ANALYSIS OF UBC UTILIZATION IN THE EXISTING COAL POWER STATION
CASE STUDY : SURALAYA POWER STATION

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ABSTRACT

Coal resources in Indonesia mostly (65 %) are categorized as LRC (Low Rank Coal). Currently, the Indonesian Government is encouraging to use LRC as the main source of energy in the national energy mixed policy, including the acceleration program of constructing 10,000 MW Power Plant. With the advanced technologies, such as Upgraded Brown Coal (UBC) process, LRC can be used optimally, particularly for the power plant.

Suralaya Generation Business Unit (SGBU), which is the largest coal power plant in Indonesia, recently has to use lignite coal or low rank coal because the price of medium and high rank coal is too expensive. This paper conducted to identify the problems faced by SGBU in using lignite coal and to evaluate the benefit of UBC process if used in SGBU to be blended with lignite. From the evaluation, it can be concluded that UBC process will give benefit to SGBU by reducing ash pollution and give economic benefit of Rp 507 billion per year maximum.

Keywords : upgraded brown coal, suralaya generation business unit

1. BACKGROUND

Coal is the largest energy resource in Indonesia followed by natural gas, crude oil, hydropower and geothermal, respectively. Among this commercial energy used, the contribution of coal increases significantly. In the year of 1985, contribution of coal was only 8% of the total energy mixed and increased up to 17% in 2006 and it is expected to increase at least 33% in 2025. In the power sector, the share of coal is also expected to grow very significantly. In 2006 the requirement of coal for power generation was 35.5 million tons and will be increased to approximately 65 million tons in 2010 and 123 million tons in 2025. Therefore, coal has played a significant role in meeting the growing energy demand as well as enhancing the security of energy supply in the country.

Coal resources in Indonesia mostly are categorized as LRC. It is estimated that 65% from 91 billion tons of coal resource in Indonesia is LRC and mostly located in Sumatera and Kalimantan islands. The extensive development of Indonesian coal industry within the last fifteen years has made a strong positive impact on the national economy. Currently, coal (most of High Rank Coal = HRC and Medium Rank Coal = MRC) is mainly for export, while the domestic use of coal is mainly limited to power generations, cement industries and paper manufactures. Other industries that are expected to switch their fuel to coal, among others fertilizer companies, small and home industries and agricultures. In general, the strategic planning of coal utilization is derived from the quality proportion of the resources in order to meet the market demand and domestic consumption for energy generation.

Currently, the Indonesian Government is encouraging to use LRC as the main source of energy in the national energy mixed policy, including the acceleration program of constructing 10,000 MW Power Plant. In that sense, the government is encouraging to use more coal domestically, while maintaining the export level. With the advanced technologies, such as Upgraded Brown Coal (UBC) developed by Kobe Steel Ltd. of Japan and the Ministry of Energy and Mineral Resources of Republic of Indonesia, LRC can be used optimally, both for export and domestic use, particularly for the existing industries and power plant, for instance Suralaya Power Station that has been allocated to use HRC and MRC.

2. OBJECTIVES

The objectives of this study are:

a. To study the problem that occurred on operation of coal fired power generating units at the Suralaya Generation Business Unit (SGBU) including technical and non technical problems for using lignite (low rank coal). These units are typical of many coal fired power generating units in Indonesia. Therefore, the study in Suralaya existing power station can be implemented to other Indonesia power plants.

b. To evaluate whether the utilization of UBC in Suralaya power station is more advantageous compared with that of raw lignite.

3. GENERAL INFORMATION

Upgraded Brown Coal (UBC)

Several upgrading techniques have been successfully developed around the world (Allardice and Young, 2001). UBC process that is developed by Kobe Steel Ltd. of Japan is one of the most advanced solutions of upgrading, due to its relatively simple and mild process and also indicated by its lower pressure and temperature. The benefit of UBC process includes increasing value added to coal, both for export and domestic markets, stabilizing coal quality feed for power generation and other industries, increasing combustion efficiency and reducing CO_2 emission.

