

ALTERNATIVE OPTIMIZATION OF ASH WASTE UTILIZATION OF STEAM POWER PLANT (2 X 1,000 MW) IN TERMS OF PRODUCTION, ENVIRONMENTAL AND ECONOMIC ASPECTS

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ABSTRACT

The Ministry of Energy and Mineral Resources recorded Indonesia's electricity consumption in 2018 amounting to 1,064 kilo Watt hours per capita. National electricity consumption continues to increase along with the increase in electrification in all regions and changes in people's lifestyles. The government, through the 35,000 MW electricity program, continues to try fulfilling the national electricity needs through the construction of power plants. Steam Power Plant is one of the alternatives due to the large availability of coal in Indonesia. Currently, there are 166 billion tons of coal resources with 37 billion tons reserve. Speaking of burning coal, it will not be separated from waste ash (fly ash and bottom ash). Many studies have been carried out on the utilization of this waste, including the use of this waste to make other products (brick, light brick, paving, etc.). However, until now each Steam Power Plant has not yet been fully integrated in utilizing the ash waste. The Steam Power Plant only carries out the process of stockpiling or paying to third parties who have permission to use B3 waste to be disposed of. The potential for the use of ash waste (fly ash and bottom ash) is very large in Indonesia and spread in various parts of Indonesia. This raises an optimization study and alternative uses of ash waste. The 1,000 MW capacity of Steam Power Plant was chosen because currently it is the largest capacity of Steam Power Plant in Indonesia. The study of optimization and utilization of ash waste is carried out by performing technical calculations, analyzing economic and environmental aspects. From the various alternatives that has been studied, the best alternatives was chosen. In the case of ash waste utilization at a 1,000 MW power plant, the best alternative was to utilize ash waste as Mortar with economic value: NPV Rp. 4,023,813,107398 with IRR reaches 15%. The Payback Period is 0.48 Years and Benevit Cost Ratio is 12.27%.

KEY WORDS : Optimization, Fly ash, Bottom ash, Steam power plant, Hazardous material.

INTRODUCTION

Coal is a source of fly ash waste which, based on ASTM D.388, is grouped into three. The first group is the Lignitic Coal which is the lowest category of coals. It has the ability to produce the lowest heat and the highest water content. It is also often called as "brown coal" because it is rather soft with the color of brown or black and is generally used to produce electricity. The second group is Sub-bituminous coal which is an intermediate

category between lignite and bituminous coal. This type of coal has the ability to generate heat, combustion and moisture content while the dam is used to generate electricity. It has 71% - 77% of carbon content in dry ash and also possess the ability to generate heat between 8,300 - 13,000 British Thermal Units per pound of coal. It is the most common type of coal and usually called as the black coal. In general, this type of coal has the ability to produce high heat and low humidity which can be used to generate electricity or melt iron ore. The

third group is Anthracite coal which is a type of coal that has the highest carbon content as well as the lowest water and ash content and is slow to burn. It has 77% - 87% of carbon content in dry ash and possess the ability to generate heat above 13,000 British Thermal Units per pound of coal.

Fly ash and bottom ash are the waste generated from burning coal at a steam power plant. Fly ash is the flying dust captured using an electrostatic precipitator while bottom ash is the leftover combustion that does not fly. Coal burning wastes are divided into two groups:

- a. Bottom ash, which is a heavy ash
- b. Fly ash, which is a fly / light ash

Chart of separation & storage of fly ash in the power plant can be explained in the following figure

Class F Fly Ash

Fly ash that contains CaO smaller than 10% which is produced from the burning of anthracite or bituminous coal.

- Levels of $(\text{SiO}_2 + \text{Al}_2\text{O}_3 + \text{Fe}_2\text{O}_3) > 70\%$.
- Level of CaO $< 10\%$ (ASTM 20%, CSA 8%)
- Carbon content (C) ranges from 5% -10%

Class F fly ash is also called low-calcium fly ash which does not have cementitious properties and is only pozzolanic.

