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EMISSION CONTROL GEOTHERMAL OPERATION
(A Lesson Learn from Wayang Windu Geothermal Field)

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ABSTRACT

Wayang Windu Geothermal operate two units with total capacity 227 MW electricity. Geothermal is renewable and environment friendly energy, however controlling any potential pollutant to environments must be strictly apply by maintain pollutant below regulation limit. Following changes of steam quality caused by new drilled wells, chemistry composition of steam produce will affect potential emission from operational process. Operator shall innovate their process to manage the emission, otherwise over limit may occurs. Managing Environment aspects at Wayang Windu performed by discipline team, management commitment combined with team work to achieve current performance. In Wayang Windu environment officer is not only one person who manages the environment. The multi discipline team with guidance by environment officer set agreed action how to mitigate potential environment aspect such as potential emission, waste management etc. and performing lesson learn for future improvement. Within fourteen years of its operational time of Unit-1 and five years operation Unit-2 have indicated an excellent performance of environmentally aspect also some continual improvement program apply referring of operation steps in geothermal field operation.
This paper reviews the experience to manage emission pollutant from operational geothermal field and continual improvement process.

Keywords: geothermal, environment, emission

BACKGROUND

Increasing of occupation and interest of the population of the world concerning the global air quality, the government and the local authorities has increased the vigilance and regulations to prevent negative effects on the health of the population and the deterioration of the quality of the environment. In any geothermal power plant, the major impact with the environment is the emissions released into the atmosphere due to the amount of non-condensable gases (NCG) that are transported with the steam utilized for the turbines, which are discharged in the majority of cases, into the atmosphere through cooling tower fans, changing the air quality in the immediate area of the power plants.
Wayang Windu Geothermal operates two units with total capacity 227 MW electricity. With 8 times cooling tower cells for each units, however controlling any potential pollutant to environments must be strictly apply by maintain pollutant below regulation limit. Following changes of steam quality caused by new drilled wells, chemistry composition of steam produce will affect potential emission from operational process. Regular check must be performing by geothermal operator to make sure the emission discharge content still in allowable limit and or in case there are showing trend increase to be exceed allowable limit can be mitigate early to maintain continuous plant operation that potentially stopped by government authority in case our emission content above allowable regulation limit.

MAJOR EMMISION AND REGULATION

In power any operation of power plant there are emission produce but for geothermal power the visible plumes seen rising from the power plants are actually not a smoke residual of fuel burn but they are water vapor emissions (steam). The geothermal power plant do not burn fuel like fossil fuel power plant, they release virtually no air emissions. The fumes through cooling tower fans discharge contents of Non Condensable Gasses that in geothermal usually consist of some poisonous gases such as Carbon Dioxide (CO_2), Hydrogen sulphide (H_2S) is major contents with additional some small proportions is ammonia (NH_3). Controlling method to maintain emission below acceptable limit is mandatory by regulation and in case there are some incident must be reported promptly to government authority with technical reasonable reason and technical justification consideration.
Emission control for geothermal power plant in Indonesia Refer to *Peraturan Menteri Negara Lingkungan Hidup Nomor 21 Tahun 2008 Tentang Baku Mutu Emisi Sumber Tidak Bergerak Bagi Usaha Dan/Atau Kegiatan Pembangkit Tenaga Listrik Termal*. Refer to section 9 about the responsibility of Geothermal Power Plant, the operator shall calculate the emission of H_2S, NH_3, and CO_2, units also have to guarantee the quality assurance and quality control system for the emission calculation for H_2S, NH_3 and CO_2. Refer to appendix V, geothermal limits for the emissions are:

- H_2S : 35 mg/Nm^3
- NH_3 : 0.5 mg/Nm^3

The external lab analisys result must be reported regularly to Minister of Environment. However there are unavailable technical guideline yet how and where the emission sample should be taken.

