



Economic Age of Boilers of Oil Palms (*Elais*) Factory of North Sumatra, Indonesia

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Abstract

Maintenance management of machinery in factory depends on the calculation of their economic usage. The purpose of this study was to determine the economic life of boilers in the Government Plantation Enterprises (PTPN II) North Sumatra Province. As a consideration for the replacement of boiler engines in the Government Plantation Enterprises (PTPN II) Tanjung Garbus Pagar Merbau, the research for determining the economic age was carried out. The engineering and forecasting economics average annual cost and cost forecasting for the next few years were conducted. In the Government Plantation Enterprises (PTPN II) for *Elais* (oil palms) Tanjung Garbus Pagar Merbau had been found a problem such. There is no determination to calculate the economic life of machine. This calculation is focused on the boiler engine. The data show that the average annual cost, the most economical life of the boiler is around 10 years, i.e. in 2005, where the minimum annual cost of boiler is the minimum of IDR. 984.805.587. This average annual cost is obtained after forecasting costs, i.e. operating costs and down time costs calculation of capital recovery. With the knowledge of the boiler's economic life, it is better for the company to consider replacing the boiler.

Key words: Economic age; boilers; forecasting; cost.

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1. Introduction

The machinery and equipment that is used have the ability to produce, but economically a machine and equipment is not always profitable to be used during its operation. The increasing age of machines and equipment, the costs incurred increase. This is because the declining condition of machinery and equipment needs to be investigated, so the total cost of production can be suppressed. The company may have limited space or because of the company's own circumstances so that the company does not calculate the economic life of its equipment but it does not mean that the company does not find any way to achieve its economic life.

The machine chosen in this study is Boiler engine owned by the Government Plantation Enterprises (PTPN II) OIL Palms in Tanjung Garbus Pagar Merbau of North Sumatra. The choice of boiler machine as a research because the age of boiler machine belonging to that company which is old, where boiler machine used from 1995 until now; so that boiler machine worth to be examined. The Boiler Engine serves as an energy conversion plane that converts chemical energy (potential) from fuel to thermal energy. Operating a Boiler requires a cost, which costs tend to rise and decrease according Boiler usage. In this case the cost that tends to rise each year is the cost of maintenance and fuel, while the cost decreases every year is a payback fund. Each maintenance and fuel cost is searched for its equivalent function using forecasting method and then summed to obtain the average annual average cost equation function as a function of the economic life of the least annual total cost.

The purpose of this determination of the economic life of this Boiler is to create a profitable Boiler replacement schedule for the company from the analysis by using the method of minimizing the average annual cost mathematical model to obtain the conclusions of Boiler's economic life so that the company can consider the replacement of the Boiler.

With regard to the background of existing problems, then the main problem is to determine how much the average annual cost of Boiler engine so it is known the economic age of the Boiler engine in the Government Plantation Enterprises (PTPN II) in Tanjung Garbus Pagar Merbau of North Sumatra.

2. Review of Literature

2.1. Boiler

In the process of oil palm processing, it occurs several stages of the process that requires energy needs. The greater the production capacity, the higher the additional energy required in the production process. Likewise, this energy demand is increasing in line with the increase of palm oil production. The Palm Oil Factory fulfills its energy needs independently using solid waste in the form of fiber and shells for Boiler fuel. Boiler is steam-producing installations used to drive Steam turbines as power in palm oil mills. Can be said Steam turbine is used to generate electrical power. In addition, the steam from the Boiler is used for boiling (sterilizer) and heating in the processing unit.

According to Muin [1], boiler is a heat engine (thermal engineering) that transfers chemical energy or automated energy into work (effort). Boiler is a tool to produce steam, which consists of two important parts: the kitchen heating, generating heat obtained from fuel combustion and boiler proper, a tool that converts water into steam

[2]. The boiler is a closed vessel in which the combustion heat is flowed into the water until a hot water (steam) of about 2500-3000°F is formed [3]. The boiler is a closed vessel where the combustion heat is flowed into water until hot or steam water is formed [4]. Hot water or steam at a certain pressure is then used to drain heat to a process. Water is a useful and inexpensive medium for delivering heat to a process. If the water is boiled down to steam, the volume will increase by about 1,600 times, producing a power that resembles an explosive gunpowder, so the boiler is a device that must be managed and maintained very well. Boiler basically consists of a drum that is closed at the end and base, where on the inside of the drum there are pipes that serve to drain water or hot gas.

Based on the fluid flowing in the pipe, the boiler is classified into:

- a. Fire tube boiler, this type of boiler on the tube flows with combustion gases and other parts that sell water flowed to be evaporated. The tubes are instantly cooled by the water that protects them. The pass number of the boiler depends on the amount of the horizontal passage of the combustion gas between the furnace and the fire pipe. The combustion gas on the furnace is calculated as the first pass. This type of boilers is widely used for processing industries ranging from small to medium scale [5].
- b. Water tube boiler is widely used for large-scale steam needs. The working principle of the water pipe boiler is contrary to the fire pipe, the combustion gas from the furnace is passed to the pipes containing the water to be evaporated [5].

