MODELING STUDIES OF AIR POLLUTION DISPERSION AS SUPPORTING TOOL FOR NEW POWER PLANT ENVIRONMENTAL IMPACT ASSESSMENT
(A case study of EIA PLTU 2 Jawa Timur)

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ABSTRACT

The air pollution modeling studies was performed as supporting tool for new power plant Environmental Impact Assessment (EIA). The power plant is PLTU 2 Jawa Timur (1 X 600-700 MW), which proposes pulverized coal fired steam, with coal consumption rate 252 ton/h. The power plant’s site is near the seashore with complex terrain in the South side. The modeling studies used analytical modeling-Gaussian Plume Model, under worst scenario (Level I assessment). Model parameters are emission rates, stack height, control pollutant technology, geography and meteorology. Modeling scenario with relation to geographical parameter, as such surface characteristic (rural), complex terrain scenario, simple terrain scenario, and shoreline fumigation scenario. The meteorology scenarios are all Pasquill’s atmospheric stability scenarios. The direction air pollution dispersion modeled from five year monitoring meteorological database. The ratios of the maximum concentration received by receptor at 0 km (ground level concentration) between simple terrain, complex terrain and shoreline fumigation are varied with the stack height. The ratios (respectively) are: 1 : 11.3 : 4.1 (stack height :118.5 m), 1 : 6.5 : 2 (stack height :200 m), 1 : 6.8 : 1.7 (stack height :240 m), and 1 : 7 : 1.6 (stack height :260 m). The control strategies give the best performance if the entire control device for NOx, SOx, and Pm is applied. Increasing the dispersion by increasing the stack height from 200 up to 240 or 260 m decreasing the maximum concentration 2.8 % under complex terrain scenario. The direction of the pollutant dispersion is prone to the South side and the West side.

Keyword : Air Pollution Modeling, EIA, Coal Fired Steam Power plant, Gaussian Plume Model, Complex terrain, Fumigation

INTRODUCTION

Economic growth increased electric power demand. As Indonesian economic growth rate was turned to plus 4.8% in 2000 and become 6% in 2005, the electric power demand in Java-Madura-Bali system also increased. In other hand this situation not followed by increasing the electric supply capacity in Java-Madura Bali, so the load balance curve will be in critical situation on the following years. These conditions drive Government of Indonesia to launch ‘10,000 MW coal power plants program’ in Java and be operated at 2009. One of power plants will build in this program is PLTU Jawa Timur- 2, a Coal Fired Steam Power Plant with capacity of 1 X (600-700) MW.

Although this project is important for human life and economics sector, we need to compromise this project with environment. It respect to environmental quality where we live and the impact for all component of the total environment (physical-chemical, biological, cultural and socioeconomic components). Power plants are significant emitters of sulfur dioxide (SO₂), nitrogen oxides (NOx), and particulate matter (Pm). These gases are harmful themselves and they contribute to the formation of acid rain, photochemical reaction, and formation of particulate matter (aerosol). Particulate matters reduce visibility, covered stomata (decrease plant productivity), and it’s a serious public health problem.

According to that, Environmental Impact Assessment for this project is important. In this EIA all off activity component, from pre construction, construction and operation are studied. One of object studies is the impact of project to ambien air quality. Here, air pollution modeling provides prediction of the impact.

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**Aims**

1. To provide environmental modeling with an air pollution sub-model
2. To predict air pollution dispersion that emitted from proposed power plant
3. To assessing the impact of air pollution from new source
4. To develop control strategies

**EXPERIMENTAL SECTION**

**METHODS**

**Data Sources**

**Air Pollution Modeling Data**

The data was collected from feasibility studies of the project documentation; environment monitoring documentation from existing PLTU Paiton I, Paiton II; background sampling data, and related document (e.g. Emission factor AP-42 US EPA)

**Map**

Map of project area and dispersion area provide by Bakosurtanal.

**Analysis**

Computer software:

- Screen3 (Screening Procedure for ISC3): processing of air pollution dispersion modeling
- Windrose: Processing wind direction
- ArcView GIS: mapping and geographic analysis
- Excel 2000: processing data

**Modeling Scenario**

In order to provide completely information that supporting tools for making decision in EIA, this study modeled in to following scenario:

I. **Emission rates scenario:**
   1. Emission rate calculated from stack sampling data of existing power plant PLTU Paiton I, II (Day Operation; not maximum operation).
   2. Emission rate from emission factor EPA AP-42 (maximum operation).

II. **Air Pollution Control Technology Scenario:**
   1. Un control
   2. Combination from Electrostatic Precipitator for particulate control, Overfire Air (OFA) and Low NOx burner for NOx control, Flue Gas Desulphurization for SOx control
### Emission Rate

**Emission rate NOX** 297.5  
**Emission rate SOX** 187.04  
**Emission rate pm** 682.5  
**Emission rate CO** 8.75

**Stack velocity:** 21.1 m/s

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**Emission rate NOX** 74.2  
**Emission rate SOX** 187.04  
**Emission rate pm** 0.026  
**Emission rate CO** 16.8

**Stack velocity:** 21.1 m/s

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### III. Stack Height Scenario

1. Stack height = PLTU Paiton I, II; that is 200 m with stack inside diameter is 6 m.
2. Stack height = minimum height Good Engineering Practice (GEP); that is 200 m with stack inside diameter is 6 m = 118.5.
3. Stack height = 240 m with stack inside diameter is 6 m.
4. Stack height = 260 m with stack inside diameter is 6 m.

