Improving Energy Efficiency at PT. PJB UP Gresik Power Plant by Converting Fuel Oil to Gas in Combustion System

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***Abstract*— In PT Pembangkitan Jawa Bali Unit Pembangkitan Gresik (PT PJB UP Gresik) retrofitting of fuel oil to gas in combustion system was performed. The retrofitting was performed to obtain energy efficiency and related benefit due to these efforts. Some modification and new installations were constructed to obtain the aims. This paper describes the methods of converting fuel oil to gas in the combustion system and the benefit to energy efficiency, production cost reduction and saving as the results of this effort. From technical and economic points of view, the retrofitting provide fuel saving about 883.9 tone fuel per year or Rp. 6.35 Trillion annually.**

***Index Terms*—Retrofit, Energy efficiency, Economic saving, Fuel oil.**

I. Introduction

The global energy demand is predicted to grow at a rate of 1.5% annually up to 2030 [1]. Fuel efficiency and environmental regulations are the key issue in the power plants. Steam power plant will be remain used as efficient system in converting liquid or gaseous fuels into electric power in the near future [2].

In order to maximize power plant fuel efficiency, retrofitting of existing fuel oil into gas operation are increasingly being looked into, in the steam power plants. There are many reasons that it makes sense. There are can be vary from emphasizing the green company image, regulation conforming and economic considerations. In the most cases, the main key driver for converting to gas is the significant fuel efficiency issue, beside the availability of gas and emission reductions [3],

This paper will describes the effort of PT. PJB UP Gresik as the owner of steam power plant in reducing the fuel oil consumption, increase plant efficiency and finally reduce the production cost, by converting fuel oil to gas in the existing steam power plant fuel system.

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II. Theory

A. Heating Value

The fuel heating value is an amount of produced heat, when the complete combustion of a unit quantity of fuel are cooled to the initial temperature (298 K) of the air and fuel. Since the heating value of fuel increases, the delivered heat content to the burner increases. The heat of combustion of a fuel is also called its potential heat.

If a fuel is burned in oxygen saturated with water vapor, the quantity of heat released is known as the high heating value (HHV) or gross calorific value (GCV) of fuel. When the latent heat of water vapor contained in the combustion fuels is subtracted from the HHV, It obtains the low heating value (LHV) or net calorific value (NCV) of fuel. In the laboratories, the HHVs of solid and liquid fuels are determined at constant volume [4].

B. Heat and Mass Balance in Thermal Equipment

The cold fluid flowing through the thermal fluid is heated by the hot streams from the fuel or waste heat stream and the amount of heat received by the cold fluid, Q_c, is given by

$$Q_c = m_c C_{p,c}\left(T_{c,o} - T_{c,i}\right) \quad (1)$$

where m_c is mass flow rate of the cold fluid, $C_{p,c}$ is specific heat of the cold fluid, $T_{c,i}$ is inlet temperature of the cold fluid, $T_{c,o}$ is outlet temperature of the cold fluid.

The amount of heat released by the hot fluid, Q_h, is given by

$$Q_h = m_h C_{p,h}\left(T_{h,i} - T_{h,o}\right) \quad (2)$$

where m_h is mass flow rate of the hot fluid, $C_{p,h}$ is specific heat of the hot fluid, $T_{h,i}$ is inlet temperature of the hot fluid, $T_{h,o}$ is outlet temperature of the hot fluid.

Under the assumption that there is no heat loss to the surroundings, the heat lost by the hot fluid stream shall be equal to the heat gained by the cold fluid stream, thus

$$Q_c = Q_h \quad (3)$$

The amount of heat transferred from the hot fluid to the cold fluid, Q, across the heat exchanger surface would be equal to Q_c and Q_h and is given by [5]

$$Q = U \bullet A \bullet F \bullet LMTD \quad (4)$$

where U is overall heat transfer coefficient, A is heat transfer surface area, *LMTD* is Log Mean Temperature Difference, F is *LMTD* correction factor [6]

III. Method

In order to convert the fuel gas and oil in combustion system, some plant modifications and new installation were performed as follows;

1. Replace 6 conventional burner with Radially Stratified Flame Core (RSFC) burner
2. Modify valves and piping system
3. Install burner management system
4. Install gas receiving and measuring system
5. Replace Force Draft Fan (FDF)
6. Modify fire protection system
7. Modify Automatic Boiler Control (ABC) and Automatic Burner System (ABS)
8. Modify heat transfer area (A) in economizer, superheater and preheater

IV. Result and Discussion

The plant design was performed using commercial software based on mass and energy balances. Piping, valves, instruments, control and equipment were design, fabricated and install properly [7]. Modification of equipment heat transfer area is tabulated in Table 1.

