechanism by setting limits on emissions and enabling the trading of emission units, which are instruments representing emission reduction [9, 10]. According to Kyoto Protocol, six types of emission, such as carbon dioxide (CO2), methane (CH4), nitric oxide (NO), hydrofluorocarbons (HFCs), perfluorocarbons (PFCs) and sulphur hexafluoride (SF6) are being accommodated in carbon market basis [2].
Two types of carbon/emission trading system have been well-developed globally, namely cap-and-trade system and baseline-and-credit system. The cap-and-trade system is designed by setting a cap as an obligation to achieve emissions reduction target [9, 11]. It is expected to internalize (some of) the costs of emissions by driving actors to seek cost-effective means in attempt to reduce their emissions. The cap is in the form of an allocation for emissions allowance for participant conducted at the beginning of the period. At the end of the period, participant must surrender quota unit to the independent institution by the actual amount of emissions they have released. Participant who pass their cap can buy additional quota from unused quota another participant.

ET was studied from an enterprise level [12] and macro level [13]. The following is a brief description of ET that have been operated in the world, European Union ETS, Swiss ETS, Kazakhstan ETS (KAZ ETS), New Zealand ETS, Korea ETS (KETS), China ETS, Japan Voluntary Emission Trading System (J-VETS), Tokyo Metropolitan ETS, Regional Greenhouse Gas Initiative (RGGI), California Cap-and-Trade Program, Quebec Cap-and-Trade Program and Ontario Cap-and-Trade Program.

Unlike cap-and-trade system, a baseline-and-credit system does not involve any projects that are implemented under regulation cap-and-trade system. This credit is generated with each new project implemented. In this system, commodities traded are emission reductions that have been certified based on the terms and conditions applicable to that market. This transaction called carbon credit [14]. One credit unit carbon is usually equivalent to reducing one ton of carbon dioxide emissions. Emission reduction is difference from the emission scenario without there are projects to reduce emissions (baseline) with actual emissions after the project.

The baseline-and-credit system has the following process:

- Proposal stage, where the project prepares the proposal documents according to applicable provision.
- Validation stage, where the suitability of the proposed document with the requirements and provisions checked.
- Registration stage, where the project is declared eligible and recorded as a participant in the crediting scheme concerned.
- Verification phase, which results in a reduction in emissions over a certain period checked the truth and suitability.
- The stage of issuing carbon credits, where some carbon credits are issued based on the results of verification.

The difference between trading and crediting system is that most trading system are on the mandatory market, while the crediting system is largely in voluntary market. As for type of crediting market that included in the mandatory market are Clean Development Mechanism (CDM) and Joint Implementation (JI), while those included in the voluntary market include Gold Standard (GS), Verified Carbon Standard (VCS), Plan Vivo, Panda Standard, American Carbon Registry and etc. Crediting system also generally can operate across national/ regional borders, unlike the case with system trading (ETS)[11].

The CDM is conducted in many developing countries such as Korea and Malaysia [15]. This scheme is intended to help developing countries to get clean technology investment in efforts towards sustainable development low carbon in their countries. The result from this scheme is CER (Certified Emission Reduction). Each CER represents a reduction in GHG emissions and equivalent with one ton of carbon dioxide that has been verified, as well as credit carbon in other schemes [16]. Indonesia as a Non-Annex I country in the UNFCCC and has ratified The Kyoto Protocol can use CDM to provide incentives for clean development activities. It means, Indonesia can participate in the CDM and sell its CER to Annex I parties who need it.

Joint Implementation (JI) works similarly with CDM, with the exception that the host country is not a developing country but another Annex I country. The result from JI project is called Emissions Reductions Units (ERUs). Corresponding adjustments is required for each credit issued under the JI in attempt to obtain the emission target obligations. In this case, the cancelation of the equivalent amount
of Kyoto Protocol allowance s—Allocated Allowance Units (AAUs) — is required from the seller country to avoid the double counting of the mitigation outcomes with those of the buyer [10]. The example JI scheme is Joint Crediting Mechanism which encourages cooperation between Japanese and Indonesian institutions to promote implementations of low carbon development activities in Indonesia [17].