2.2. Palm oil

Palm oil is one of the most important plantation crops in the agricultural sector, and the plantation sector in particular. This is because of the many plants that produce oil or fat, oil palm that produces the largest economic value per hectare in the world [6].

Oil palm cultivated consists of two types: *E. guineensis* and *E. oleifera*. The first type of the widest cultivated person from both these species of oil palm has their respective advantages. *E. guineensis* has a very high production and *E. oleifera* has a low plant height. Many people are crossing these two species to get a species that is high in production and easy to harvest. *E. oleifera* is now beginning to be cultivated as well to add to the diversity of genetic resources.

According to Setyohadi palm oil superiority as a food is as an anti-cancer and tekoferun as a source of vitamin E, which includes anti-oxidant substances. Another advantage of linoleic acid content is low so that cooking oil made from coconut fruit has stability [7].

The type of oil palm based on the thickness of its shell, which consists of: Dura, Pisifera, Tenera. Dura is a palm whose fruit has a thick shell that is considered to shorten the life of processing machines but usually large fruit bunches and oil content per cluster ranges from 18%. Pisifera fruit does not have a shell, so it does not have a core (kernel) that produces economical oil and sterile females so very rarely produce fruit. Tenera is a cross between the parents of Dura and the male Pisifera. This species is regarded as a superior seed because it

complements the deficiencies of each parent with the nature of thin fruit shells but females remain fertile. Some superior Tenera have a percentage of meat per fruit reaching 90% and the oil content per bunch can reach 28%. Based on the color of the palm fruit is divided into 2 types, among others: 1.

Characteristics Type Higrascens - Characteristics: Raw raw fruit (purple) to green at the end, while pale slightly pale after baked turns into reddish yellow. 2. Character Type Virescens: Raw fruit is green after cooked into reddish orange but the tip is still greenish. The process of oil formation in the fruit lasts for 24 days, ie when the fruit starts cooking. Harvesting done before the oil formation process is complete will produce less oil, while the harvest after the oil formation process is completed will be detrimental because many fruits are loose and fall to the ground.

Fruit that is too much of some oil content will turn into free fatty acid that produces low quality palm oil. Good coconut planting is: all mature bunches must be harvested, fruit bunches cut with dodos or tree trunks, bark marks should be curved like hooves tilted tilted, leaf leaves cut from the tree must be stacked regularly in *Gawangan* and at face down.

2.3. Palm Oil Industry

The rapid development of oil palm plantations is inseparable from the very promising level of profitability of this business. The high level of profit is allegedly influenced by the price factor of Fresh Fruit Bunches (FFB) which is always increasing significantly. In the period 2002-2011 the price of FFB has jumped sharply to more than threefold. The income level of palm oil plantation growers is much larger than other agricultural commodities allegedly caused not a few other commodity farmers who switched to oil palm plantations.

The high price increase of FFB has prompted many people to invest in oil palm plantations. Some people started oil palm plantation business as a new business but some other people who have been working on other agricultural commodities such as rubber and rice are not the few who turned to oil palm crops. The palm oil industry is used by companies to gain profit.

Oil Palm Plantation in Indonesia is currently one of the very large export commodities in Indonesia [8]. The development of the palm oil industry is currently very rapid, with an increase in the number of oil palm production in line with the increasing needs of the community. The amount of production that can be produced has a positive impact for the Indonesian economy. In the future, the palm oil industry can be expected to become the motor of national economic growth.

3. Research Methods

3.1. Place and time of research

This research was conducted at boiler station at the government plantation enterprise (PTPN II) for elais oil palms of Tanjung Garbus Pagar Merbau. It is used for CPO production located in Merbau of Deli Serdang District. The time of the research is done when doing field work practice.

3.2. Types and Data Sources

Types of data obtained were two types:

1. Primary Data

Primary data were obtained from the observation, measurements and interviews conducted on workers. The required data are as follows:

- a. Boiler Machine Specification Data.
- b. Boiler Machine Price Data
- c. Fuel Cost of Boiler Machine.
- d. Boiler Machine Lubricant Cost Data.
- e. Data Replacement Cost Spare Parts.
- f. Data Hours Operation and Clock Boiler Repair machine.
- g. Boiler Operators Wage Data

2. Secondary Data

Secondary data were obtained from library search and information or data from company. In this study the required secondary data were as follows:

- a. Company historical data
- b. Business scope
- c. Organizational structure of the company
- d. Production process

3.3. Technique of Collecting Data

To facilitate the smooth writing of bachelor's duties, then in need of a data collection method so that taken can be perfect and timely and cannot interfere with the work of the company. Data obtained from this company is done in several ways:

1. Making a direct observation.
2. Recording data and information available in the company.
3. Conducting interviews with the parties who provide the necessary information.
4. Reading books that can help solve problems.

