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Biomass (Palm kernel shell) in renewable energy for CFB boiler in Indonesia

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Abstract:

Coal-fired power plants are one of the most economical power plants for the fuel side if it is efficiently operated compared to other fossil powered power plant. Coal-fired power plant boiler has several types. One of them is CFB Boiler that also can be used fuel from biomass. CFB boiler are relatively new among boiler for power plant due to the efficiencies. This can be an opportunity to reduce the emission by the used of the fuel using biomass. And the palm kernel shell is the one of the potential option that maybe not need modification to the boiler and the infrastructure for certain portion. This study aims to find an analysis of the feasibility of investment for operating CFB boiler with palm kernel shell to reduce the use of fossil fuel with minimum adjustment to the system. with technical considerations to determine whether it is possible to not modify and how much it can be reduced from the fuel cost and emission. It is expected that this research will shows the difference of cost and emission between single coal fuel and mixed several ratios with PKS.

Keywords: *Biomass, CFB Boiler, Coal-fired, Power Plant, Energy, Renewable Energy*

I. INTRODUCTION

Indonesia have potential biomass energy from palm kernel shell and wood pallet.

CFB boiler are relatively new for boiler power plant due to the higher efficiencies compare to pulverized boiler. In Indonesia there are several power plant using CFB boiler.

Indonesia aiming to increasing the renewable energy until 23% of the total energy or 16.714 MW until 2028. And biomass itself at 794 MW (RUPTL 2019-2028).

In 2018, Indonesia have total power capacity at 57.822MW. PLN power plant at 41.696MW (72%) and private power plant 16.126 MW (28%). And by the 2028 the power demand forecasted at 56.395MW, that is mean the capacity need to be double up in 10 years.

Due to the target, government through PT. Perusahaan Listrik Negara (Persero) and independent power producer plan to increase the capacity of the power plant by building new power plant. And mostly are coal-fired power plant. This are big treat to existing independent power producer that already in operation if they do not secure the purchasing contract and does not provide added value in their operation.

POWER PLANT CAPACITY IN INDONESIA

NO	YEAR	PLN MW	PRIVATE MW	TOTAL MW
1	2013	34.205	11.252	45.457
2	2014	39.258	12.363	51.621
3	2015	40.265	12.594	52.859
4	2016	39.785	14.880	54.665
5	2017	39.652	16.274	55.926
6	2018	41.696	16.126	57.822

TABLE 1. Power plant capacity in Indonesia

This also an opportunity for the independent power producer that already using CFB boiler system to maintain the contract or renegotiation with the PLN for using the biomass with the existing CFB boiler and helping the government increasing the output of renewable energy.

This study is focusing to mix the use of the palm kernel shell in existing coal-fired CFB boiler power plant by using ratio of percentage from palm kernel shell and coal into the existing system.

II. PALM KERNEL SHELL POTENTION FOR CFB BOILER IN INDONESIA

Palm oil plantation in Indonesia increasing every year. Since the last five-year palm oil plantation increase around 2,77 until 10,55% / year. In 2014

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recorded 10,75 Ha and in 2019 becoming 12,76 Ha (Statistik Kelapa Sawit Indonesia, 2018).

Refer to regulation of The Minister of Energy and Mineral Resources of the Republic of Indonesia number 21 year 2016 concerning purchase of electric power from biomass power generator and biogas power plant by PT. Perusahaan Listrik Negara (Persero). The purchase price for the maximum capacity until 20MW are 16,00 cent USD/kWh for low voltage and 13,50 cent USD/kWh for middle and high voltage.

Compare to coal purchase price based on regulation of The Minister of Energy and Mineral Resources of the Republic of Indonesia number 3 year 2015 concerning purchase of electric power from coal-fired are lower than biomass. 11.82 cent USD/kWh for ≤10 MW until 10,60 cent USD/kWh for 25MW.

This of course a potential additional input for the Power Plant Company and increasing bargaining position for independent power producer to extend the contract period to PT. PLN (Persero).

The palm oil plantation in Indonesia are divided by two major plantations. Private and government, in 2017, big private company palm oil plantation in Indonesia are 6,05 million Ha (48,83%), 5,70 million Ha (46,01%) by small private plantation and by government around 0,64 million Ha (5,15%). In 2018 the number increased for big private company become 6,36 million Ha (49,81%), small private plantation in 5,81 million Ha (45,54%) and government around 0,59 million Ha (4,65%).