Table -1 Comparison emission geothermal & Coal
(*adopt from A Guide to Geothermal Energy and the Environment by Alyssa Kagel, Diana Bates, & Karl Gawell
Geothermal Energy Association www.geo-energy.org)

Emission	Nitrogen Oxide (NOx)	Sulfur Dioxcide (SO2)	Particular Matter (PM)	Carbon Dioxide (CO2)
Sample Impact	Lung irritation, coughing, smog formation, Water quality deterioration	Wheezing , chest tightness, respiratory illness, ecosystem damage	Asthma, bronchitis, cancer, atmospheric deposition, visibility impairment	Global warming product by carbon dioxcide increase sea level, flood risk, glacial melting
Geothermal emission (lb/MWh)	0	0 ~ 0.35	0	0 ~ 88,8
Coal emission	4.31	10.39	2.23	2191
Emission offset by geothermal use (per year)	32 thousand tons	78 thousand ton	17 thousand ton	16 Million tons

The NCG in geothermal come from steam production wells the content may vary from each production wells connected to the system. In geothermal power plant most of them directly discharge to environment through cooling tower, in some geothermal field caused of high concentration may utilized of H_2S abatement system. H_2S will partition itself between the condensate and the NCG depending on the type of geothermal power system, particularly the type of condenser. Consequently, the type of H_2S removal system employed will depends on the amount of H_2S present and how it partitions between the condensate and the NCG.

NCG content from each production wells connected to system may different each other depend on reservoir condition itself. However in Wayang Windu Geothermal Power Plant All production wells connected to separator station (consist of 6 vessels / 3 for each unit) then scrubber (consist on 4 vessel / 2 for each unit), in both station they have interconnection lines between each unit than entering to Turbine with separate pipe line. The NCG from main condenser discharged directly into cooling tower through gas removal facility (see figure 1). By using this arrangement, gas content at header point will be at same level with the interface on each unit.

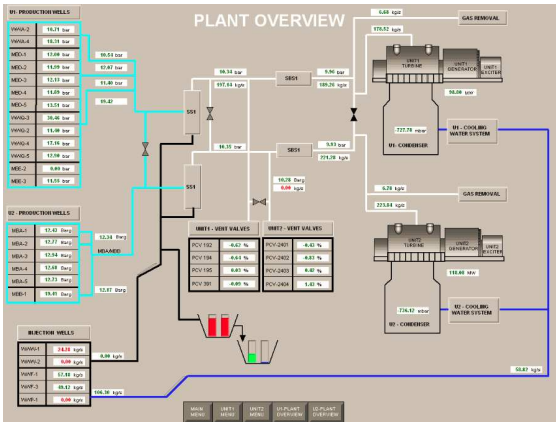

Figure 1. WW Plant Process Overview

From the composition of NCG which majority consist of H_2S, CO_2 and NH_3, the H_2S gases is the most dangerous and produces the most concern, mainly for the disagreeable odor of rotten eggs at low concentrations, irritating the eyes at medium concentrations, and at high concentrations, respiratory damage and even death potentially can be occured. In geothermal power plants do not emit sulfur dioxide directly, once hydrogen sulfide is released as a gas into the atmosphere, it eventually changes into sulfur dioxide and sulfuric acid. Therefore, any sulfur dioxide emissions associated with geothermal energy derive from hydrogen sulfide emissions.

The NCG that direct flowing together with steam entering to powered steam turbine, at the main condenser (direct contact condenser type) the gas will separate from the fluid by specific gravity between condensate and the NCG.

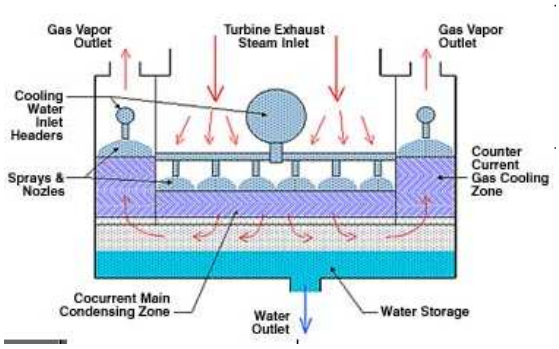

Figure 2. Illustration of direct contact condenser

The NCG that collected into gas cooling zone of condenser sucking by Gas removal system that consist of 3*50 % capacity than flowing to cooling tower fan cell to atmosphere, each cooling tower have independent gas inlet isolation valve in case isolated the cell will be shut the only cell has been isolated. The water collected in bottom of condenser pumping through hot well pump, some of the water injected to condensate injection well, while some re-circulated to condenser again for cooling system but the most of them vaporized to atmosphere as effect of cooling system.

For operational control of emission, Wayang Windu operation is not only managing by environment officer. The environment officer as the expert guide operation team to verify maximum allowable limit exposure also update new regulation if there any. They set short and long term objective target performance that running by each team independently as required by routine operation need.

WW PLANT EMISSION CONTROL

The environment officer that has an expertise on how to compliance of any environment aspect, develop Objective target performance of each aspect related the environment as well inform to all parties related new regulation that must be comply if there any. The objective target must be followed by all parties in daily operational include assessment of daily activity that shall include potential of environment aspect.