3.4. Data Processing Technique

Data obtained from data collection then performed data processing. The steps used in data processing are as follows:

3.5. Down Time Cost Calculation

Down Time represents a loss of machine opportunity to operate because the machine is damaged or is being repaired. The cost of down time is calculated based on the machine repair hour per year divided by the normal machine working hours per year multiplied by the operator's cost each year (BO).

4. Results and Discussion

4.1 The economical age of the boiler machine is found in the 10th year found in 2005

4.2 The total annual cost of the minimum average boiler engine is Rp. 984.805.587

4.3 The total annual cost of the average maximum boiler engine is Rp. 1.059.031.810

5. Discussion

5.1. Calculation of Depreciation of Boiler Machine Annual

Before depreciation (Capital Recovery) is calculated, it is necessary to determine the Present Value (P) of Boiler Engine for each year calculated based on the Declining Balance Method.

This method is often also called Methensen Formula. The comparative annual depreciation value of the cost value at the beginning of the year is constant throughout its lifetime.

The applicable formula: $L = P (1-k)^t$; the value of $C = 2 / n = 2/25 = 0.08$

Where :

L = end price of machine at year n

P = Machine starting price

C = Constant

t = Year t

n = Machine in age

After the starting price of the machine (P) and the final price (L) per year Boiler is obtained, annual depreciation (CR) is determined by the formula:

$$CR = (P-L) (A / P, i, n) + Li$$

The preferred interest rate is adjusted to the bank deposit rate: $i = 6\%$.

The payback funds for the first year (1996) up to the 25th year (2020) are calculated the same way. The results

can be seen in table 1 below.

Tabel 1: Calculation of Boiler Machine Annual Depreciation

Year	(I-S)(A/P,6%,n) (Rp)	Li (Rp)	Capital Recovery (Rp)
1996	436.720.000	284.280.000	721.000.000
1997	431.433.216	261.537.600	692.970.816
1998	426.383.018	240.614.592	666.997.611
1999	421.522.307	221.365.425	642.887.732
2000	416.810.339	203.656.191	620.466.530
2001	412.347.072	187.363.695	599.710.768
2002	407.826.819	172.374.600	580.201.419
2003	403.614.571	158.584.632	562.199.203
2004	399.600.239	145.897.861	545.498.101
2005	395.863.036	134.226.032	530.089.069
2006	392.048.799	123.487.950	515.536.749
2007	388.502.609	113.608.914	502.111.524
2008	385.103.622	104.520.201	489.623.823
2009	381.695.604	96.158.585	477.854.190
2010	378.583.542	88.465.898	467.049.440
2011	375.558.767	81.388.626	456.947.393
2012	372.254.717	74.877.536	447.132.254
2013	369.773.507	68.887.333	438.660.840
2014	366.797.989	63.376.346	430.174.336
2015	364.341.599	58.306.239	422.647.838
2016	361.757.535	53.641.740	415.399.275
2017	359.181.946	49.350.400	408.532.346
2018	357.174.790	45.402.368	402.577.159
2019	354.97.0279	41.770.179	396.740.458
2020	352.644.770	38.428.565	391.073.335

5.2. Calculation of Operating Expenses for Boiler of Year

Operating cost of Boiler machine is the sum of fuel cost, spare part cost, lubricant cost, and wage of Boiler machine operator can be seen in following table

Table 2: Calculation of Boiler Machine Operating Costs

Year	Lubricant cost per year	Spare parts cost per year	Fuel costs per year	Operator wages per year	Operating cost per year
1996	440.000	720.000	33.400.000	269.400.000	303.960.000
1997	500.000	1.170.000	38.700.000	327.600.000	367.970.000
1998	620.000	1.725.000	42.200.000	345.360.000	389.905.000
1999	700.000	2.220.000	54.000.000	345.600.000	402.520.000
2000	817.000	2.500.000	65.400.000	386.400.000	455.117.000
2001	920.000	3.350.000	73.600.000	390.000.000	467.870.000
2002	1.050.000	3.670.000	75.000.000	442.200.000	521.920.000
2003	1.184.000	3.860.000	77.400.000	492.000.000	574.444.000
2004	1.231.000	4.200.000	78.900.000	508.200.000	592.531.000
2005	1.281.000	5.435.000	79.300.000	551.520.000	637.536.000
2006	1.490.000	6.170.000	80.300.000	589.200.000	677.160.000
2007	1.549.000	6.945.000	83.000.000	633.000.000	724.494.000
2008	1.754.000	7.750.000	89.700.000	669.600.000	768.804.000
2009	1.812.000	8.635.000	94.850.000	698.400.000	803.697.000
2010	1.935.000	9.456.000	98.400.000	763.200.000	872.991.000
2011	2.045.000	10.300.000	103.200.000	811.200.000	926.745.000
2012	2.170.000	10.750.000	107.400.000	838.960.000	959.280.000
2013	2.280.000	10.850.000	109.000.000	858.500.000	980.630.000
2014	2.490.000	11.050.000	109.750.000	841.800.000	965.090.000
2015	2.600.000	11.300.000	110.120.000	819.600.000	943.620.000

5.3. Calculation of Down Time Cost

Down Time represents a loss of machine opportunity to operate because the machine is damaged or is being repaired. The cost of down time is calculated based on the machine repair hour per year divided by the normal machine working hours per year multiplied by the operator's cost each year.