A pilot plant scale in Palimanan, Cirebon with the capacity of 5 tons/day has been established in 2003. UBC process upgrades LRC into coal of 6,000 – 6,800 kcal/kg (air dried basis/adb) heating value, mostly through moisture content reduction technique from 20 – 40% in the feed coals to less than 5% in the dewatered product. The final product can be UBC powder, slurry or briquette, and it is very stable after the coal has reached equilibrium conditions with minimum pollution of the waste water.

Indonesia in cooperation with JCOAL and Kobe Steel Ltd. of Japan are developing the demonstration plant in Satui (South Kalimantan) to implement the UBC in coal industry. The demonstration plant has production capacity of 600 tons/day or 1,000 tons/day feed. This project is started since April 2006 and the operation of this plant will be expected to commence in 2008. After the demonstration stage, it is expected to proceed the commercial stage with the plant capacity of 5,000 tons/day or 1.7 million tons/year that will be operated in 2012.

Suralaya Generation Business Unit

a. Location of SGBU
The SGBU is one of the power plant belong to PT Indonesia Power Stations. It is the largest coal fired plant in Indonesia. SGBU is located at Western end of the island of Java on the coast line. Geographically, SGBU has a strategic location; it is much closed to fuel supply (coal) and other required facilities. It can be reached by sea via Merak Ferry Port and by car using Tomang Merak highway. Figure 1 shows the location of the SGBU.

SGBU located on 239 Ha land with facilities including central building (78 Ha), ash valley (8 Ha) and housing complex (30 Ha), while the rest consists of hills and jungles.

b. Installed Capacity of SGBU
The installed capacity of SGBU is about 38% from the entire installed capacity of PT Indonesia Power Generation Business Unit. It supplies approximately 20% of the electricity in Java - Bali (Suralaya 3,400 MW and Java - Bali installed capacity = 18,696 MW). Table 1 and Figure 2 show the detailed installed capacity of power plant belong to PT Indonesia Power Generation Business Unit.

Source : www.suralaya.com

Figure 1. Location of SGBU

Table 1. Capacity of Each Business Unit

Generation Business Unit	Type	Capacity (MW)
Suralaya	Steam Coal PP	3,400
Priok	GT, CCST & Diesel PP	1,248
Saguling	Hydro	797
Kamojang	Geothermal	375
Mrica	Hydro	306
Semarang	CCST & SPP	1,469
Perak-Grati	SPP	864
Bali	GT & Diesel	428
Total Indonesia Power		8,888

Source : www.indonesiapower.co.id

Note : PP : Power Plant
GT : Gas Turbine
CCST : Combined Cycle Steam Turbine
SPP : Steam Power Plant
MW : Mega Watt

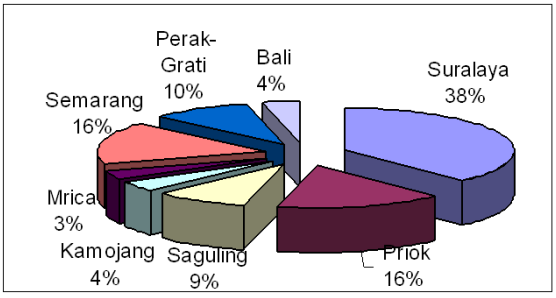

Figure 2. Installed Capacity of Power Plant

d. Electricity Production

The production of SGBU is increased from 21,212 GWH (Giga Watt hour) in the year of 2000 up to 25,247 GWH in the year of 2006 as shown in Figure 3. The increasing of electricity production is required to support Java - Bali grid system. High demand of electricity is recognized along the Java - Bali grid system.

The electricity in Indonesia has been growing at average 7% per annum, and this trend will be continued in the coming years. Total electricity productions of PT Indonesia Power are shown in Figure 4.

