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Article Review

Comparative Reaction of Substitution of Diesel-fueled Steam Power Plant and Coal-fueled Steam Power Plant

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Abstract

The global crude oil price has begun to rise once more lately, nearing the level of US$ 90, which has significantly raised the operational expenses of diesel-powered power plants. Considering that the fuel expenses for power plants account for 60% to 80% (varying by the kind of power plant) of their operating costs. For this purpose, it is essential to replace diesel-powered plants with coal-powered plants as quickly as possible. This is due to the substantial coal energy reserves in Indonesia, which ensures a consistent coal supply to fulfill fuel requirements throughout the operational period of the PLTU (30 years). The global price of coal is significantly lower than that of diesel fuel, making coal-fired power stations an excellent substitute for diesel-powered plants. Despite the higher investment and operating expenses of coal-fired power plants compared to oil-fired ones, when accounting for fuel as the main cost, the overall expense of coal-fired power plants remains significantly lower than that of oil-fired power plants

Keywords: *Comparative, Diesel-fueled Steam Power Plant, Coal-fueled Steam Power Plant*

INTRODUCTION

The world price of crude oil has started to soar again recently, approaching the range of US$ 90, resulting in a drastic increase in the operating costs of diesel-fueled power plants. Given that the portion of fuel costs for power plants is between 60% and 80% (depending on the type of power plant) of operating costs, the increase in the price of crude oil, which has resulted in an increase in the price of fuel oil (BBM), has resulted in the production costs of power plants swelling. The increase in operating costs is no longer covered by the current electricity tariffs, in other words, the cost of electricity production is higher than the selling price (Yati et al., 2024) and (Suratno et al., 2018). To solve this problem, the actions that can be taken to help, if not to say save, national electricity are: 1) Increasing the basic electricity tariff, 2) Increasing electricity subsidies by the Government, 3) Finding other cheap energy alternatives.

Alternative b will also be very difficult to implement, because the government does not have enough money to provide subsidies, considering that the current government budget is mostly used to pay Indonesia's debt installment obligations. Alternative c is the most feasible to implement, considering that Indonesia still has other energy besides oil that can be utilized, such as coal, gas, water, geothermal, solar and others.

In the construction of power plants, there are several aspects that must be taken into account such as the continuity of energy supply, international energy price trends (given that national energy policies refer to international prices), technology that has been mastered and the feasibility of investment and operating costs. Given the large supply of coal and the long mastery of technology, coal-fired power plants are the most attractive alternative to replace oil-fired power plants. Furthermore, this article will compare the costs of using coal and oil fuels in power plants.

Most of the BBM in Indonesia is used as fuel for transportation, power plants, and industry. The utilization of calories produced in combustion engines with available technology, only reaches a maximum of 35%. More than half of Indonesia's petroleum reserves are located in central Sumatra, namely the oil fields in Riau (Duri, Minas, Zamrud). Other areas that are quite fat with petroleum reserves are southern Sumatra, especially South Sumatra, northern West Java and East Kalimantan.

Likewise, the world's large reserves of coal ensure that in the next era when oil reserves are depleted, coal energy sources will be crucial. Economic growth in the industrial world over the past three decades has been based on oil and gas, so infrastructure and environmental standards are heavily influenced by the technology available for these fuels. Coal substitution requires technology to adapt it to existing infrastructure. The development of technology to adapt coal to oil fuel infrastructure has grown rapidly today, even on a commercial scale. With large reserves of coal in the future, it will play a greater role, as a result, the availability of coal in the market will be more secure. However, it is necessary to pay attention to the possibility of increasing coal prices, considering that market demand will also increase.

LITERATURE REVIEW

In the interconnected electrical system, usually using a generator with a large capacity, because it is more efficient. While for the basic load, a Steam Power Plant is usually used. Steam turbines are a type of rotary engine, which is usually more reliable than reciprocating engines, such as diesel engines. In addition, steam turbines are also more efficient than gas turbines. So in this discussion the comparison made is for Steam Power Plants and is limited only to the costs required to generate electrical energy at the generator output.

Meanwhile, the aspects that need to be considered in calculating the cost of generating electricity are as follows: 1) Availability of sufficient energy sources, 2) Capital return costs, 3) Operating and maintenance costs, 4) Fuel prices. To make a comparison of energy usage, as described in the background of the problem, it is necessary to understand the generating system required for each type of fuel, so that the investment and operating costs that will arise can be estimated (Budiningtyas & Hutabarat, 2024). By understanding the power generation system and the price trends of fuel oil and coal, it is hoped that a complete picture will be obtained in determining the most economical fuel choice for power generation, so as to reduce the cost of producing electricity.