Normal working hours per year is 4500 hours, calculated based on normal working hours 15 hours / day multiplied by 1 year of work (300 working days).

The calculation of down time costs is calculated by the equation:

$$Bd = jr / jk \times BO$$

Where :

Bd = Down time cost

jr = Hour of reparations per year

jk = normal machine working hours per year

BO = Maintenance Fee

5.4. The Calculation of Average Annual Cost

The calculation of the average annual cost of Boiler machines includes the average annual downtime cost as shown in Table 3, the average annual operating costs as in Table 4 and capital recovery.

Table 3: Cost Calculation of Down Time Boiler Machine

Year	Hours of improvement per year (Hours)	Normal working hours per year (Hours)	The cost of Maintenance per year (Rp)	The cost of downtime per year (Rp)
1996	146	4500	1.160.000	37.636
1997	152	4500	1.670.000	56.409
1998	168	4500	2.345.000	87.547
1999	180	4500	2.920.000	116.800
2000	204	4500	3.317.000	150.371
2001	218	4500	4.270.000	206.858
2002	248	4500	4.720.000	260.124
2003	262	4500	5.044.000	293.673
2004	274	4500	5.431.000	330.688
2005	288	4500	6.716.000	429.824
2006	296	4500	7.660.000	503.858
2007	304	4500	8.494.000	573.817
2008	316	4500	9.504.000	667.392
2009	310	4500	10.447.000	719.682
2010	300	4500	11.391.000	759.400
2011	296	4500	12.345.000	812.027
2012	305	4500	12.920.000	875.689
2013	335	4500	13.130.000	977.456
2014	310	4500	13.540.000	932.756
2015	295	4500	13.900.000	911.222

5.5. The Average Calculation of Down Time Annual Cost

Table 4: Calculation of the average annual Down Time cost of the Boiler engine

Year	Cost of Down Time Per Year (Rp)	Present Worth Factor (P/F, 6%,n)	P.V Cost of Down Time (Rp)	Σ P.V Cost of Down Time (Rp)	Capital Recovery Factor (A/P, 6%,n)	Average of Down Time Cost (Rp)
1996	37.636	0.9434	35.504	35.504	1.06	37.634
1997	56.409	0.8900	50.203	85.707	0.5454	46.745
1998	87.547	0.8396	73.503	159.210	0.3741	59.560
1999	116.800	0.7921	92.517	251.727	0.2886	72.648
2000	150.371	0.7473	112.371	364.098	0.2374	86.437
2001	206.858	0.7050	145.834	509.932	0.2034	103.720
2002	260.124	0.6651	173.008	682.940	0.1791	122.315
2003	293.673	0.6274	184.249	867.189	0.1610	139.617
2004	330.688	0.5919	195.733	1.062.922	0.1470	156.250
2005	429.824	0.5584	240.013	1.302.935	0.1359	177.069
2006	503.858	0.5268	265.431	1.568.366	0.1268	198.869
2007	573.817	0.4970	285.186	1.853.552	0.1193	221.129
2008	667.392	0.4688	312.873	2.166.425	0.1130	244.806
2009	719.682	0.4423	318.315	2.484.740	0.1076	267.358
2010	759.400	0.4173	316.897	2.801.637	0.1030	288.569
2011	812.027	0.3936	319.613	3.121.250	0.0990	309.004
2012	875.689	0.3714	325.230	3.446.480	0.0954	328.794
2013	977.456	0.3503	342.402	3.788.882	0.0924	350.093
2014	932.756	0.3305	308.275	4.097.157	0.0896	367.105
2015	911.222	0.3118	284.119	4.381.276	0.0872	382.047

a. Average of Annual Operating Cost

Calculation of the average annual operating cost of boiler machine can be seen in table 5 below.