Wayang Windu emission directly discharge to atmospheric via cooling tower, the NCG content in the steam is relatively low, however in some production well there are containing of high NCG level that may require extra special notice when the wells ready to online to system. In these case, start standby Gas Removal System may require to safe operation purposed. NCG from main condenser is sucked through Gas Removal System facility. There are 3 trains of GRS with capacity 50 % (3 * 50%). In normal operation 2 hybrid operate at all the time, the standby ejector as standby GRS train. Between GRS and cooling tower there are online gas flow meters that measure total NCG from the system operation. In the beginning operation of 1st unit, the gas flow meter had uninstalled yet, it was modified by equipped the line with the flow meter on 2006. With this flow meter operator can be monitoring if there are increase or decreasing NCG produce from the system such as opening new well, so they can operate all of GRS trains (3 units) to make sure sufficient process operational to allowed additional gas that may pass through to the process operational system.

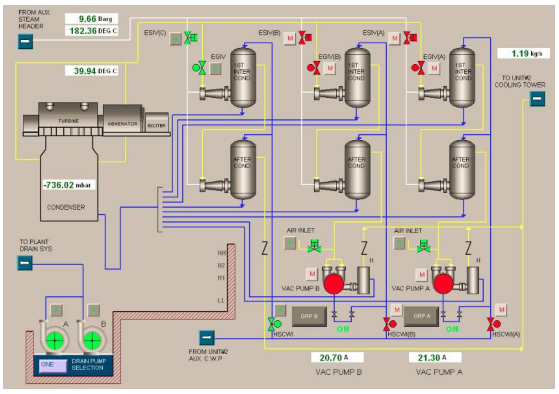

Figure 3. WW GRS on DCS Layout

Although both unit NCG discharge at cooling tower fan stack, the unit 2 has an improvement on location of gas inlet discharge at the stack, the gas inlet located at top of fan stack. With this improvement arrangement, assumed that cooling tower fan blade Unit-2 saver from the NCG which caused the corrosion for the equipment.

Figure 4a. Inlet NCG CT Unit-1

Figure 4b. Inlet NCG CT Unit-2

The regular test for gas content monitored regularly by internal laboratory officer, monthly basis for well site and twice a week for interface power plant. Value of lab analisys will useful for operation purpose to verify potential increasing or decreasing of gas content either at several wells or incoming new wells. In case there are potential gas content above GRS capacity, start standby train GRS may require. From the data analysis, plant can be operated only by using single GRS train, however for plant operational safety reason, at least 2 trains on service. It is used to prepare if one train failed then the NCG still flow, the other train still capable to handle plant operation.

The gas content monitored by the laboratory officer are Carbon Dioxide (CO_2), Hydrogen Sulphide (H_2S) and residual gasses (RSD: residual gasses content of some gases with small amount such as methane, hydrogen, nitrogen, argon etc.), average content on each units that didn't much different:

Table.2 Average Gas Content Sampling by Internal Lab at Interface point

No	Description		Unit 1	Unit 2
1	CO_2	% mole (Dry Gas)	92.56	93.41
2	H_2S		4.10	3.49
3	RSD		5.99	9.75
4	CO_2	%Weight (Gas in Steam)	0.96	1.09
5	H_2S		0.04	0.03
6	RSD		0.02	0.02
7	TGC		1.00	1.13

The environment officer collaborates with production in regular basis perform calculated air pollutant level. The calculation based on total steam flow to the plant in mass per hour, the mass ratio of steam to total non-condensable gas, net generation, and concentration of the gaseous component from laboratory sampling. The calculation result routinely report to BPLHD as a SHE Report as regulated on *Peraturan Menteri Negara Lingkungan Hidup Nomor 21 Tahun 2008 Tentang Baku Mutu Emisi Sumber Tidak Bergerak Bagi Usaha Dan/Atau Kegiatan Pembangkit Tenaga Listrik Termal*. Those calculation are monitored by internal Wayang Windu to define the CO_2 and H_2S content from the total generation. Refer to the regulation, the pollutant level also monitored by external parties twice per year.

