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Capacity Upgrade by Turbine Modification at Gunung Salak Geothermal Power Plant and Its Voluntary Emission Credits Generation

Alin Pratidina[1] and Antonius R. T. Artono[2]

[1]South Pole Carbon Asset Management Ltd. - Jl. Terusan Hang Lekir II/15, Jakarta 12220, Indonesia
[2]PT. Indonesia Power. - Jl. Jend. Gatot Subroto Kav. 18, Jakarta 12950, Indonesia

a.pratidina@southpolecarbon.com and antonius.artono@indonesiapower.co.id

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ABSTRACT

Geothermal energy source is one renewable source that is abundant all over Indonesia due to its location on the ring of fire. PT. Indonesia Power, an Indonesian power generation company, is aware that geothermal power plant capacity upgrade could be one solution to increase electricity generation from renewable energy. Meanwhile, other power generation companies consider new geothermal power plant construction as an option to generate more renewable electricity. Turbine modification at Gunung Salak Geothermal Power Plant was conducted to get 3 x 5 MW additional capacity by increasing its diaphragms nozzle size without changing the whole initial system. The additional capacity will be also registered against the Voluntary Carbon Standard (VCS) 2007, that will generate Voluntary Carbon Units (VCUs) similar to Certified Emission Reductions (CERs) issued by UNFCCC through the Clean Development Mechanism (CDM). The paper will elaborate the modification of steam turbines and also its voluntary credits registration due to capacity upgrade activity at one renewable power plant, in this case geothermal power plant.

1. INTRODUCTION

Indonesia, which is situated in the "Ring of Fire", has great potential for geothermal energy resources that are not yet fully exploited. Sudarman et. al (2000) wrote until January 2000, that from a total geothermal energy reserve of 9,100 MWe, only 769.5 MWe are cumulatively installed in Sumatra, Java-Bali, Sulawesi, and other islands, which accounted for 3.9% of the total energy mix. This small proportion of the total energy mix is due to slow development progress in geothermal energy utilization due to the high capital investment required and a high level of risk involved in the project. These factors are the two main concerns for geothermal power plant owners seeking to improve their power plants' efficiency in order to utilize more geothermal energy resources in the country.

PT. Indonesia Power is the second largest power generation company in Indonesia in term of geothermal-sourced power plant after PT. Chevron Geothermal Indonesia. As one of the commitment to "go green", PT. Indonesia Power ensures that catching up with a new approach or technology to be more efficient in electricity generation is becoming an important task to do, as shown by an example turbine modification that will be explained afterwards.

In the mean time, PT. Indonesia Power is also following the carbon credit market and trend that provide an incentive to public or private entity if they would invest in renewable energy power plant whether it is a new or retrofit or modified power plant. Considering this carbon credit revenue stream, PT. Indonesia Power is currently in process of registering the capacity upgrade at Gunung Salak Geothermal Power Plant against the Voluntary Carbon Standard 2007 (VCS 2007), that will generate Voluntary Carbon Units (VCUs) similar to Certified Emissions Reductions (CERs) issue by the UNFCCC through the Clean Development Mechanism (CDM).

The capacity upgrade at Gunung Salak Geothermal Power Plant involves Unit #1, Unit #2 and Unit #3 that provide an additional 3 x 5 MW installed capacity from 55 MW to 60 MW for each Unit at Gunung Salak Geothermal Power Plant.

2. TURBINE MODIFICATION

The key purpose of the modification is to increase utilization of geothermal resources in the mountainous areas surrounding Gunung Salak to generate zero emission electricity to be transmitted to the Jawa-Madura-Bali (JAMALI) grid through the Bogor Baru PLN main station, with 150 kV transmission line.

Turbine modification means to modify first and second stage diaphragms by increasing nozzle size from $\alpha 1$ to $\alpha 2$ to allow steam turbine efficiency as shown in Figure 1 and Table 1. An increase in α and β will increase blade velocity (u) that is proportional to turbine power performance, which means achieving higher "flow capability" of the steam turbine and optimising steam efficiency. In the end, the capacity output will also increase.