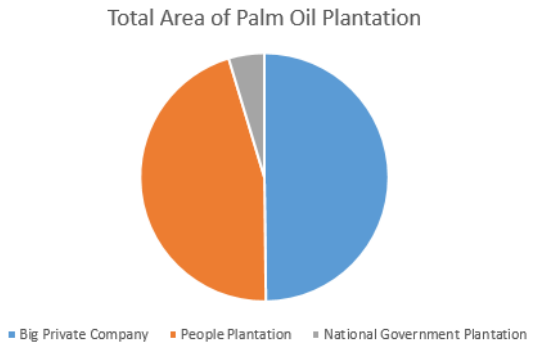

FIGURE 1. Total area of palm platation

II.1 Palm Kernel Shell Production

According to Susanto, Santoso and Suwedi (2017). 1 ton of fresh palm fruit can produce 65kg of palm kernel shell (6,5%).

Refer to 2018 report from Stasitik Kelapa Sawit Indonesia, 2018. Total production is 36.594.813 ton, and the palm kernel itself production volume are 7.318.963 ton for total production capacity.

Palm kernel is also imported several countries, most of it to Asia (China) & America. The amount of imported palm kernel is more than 15%. It is mean the excess of production can be used for one of them is as fuel for power plant.

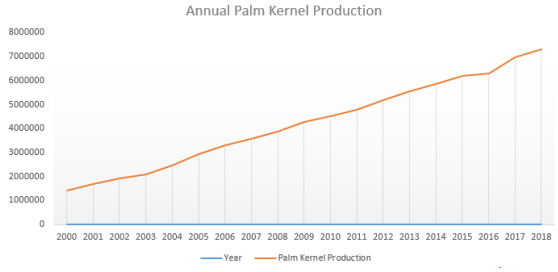

FIGURE 2. Annual palm kernel production

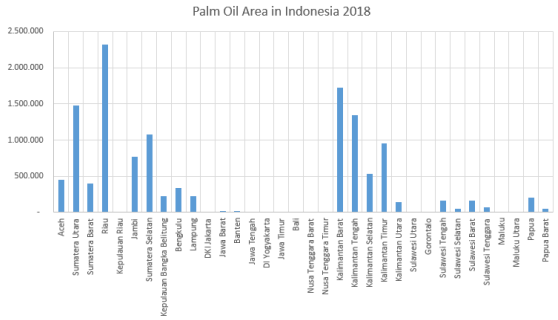

FIGURE 3. Palm oil area in Indonesia 2018

II.2 Palm Kernel Shell in Megawatt

Compare to research from Oladosu, Ajayeoba, Kareem and Akinnuli (2018) the ratio between the volume of the palm kernel shell and the energy produced are 3,46T/MWh

The increasing of the palm oil plantation also brings good opportunity to be used as the mixed fuel of CFB boiler that already running with full coal as the fuel.

$$Energy\ input\ boiler = \frac{Boiler\ steam\ load}{(Fuel\ efficiency/100)} * 860$$

$$Fuel\ flow = \frac{Energy\ input\ boiler}{Fuel\ calorie}$$

$$Specific\ fuel\ consumption = \frac{Fuel\ flow}{Active\ power}$$

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II.3 Palm Kernel Shell Ratio with Coal in CFB Boiler

Biomass in this journal specifically studying for the use of palm kernel shell, which can be used as fuel in CFB boiler coal-fired power plant with minor modification. All the fuel handling system for coal can be used for PKS. However, the PKS also have the downside effect on boiler due to their natural content.

Study case at coal-fired power plant using several option of palm kernel shell and coal ratio based on the power output as follow.

The reading taken by DNA of DCS for Fuel Efficiencies, Boiler Steam Load, and Active Power of the CFB Boiler.

In Friday 21 June 2019 the coal used for fuel is 100%. The Specific Fuel Consumption (SFC) are 0,588 T/MWh and the cost are Rp. 103.685.556,-. In Friday 16 August 2019 trial was commenced with 6% PKS of the total fuel and the Specific Fuel Consumption (SFC) are 0,588 T/MWh with the cost Rp. 102.744.422,640-. Saturday 17 August 2019 the PKS raised to 10% and The Specific Fuel Consumption (SFC) are raised to 0,589 T/MWh and the price are decreased to Rp. 102.117.000,400-.

This shows that using 10% PKS in CFB Boiler are increasing The Specific Fuel Consumption to 0,247% and decreasing fuel price to 1,513%. In long term this number will increase significant

III. EMISSION

Emission regulation for power plant in Indonesia are regulated in Regulation of The Minister of State Environment no 21 Year 2008 for The Quality of Emission for Thermal Power Plant.