### IV. Meteorological Scenario

- All Pasquill’s atmospheric stability

### V. Terrain Scenario

- Complex terrain and simple terrain.

### VI. Surface Characteristic Scenario

- Rural

### VII. Fumigation Scenario

- Including shoreline fumigation
Emission rate:

- Emission rate NOX: 74.2 g/s
- Emission rate SOX: 3.836 g/s
- Emission rate pm: 0.026 g/s
- Emission rate CO: 16.8 g/s

Stack velocity: 21.1 m/s

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* 1 Hour Concentration
** 24 Hour Concentration
Conversion factor for complex terrain: 4 (1 hour), 1 (24 hour), 2.8 (8 hour), 0.125 (annual)

Modeling The Direction of Air Pollution Dispersion

The direction of air pollution dispersion gained by modeling 5 years meteorological monitoring data from PLTU Paiton I, Paiton II.

Modeling The Annual Trend of Ambien Air (Ground Level) Pollutant Concentration

The input data is monitoring inventories held by PT PJB (per 3 months) during 2001-2006. One of the monitoring location is Selobanteng district, which is located at South side the power plant location, and it’s within reach 5 km from the existing power plant area.

Assesing the Impact.

The study compare the maximum predicted concentration with Ambien Air Quality Standards. The background concentration taken from ambien air sampling data which conduct on 2006 by PSLH UGM (Research center for Environmental studies of Gadjah Mada University); especially which held at Sumberejo district within reach about 3 km (similar with the modeled distance to maximum).

RESULT AND DISCUSSION

In order to evaluate the impact magnitude of PLTU 2 Jawa Timur’s emission, the modeling study predicted the worst case of concentration that received by receptor at 0 km (ground concentration). The worst case scenario assumed that the pollutants being stable as long as transported by mechanical turbulence, so it assumed that deposition (wet/dry deposition) and chemical reaction being neglected. Actually the predicted concentration will be over estimate, but it can provide good assessment. Furthermore the modeling assume that there are constant wind speed at distinct altitude, and the gaussian distribution in use.

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Modeling The Direction of Air Pollution Dispersion

The direction of air pollution dispersion gained by modeling 5 years meteorological monitoring data from PLTU Paiton I, Paiton II.
The Effect of Geographical Condition

The location of proposed power plant, PLTU 2 Jawa Timur (1 x 600-700 MW) is on north east coast of Java. The site area borders the shoreline of Selat Madura in the north and is located at eastern edge of Probolinggo regency, East Java Province. The site area is situated between the villages of Sumber Glatik and Bhinor in Paiton sub district.

The South side of the power plant site is terrain with complex features. The west side of the power plant site is flat terrain area, and the surface characteristic is rural.

The modeling gives result that the most affected component is complex terrain features. The ratios of the maximum concentration received by receptor at 0 km (ground level concentration) between simple terrain, complex terrain and shoreline fumigation are varied with the stack height.

The ratios (respectively) are: 1 : 11.3 : 4.1 (stack height :118.5 m), 1 : 6.5 : 2 (stack- height :200 m), 1 : 6.8 : 1.7 (stack height :240 m), and 1 : 7 : 1.6 (stack height :260 m).

The Effect of Air Pollution Control Technology

In order to know the impact magnitude of PLTU 2 Jawa Timur to ambien air quality, this study modeled into several alternatives technology of air pollution control. Air pollution control technologies used for the modeling studies are: Overfire Air (OFA), Low NOx burner, Flue Gas Desulphurization (FGD), and Electrostatic Precipitator (ESP). Schematic diagram for control pollutant devices:

OFA can achieve 20 to 30 percent NOx reduction from uncontrolled level (US EPA AP-42). This modeling study assumes 30 % reduction. Combination Low NOx burner and OFA can reach control efficiency 50 to 60 percent (US EPA AP-42); in this modeling it’s assume 60 %. The Flue Gas Desulphurization has diverse control efficiency and here, it assumes control efficiency of FGD is 95%. ESP can reach collection efficiency as high as 95 % (for small and old device) up to 99.5 % percent. Here, it’s assume 99.5 % efficiency.

The modeling results are:

The Effect of Stack Height

This study modelled several stack height, i.e. 118.5 m, 200 m, 240 m, 260 m. The first one is minimum stack height up to standard Good engineering practice (GEP). The GEP avoid downwash caused by building near the stack. The second one is existing powerplant’s height (PLTU Paiton), the third one is proposed stack height of PLTU 2 Jawa timur.