RESEARCH METHOD

The approach taken in this study involves gathering information from existing literature, sourced from libraries as well as the internet. Option a is challenging to execute as it will lead to increased inflation and a drop in investment competitiveness, resulting in diminished purchasing power for individuals and reduced interest from investors in allocating their funds. Furthermore, it is highly possible that current investors will relocate their capital to other, more favorable environments.

RESULTS AND DISCUSSION

RESULT

The Indonesian people have known, produced and utilized petroleum since the colonial era. The increase in the use of BBM (Fuel Oil) in the country has continued to increase not only as fuel but also for industrial needs as raw materials. Petroleum exploration and production activities have been carried out on a large scale since 30 years ago. As a result, the number of proven reserves has increased from around two billion barrels (1970) to five billion barrels (1980s). Even until the 1990s - now, new reserves are still being discovered.

Indonesia's petroleum production in the late 1970s reached 600 million barrels per year. But in the last 10 years, around 565 million barrels per year. Decreasing due to security instability in several regions. Looking at the development of production volume over the last 30 years and also the availability of existing reserves, it seems that Indonesia's oil production has reached its maximum capacity. It even tends to decline in the coming years. In fact, the demand for fuel will continue to increase. If production can be maintained at 550 million barrels per year, and demand for domestic refinery products grows by 5% per year, then it can be estimated that in the next 10 years Indonesia will become a net oil importer, which is a time when oil can no longer be expected as a source of state income. There are two ways to postpone that period, first, increasing oil exploration and production activities and second, reducing the rate of domestic fuel consumption.

History of Coal as an Energy Source.

In the mid-20th century, coal was the world's dominant energy source. However, because the prospects for providing energy from oil and nuclear are quite promising, a shift in energy sources from coal is inevitable. But starting around the 1970s, there was a fairly dramatic change in attitude, due to rising oil prices and rejection of plans to utilize nuclear energy. This has led to a shift in the general perception that coal can once again make a long-term contribution to the energy sector. At the same time, there has been a renewed interest in coal technology, particularly in how it can be used more efficiently, more environmentally friendly and with greater capacity than ever before.

Coal is the remains of prehistoric plants that have changed shape and originally accumulated in swamps and peatlands. Coal is a fossil fuel and can burn. Coal is formed from sediment, organic material that is mainly composed of carbon, hydrogen and oxygen. Coal is formed from plants that have been consolidated between other rock strata and changed by a combination of pressure and heat over millions of years to form coal seams. The accumulation of silt and other sediments, together with shifts in the earth's crust (known as tectonic shifts) buried swamps and peat often to very great depths. With this accumulation, the plant material was exposed to high temperatures and pressures. The high temperatures and pressures caused the plants to undergo physical and chemical changes and turned the plants into peat and then coal.

The formation of coal began in the Carboniferous Period (Carboniferous or Coal Formation Period) - known as the first coal age which lasted between 360 million and 290 million years ago. The quality of each coal deposit is determined by temperature and pressure and the length of time of formation, which is called 'organic maturity'.

The initial process of peat turning into lignite or 'brown coal' – This is a type of coal with low organic maturity. Compared to other types of coal, lignite is relatively soft and its color varies from jet black to brownish. Under the influence of temperature and pressure continuously for millions of years, lignite undergoes changes that gradually increase its organic maturity and turn lignite into 'sub-bituminous' coal. Chemical and physical changes continue until the coal becomes harder and blacker in color and forms 'bituminous' or 'anthracite'. Under the right conditions, the increase in organic maturity continues until it forms anthracite. The coalification or carbonization process occurs in 2 stages: 1) Biochemical (diagenetic), 2) Geochemical (Metamorphosis)

Coal that is directly taken from underground, called run-of-mine (ROM) coal, often contains undesirable admixtures such as rocks and mud and is in the form of fragments of various sizes. However, coal users require coal with consistent quality. Coal processing - also called coal benification or "coal washing" refers to the handling of mined coal (ROM Coal) to ensure consistent quality and suitability to the needs of specific end users. The processing depends on the coal content and its intended use. The coal may only require simple crushing or may require complex processing to reduce the admixture content.

To remove admixtures, raw run-of-mine coal is crushed and then separated into fractions of various sizes. Larger fractions are usually processed using the 'solids media separation' method. In such a process, the coal is separated from the other components by floating it in a tank containing a liquid of a certain gravity, usually a material in the form of fine-ground magnetite. Once the coal is lightened, it floats and can be separated, while the heavier rocks and other components sink and are discarded as waste. The smaller fractions are processed by a number of methods, usually based on differences in density, such as in a centrifuge. A centrifuge is a machine that spins a container very quickly, separating the solids and liquids in the container. An alternative method uses different surface properties of the coal and waste. In 'foam flotation', the coal particles are separated in a froth produced by air blown into a water bath containing chemical reagents. The froth attracts the coal but not the waste and is then discarded to obtain fine coal. Recent technological advances have helped to improve the yield of very fine coal material.