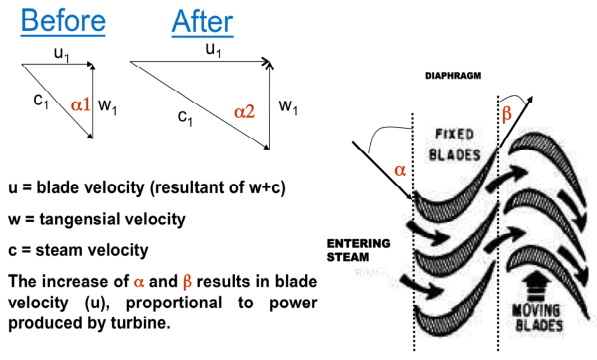

Figure 1: Nozzle increase in the diaphragm (source: PT. Indonesia Power).

Another activity carried out in order to manage a higher capacity output is an ejector line replacement, which means to replace a smaller line of ejectors with a new design to increase the flow rate of Non-Condensable Gases (NCG) which is caused by an increase of steam flow due the turbine modification.

Table 1: Inlet (α) and outlet (β) after and before the capacity upgrade (source: PT. Indonesia Power)

Diaphragm	55 MW		60 MW	
	Inlet α	Outlet β	Inlet α	Outlet β
1st stage	73⁰	7⁰	82⁰	9⁰
2nd stage	86⁰	8⁰	87⁰	13⁰

3. VOLUNTARY CARBON OFFSET

The voluntary carbon offset is similar to emission reduction activity through the CDM with a different registration body and also emission credits to be generated. Voluntary Emission Reductions (VERs) are tradable in the voluntary market as such Certified Emission Reductions (CERs) in the compliance market. However, VERs are mostly purchased by companies outside compliance buyers that would like to offset their Greenhouse gases (GHGs) emission. VERs are also tradable under Chicago Climate Exchange (CCX).

3.1 The Voluntary Carbon Standard Program (the VCS Program)

One of the standard programs acknowledged by voluntary buyers is the Voluntary Carbon Standard Program (the "VCS Program"). The VCS Program is a program that has been developed to provide a rigorous, trustworthy and innovative global standard and validation and verification program for voluntary greenhouse gas offsets. A project that is registered against the VCS Program will generate tradable Voluntary Carbon Units (VCUs).

The Climate Group, the International Emissions Trading Association (IETA) and the World Business Council for Sustainable Development are partnered to develop the VCS Program since the beginning. At the moment, the VCS Association has released the newest version of VCS program on 18 November 2008, which is VCS 2007.1.

3.1.1 VCS Project Process Flowchart

As presented in the VCS Program Guidelines 2007.1, the VCS project process will follow several steps:

Step 1: Project proponent submits documentation to verifier.

Step 2: Verifier accesses the claim against VCS 2007.1 and produces a validation and verification report.

Step 3: Project proponent submits documentation to the VCS Registry operator.

Step 4: VCS Registry operator checks documentation and submits it to the VCS Project Database.

Step 5: VCS Project Database checks that the project has not been previously registered and issues VCU serial numbers. VCS Registry operator requests and receives VCS Registration Levy.

Step 6: VCS Registry operator places documents into custodial service and issues VCUs into the account of the project proponent.

3.1.2 VCS Program Scope

The scope of the VCS Program includes:

- All six Kyoto Protocol greenhouse gases;
- All technologies supported by an approved VCS Program methodology, including AFOLU project types as set out on www.v-c-s.org;
- Any approved GHG Programs;
- Project category(ies) which is a part of an approved GHG Program;
- Project methodologies, not a part of an approved GHG Program, when approved under the VCS Program through the double approval process.