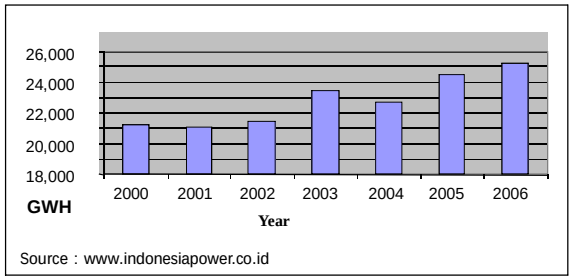

Figure 3. Electricity Productions of SGBU

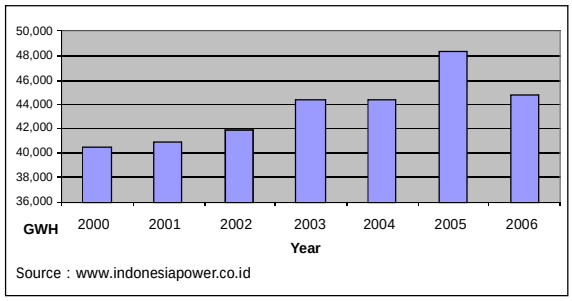

Figure 4. Total electricity productions of PT Indonesia Power

e. Coal Supplier

SGBU consumes approximately 40,000 ton of coal per day or 12 million ton of coal per year. The coal is supplied mostly from Tanjung Enim, South Sumatera by PT Bukit Asam Coal Mining Company. Bukit Asam provides about 6.1 million ton coal every year and the contract will be continued until 2012. Other coal suppliers to SGBU, among others PT Kideco Jaya Agung, PT Berau Coal, PT Senco, PT Arutmin Indonesia, PT Natuna Energi Indonesia and PT Central Korporindo Internasional Tbk. The contract between SGBU and these coal supliers is mostly for short term, that is about 1 - 2 million ton of coal per year of each company. Figure 5 shows the quantity of coal that has been used in SGBU since year 2000 up to year 2006.

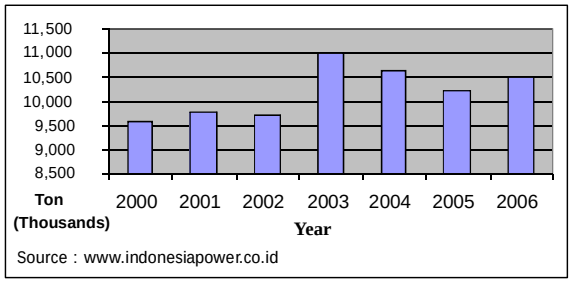

Figure 5. Coal used in SGBU

4. METHODOLOGY

The methodology of this research includes study literature, site investigation and interview with the staffs of SGBU, especially in coal division.

5. RESULTS AND EVALUATION

5.1. Technical Problems

5.1.1. Results

Table 2 shows several problems that can be affected by the quality of coal. During the investigation in SGBU, two main problems have been identified that can affect the performance of SGBU at the moment and in the future when lignite is used, they are maintenance of pulverizers and environmental issues relating to ash production.

- Pulverizers Maintenance

Pulverizer is one of the important components in coal fired plant. It turns coal from rock-shape to fine powder (200 mesh). Each units of 1, 2, 3 and 4 has 5 pulverizers, and each units of 5, 6 and 7 has 6 pulverizers. All the units should have back-up pulverizers as a contingency plan if problems occur. Normally, units 1, 2, 3 and 4 suppose to operate only 4 pulverizers, because 1 pulverizer is off for a back up, so that units 5, 6 and 7 suppose to operate 5 pulverizers, 1 pulverizer is allocated as a back up. During the site inspection, it was discovered that there was no back up pulverizer. All pulverizers were operated in order to get the maximum output of 3,400 MW. This condition forced all the maintenance staffs to work harder than usual time. In addition, the cost of

Table 2. Parameters affected SGBU performances

No.	Parameters	Effect
1	Calorific Value	Power, trend of load change
2	Moisture	Mill capacity, coal handling
3	Ash	Mill capacity, ignition, ash handling, quality of fly-ash
4	Volatile Matter	Ignition, NO_x formation, Unburned carbon
5	HGI	Mill capacity, Unburned carbon
6	Sulfur	SO_2 emission, FGD capacity
7	Chlorine	Corrosion
8	Ash Fusion Temperature	Slugging and Fouling Potential
9	Ash composition	Potential slugging and fouling, efficiency EP, ash quality

maintenance also becomes more expensive because apart from the pulverizer, all the equipment that supported pulverizers such as primary air fan and intermediate draught fan also had to work in a full capacity.