The method of transporting coal to where it will be used depends on the distance. For short distances, coal is generally transported by conveyor belt or truck. For longer distances within the domestic market, coal is transported by rail or barge or alternatively by mixing the coal with water to form a slurry and transported through a pipeline. Ships are generally used for international transport in sizes ranging from Handymax (40-60,000 DWT), Panamax (about 60-80,000 DWT)

Most steam power plants in Indonesia use the pulverized coal firing method. Because it uses large, efficient and reliable construction. The idea of coal refining is based on the fact that if the coal is made fine enough it will burn easily and efficiently like gas. To burn coal, which has been refined, in a furnace two requirements are required, namely, (1) The number of fine coal particles, to ensure good initial combustion, the ratio of the coal surface area to volume must be considered. (2) The presence of a minimum number of fine particles to ensure high combustion efficiency, usually with a size of 50 mesh, because too many coarse particles will cause crusting and reduce combustion efficiency.

Typical sizes for pulverized coal, about 80% of coal passes a 200 mesh screen (about 0.074 mm) and about 99.99% passes a 50 mesh screen (0.297 mm), which is only 0.1% larger than 0.297 mm. Coal is usually sent to the power plant in size according to the refiner specifications. If the coal size is larger, it must be reduced by a crusher, which is part of the coal conveying system and is usually placed in the crusher house at the best point of the conveying system.

As a mining material, coal contains three components, namely water content (moisture), mineral matter (mineral matter) and dry, mineral-matter-free coal. The water content in coal is termed free water content, which can be removed by drying in air. The remainder is inherent water content; the amount of which varies with the type of coal, but is generally less than 10%.

Mineral matter in coal is of two kinds. Minerals in the form of discrete particles (for example, boundary layers or intermediate "dirt bands") and can mostly be removed by ordinary washing techniques.

In addition, coal also contains inherent mineral matter which is very fine (particle size is usually smaller than 0.1 mm) and is spread throughout the coal substance, so that removal by washing is only possible to a limited extent. The type and properties of these minerals depend on the location and mining method. The content of inherent mineral matter is usually less than 10%, although some can reach 30%. Dry, mineral-matter-free coal is a term for pure organic coal substance. Dry, mineral-matter-free coal contains mainly the elements carbon, hydrogen, oxygen, nitrogen and sulfur.

The thermodynamic cycle of a steam turbine is the Rankine cycle. In this cycle, water is pumped so that it is under high pressure, then heated to a temperature above its boiling point. Furthermore, this high-pressure steam is "expanded" in a multi-stage turbine into low-pressure steam and cooled in a condenser under vacuum conditions.

The area to the left is the subcooled liquid region. The curve line to the right of the critical point is the loci of the saturated vapor point and the saturated vapor line. The area to the right of this line is the superheated region. The area below the cube represents the two-phase mixture region (Liquid – Vapor), sometimes also called the wet region.

Cycle 1 – 2 – 3 – 4 – B – 1 is a saturated Rankine cycle, where saturated vapor enters the turbine. Cycle 1` - 2` - 3 – 4 – B - 1` is a superheated Rankine cycle, where superheated vapor enters the turbine. This cycle will become reversible after undergoing the following processes: 1 – 2 or 1` - 2`: Reversible adiabatic expansion through the turbine. The vapor that exits at 2 or 2` is usually in the two-phase region. 2 – 3 or 2`-3 : Constant temperature and, being a two-phase mixture process, heat rejection at constant temperature in the condenser.

3 – 4 : Reversible adiabatic compression by the pump of saturated liquid at condenser pressure, 3, to subcooled liquid at steam generator pressure, 4. Line 3 – 4 is vertical on both the P – V and T – S diagrams because the liquid is essentially incompressible and the pump is reversibly adiabatic.

The main differences between diesel and coal-fired PLTUs are in the size of the boiler, the fuel feed system, handling of combustion ash and the area of land required. Coal-fired boilers are larger than oil-fired boilers. This is because the time to achieve perfect combustion of coal takes longer, so the surface area of heat transfer in the boiler must be larger.

Coal cannot be burned directly in the boiler, it must be ground first, this grounding equipment is usually called a Pulverizer. After that, the ground coal is filtered, so that only coal with a certain grain size is blown into the boiler. In addition, coal storage requires a large area and requires a transportation system (coal handling) from the storage area to the Pulverizer, which usually uses a belt conveyor. The amount of coal combustion ash contained in the exhaust gas is quite large, to capture the coal ash requires its own equipment, and usually uses a Precipitator. In addition, because the amount is quite large, separate land and coal ash handling methods are required, so it needs to be calculated as an additional operating cost.