Lampiran I B
Peraturan Menteri Negara
Lingkungan Hidup
Nomor : 21 Tahun 2008
Tanggal : 1 Desember 2008

BAKU MUTU EMISI SUMBER TIDAK BERGERAK BAGI PLTU

No.	Parameter	Kadar Maksimum (mg/Nm³)		
		Batubara	Minyak	Gas
1.	Sulfur Dioksida (SO_2)	750	650	50
2.	Nitrogen Oksida (NOx) dinyatakan sebagai NO_2	750	450	320
3.	Total Partikulat	100	100	30
4.	Opasitas	20 %	20 %	-

FIGURE 4. Regulation of quality emission of power plant 2008

However, the parameter is renewing with the new Regulation of the Minister of State Environment no 15 Year 2019 for The Quality of Emission for Thermal Power Plant. And the parameter has to comply within 3 years after the new regulation released.

A. BAKU MUTU EMISI PEMBANGKIT LISTRIK TENAGA UAP (PLTU) YANG DIBANGUN ATAU BEROPERASI SEBELUM PERATURAN MENTERI INI BERLAKU

NO	Parameter	Kadar Maksimum		
		Batubara (mg/Nm³)	Minyak Solar (mg/Nm³)	Gas (mg/Nm³)
1	Sulfur Dioksida (SO_2)	550	650	50
2	Nitrogen Oksida (NO_x)	550	450	320
3	Partikulat (PM)	100	75	30
4	Merkuri (Hg)	0,03	-	-

FIGURE 5. Regulation of quality emission of power plant 2019

From the reading of sensor in DCS the parameter as mentioned in the government rules in normal operation already under the emission standard. With single used of full coal in 21 June 2019 as we compared to the DCS reading for 6% of mixed PKS and from 10% of mixed PKS as follow

DATE	HOUR	Stack #1 SO_2 (mg/Nm³)	Stack #1 NO_2 (mg/Nm³)	Stack #1 Particulate (mg/Nm³)	Stack #1 Opasitas (%)	Limit SO2 / NO_2 (mg/Nm³)	Limit Particulate (mg/Nm³)	Limit Opasitas (%)
21 Juni 2019	05:00:00 - 05:59:59	159,78	182,73	11,31	2,26	750	100	20
	06:00:00 - 06:59:59	157,50	188,39	13,69	2,74	750	100	20
	07:00:00 - 07:59:59	164,79	191,16	14,83	2,97	750	100	20
16 Agustus 2019	05:00:00 - 05:59:59	175,13	210,00	21,76	4,35	750	100	20
	06:00:00 - 06:59:59	175,01	209,98	19,54	3,91	750	100	20
	07:00:00 - 07:59:59	178,03	211,22	18,94	3,79	750	100	20
17 Agustus 2019	02:00:00 - 02:59:59	169,41	218,22	21,87	4,37	750	100	20
	03:00:00 - 03:59:59	166,89	214,06	20,29	4,06	750	100	20
	04:00:00 - 04:59:59	165,27	213,78	19,52	3,90	750	100	20

FIGURE 6. DCS reading of emissions compare to regulation

The parameter reading for SO_2, NO_2, Particulate and Opacity from full coal to mixed fuel coal with

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PKS are increasing. However the parameter still in government regulation.

IV. PALM KERNEL SHELL & COAL PRICE

Palm kernel shell price data from Babelan Power Plant in August 2019 is at Rp. 1.036.855,56 -/ton with 4200 – 4300 kkal. And Coal with the similar kkal are cheaper. The price is Rp. 880.000,-/ton -.

The price of those fuel of course effected by the transportation from the resource to the power plant. The coal and PKS are the using the similar handling system.

V. RESEARCH METHOD

V.1 Types of Research

Research in this study are experiment research. The comparison data from un existed variable data that need to be taken by processing special treatment to the subject and then the data result are calculated for the research impact. Between full coal and mixed with palm kernel shell in different ratio with certain parameters such as the emission based on the regulation, energy produced in hour per volume used by single fuel or mixed fuel between coal and palm kernel shell for different ratio and the fuel price between coal and palm kernel shell.

V.2 Location of Research

Location for this research is located at Babelan Coal-fired Power Plant in North Bekasi. The palm kernel shell are taken from Palm Oil Plantation in Sumatra and the coal are taken from Batu Licin, South Kalimantan.