The problems of pulverizer occurred since the calorific value of coal supply is lower than the initial design. The initial design of power plant is for coal from Bukit Asam with 5,850 kcal/ kg (air dried basis/adb) calorific value. However, currently SGBU consumes coal with lower calorific value, around 5,300 kcal/kg (adb). Consequently, all the pulverizers have to be operated in full time in order to meet the entire electricity production.

- Ash Production (Environmental Issue)

Ash, some of the burned coal falls to the bottom of the boiler where it is collected and sold for use in making building blocks. More than 99.5% of the dust is extracted by electrostatic precipitators (ESP). The ESP charges the fine particles, therefore they are attracted to the screens in where they can be collected mechanically. Pulverized ash has a variety of uses, from civil engineering projects to a partial substitute for cement in concrete manufacture. 80% of ash in coal supply will become as fly ash and the rest will become as bottom ash. Bottom ash that produced by SGBU is approximately 400 tons per day and up to the present the bottom ash that has been collected in ash valley of 276,489 m^2 wide area is about 267,000 tons.

Production of ash has a strong correlation with the amount of coal that has to be supplied to SGBU. Coal of lower calorific value will consumed more coal compared with the normal quality of coal (approximately 5,850 kcal/kg, adb), therefore the power plants will produce more ash that also create more environmental problems.

5.1.2. Evaluation

- Pulverizers Maintenance :

Problems in pulverizer happened because SGBU could not provide coal supply of the same quality (calorific value) as required by initial design. Therefore, SGBU had to operate all the pulverizers, without allocate any back up pulverizers. UBC product could be used, both as a single feeding or blended with raw coal to achieve an average quality of coal approximately 5,850 kcal/kg (adb) calorific value. In this case, SGBU has one pulverizer as a back up system in each unit. By using the medium to high rank coals will also reduce the workload of maintenance staffs and then the maintenance staffs could make a better maintenance schedule. At the end, it will reduce the maintenance cost of approximately Rp 0.42 billion per year or almost 18% of usual maintenance cost.

The calculation is as follows:

Low Quality of Coal (current status)
38 pulverizers, each needs 2 simple inspections per year
Cost of simple inspection = Rp 30.000.000,- per pulverizer
Total cost per year for simple inspection is Rp 2.28 billion

Medium to High Quality of Coal (blended with UBC product)
31 pulverizers, each needs 2 simple inspections per year
Cost of simple inspection = Rp 30.000.000

per pulverizer
Total cost per year for simple inspection is Rp 1.86 billion

Total reduction is Rp 2.28 billion – Rp 1.86 billion = Rp 0.42 billion

- **Ash Production:**

Environmental aspect has become an important issue in coal world market. Many people against the development of coal fired station plant because they worried about the environmental pollution caused by coal burning. Table 3 shows ash production generated by SGBU both using Bukit Asam coal and Mulia coal. Current production of ash in SGBU is approximately 456,236 ton per year as shown in the Table 3. Ash produced from Bukit Asam coal is 402,799 tons (88%) and the rest 53,437 tons (12%) derived from Mulia coal. The amount of Bukit Asam coal and Mulia coal consumed in 2006 was relatively equal, however the ash content of the coals was very different, 8% for Bukit Asam coal and 0.98% for Mulia coal.