Scenario 6 : Emission rate: EPA AP-42, Control : ESP, OFA, Low NOx burner, without FGD; Stack height 118.5 m (=GEP), stack diameter 6 m
From the result, it can draw a conclusion that the maximum concentration reached at 1875 m. In turn, maximum concentration (24 hour concentration) for NOx, SOx, PM$_{10}$, and CO is 153.7 ug/m$^3$, 387.4 ug/m$^3$, 0.0543 ug/m$^3$, and 34.8 ug/m$^3$. The dispersion scheme from simple terrain scenario:

From the distribution scheme (vide supra) we can draw a conclusion that although this height (118.5 m) not causes downwash by building near the stack, but it drives to downwash by nearest hill (look at the first peak).

**Scenario 3** : Emission rate: EPA AP-42, Control : ESP, OFA, Low NOx burner, without FGD; Stack height 200 m, stack diameter 6 m

The results show that the maximum concentration reached at 3000 m. The maximum concentration (24 hour concentration) for NOx, SOx, PM$_{10}$, and CO respectively is 101.9 ug/m$^3$, 256.9 ug/m$^3$, 0.036 ug/m$^3$, and 23.07 ug/m$^3$. The dispersion scheme from simple terrain scenario:

The scheme shows that there is no downwash by nearest hill, and pollutant concentrations near the stack are lower than the concentration under 118.5 m scenario. But for long distance, for example 5000 m; the concentrations not quite different with previous scenario.

**Scenario 7** : Emission rate : emission factor US EPA-AP 42, Control : OFA, Low NOx burner, and ESP (without FGD); Stack height 240 m, stack diameter 6 m

The maximum concentration (24 hour concentration) for NOx, SOx, PM$_{10}$, and CO respectively is 99.08 ug/m$^3$, 249.8 ug/m$^3$, 0.035 ug/m$^3$, and 22.43 ug/m$^3$. These concentration 2.8 % lower than the maximum concentration of 200 m scenario. The distance to maximum concentration is 3075 m, 75 m (2.5%) longer than the 200 m scenario. The schematic dispersion (simple terrain scenario):

The dispersion pattern show similarity with 200m scenario, lower concentration at location near the stack, but no distinction at a distance. Further more, it just slight shifting in distance to maximum concentration, and maximum concentration.

**Scenario 8** : Emission rate : emission factor US EPA-AP 42, Control : OFA, Low NOx burner, and ESP (without FGD); Stack height 260 m, stack diameter 6 m

The results illustrate that there is no different in maximum concentration and the distance to maximum concentration between the 260 m scenario and 240 m scenario. It just slightly different for simple terrain scenario ie. the maximum concentration is 3.6 % lower than in 240 m scenario, and the distance to max. is 14 m further than 240m scenario. The schematic dispersion :

As a whole we can draw a conclusion that increasing stack height strategy prone to decreasing pollutant concentration, which received by receptor near the stack, but it doesn’t take effect at a distance.

**III.5 Direction of air pollution dispersion**

In order to know where the pollutant will disperse, modeling the wind direction and the wind speed were performed. The inputs are five years inventories data taken from regular monitoring that held by PT PJB (existing power plant near the proposed PLTU 2 Jawa Timur). The modeling result:

The wind rose shows that the most probable direction for dispersion of pollutants is the South side, then following by West side. The West side area is housing land use and farming; it’s a rural area. The land uses of South side area are also for housing area, farming, ash disposal area, and forest in part. Looking at the wind speed, that the wind speed directed to the South is smaller than to the West; its convenience to say that the accumulation of pollutant is higher in South side rather than the West one.
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III. 6 The Annual Trend of Air Ambien (Ground Level) Concentration.

Indonesia has two seasons per annum. There are the Dry season (called Kemarau) and the Rainy season (called Penghujan). With the view of studying the season effect, and annual trend of pollutant concentration in ambien air at the proposed location, with relation to the fate of pollutant this study was performed. The input data is monitoring inventories held by PT PJB (per 3 months) during 2001-2006. One of monitoring location is Selobanteng village, which located at South side the power plant location, and it’s within reach 5 km from the existing power plant area.

Assessing the Impact.
The final step from this study is predicting and assessing the impact of PLTU 2 Jawa timur to ambien air quality. In this step, the study compares the maximum predicted concentration with Ambien Air Quality Standards. The maximum predicted concentration calculated by adding the maximum modeled concentration with background concentration. The background concentration taken from ambien air sampling data which conduct on 2005 by PSLH UGM (an environment study centre of Gadjah Mada University); especially which held at Sumberejo village within reach about 3 km (similar with the modeled distance to maximum). The results:

CONCLUSION

From the results we know that the impact of the proposed power plant will depend on air pollutant control strategies. Applying air pollutant control technologies (OFA, LNB, ESP and FGD) as scenario 5, 9 and 10, show compliance with allowable concentration (Ambient air Quality Standard). The control technologies hold more dominant rather than controlling the air pollutant by increasing stack height. On the complex terrain features, the increasing dispersion strategy by increasing the stack height doesn’t give significant effect. Thus, although FGD has a high cost value, up to 20 % from construction cost for a new power plant, applying FGD policy is more suggestible rather than increasing the stack height up to 240 or 260 m.
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