V.3 Procedures of Research

The procedure of research are taken step by step in sequence. Procedures in this research are :

1. Collecting literature data
2. Collecting data of coal
3. Collecting data of palm kernel shell
4. Collecting data of existing coal parameter
5. Mixing ratio between coal and palm kernel shell
6. Testing the mixing ratio
7. Collecting data from the test (taken from DCS)
8. Analyzing data

V.4 Analyzing Data

Analyzing data are crucial step in research. Because from this step define the result of the study itself. The analyzing data using step as follow :

1. Energy input boiler
2. Fuel flow
3. Specific fuel consumption
4. Coal fuel consumption
5. PKS fuel consumption
6. Price fuel for 1 Megawatt

VI. CONCLUSION

The used of palm kernel shell in study are only for reducing the use of existing fossil fuel and not increasing the capacity of the power plant and how it effecting the cost and the emission.

This study still does not need modification in the existing system. Whether the fuel handling or the boiler itself. For further information about the most efficient ratio between coal and PKS should be in further researches.

The emission from the used of palm kernel shell mixed with coal based on the data reading are not effecting the emission. However, the power plant in Babelan are using ESP that significantly reducing the fly ash.

The Specific Fuel Consumption between fully coal, 6% mixed PKS and 10% mixed PKS with the fuel price are increasing. The trial with 10% of mixed PKS from total 100% coal 0,588 T/MWh to 0,589 T/MWh (0,247%) and the fuel price are decreasing from Rp. 103.685.556,- to Rp. 102.117.000,400- (1,513%).

The higher use of mixed PKS with coal, the price is lower and the Specific Fuel Consumption are higher, this is good thing from an economic perspective.

VI.2 Suggestion

Concern in different purchasing price between coal and biomass will be bring challenge for how to measure the output ratio of the coal and biomass. This will need third parties or the specialized institution to validate the output.

The transportation cost is also effecting the total

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fuel price if the PKS or the coal are in significant different resources.

Need a good accuracy to do the calibration of the sensor to collect the accurate data, since the fuel are changing from the original design.

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Specific Fuel Consumption (T/MWh)

$$Energy\ input\ boiler = \frac{Boiler\ steam\ load}{(Fuel\ efficiency/100)} * 860 \qquad Fuel\ flow = \frac{Energy\ input\ boiler}{Fuel\ calorie} \qquad Specific\ fuel\ consumption = \frac{Fuel\ flow}{Active\ power}$$

Kurs

		Fuel efficiency	Boiler Steam Load	Energy Input Boiler	Fuel Calorie	Fuel Flow	Active Power	Specific Fuel Consumption	Percentage PKS	Coal Fuel Consumption	Price Fuel Megawatt
		%	MW	Mkal	kcal/kg	T/hr	MW	T/MWh	%	T	Rp/MWh
21-Jun-19	Average:	85,756	343,990	344.968,377	4.200	82,135	139,725	0,588	-	58,78	103.685.556,00
	Total:	10.462,250	41.966,795	42.086.142,055	4.200	10.020,510	17.046,391	71,717	-	7.171,66	12.649.637.832,00
	Max:	85,805	344,788	345.922,303	4.200	82,362	140,729	0,591	-	59,07	103.685.556,00
	Min:	85,665	343,734	344.531,229	4.200	82,031	139,015	0,585	-	58,48	103.685.556,00
16-Aug-19	Average:	85,817	343,467	344.200,916	4.200	81,953	139,313	0,588	6,00	55,30	102.744.422,64
	Total:	10.298,020	41.216,000	41.992.511,801	4.200	9.998,217	16.717,510	71,769	6,00	6.746,30	12.534.819.562,08
	Max:	85,901	343,675	344.586,562	4.200	82,044	140,650	0,593	6,00	55,78	102.744.422,64
	Min:	85,756	343,028	343.496,420	4.200	81,785	138,126	0,582	6,00	54,75	102.744.422,64
17-Aug-19	Average:	85,767	343,497	344.425,165	4.200	82,006	139,159	0,589	10,00	53,04	102.117.000,40
	Total:	10.292,060	41.219,630	42.019.870,073	4.200	10.004,731	16.977,432	71,894	10,00	6.470,49	12.458.274.048,80
	Max:	85,899	344,751	345.734,963	4.200	82,318	140,098	0,592	10,00	53,31	102.117.000,40
	Min:	85,693	342,130	343.071,690	4.200	81,684	138,236	0,586	10,00	52,75	102.117.000,40

14268 Coal Price Augustus $/T

72,67 PKS Price Augustus Rp/kg

880