Table 3. Comparison of ash production from Bukit Asam and Mulia coals in 2006

Source of Coal	Ash (%, adb)	Quantity of Coal (ton)	Quantity of Ash (ton)
Bukit Asam	8	5,034,989	402,799
Mulia	0.98	5,452,769	53,437
Total		10,487,758	456,236

The reduction of ash production would be very significant if SGBU consumes UBC product from Mulia coal. The advantages of the Mulia UBC product compared with Bukit Asam raw coal are the UBC product has higher in calorific value and lower in ash content. With this condition, it will reduce approximately 34% of ash production that is from 456,236 tons per year to be 301,635 ton per year as shown in Table 4. In the case of bottom ash, it is 20% of the total ash, therefore, the bottom ash will reduce from 295 ton per day to be 195 tons per day. At the end, the system will reduce the cost of cleaning the air and the pollution surround the coal fired power plant.

Table 4. Ash production from blended coal feeding

Source of supply	Ash (%)	Coal Quantity (ton)	Quantity of Ash (ton)
Bukit Asam raw Coal	8	2,600,000	208,000
Mulia raw Coal	0.98	6,237,758	61,130
Mulia UBC	1.97	1,650,000	32,505
Total		10,487,758	301,635

5.2. Non Technical Problems

5.2.1. Results

- **Price of Coal**

The price of energy supplies such as oil or coal is driven by principle of supply-demand scheme. Crisis in Middle East and the awakening of Chinese economy had caused the increased of oil price. Coal as primary substitute for oil due to its abundant resources, especially for electricity sector is also affected. Coal price in spot market increased since coal international price also increase. For example, the price of coal from Bukit Asam for Suralaya in 2007 was Rp 484,000 per ton (www.ptba.co.id). This price increased almost 30% compared with the price of coal in 2006, that was Rp 375,000 per ton.

Many of coal producers prefer to export their coal rather than to sell coals for domestic market (for instance power plants) due to the big margin price between export and domestic markets. SGBU as a consumer of coal is really affected by this condition. With this situation, SGBU could not provide coal of medium to high calorific value to meet the requirement.

- **Quality of Coal**

The increase of coal price affects the quality of coal supply to SGBU. The calorific value decreases from above 5,850 kcal/kg (adb) to less than 5,400 kcal/kg (adb). Currently, SGBU also purchases lignite with calorific value of less than 5,000 kcal/kg (adb). One of the companies that supply lignite of less than 5,000 kcal/kg (adb) calorific value is PT. Arutmin Indonesia derived

from their coal mining in Satui, South Kalimantan.

Calorific value and moisture content are two main factors that affect the performance of power plants as show in Table 2. Table 5 shows the comparison of quality between UBC product of Mulia coal, raw coal of Mulia (PT Arutmin Indonesia) and raw coal from Bukit Asam.

- UBC Utilization

There are two options for SGBU to utilize UBC:

1. UBC Commercial Plant is constructed at Satui/Mulia area, belong to PT Arutmin Indonesia. In this case, SGBU is as a buyer.
2. UBC Commercial Plant is constructed at Suralaya area. In this case SGBU is the owner of the plant.

Table 5. Comparison of quality of UBC product and two raw coals

Parametres	UBC Product	Coal from Mulia	Coal from PT BA
Calorific Value (kcal/kg, adb)	6,251	4,873	5,850
Ash (%, adb)	1.97	0.98	10
Sulphur (%, adb)	0.18	0.17	0.8
Total Moisture (%)	5.96	32.38	28
Volatile Matter (%, adb)	45.80	37.8	40

5.2.2. Evaluation

The main question for the non technical problem is economic value of using UBC product. From the technical aspect, it seems to be no particular problem will be occurred. UBC product can be used both as a single feed or as a blended material for lower rank coal in power plant. Currently, SGBU utilizes approximately 30,000 – 40,000 tons of coal per day which is much larger than the capacity of UBC demonstration plant of 600 tons per day that is under constructing in Satui, South Kalimantan that has plan to use the Mulia coal. The UBC product can be utilized as a blended material to produce coal of approximately 5,850 kcal/kg (adb) calorific value.