Based on data sampling by laboratory per day taken from Cooling Tower, CO_2 content comparing with total generation per unit is:

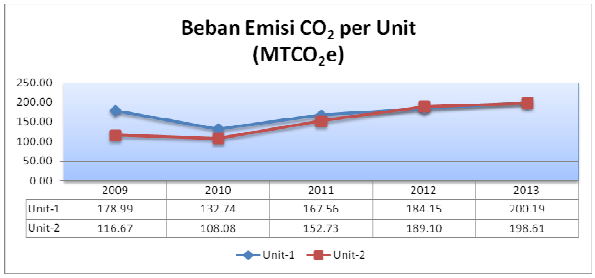

Figure 5. Average CO_2 (Ton) / year

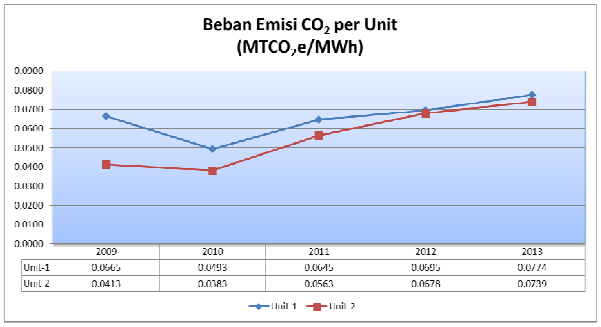

Figure 6. Total CO_2/year compared with Total Generation

Based on data sampling by laboratory per day taken from Cooling Tower, H_2S content comparing with total generation per unit is:

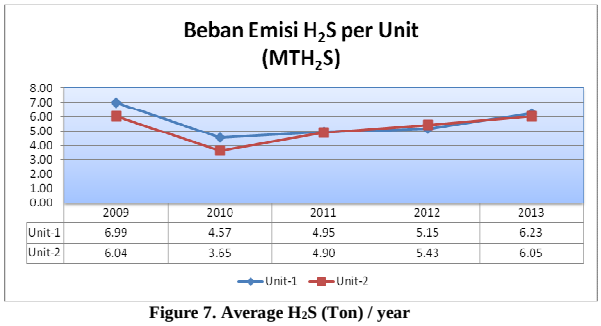

Figure 7. Average H_2S (Ton) / year

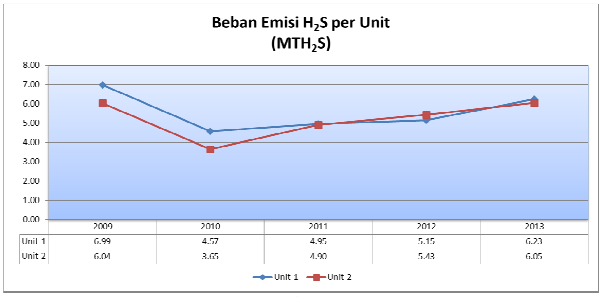

Figure 8. Total H_2S/year

These is based on *Peraturan Menteri Negara Lingkungan Hidup Nomor 21 Tahun 2008 Tentang Baku Mutu Emisi Sumber Tidak Bergerak Bagi Usaha Dan/Atau Kegiatan Pembangkit Tenaga Listrik Termal* part attachment VII for Emission Calculated manually. The data is shown that CO_2 and H_2S content at Unit-1 is slightly bigger than Unit-2. It might be caused by the arrangement of NCG inlet at Cooling Tower. For NH_3, Wayang Windu have not calculated manually yet, only used the data from external lab. All of data from the external lab, always shown under of regulation limit. We have trial to measure of gas content at cooling tower cells with several located (different height on sample point) the result singly different but still below limit.

Referring this case the sample measure near gas outlet and or located of sampling (cooling tower fan stack) that may at the sampling point measurement turbulence flow will affected different result value, however there are no technical standard yet to measured emission of geothermal power plant operation refer current Penmen LH. In Wayang Windu case for example if Unit-2 cooling tower measured at middle of fan stack there will be 0 emission since the gas outlet at top of cooling tower stack (see Figure-4), however measured at top of cooling tower fan stack will be found some gas component.

LESSON LEARN FROM IMPLEMENTED PROCESS

1. Emissions for Geothermal Power Plant refer to *PERMEN LH 21 tahun 2008* that measuring at cooling tower cell may affect a different value as result of gas outlet discharge location.
2. Consistency gas content measuring by online might be necessary for operation to take action for operational improvement purpose.
3. Needs more analysis for standard locations of emission sampling point (measuring purpose) for geothermal operation, NCG outlet point to sampling measurement point which really affected to the analisys result. Collaboration from all geothermal operator will help to suggest the proper standard measurement for gas content to KLH.
4. Decision to located gas outlet at Cooling Tower Fan stack may minimize the NCG effect either to proses operational and or environment emission control.

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