Class C Fly Ash

Fly ash that contains CaO above 10% which is produced from burning lignite or sub-bituminous coal (young / sub-bituminous coal).

- Levels of $(\text{SiO}_2 + \text{Al}_2\text{O}_3 + \text{Fe}_2\text{O}_3) > 50\%$.

CaO level $> 10\%$ (ASTM 20%, CSA sets the percentage to range between 8-20% for CI type and above 20% for CH)

- Carbon content (C) is around 2%

Class C Fly ash is also called as a high-calcium fly ash

Due to its high CaO content, type C fly ash has cementitious properties as well as pozzolan properties. Since it contains high level of CaO and has cementitious properties, it will hydrate and harden in about 45 minutes if it is exposed to water or moisture.

Class N Fly Ash

Natural pozzolan or combustion products which can be classified are diatomaceous earth, opaline cherts, shales, tuff and volcanic ash. These types are processed through combustion or not through the combustion process. Besides that, they also have

good pozzolanic qualities.

RESEARCH METHOD

The optimization system for utilizing ash waste is arranged to ease the determination of the type of ash waste, the selection of alternative uses of ash waste, and the optimization of the use of ash waste. This large system is further divided into smaller sub-systems, namely:

1. Sub System I: Determination of the type of Steam Power Plant ash waste based on ash characteristics
 - a) Sub system I is a system that functions to determine the type of ash waste, whether it is included in the category of fly ash or bottom ash.
 - b) Input: Chemical content in ash waste. Determination of the types of fly ash or bottom ash waste is carried out by looking at the chemical content in the ash waste.
 - c) Output: Type of ash waste, including fly ash or bottom ash.
2. Sub System II: Selection of alternative utilization of ash waste.
 - a) Sub system II is a system that functions to select alternative utilization of ash waste.
 - b) Input: the output produced in sub-system I becomes the input to sub-system II. The selection of alternative utilization of ash waste can be seen in the following chart:
3. Sub System III: Calculation of economic and environmental values.

Calculation of economic aspects is done by calculating several parameters related to economic values, namely:

- a) Net Present Value (NPV) which has the greatest value.
- b) Internal Rate of Return (IRR) which has the greatest value.
- c) Payback Period which has the smallest value.
- d) Benefit Cost Ratio which has the greatest value

The stages of research are arranged in a flowchart so that the problems raised in this paper can be resolved and the desired objectives can be achieved. Research flowcharts are arranged as follows:

RESULTS AND DISCUSSION

Fly Ash is a waste material that is mostly produced

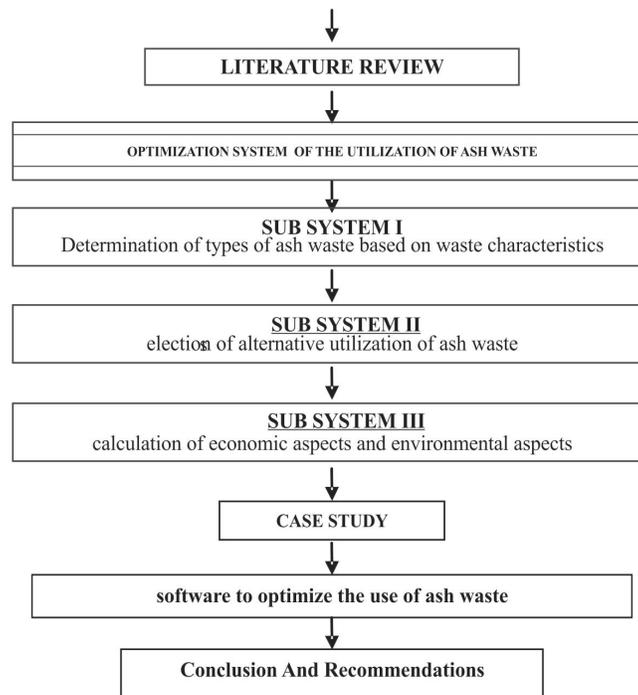


Fig. 2. Research Flowchart

in electricity production (Escheetz *et al.*, 1998). Fly ash has good potential for the use in construction industry which can increase CBR values quite highly and can be used as adsorbent media (Ahmaruzzaman, 2010; Karthik *et al.*, 2014). High CBR values mean that the stabilization potential of cement and fly ash mixtures produces concrete with higher density and strength (Amu *et al.*, 2005; Misra, 1998; Swamy, 1990). Moreover, adding phosphogypsum can provide cheap and profitable construction products (Degirmenci *et al.*, 2007). Besides, the addition of fly ash increases the pH value so that heavy metal immobilization will occur in the materials which are about to be solidified (Dermatas *et al.*, 2003; Fernández-Jiménez and

Palomo, 2003; Xenidis *et al.*, 2002; Bertocchi *et al.*, 2010). Fly ash mixed with benyinite has permeable ($k < 1.00 \times 10^{-7}$ cm/s) which can be used as a geopolymer in a waste treatment (Mollamahmutođlu, 2001). This geopolymer is made by mixing fly ash, kaolinite, sodium silicate solution, NaOH, and water (Swanepoel and Strydom, 2002; Ram *et al.*, 2010; Van Jaarsveld *et al.*, 1999; Van Jaarsveld *et al.*, 1999). Application of fly ash on agricultural land provides additional supply of Ca, S, B, Mo, and Se to the soil (Adriano *et al.*, 1980; Mittra *et al.*, 2005; Pandey *et al.*, 2010).

The utilization of ash waste in the Steam Power Plant is carried out in the 2 x 1,000 MW Power Plant. Production of ash per day is around 1,350 tons with

Table 1. Economic Value of Utilizing 2 x 1,000 MW of Steam Power Plant Ash Waste

No	Alternative Utilization	Economic Aspects			
		NPV (\$)	IRR (%)	PP (Year)	BCR (%)
1	Filtration membranes	247.205.00	15	2,3	2,28
2	Concrete blocks	640.810.31	15	5,4	1,1
3	Light bricks	93.748.58	15	5,44	1.16
4	Paving Blocks	1.235.734.38	15	5,44	1.16
5	Ready Mix	2.400.591.68	15	5,65	2,18
6	Mortar	284.201.919.78	15	0,48	12,27
7	Raw Fly Ash	522.043.99	15	1	3,28

NPV= Net Present Value, (IRR)=Internal Rate of Return () yang memiliki nilai terbesar, (PP)=Payback Period, (BCR)=Benefit Cost Ratio.

ash quality as follows: Levels of (SiO₂ + Al₂O₃ + Fe₂O₃) = 70%, Level of CaO = 8%, Carbon content (C) = 9%, Judging from the ash quality, it can be classified into class F fly ash. It has several alternative choices of ash waste utilization including filtration membranes, concrete blocks, light brick, paving blocks, ready mix, mortar and raw fly ash. The economic value of the utilization of 1 x 1,000 MW Steam Power Plant ash waste is carried out by calculating the feasibility study of several alternative uses of ash waste which can be economically seen in Table 1 below:

In the alternative use of ash waste, mortar products have the highest economic value. Besides, the consumption of fly ash for mortar products also experiences market prospects which are increasing from year to year. By using the results of the regression equation obtained, then in 2033 or in the next 15 years start from 2018, the market value for mortar reaches 7953.8 billion tons.

CONCLUSION

Some conclusions that can be drawn from the study of optimizing the utilization of 2 x 1,000 MW Steam Power Plant ash waste are as follows:

1. Mortar products are the most optimal alternative utilization of waste for 2 x 1,000 MW Steam Power Plant.
2. Judging from the economical side of the utilization of ash waste for Mortar products, it has NPV value = Rp 4,023,813,107,398, -, IRR = 15%, Payback Period = 0.48 Years and BCR = 12.27%.
3. Judging from the environmental side of ash waste utilization, it can reduce the effect of ash waste disposal by 492,750 tons / year.

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