Table 1 Equipments heat transfer area before and after retrofit.

Equipment	Heat transfer area	
	Before retrofit (m^2)	After retrofit (m^2)
Economizer surface	2210	1474
Primary super heater surface	1680	2980
Secondary superheater surface	1050	1310
Final superheater surface	820	1277
Reheater surface	6200	7292

The plant piping and instrumentation diagram after retrofit is shown in Figure 1. Some modifications and new installations were performed to assure mass and energy balances and control ability of the plant. The typical plant monitoring and control system for this purpose is shown in Figure 2

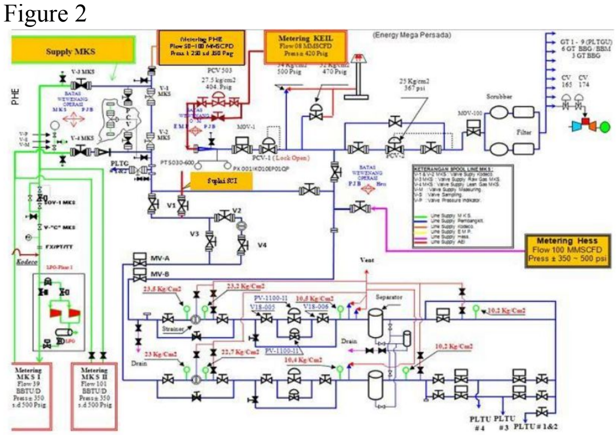

Figure.1. Plant's piping and instrumentation diagram after retrofit

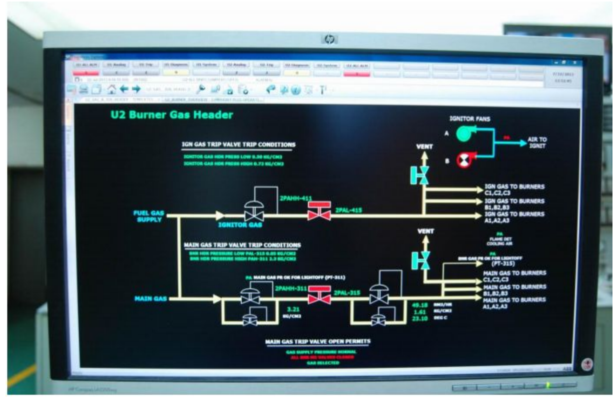

Figure 2. The typical plant monitoring and control system

Figure 3. Plant piping and instrumentations after retrofit

After commissioning, the monitoring system have been recording the performances of the plant. The efficiency improvement is indicated using Net Plant Heat Rate (NPHR). The value of NPHR before and after retrofit exhibit decreasing trend. It shown the utilization of fuel gas (BBG) resulted the increasing energy efficiency in the power plant, and it is shown in Figure 4.

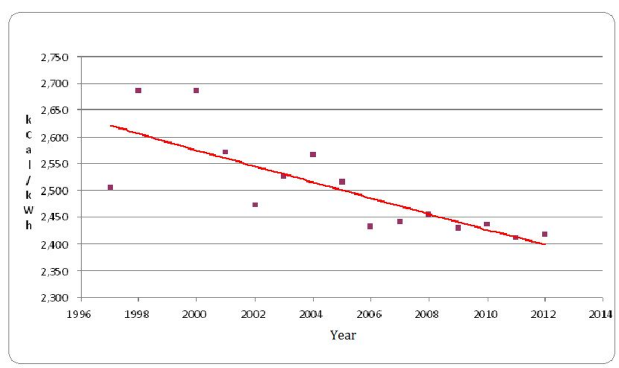

Figure 4. Value of NPHR before and after retrofit over the time

Figure 5 shows the electric productivity increases from year 2000 up to 2012 due to retrofitting the plant. Plant retrofitting increase efficiency or in another word increase selling point due to production cost reduction. Increase in selling point will increase the amount of electricity selling from this plant as shown in Figure 6.