In 2006, SGBU consumed 10,487,758 tons of coal with the calorific value of 5,342 kcal/kg (adb) to produce 25,247 GWH. Initial design of SGBU requires coal of 5,850 kcal/kg (adb) calorific value. If the coal supply is 5,850 kcal/kg (adb) calorific value, the SGBU only consumes approximately 9.58 millions ton of coal per year (5,342/5,850 X 10,487,758 tons = 9,577,026 tons). In this condition, one pulverize of each unit can be allocated for a back up system. Since there is a limitation about the quantity of Bukit Asam Coal and UBC Coal that can be sent to SGBU, then there will be no change about the quantity of the coal that consumed by SGBU. It is still 10,487,758 tons of coal with average calorific value 5,342 kcal/kg (adb).

1. UBC Commercial Plant is Constructed at Satui Area
   Advantage : SGBU does not need to invest the UBC construction plant.
   Disadvantages include :
   - SGBU has to pay the coal (UBC product) with the market price,
   - The coal supplier will be limited, only 1 company (PT Arutmin Indonesia),
   - SGBU can not control the price, and
   - SGBU can not control the continuity of coal supply.

   Table 6 shows the cost of coal supply for SGBU, both from Bukit Asam and Mulia. In comparison, Tables 7 shows the cost of coal supply, blended from UBC product from Mulia coal and Mulia raw coal and Bukit Asam raw coal. The assumption of the UBC product price is US$ 65,73 per ton or Rp 591,570 per ton, based on the average export price of Indonesian coal in 2007 (www.republika.co.id). The average price of Mulia Coal in 2007 is US$ 21.1 per ton or Rp 190,000 (www.bhaktisecurities.com).

   From the Tables 6 and 7, it is cleared that there is a reduction cost of coal supply of approximately Rp 154 billion per year if SGBU consumes at least 15% of UBC from the total coal used.

Table 6. Total cost of coal supply using Bukit Asam and Mulia raw coals

Source of Coal	Calorific Value (Kcal/kg, adb)	Quantity (ton)	Price per Ton (Rp)	Total Cost (Rp Billion)
Bukit Asam	5,850	5,034,989	484,000	2,437
Mulia	4,873	5,452,769	190,000	1,036
Total	-	10,487,758	-	**3,473**

Table 7. Total cost of coal supply using Mulia raw coal and UBC product

Source of Coal	Calorific Value (Kcal/kg, adb)	Quantity (ton)	Price per Ton (Rp)	Total Cost (Rp Billion)
Bukit Asam	5,100	2,600,000	484,000	1,258
Mulia Raw	4,300	6,237,758	190,000	1,185
Mulia UBC	6,873	1,650,000	591,570	976
Total		10,487,758		**3,319**

2. UBC Commercial Plant is constructed at the area of SGBU
   Advantages:
   - UBC commercial plant could be constructed integrates with the existing power plants (units 1-7). In this case, the briquetting unit (section 5) does not need to be constructed because the fine UBC product can be used directly in the pulverizer. Therefore the investment cost for UBC construction at the area of SGBU is much cheaper compared with that of constructing of UBC plant in coal mine mouth. Transportation of raw low rank coal has to be considered.
   - SGBU can utilize several low rank coals from different sources to produce UBC.
   - SGBU can control the continuity of supply and the price of the UBC product.

   Disadvantage:
   SGBU has to provide capital expenditure to construct UBC commercial plant and probably has to create a new company to run the UBC plant because the main business of SGBU is coal fired plant.

   The calculation of cost production for 1 ton UBC that is constructed at the site of SGBU is based on quality of the coal (Table 8) and some assumption as can be seen in Table 9. The calculation of processing cost and total cost to produce 1 ton UBC is shown in Table 10.