Table 5: Average Calculation of Annual Operating Cost of Boiler Machine

Year	Operating Cost Per Year (Rp)	Present Worth Factor (P/F, 6%,n)	P.V Cost Of Operation (Rp)	∑ P.V Cost Of Operation (Rp)	Capital Recovery Factor (A/P, 6%,n)	Average Cost of Annual Operating (Rp)
1996	303.960.000	0.9434	286.755.864	286.755.864	1.06	303.961.216
1997	367.970.000	0.8900	327.493.300	614.249.164	0.5454	335.011.494
1998	389.905.000	0.8396	327.364.238	941.613.402	0.3741	352.257.574
1999	402.520.000	0.7921	318.836.092	126.0449.494	0.2886	363.765.724
2000	455.117.000	0.7473	340.108.934	160.055.8428	0.2374	379.972.571
2001	467.870.000	0.7050	329.848.350	193.0406.778	0.2034	392.644.739
2002	521.920.000	0.6651	347.128.992	2.277.535.770	0.1791	407.906.656
2003	574.444.000	0.6274	360.406.165	2.637.941.936	0.1610	424.708.652
2004	592.531.000	0.5919	350.719.098	2.988.661.035	0.1470	439.333.172
2005	637.536.000	0.5584	356.000.102	3.344.661.137	0.1359	454.539.449
2006	677.160.000	0.5268	356.727.888	3.701.389.025	0.1268	469.336.128
2007	724.494.000	0.4970	360.073.518	4.061.462.543	0.1193	484.532.481
2008	768.804.000	0.4688	360.415.315	4.421.877858	0.1130	499.672.198
2009	803.697.000	0.4423	355.475.183	4.777.353041	0.1076	514.043.187
2010	872.991.000	0.4173	364.299.144	5.141.652.186	0.1030	529.590.175
2011	926.745.000	0.3936	364.766.832	5.506.419.018	0.0990	545.135.483
2012	959.280.000	0.3714	356.276.592	5.862.695.610	0.0954	559.301.161
2013	980.630.000	0.3503	343.514.689	6.206.210.299	0.0924	573.453.832
2014	965.090.000	0.3305	318.962.245	6.525.172.544	0.0896	584.655.460
2015	943.620.000	0.3118	294.220.716	6.819.393.260	0.0872	594.651.092

b. Total Average of Annual Cost

Total average annual cost is calculated by the formula:

Total average annual cost = Capital Recovery (CR) + average annual operating cost + average annual down time cost. Annual Cost Calculation The average Sheeter machine can be seen in Table 6 below.

Table 6: Calculation of Total Average Boiler Annual Costs

Year	Average Cost of Annual Operating (Rp)	Average Cost of annual Down Time (Rp)	Capital Recovery (Rp)	Average Cost of Total Annual (Rp)
1996	303.961.216	37.634	721.000.000	1.024.998.850
1997	335.011.494	46.745	692.970.816	1.028.029.055
1998	352.257.574	59.560	666.997.611	1.019.314.745
1999	363.765.724	72.648	642.887.732	1.006.726.104
2000	379.972.571	86.437	620.466.530	1.000.525.538
2001	392.644.739	103.720	599.710.768	992.459.227
2002	407.906.656	122.315	580.201.419	988.230.390
2003	424.708.652	139.617	562.199.203	987.047.472
2004	439.333.172	156.250	545.498.101	984.987.523
2005	454.539.449	177.069	530.089.069	984.805.587
2006	469.336.128	198.869	515.536.749	985.071.746
2007	484.532.481	221.129	502.111.524	986.865.134
2008	499.672.198	244.806	489.623.823	989.540.827
2009	514.043.187	267.358	477.854.190	992.164.735
2010	529.590.175	288.569	467.049.440	996.928.184
2011	545.135.483	309.004	456.947.393	1.002.391.880
2012	559.301.161	328.794	447.132.254	1.006.762.209
2013	573.453.832	350.093	438.660.840	1.012.464.765
2014	584.655.460	367.105	430.174.336	1.015.196.901
2015	594.651.092	382.047	422.647.838	1.017.680.977

5.6. Forecasting

Operating cost calculation is obtained from sum of lubricant usage cost, spare part cost, fuel cost. The calculation of boiler machine operating costs can be seen in Table 7 below.

a. Calculation of Forecasting Operating Costs

For the calculation of boiler operating cost forecasting parameters from 2016-2020 consist of calculation of fuel cost forecasting, spare parts cost and lubricant cost in Table 8 below.