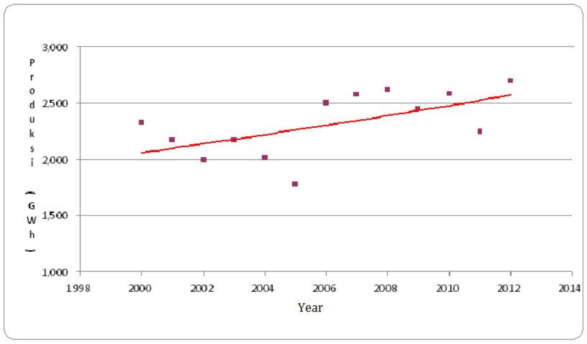

Figure 5. The annual electric productivity increase

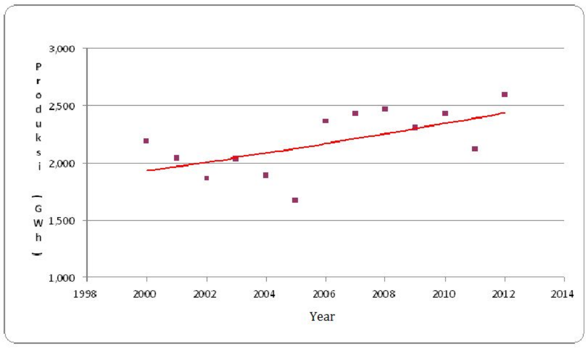

Figure 6. Annual electricity selling increase

From the results, it can be concluded that the retrofitting of combustion plant from fuel oil to fuel gas reduced the production cost or NPHR, Hence, it increases the selling point of produced electricity of this plant to National Power Company (PLN), and finally increase the company profit (PT. PJB UP Gresik).

In detail, the production cost reduction due to retrofit in combustion plant for each units are described as follows:

- Cost production for units 1 and 2 before retrofit (BBM) is Rp. 1.756,84 / kWh, and after retrofit (BBG), it reduced up to Rp. 479,88 / kWh.
- The National Power Company (PLN) fit in tariff (TTL) R1/TR 1300 VA class is Rp.833/kWh.

The graphical illustration for production cost using fuel oil (BBM), fuel gas (BBG) and the selling price of electricity can be shown in Figure 7

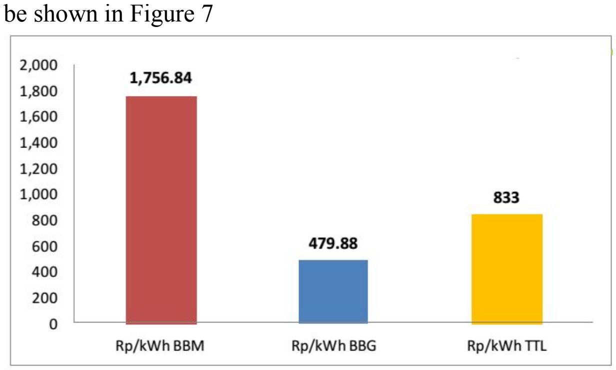

Figure 7. Graphical illustration for production cost and selling price of electricity

Figure 7 also clearly described that the retrofit not only reduces the subsidy, moreover it become profit generator to the company and this country. This effort resulted huge energy reduction in fuel consumption up to 883,9 tone per year or saving about Rp. 6,35 Trillion per year. It evident is shown in Figure 8.

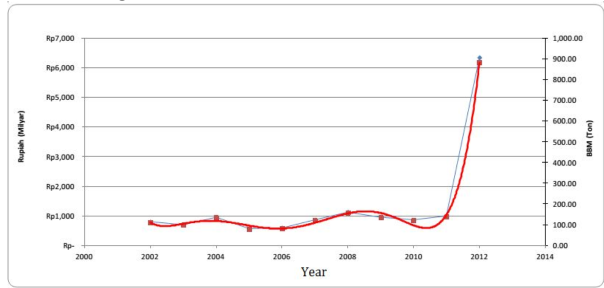

Figure 8. Energy reduction in fuel consumption and saving

V. CONCLUSIONS

The retrofiting of combustion system by convertting the fuel oil to gas was successfully performed. The results of this effort can reduce electricity production cost, no subsidy required, increase profit and productivity. This effort resulted huge energy reduction in fuel consumption up to 883,9 tone per year or saving about Rp. 6,35 Trillion per year.

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