The VCS is a nonprofit organization that develops and manages greenhouse gas emission accounting standards to allow vetted projects to receive carbon credits that are tradable in voluntary markets [18]. Since 2007, VCS has become the largest standard in many sector. There are agriculture, forestry, and other land use (AFOLU) sector of carbon offsets [19] and has initiated projects and methodologies for forest conservation, improved forest management, and agricultural land management [20]. In Indonesia, many VCS were developed after 2012. Indonesia is currently one of the countries that actively developing this scheme. The project that produces high credit is forest conservation in Katingan with a total credit of more than 7 million tons of VCU each year. This project is the largest project of VCS in the forestry sector in the world.

The Gold Standard was founded in 2003 by the NGOs World Wildlife Fund (WWF). Gold Standard label on a GHG emission reduction project gives certainty that the project has a positive economic impact, environmental and social [21]. Criteria that must be in the GS’s project is contributing to the reduction of CO emissions, involving the local community, adding knowledge and experience with renewable energy development in developing country, protecting the environment, contribute to biodiversity conservation and utilization natural resources in a sustainable way.

The Plan Vivo is a framework and standard used by forest carbon projects. It was formulated in 1996 with funding from the UK Department for International Development (DFID) [22]. This organization certifies the implementation of project activities that enhance ecosystem services and allow communities to formally recognise and quantify carbon sequestration, biodiversity or watershed protection. The result from this certification is Plan Vivo Certificates (PVC) and it can be published before verification done. The PVC requirement is that the project has been registered in the Plan Vivo and has been monitoring every year. Verifications made by third parties are only required at least once in five years [23].

3. Methods

This paper concerns on proposing business scheme of emission trading for power sector in Indonesia. The proposed scheme is designed based on selected study cased power plant – in particularly in Muaratavar Power Plant Complex – through a comprehensive evaluation on GHG emission report and baseline and also proportionally weighting and scoring on type of carbon trading. The comprehensive evaluation is conducted by comparing the history recorded of GHG along 4 (fours) year consecutively (from 2015-2019) with the standard baseline of GHG emission issued by Ministry of Energy and Mineral Resource (MEMR) using formulas as follows:

3.1 Calculation of CO$_2$ Emission

Data such as total emission ($E_{CO2}$ in tons CO$_2$), data of consumption energy (TJ) and emission factor (FE in tons/ TJ) can be obtained as follows:

$$E_{CO2} = DA \times FE$$ (1)

Data for consumption of energy depends on the energy used. For instances, by using natural gas or LNG is estimated as follows:

$$DA_{BBG} = F_{BBG} \times K$$ (2)

where $DA_{BBG}$ is assumed as data of activities (TJ), $F_{BBG}$ is total consumption in one year (MMBTU) and K is conversion (0.001055 TJ/ MMBTU). For using oil as fuels is estimated as follows:

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\[ DA_{BBM} = F_{BBM} \times \rho \times NCV \times 10^{-3} \]  
(3)

where \( DA_{BBM} \) is accounted for data of activities (TJ), \( F_{BBM} \) is total consumption in one year (kl), \( NCV \) is net heating value of fuel (TJ/GgBBM) and \( \rho \) is density (kg CH\(_4\)/TJ or kg N\(_2\)O/TJ).

### 3.2 Estimation of N\(_2\)O and CH\(_4\) Emissions

Value N\(_2\)O and CH\(_4\) Emissions are obtained by multiplying value between data activities (DA in TJ) and emission factor (FE in kg CH\(_4\)/TJ or kg N\(_2\)O/TJ), CH\(_4\) = 1 and N\(_2\)O = 0.1.

\[ E_{CH_4,N_2O} = DA \times FE \]  
(4)

### 3.3 Potential Emission Reduction

The potential emission reduction is estimated as follows:

\[ ER_y = BE_y - PE_y - LE_y \]  
(5)

where, \( ER_y \) is the emissions reductions in year \( y \) (tCO\(_2\)), \( BE_y \) is baseline emissions in year \( y \) (tCO\(_2\)), \( PE_y \) is project emissions in year \( y \) (tCO\(_2\)) and \( LE_y \) is leakage emissions in year \( y \) (tCO\(_2\)). For leakage value can be obtained as follows:

\[ LE_y = LE_{upstream,y} + LE_{HR,y} \]  
(6)

\( LE_y \) is leakage emissions in year \( y \) (tCO\(_2\)/year), \( LE_{upstream,y} \) is leakage emissions associated with the upstream emissions of an increase in fossil fuel use in the project activity in year \( y \) (tCO\(_2\)/year) and \( LE_{HR,y} \) is leakage emissions due to a decrease in the amount of heat recovered from exhaust heat for purposes other than power generation in the project, compared to the most recent year prior to the implementation of the project activity, in year \( y \) (tCO\(_2\)/year).