Table 7: Calculation of Operating Cost of Boiler Machine

Year	Lubricant cost per year	Spare parts cost per year	Fuel costs per year	Operator wages per year	Operating cost per year
1996	440.000	720.000	33.400.000	269.400.000	303.960.000
1997	500.000	1.170.000	38.700.000	327.600.000	367.970.000
1998	620.000	1.725.000	42.200.000	345.360.000	389.905.000
1999	700.000	2.220.000	54.000.000	345.600.000	402.520.000
2000	817.000	2.500.000	65.400.000	386.400.000	455.117.000
2001	920.000	3.350.000	73.600.000	390.000.000	467.870.000
2002	1.050.000	3.670.000	75.000.000	442.200.000	521.920.000
2003	1.184.000	3.860.000	77.400.000	492.000.000	574.444.000
2004	1.231.000	4.200.000	78.900.000	508.200.000	592.531.000
2005	1.281.000	5.435.000	79.300.000	551.520.000	637.536.000
2006	1.490.000	6.170.000	80.300.000	589.200.000	677.160.000
2007	1.549.000	6.945.000	83.000.000	633.000.000	724.494.000
2008	1.754.000	7.750.000	89.700.000	669.600.000	768.804.000
2009	1.812.000	8.635.000	94.850.000	698.400.000	803.697.000
2010	1.935.000	9.456.000	98.400.000	763.200.000	872.991.000
2011	2.045.000	10.300.000	103.200.000	811.200.000	926.745.000
2012	2.170.000	10.750.000	107.400.000	838.960.000	959.280.000
2013	2.280.000	10.850.000	109.000.000	858.500.000	980.630.000
2014	2.490.000	11.050.000	109.750.000	841.800.000	965.090.000
2015	2.600.000	11.300.000	110.120.000	819.600.000	943.620.000

$$a = \frac{\sum y}{n} \qquad a = \frac{1.603.620.000}{20} = 80.181.000$$

$$b = \frac{\sum xy}{\sum x^2} \qquad b = \frac{1.805.430.000}{670} = 2.694.672,642$$

$$Y = 80.181.000 + 2.694.672,642 (x)$$

Calculation of Spare Parts Forecasting Parameters

$$a = \frac{\sum y}{n} \qquad a = \frac{122.056.000}{20} = 6.102.800$$

$$b = \frac{\sum xy}{\sum x^2} \qquad b = \frac{349.309.000}{670} = 521.356,716$$

$$Y = 6.102.800 + 521.356,716 (x)$$

Table 8: Calculation of Fuel Cost Forecasting Parameters

Year	Period (x)	Cost Y (Rp)	xY (Rp)	x ²
1996	-10	33.400.000	334.000.000	81
1997	-9	38.700.000	348.300.000	64
1998	-8	42.200.000	337.600.000	49
1999	-7	54.000.000	378.000.000	36
2000	-6	65.400.000	392.400.000	25
2001	-5	73.600.000	368.000.000	16
2002	-4	75.000.000	300.000.000	9
2003	-3	77.400.000	232.200.000	4
2004	-2	78.900.000	157.800.000	1
2005	-1	79.300.000	79.300.000	0
2006	0	80.300.000	-	1
2007	1	83.000.000	83.000.000	4
2008	2	89.700.000	179.400.000	9
2009	3	94.850.000	284.550.000	16
2010	4	98.400.000	393.600.000	25
2011	5	103.200.000	516.000.000	36
2012	6	107.400.000	644.400.000	49
2013	7	109.000.000	763.000.000	64
2014	8	109.750.000	878.000.000	81
2015	9	110.120.000	991.080.000	100
Total Σ		1.603.620.000	1.805.430.000	670

Calculation of Forecasting Parameters of Lubricant Usage Cost

$$a = \frac{\sum y}{n} \qquad a = \frac{28.868.000}{20} = 1.443.400$$

$$b = \frac{\sum xy}{\sum x^2} \qquad b = \frac{61.001.000}{670} = 91.046,268$$

$$Y_t = 1.443.400 + 134.132,835 (x)$$

Calculation of Operator Wage Forecasting Parameters

$$a = \frac{\sum y}{n} \qquad a = \frac{11.581.740.000}{20} = 579.087.000$$

$$b = \frac{\sum xy}{\sum x^2} \qquad b = \frac{16.424.660.000}{670} = 24.514.417,91$$

$$Y_t = 579.087.000 + 24.514.417,91 (x)$$

Cost Forecasting Calculation of Down Time

For the calculation of Cost Forecasting parameters of Down Time Boiler from 2016-2020 can be seen in Table 9 below.

Table 9: Calculation of Down Time Cost Forecasting

Year	x	Y (Rp)	xY (Rp)	x ²	x ² Y (Rp)	x ⁴
1996	-10	37.636	(376.360)	100	3.763.600	10.000
1997	-9	56.409	(507.681)	81	4.569.129	6.561
1998	-8	87.547	(700.376)	64	5.603.008	4.096
1999	-7	116.800	(817.600)	49	5.723.200	2.401
2000	-6	150.371	(902.226)	36	5.413.356	1.296
2001	-5	206.858	(1.034.290)	25	5.171.450	625
2002	-4	260.124	(1.040.496)	16	4.161.984	256
2003	-3	293.673	(881.019)	9	2.643.057	81
2004	-2	330.688	(661.376)	4	1.322.752	16
2005	-1	429.824	(429.824)	1	429.824	1
2006	0	503.858	-	-	-	-
2007	1	573.817	573.817	1	573.817	1
2008	2	667.392	1.334.784	4	2.669.568	16
2009	3	719.682	2.159.046	9	6.477.138	81
2010	4	759.400	3.037.600	16	12.150.400	256
2011	5	812.027	4.060.135	25	20.300.675	625
2012	6	875.689	5.254.134	36	31.524.804	1.296
2013	7	977.456	6.842.192	49	47.895.344	2.401
2014	8	932.756	7.462.048	64	59.696.384	4.096
2015	9	911.222	8.200.998	81	73.808.982	6.561
Jumlah ∑	10	9.703.229	31.573.506	670	293.898.472	40.666