In estimating the cost of generating electricity, there are several aspects that need to be studied, namely: 1) Capital Recovery Cost, 2) Operational Fixed Cost, 3) Operational Variable Cost, 4) Fuel usage cost

To get a complete picture of the total costs required, these things need to be considered. Furthermore, the cost of generating electricity is usually written in the form of Rp / kWh, considering that the sale of electricity to customers is based on kWh., making it easier to compare the Cost of Production with the Cost of Sales.

Basically, the return on investment cost depends on the amount of investment to be invested and the estimated economic life of the PLTU. As explained above, that the Coal PLTU requires some additional equipment, a larger boiler and a larger land requirement compared to the Oil PLTU. So it is understandable that the investment cost of the Coal PLTU will be greater than the operating cost of the Oil PLTU.

The estimated investment cost for the Coal PLTU is usually around $US 1,000 / kW, while for the Oil PLTU it is around $US 700 / kW. While the economic life of the Coal and Oil PLTUs is usually estimated to be the same, namely for 30 years. Assuming the exchange rate of Rp to $ US is Rp 9000 / $ US and an interest rate of 8% / year, the return cost and the presentation of equity to debt of 30%, the investment in the Coal PLTU is Rp 224 / kWh. While for the Solar OIL PLTU it is Rp 157 / kWh

Fixed operating costs are employee costs and overhead. As previously explained, coal-fired power plants require more additional equipment such as coal handling and coal ash waste, thus requiring higher employee costs. In addition, with a larger land area and number of employees, the overhead costs of coal-fired power plants will increase. The estimated overhead costs for coal-fired power plants and oil-fired power plants, based on experience at PLN, are around Rp. 40 / kWh and Rp. 30 / kWh.

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Variable costs are costs that arise in proportion to the amount of electrical energy production. The components of variable costs are maintenance costs and lubricant costs. Given that the coal-fired power plant system is more complex and larger than the oil-fired power plant, the maintenance costs of coal-fired power plants are higher. The variable operating costs of coal-fired power plants are estimated at around Rp. 8 / kWh, while for diesel-fueled power plants it is estimated at Rp. 6 / kWh.

The heat rate of the power plant is generally around 30%. The calorific value of coal used for the planned construction of PLTU in Indonesia in the future is generally the calorific value of coal used is around 4500 kcal/kg. While the calorific value of diesel oil is around 9253 kcal/lt. To generate one kWh of electrical energy, 0.505 kg of coal or 0.309 liters of diesel oil are needed. The price of coal with a calorific value of 4500 kcal/kg is currently around Rp. 350/kg while the price of diesel oil is currently around Rp. 5450/lt. This price includes transportation costs of Rp. 100/lt. So the fuel cost per kWh with coal is Rp. 222.22/kWh. The cost per kWh with diesel fuel is Rp. 1,682.85/kWh.

CONCLUSION

This research determined that: 1) Indonesia has substantial coal energy reserves, ensuring that coal supply stability can be maintained to fulfill fuel requirements throughout the operational lifespan of the PLTU (30 years). The global cost of coal is significantly lower than that of diesel oil, making coal-fired power plants an excellent option to substitute diesel oil PLTUs. 3) Even though the investment and operating expenses of coal-fired energy plants are higher than those of oil-fired plants, taking into account that the main expense is fuel, the overall cost of coal-fired power plants remains significantly lower than that of oil-fired plants

REFERENCES

Merrick, David. 1984. *Coal Combustion and Conversion Technology.* Macmilan Publisher Ltd. Hongkong.

El – Wakil, M.M. 1984. *Powerplant Technology.* McGraw-Hill Book Company. United States.

Yusgiantoro, Purnomo. 2000. Ekonomi Energi Teori dan Praktik. Pustaka LP3ES.Jakarta.

Budiningtyas, D. P., & Hutabarat, Z. S. (2024). Model Intellectual Capital Sebagai Variabel Moderating Ditinjau Dari Likuiditas, Leverage, dan Profitabilitas Pengaruhnya Terhadap Nilai Perusahaan. *Owner*, *8*(1), 885–892. https://doi.org/10.33395/owner.v8i1.2104

Suratno, M., Saputra Hutabarat, Z., & Sari, N. (2018). *The Development of Instructional Medium Based on E-learning in Taxation Subject at Economic Education Department, Jambi University*. *147*(Icsse 2017), 299–304. https://doi.org/10.2991/icsse-17.2018.67

Yati, Siswanto, R., Sumiyati, S., Munir, S., Kadarisma, Sucipto, Jaya, F., Saputra, Z., & Hutabarat. (2024). Dinamika Pencegahan Dan Resolusi Kekerasan Di Ruang Kelas:

Menggagas Paradigma Baru Dalam Manajemen Pendidikan. *Jurnal Review Pendidikan Dan Pengajaran*, *7*(1), 1389–1396.