Table 8. Quality of Coal

	Raw	UBC
Calorific Value (kcal/kg)	4,873	6,251
Ash (%)	0.98	1.97
Sulphur (%)	0.17	0.18
Total Moisture (%)	32.38	5.96
Volatile Matter (%)	37.8	45.80

i. Plant cost: US$ 47.6 million (reduced 35% from US$ 78 million of normal plant cost (Hudaya, G.K, 2007). The reduction of 35% derived from briquetting cost. As stated earlier that the final product is UBC powder that can be utilized direct to pulverize or boiler in the power plant unit.

ii. Raw coal cost : Rp 190,000,- or US$ 21.1 (1 US$ = Rp 9,000,-) per ton.

The cost of UBC is US$ 35.22 per ton or Rp 317,000. The total cost of coal supply to SGBU including coal from Bukit Asam, Mulia and UBC product to produce coal of approximately 5,000 kcal/kg (adb) calorific value can be seen in Tables 11 and 12.

From Tables 11 and 12, it is cleared that there is a reduction cost of coal supply of approximately Rp 507 billion per year if the UBC plant of 1.65 million ton per year capacity is constructed at SGBU.

Table 9. Assumptions for calculating the UBC investment

Production Capacity (ton/day)	5,000
LSWR (Light Sulfur Wax Residue) Cost ($/ton)	95
Worker (people)	46
Cost of worker ($/man.year)	6,161
Maintenance Cost (US$ M/year)	0.714
Insurance & Tax Cost (US$ M/year)	0.952
Depreciation (year)	15
Company Tax (%)	30
Equity Ratio (%)	25
Loan Installment Period (Year)	15

Table 10. Calculation of process cost

Variable		t/t-UBC	$/t	$/t-UBC
Cost	Raw Coal	1.380	21.1	29.19
	Light Oil	0.0041	288	1.18
	Heavy Oil	0.0045	95	0.43
	Water	1.2	0.01	0.01
	Steaming Coal	0.027	21.1	0.50
	Power kWh	70	0.025	1.75
	Variable Cost Total			33.06
Fixed Cost		base	Rate	$/t-UBC
	Labor	46	6161	0.17
	Maintenance	47	1.5%	0.43
	Direct Overhead	0.17	45%	0.08
	Plant Overhead	0.60	80%	0.48
	Insurance &Tax	47	2%	0.57
	Depreciation	47	1.50%	0.43
	Fixed Cost Total			2.16

Table 11. Total cost of coal supply using Bukit Asam and Mulia raw coals

Source of Coal	Calorific Value (Kcal/kg, adb)	Quantity (ton)	Price per Ton (Rp)	Total Cost (Rp Billion)
Bukit Asam	5,850	5,034,989	484,000	2,437
Mulia	4,873	5,452,769	190,000	1,036
Total		10,487,758		**3,473**

Table 12. Total cost of coal supply using Mulia raw coal and UBC product

Source of Coal	Calorific Value (Kcal/kg, adb)	Quantity (ton)	Price per Ton (Rp)	Total Cost (Rp Billion)
Bukit Asam	5,850	2,600,000	484,000	1,258
Mulia	4,873	6,237,758	190,000	1,185
UBC	6,251	1,650,000	317,000	523
Total		10,487,758		**2,966**

6. CONCLUDING REMARKS

The technical and non technical problems caused by using lignite coal in SGBU are :

1. Problems in pulverizer, SGBU could not provide coal supply with the calorific value as required by initial design. Therefore, SGBU had to operate all of the pulverizers, without allocate any back up pulverizers. It also requires high maintenance cost.

2. Production of ash increases because more coals are needed to reach the same power if SGBU uses coal with higher calorific value.

SGBU could improve the performances of the power plant units by utilizing UBC product that can be blended with Bukit Asam and Mulia raw coals. The benefits of UBC utilization include:

i. Reduced Rp 154 billion per year of annual cost for coal (from Rp 3,473 billion to Rp 3,319 billion) if SGBU use UBC product as consumer.

ii. Reduced Rp 507 billion per year of annual cost for coal (from Rp 3,473 billion to Rp 2,966 billion) if SGBU build UBC plant near SGBU's site.

iii. Reduced 100 tons per day of bottom ash production (from 295 tons to 195 tons per day). It reduces the pollution to the environment.

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