### 3.4 Determine the emission factor of the grid system

Grid emission factor is required to estimate the production scenario after the installation of the Add On plant exceeds the maximum annual value and the plant is still in single cycle configuration. The cumulative value of margin emission factor of thermal power plant activities show in Table 3.

**Table 3. Emission Grid Factor for Java-Bali System in 2018**

| Grid           | Province               | OM (ton CO\(_2\)/MWh) | OM Ex ante (ton CO\(_2\)/MWh) | BM (ton CO\(_2\)/MWh) | CM Ex Post | CM Ex ante |
|----------------|------------------------|------------------------|-------------------------------|------------------------|------------|------------|
| (1)            | (2)                    | (3)                    | (4)                           | (5)                    | (6)        | (7)        | (8)        | (9)        |
| Java-Bali      | Bali, Banten, Yogyakarta, Jakarta, W. Java, C. Java, E. Java | 0.79                    | 0.79                          | 0.98                   | 0.88       | 0.84       | **0.88**   | 0.83       |

*Source: Report Value Emission Factor GRG System, Gatrik ESDM 2018.*

By referring through the comprehensive evaluation and mitigation as obtained by formulas above, a suitable carbon trading system is then aligned to normal condition in power sector in Indonesia, in particular, PT PLN (persero) as the National Utility Company. Several options for carbon trading
system can be considered such as *Cap and Trade, Energy Efficiency Certificates Trading, Carbon Offsetting Mechanism* through CDM, *Carbon Offsetting Mechanism* through JCM and *Carbon Offsetting Mechanism Voluntary* through VCS. The weighting and scoring method using several criteria is conducted on selected system, such as scope, regulation, organization framework, MRV, financial and risk aspect [24].

The scope is designed to focus on energy efficiency series including electricity sector and sub-sectors of the industrial sector covered by Green Industry Standards (GIS). Regulation point will be then based on policy and the existing regulatory framework such as PROPER and GIS, and both are at the installation level. It is then to be aligned in the organizational framework. On MRV aspect, the framework for the trading certificate built on policy frameworks such as the National Industrial Information System (SIINAS), government regulation like Green Industry Standards, and ministry regulation.

4. Case Study on Add On Muara Tawar Project

4.1 Muaratawar Power Plant Complex

Muaratawar Power Plant Complex – owned and operated by PT Pembangkitan Jawa-Bali (PJB), a subsidiary of PLN – has total capacity as 1,778 MW and consists of 3 blocks of gas turbine (GT) plant – Block 2 with installed capacity 280 MW, Block 3 and Block 4 each has 3 units of GT with total capacity 858 MW – and also 2 blocks combined cycle plant – Block 1 with installed capacity 640 MW is formed by 3-3-1 configuration (3 gas turbines (GT), 3 Heat Recovery Steam Generators (HRSG) and 1 Stream Turbine Generators (STG)) and Block 5 with total capacity 225 MW is formed by 1-1-1 configuration. It is one of the main electricity suppliers for the capital of Jakarta and connected to the 150 kV grid network system.

![Location map of Muara Tawar power plant](image)

*Figure 1. Location map of Muara Tawar power plant*

Due to, the growing electricity demand in Jakarta area in the last few years has been putting an increasing pressure to the electricity grid in the area, it is currently under developing an add-on plant for Block 2, 3 and 4 from open cycle gas turbines to closed cycle gas turbine combined cycle plant by installing HRSG and STG. This Add-on project on block 2, 3, 4 will add the capacity as much as 650 MW without additional fuel. STG of block 2 can have capacity addition of 150 MW, while STG of block 3 and 4 each can have additional capacity of 250 MW. The project is expected to start synchronizing by 2021 to support for Greater Jakarta power grid system as well as to reduce GHG emission compare to current condition.
Figure 2. Schematic diagram of Muara Tawar power plant

4.2 Evaluation based on Historical Data and Baseline: Muaratawar case study

Every year Muaratawar power plant complex, particularly in Block 2, 3 and 4 generated in average GHG emission as 0.80 Tons CO₂/MWh (see Table 5). It is higher than the emission cap value of 0.65 Tons CO₂/MWh declared by MEMR. By adding additional HRSG and STG configuration system into Block 2, 3 and 4 is expected to reduce GHG emissions by 0.15 Tons CO₂/MWh or nearly close to the the potential reduction based on Block 1 and Block 5 (see Table 4).