Following the VCS Program scope, any renewable energy and energy efficiency project could be registered as the VCS Project as long as the other GHG Program such as CDM approves them with specific approved methodology.

3.1.3 VCS Project Start Date and Crediting Period

As referred to the VCS Program 2007.1, the project validation shall be completed within two years of the Project Start Date, or shall be completed or contracted before 19 November 2008. In relation to validation contracts entered into before 19 November 2008, validation shall be completed before 19 November 2009 and a proof of contracting prior to 19 November 2008 shall be provided.

The earliest Project Crediting Period Start Date under the VCS 2007.1 shall be 28 March 2006 for non-AFOLU projects with 10 years as the crediting period.

4. CAPACITY UPGRADE AT GUNUNG SALAK GEOTHERMAL POWER PLANT

Due to the capacity upgrade, an additional 5 MW capacity from geothermal energy source is exported to the JAMALI grid, which replaces electricity that would have been generated from fossil-fueled power plant. Geothermal energy is one of renewable energy sources that are applicable to be registered as the CDM project under the approved baseline and methodology, ACM0002.

ACM0002 is applicable for a newly built, retrofit and modified renewable energy power plant that is connected to the grid system. Therefore, the capacity upgrade project follows all requirements and applicability referred to ACM0002.

4.1 ACM0002 Applicability

a. The project is a modification of a geothermal power plant that involves electricity capacity addition from total capacity of 165 MW to 180 MW.

b. The project is a renewable electricity generation plant from geothermal energy sources, which is connected to the JAMALI grid.

c. The project exports its electricity to the clearly identified regional Jawa, Madura, and Bali interconnected power grid (JAMALI grid). The value and characteristics of the grid are also publicly available.

d. The project is not an activity that involves fossil fuel switching to renewable energy at the site of the project activity.

e. Historical data of 5 years are available for the modification/retrofit project that is implemented in an existing power plant.

4.2 Emission Reductions

As referred to one registered project at the UNFCCC website, the JAMALI grid emission factor is 0.901 tCO_2/MWh.

Therefore, emission reductions for 10 years crediting period are as follows:

Table 2: Emission reduction from Capacity Upgrade project

Year	Vintage	Annual Agreed Volume*
2006	1 April 2006 - 31 March 2007	76,967
2007	1 April 2007 - 31 March 2008	109,212
2008	1 April 2008 - 31 March 2009	122,309
2009	1 April 2009 - 31 March 2010	122,309
2010	1 April 2010 - 31 March 2011	122,309
2011	1 April 2011 - 31 March 2012	122,309
2012	1 April 2012 - 31 March 2013	122,309
2013	1 April 2013 - 31 March 2014	122,309
2014	1 April 2014 - 31 March 2015	122,309
2015	1 April 2015 - 31 March 2016	122,309
Total estimated reductions (tCO_2e)		1,164,651
Total number of crediting years		10 years
Annual average of the estimated reductions over the crediting period (tCO_2e)		116,465

4.3 Additionality

Additionality of the capacity upgrade project is referred to an approved “Tool for the demonstration and assessment of additionality” as mentioned in the ACM0002. One analysis that is chosen to be elaborated in the documentation is Barrier analysis such as technological risks.

As the first of its kind project in Indonesia, PT. Indonesia Power has no reference found within the country on this type of modification. However, the project owner was willing to take the significant technological risks as a part of the capacity increase.

Changes in nozzle size mean an increase in steam flow creating a significant increase of impurities to be introduced into the turbine. Impurities could cause a clogging or deposition in the turbine, which could reduce technical lifetime of the turbine.

Besides that, prior to the project implementation PT. Indonesia Power identified potential problems due to geothermal steam quality, which must be taken into account.

5. CONCLUSION

The project, which only modifies certain equipment of the power plant, could also increase the power plant capacity such as turbine modification. The turbine modification could also be registered against the voluntary carbon offset program like the VCS Program that will generate tradable VERs.

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