$$b = \frac{\sum xy}{\sum x^2} \qquad b = \frac{31.573.506}{670} = 47.124,63$$

$$c = \frac{n \sum x^2 Y - \sum x^2 \sum Y}{n \sum x^4 - (\sum x^2)^2} \qquad c = \frac{20(293.898.472) - (670)(9.703.229)}{20(40.666) - (670)^2} = 1.710,098$$

$$a = \frac{\sum Y - c \sum x^2}{n} \qquad a = \frac{9.703.229 - 1.710,098 (670)}{20} = 427.873,16$$

$$Y = 427.873,16 + 47.124,63(x) + 1.710,098(x)^2$$

Average Annual downtime fee (2016-2020)

The calculation result of annual down time cost of boiler machine average can be seen in table 10 below.

Table 10: Calculation of Down Time Average Cost of Boiler

Year	Cost of Down Time Per Year (Rp)	Present Worth Factor (P/F, 6%,n)	P.V Cost of Down Time (Rp)	∑ P.V Cost of Down Time (Rp)	Capital Recovery Factor (A/P, 6%,n)	The Average Cost of Down Time (Rp)
1996	37.636	0.9434	35.504	35.504	1.06	37.634
1997	56.409	0.8900	50.203	85.707	0.5454	46.745
1998	87.547	0.8396	73.503	159.210	0.3741	59.560
1999	116.800	0.7921	92.517	251.727	0.2886	72.648
2000	150.371	0.7473	112.371	364.098	0.2374	86.437
2001	206.858	0.7050	145.834	509.932	0.2034	103.720
2002	260.124	0.6651	173.008	682.940	0.1791	122.315
2003	293.673	0.6274	184.249	867.189	0.1610	139.617
2004	330.688	0.5919	195.733	1.062.922	0.1470	156.250
2005	429.824	0.5584	240.013	1.302.935	0.1359	177.069
2006	503.858	0.5268	265.431	1.568.366	0.1268	198.869
2007	573.817	0.4970	285.186	1.853.552	0.1193	221.129
2008	667.392	0.4688	312.873	2.166.425	0.1130	244.806
2009	719.682	0.4423	318.315	2.484.740	0.1076	267.358
2010	759.400	0.4173	316.897	2.801.637	0.1030	288.569
2011	812.027	0.3936	319.613	3.121.250	0.0990	309.004
2012	875.689	0.3714	325.230	3.446.480	0.0954	328.794
2013	977.456	0.3503	342.402	3.788.882	0.0924	350.093
2014	932.756	0.3305	308.275	4.097.157	0.0896	367.105
2015	911.222	0.3118	284.119	4.381.276	0.0872	382.047
2016	2.171.644	0.2942	638.898	5.020.174	0.085	426.715
2017	2.292.302	0.2775	636.113	5.656.287	0.083	469.472
2018	2.416.381	0.2618	632.609	6.288.896	0.0813	511.287
2019	2.543.880	0.2470	628.338	6.917.234	0.0797	551.304
2020	2.674.800	0.2330	623.228	7.540.462	0.0782	589.664

5.7. Average Cost of Annual Operating (Year 2016-2020)

The calculation of the average annual operating cost of a boiler machine can be seen in the table