**Table 4. GHG Emission of Muara Tawar Plant Power Block 1 and 5**

| Year | PLTG | \( \Sigma E\) CO₂e (ton) | \( \Sigma \text{Net EP}\) (MWh) | Net Intensity (ton CO₂e/MWh) | Emission Cap (Ton CO₂/MWh) | Difference | Surplus Emission (Ton) |
|------|-----|------------------------|-------------------------|-----------------|-----------------|--------------|----------------------|
| 2015 | Block 1 | 1,721,843.22 | 3,272,911.00 | 0.53 | 0.65 | (0.12) | (405,548.93) |
| 2015 | Block 5 | 689,236.62 | 1,490,345.09 | 0.46 | 0.65 | (0.19) | (279,487.69) |
| 2016 | Block 1 | 1,607,239.51 | 3,060,687.23 | 0.53 | 0.65 | (0.12) | (382,207.19) |
| 2016 | Block 5 | 742,729.93 | 1,629,654.10 | 0.46 | 0.65 | (0.19) | (316,545.24) |
| 2017 | Block 1 | 1,251,102.51 | 2,516,420.19 | 0.50 | 0.65 | (0.15) | (384,570.61) |
| 2017 | Block 5 | 220,381.36 | 491,327.38 | 0.45 | 0.65 | (0.20) | (98,981.44) |
| 2018 | Block 1 | 1,493,828.93 | 3,035,811.60 | 0.49 | 0.65 | (0.16) | (479,448.61) |
| 2018 | Block 5 | 474,263.49 | 1,039,672.84 | 0.46 | 0.65 | (0.19) | (201,523.86) |
| 2019 | Block 1 | 1,371,714.80 | 2,706,711.85 | 0.51 | 0.65 | (0.14) | (387,647.90) |
| 2019 | Block 5 | 635,040.71 | 1,411,271.21 | 0.45 | 0.65 | (0.20) | (282,285.58) |

**Table 5. GHS Emission of Muara Tawar Plant Power Block 2, 3 and 4**

| Year | PLTG | \( \Sigma E\) CO₂e (ton) | \( \Sigma \text{Net EP}\) (MWh) | Net Intensity (ton CO₂e/MWh) | Emission Cap (Ton CO₂/MWh) | Difference | Defisit Emission (Ton) |
|------|-----|------------------------|-------------------------|-----------------|-----------------|--------------|----------------------|
| 2015 | Block 2 | 103,048.29 | 134,013.30 | 0.77 | 0.65 | 0.12 | 15,939.65 |
| 2015 | Block 3 | 300,915.63 | 414,956.50 | 0.73 | 0.65 | 0.08 | 31,193.91 |
| 2015 | Block 4 | 368,448.74 | 508,943.00 | 0.72 | 0.65 | 0.07 | 37,635.79 |
| 2016 | Block 2 | 222,207.88 | 280,478.90 | 0.79 | 0.65 | 0.14 | 39,896.59 |
| 2016 | Block 3 | 526,813.18 | 665,880.00 | 0.79 | 0.65 | 0.14 | 93,991.18 |
| Year | Block | Production 2021 | Emission Factor Baseline | Baseline Emission CO₂e (tons) |
|------|-------|----------------|--------------------------|-------------------------------|
| 2017 | Block 2 | 9,153.35 | 0.89 | 0.65 | 0.24 | 2,444.54 |
|      | Block 3 | 163,974.75 | 0.83 | 0.65 | 0.18 | 35,493.33 |
|      | Block 4 | 208,042.51 | 0.85 | 0.65 | 0.2 | 49,198.55 |
| 2018 | Block 2 | 131,785.44 | 0.82 | 0.65 | 0.17 | 27,523.69 |
|      | Block 3 | 535,890.51 | 0.83 | 0.65 | 0.18 | 117,117.82 |
|      | Block 4 | 511,524.38 | 0.85 | 0.65 | 0.2 | 119,142.94 |
| 2019 | Block 2 | 74,091.57 | 0.74 | 0.65 | 0.09 | 9,066.04 |
|      | Block 3 | 469,599.16 | 0.82 | 0.65 | 0.17 | 97,860.12 |
|      | Block 4 | 383,514.04 | 0.83 | 0.65 | 0.18 | 83,136.94 |