Table 11: Calculation of Mean Operating Costs of Boiler Average

Year	Cost Operation Per year (Rp)	Present Worth Factor (P/F, 6%,n)	P.V Cost Operation (Rp)	∑ P.V Cost Operation (Rp)	Capital Recovery Factor (A/P, 6%,n)	Average Cost of Annual Operating (Rp)
1996	303.960.000	0.9434	286.755.864	286.755.864	1.06	303.961.216
1997	367.970.000	0.8900	327.493.300	614.249.164	0.5454	335.011.494
1998	389.905.000	0.8396	327.364.238	941.613.402	0.3741	352.257.574
1999	402.520.000	0.7921	318.836.092	126.0449.494	0.2886	363.765.724
2000	455.117.000	0.7473	340.108.934	160.055.8428	0.2374	379.972.571
2001	467.870.000	0.7050	329.848.350	193.0406.778	0.2034	392.644.739
2002	521.920.000	0.6651	347.128.992	2.277.535.770	0.1791	407.906.656
2003	574.444.000	0.6274	360.406.165	2.637.941.936	0.1610	424.708.652
2004	592.531.000	0.5919	350.719.098	2.988.661.035	0.1470	439.333.172
2005	637.536.000	0.5584	356.000.102	3.344.661.137	0.1359	454.539.449
2006	677.160.000	0.5268	356.727.888	3.701.389.025	0.1268	469.336.128
2007	724.494.000	0.4970	360.073.518	4.061.462.543	0.1193	484.532.481
2008	768.804.000	0.4688	360.415.315	4.421.877858	0.1130	499.672.198
2009	803.697.000	0.4423	355.475.183	4.777.353041	0.1076	514.043.187
2010	872.991.000	0.4173	364.299.144	5.141.652.186	0.1030	529.590.175
2011	926.745.000	0.3936	364.766.832	5.506.419.018	0.0990	545.135.483
2012	959.280.000	0.3714	356.276.592	5.862.695.610	0.0954	559.301.161
2013	980.630.000	0.3503	343.514.689	6.206.210.299	0.0924	573.453.832
2014	965.090.000	0.3305	318.962.245	6.525.172.544	0.0896	584.655.460
2015	943.620.000	0.3118	294.220.716	6.819.393.260	0.0872	594.651.092
2016	1.253.065.553	0.2942	368.651.886	7.188.045.146	0.085	610.983.837
2017	1.280.887.046	0.2775	355.446.155	7.543.491.301	0.083	626.109.778
2018	1.308.708.539	0.2618	342.619.896	7.886.111.196	0.0813	641.140.840
2019	1.336.530.032	0.2470	330.122.918	8.216.234.114	0.0797	654.833.859
2020	1.364.351.525	0.2330	317.893.905	8.534.128.020	0.0782	667.368.811

5.8. Determination of the Economical Age of Boiler Machine

The economic life of a Boiler machine is a proactive and profitable period of Boiler machine usage. Economic life is earned at the time of the smallest average annual total cost. Calculation of Boiler's average cost of annual can be seen in Table 12 below.

Table 12: Calculation of Average Annual Boiler Cost

Year	Average Cost of Annual Operating (Rp)	Average Cost of annual Down Time (Rp)	Capital Recovery (Rp)	Total Average Annual Cost (Rp)
1996	303.961.216	37.634	721.000.000	1.024.998.850
1997	335.011.494	46.745	692.970.816	1.028.029.055
1998	352.257.574	59.560	666.997.611	1.019.314.745
1999	363.765.724	72.648	642.887.732	1.006.726.104
2000	379.972.571	86.437	620.466.530	1.000.525.538
2001	392.644.739	103.720	599.710.768	992.459.227
2002	407.906.656	122.315	580.201.419	988.230.390
2003	424.708.652	139.617	562.199.203	987.047.472
2004	439.333.172	156.250	545.498.101	984.987.523
2005	454.539.449	177.069	530.089.069	984.805.587
2006	469.336.128	198.869	515.536.749	985.071.746
2007	484.532.481	221.129	502.111.524	986.865.134
2008	499.672.198	244.806	489.623.823	989.540.827
2009	514.043.187	267.358	477.854.190	992.164.735
2010	529.590.175	288.569	467.049.440	996.928.184
2011	545.135.483	309.004	456.947.393	1.002.391.880
2012	559.301.161	328.794	447.132.254	1.006.762.209
2013	573.453.832	350.093	438.660.840	1.012.464.765
2014	584.655.460	367.105	430.174.336	1.015.196.901
2015	594.651.092	382.047	422.647.838	1.017.680.977
2016	610.983.837	426.715	415.399.275	1.026.809.827
2017	626.109.778	469.472	408.532.346	1.035.138.596
2018	641.140.840	511.287	402.577.159	1.044.229.286
2019	654.833.859	551.304	396.740.458	1.052.125.621
2020	667.368.811	589.664	391.073.335	1.059.031.810
Total Σ				25.239.526.989

From the calculation of the total average annual cost in Table 12, it was that the average annual operating cost, average annual down time cost, and depreciation cost (capital recovery) from 1996 to 2020, so that the Government Plantation Enterprises (PTPN II) Pagar Merbau can determine the total the average annual cost of a Boiler engine.

The company can also pay attention to maintenance (maintenance) boiler machine for maximum production process and profitable for the Government Plantation Enterprises (PTPN II) Pagar Merbau. From the calculation, the average total annual cost of the youngest economic life of boiler in was on the 10th year (2005) since the purchase of Boiler machine (year 1995) of IDR. 984.805.587.

6. Conclusion

After the calculation and analysis done, it can be taken a conclusion. The average total annual cost of the youngest economic life of boiler in was on the 10th year (2005) since the purchase of Boiler machine (year 1995) The economic life of the boiler engine is found in the 10th year found in 2005.

Total average annual cost of boiler engine minimum was IDR. 984.805.587. The total annual cost of the average maximum boiler engine was IDR 1.059.031.810

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