Table 6. Result of Calculation CO₂ Emission

| Gas Consumption (MMBTU) | Emission N₂O (tons) | Emission CH₄ (tons) |
|-------------------------|---------------------|---------------------|
| Block 2 | 14,017,711.99 | 14.79 | 1.48 |
| Block 3 | 21,841,551.25 | 23.04 | 2.30 |
| Block 4 | 21,841,551.25 | 23.04 | 2.30 |

Table 7. Result of Calculation N₂O and CH₄ Emissions

| Year | PLTGU | Estimated Production (MWh) | Baseline Emission CO₂e (tons) | Project Emission CO₂e (tons) | Leakage Emission CO₂e (tons) | Potential Emission Reduction CO₂ (tons) |
|------|-------|-----------------------------|-----------------------------|-------------------------------|-----------------------------|----------------------------------------|
| 2021 | Block 2 | 2,260,080.00 | 1,673,871.43 | 853,189.26 | 112,178.23 | 708,503.94 |
|      | Block 3 | 3,521,520.00 | 2,891,563.00 | 1,329,385.92 | 127,092.45 | 1,435,084.62 |
|      | Block 4 | 3,521,520.00 | 2,922,523.21 | 1,329,385.92 | 137,315.16 | 1,455,822.12 |
|      | Total |                |                      |                              |                            | 3,599,410.69 |

Table 8. Result of Potential Emission Reduction

| Aspect & Score | Cap and Trade | Energy Efficiency Certificate Trading | CDM (Clean Development Mechanism) | JCM (Joint Crediting Mechanism) | VCS (Verified Carbon System) |
|----------------|---------------|----------------------------------------|----------------------------------|---------------------------------|------------------------------|
| Scope (15%) | Electricity sector and GHG CO₂, N₂O, CH₄ | The electricity sector can’t be eligible if energy consumption < 6,000 TOE | Add on project and full GHG coverage | The scope of the project is outside the JCM mechanism | The electricity sector is covered and can be cross-sectoral participation |
| Regulation (20%) | Installation level is available | Installation level is available | Installation level is available | A certain level of project that hasn’t | Not yet available domestic |

Table 9. Result of Choosing Carbon Trading
The potential emission reduction at Add-On plant can be identified using the approved method of CDM by calculating first CO\textsubscript{2} emission using formula (1) as shown in Table 6 [25]. N\textsubscript{2}O and CH\textsubscript{4} emissions are then calculated (see Table 7) using formula (4). Therefore, potential emission reduction (see Table 8) can be calculated by using formula (5) along with leakage value can be obtained by using formula (6). After conducting a comprehensive evaluation based on historical recorded data and emission baseline, a weighted and scoring system are considered to select the most suitable carbon trading based on PLN condition as show in Table 9.

5. Conclusion and Recommendation

The increase of electricity demand in Indonesia forced the government to develop several large scale power plant to electrify some region. However, due to economical and operational aspects, mostly majority of plants are build based on coal-fired plant, where it can give bad impact to environment. Recently, some mitigation has been taken into account in attempt to reduce the GHG emissions. One of the option is by evaluating on a case in Muaratawar add-on project (Block 2, 3 and 4). This plant based on historical record data of emission, it exhausts about 0.15% higher than the proposed cap by MEMR, which as 0.65%. It is indeed required a strategy mitigation to reduce GHG emission by
installing additional HRSG and STG system. After the project accomplish later on, this plant could reduce emission up to 3,599,410 tons of CO₂ by 2021. It is caused carbon quota of Muara Tawar is likely able to trade through market-based alternative instruments including: Cap and Trade; Energy Efficiency Certificates Trading, Carbon Offsetting Mechanism through CDM, Carbon Offsetting Mechanism through JCM, Carbon Offsetting Mechanism Voluntary through VCS. The result of the calculation by the weighting method at several aspects obtained the best market instrument that can be chosen by Muara Tawar in conducting carbon trading is a Cap and Trade instrument with a weighting value of 4.35.

For the future, the success of carbon trading implementation of NDC in Indonesia, it is necessary to have commitment from all parties starting from the central government, local governments, companies to other stakeholders which are divided into 9 programs including: Development of Ownership and Commitment, Capacity Development, Enabling Environment, Development of a Framework and Communication Network, One Data GHG Policy, Preparation of Intervention Policies, Plans and Programs, Preparation of NDC Implementation Guidelines, NDC implementation, and NDC Monitoring And Review.

References

[1] Cuellar-Franca, R.M. and A.J.J.o.C.u. Azapagic, Carbon capture, storage and utilisation technologies: A critical analysis and comparison of their life cycle environmental impacts. 2015. 9: p. 82-102.
[2] Freedman, M. and B. Jaggi, Global warming disclosures: impact of Kyoto protocol across countries. Journal of International Financial Management & Accounting, 2011. 22(1): p. 46-90.
[3] Lesnikowski, A., et al., What does the Paris Agreement mean for adaptation? 2017. 17(7): p. 825-831.
[4] Di Silvestre, M.L., et al., How Decarbonization, Digitalization and Decentralization are changing key power infrastructures. 2018. 93: p. 483-498.
[5] Voll, D., et al., Cost estimation of fossil power plants with carbon dioxide capture and storage. 2012. 23: p. 333-342.
[6] Siagian, U., et al., Low-carbon energy development in Indonesia in alignment with Intended Nationally Determined Contribution (INDC) by 2030. 2017. 10(1): p. 52.
[7] Pardiansyah, I. and A.A. Untoro. The Development of 35 GW Power Generation for Sustainability of PJB Existing Power Plant: An Assessment and Analysis on Java-Bali System. in 2019 International Conference on Technologies and Policies in Electric Power & Energy. 2019. IEEE.
[8] PLN, P., Rencana usaha penyediaan tenaga listrik (RUPTL) PLN 2019-2028. 2019.
[9] Streck, C., M.J.C. von Unger, and C.L. Review, Creating, regulating and allocating rights to offset and pollute: Carbon rights in practice. 2016: p. 178-189.
[10] Santikarn, M., et al., State and trends of carbon pricing 2020. 2020: The World Bank.
[11] Haites, E.J.C.p., Carbon taxes and greenhouse gas emissions trading systems: what have we learned? 2018. 18(8): p. 955-966.
[12] Liu, X. and Y.J.E.P. Fan, Business perspective to the national greenhouse gases emissions trading scheme: a survey of cement companies in China. 2018. 112: p. 141-151.
[13] Chang, K., et al., Exploring the price dynamics of CO2 emissions allowances in China's emissions trading scheme pilots. 2017. 67: p. 213-223.
[14] Gupta, M.Y.J.G.J.o.M. and B. Research, Carbon credit: a step towards green environment. 2011. 11(5).
[15] Koo, B.J.E.P., Examining the impacts of Feed-in-Tariff and the Clean Development Mechanism on Korea's renewable energy projects through comparative investment analysis. 2017. 104: p. 144-154.
[16] Koop, G. and L.J.J.o.E.F. Tole, *Modeling the relationship between European carbon permits and certified emission reductions*. 2013. 24: p. 166-181.

[17] Amellina, A., *Enhancing the Joint Crediting Mechanism MRV to Contribute to Sustainable Development*, in *Evaluating Climate Change Action for Sustainable Development*. 2017, Springer, Cham. p. 111-127.

[18] Needelman, B.A., et al., *The science and policy of the verified carbon standard methodology for tidal wetland and seagrass restoration*. 2018. 41(8): p. 2159-2171.

[19] Standard, V.C.J.V.V., *Agriculture, forestry and other land use (AFOLU) requirements*. 2013. 3.

[20] Hamrick, K. and A.J.F.T.E.M. Goldstein, Washington, DC, USA, *Ahead of the curve: state of the voluntary carbon markets*. 2015.

[21] Wood, R.G., *Carbon finance and pro-poor co-benefits: The Gold Standard and Climate, Community and Biodiversity Standards*. Vol. 4. 2011: IIED.

[22] Morrison, A.J.T.c., available at, *Carbon Sequestration-Scolel Té Plan Vivo Program*. 2010.

[23] Pra, A. and L. Brotto, *Forest carbon offsetting and standards*, in *Forest Management Auditing: Certification of Forest Products and Services*. 2018, Routledge New York.

[24] LLC, D.T., *Kajian Opsi Kebijakan Mitigasi Perubahan Iklim Berbasis Pasar di Indonesia*. 2019, Direktorat Jenderal Pengendalian Perubahan Iklim, Kementerian Lingkungan Hidup dan Kehutanan. p. 129.

[25] (UNFCCC), U.N.F.C.o.C.C., *Conversion from Single Cycle to Combined Cycle Power Generation*. 2012.