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Analysis of Spinning Reserve Settings Against Anticipation of Black Out and Total Fuel Use at Power House Division

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ABSTRACT

Analysis Of Spinning Reserve Settings Against Anticipation Of Black Out And Total Fuel Use At Power House Division. *One of the biggest users of electrical energy in Batam City is the Batamindo Industrial Park area, so that area is required to have an electricity provider managed by the Batamindo Power House Division. To anticipate generation problems such as fuel gas trips in the power generation system, generation failures such as power disruption or even total blackouts, Power House Batamindo has a big responsibility. Power House Batamindo makes maximum and minimum power reserve limits. However, this can result in a large use of fuel for power generation and will also increase the cost of electricity production. In a converted generator engine, it will produce more power if it uses diesel fuel rather than gas. The results of research conducted for one month and data analysis carried out, as much as 84.7% of the installed spinning reserves are at 10-14 MW and as much as 5.1% are below the limit of the provision for spinning reserves (10-14 MW) which must be suppressed the numbers. The results of the research also prove that to prevent high diesel fuel emissions in generator engines, it is necessary to save diesel fuel by avoiding generation problems, one of which is paying the spinning reserve limit.*

Salah satu pemakai energi listrik terbesar di Kota Batam ialah kawasan Batamindo Industrial Park, sehingga kawasan tersebut wajib memiliki penyedia tenaga listrik yang dikelola oleh Divisi Power House Batamindo. Untuk mengantisipasi terjadinya permasalahan pembangkitan seperti *fuel gas trip* pada sistem pembangkit tenaga listrik, kegagalan-kegagalan pembangkitan seperti *power disruption* atau bahkan Pemadaman total, Power House Batamindo memiliki tanggung jawab yang besar. Power House Batamindo membuat peraturan batas maksimum dan minimum pencadangan daya. Namun hal ini dapat mengakibatkan besarnya penggunaan bahan bakar pembangkit listrik dan akan memperbesar biaya produksi listrik pula. Pada mesin pembangkit *converted*, akan menghasilkan daya yang lebih besar jika menggunakan bahan bakar solar dari pada gas. Hasil penelitian yang dilakukan selama satu bulan dan analisis data yang dilakukan, sebanyak 84,7% *spinning reserve* yang terpasang berada pada 10-14 MW dan sebanyak 5,1% berada dibawah batas ketetapan *spinning reserve* (10-14 MW) yang harus ditekan lagi angkanya. Hasil penelitian juga membuktikan bahwa untuk mencegah emisi bahan bakar solar yang tinggi pada mesin pembangkit, maka perlu adanya penghematan bahan bakar solar dengan cara menghindari terjadinya permasalahan pembangkitan, salah satunya adalah menaati ketetapan batas *spinning reserve.*

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1. Introduction

This increased electrical load must be balanced with the addition of power generated. It is not possible to serve all energy needs using only one large-capacity plant. Especially with the development of industrial equipment that switched from steam engines to electric engines. This development is in accordance with the industrial revolution, where the need for electrical energy has increased sharply [1], [2].

One of the largest users of electrical energy in Batam City is an industrial area, this is due to Batam's very strategic geographical conditions so that within just a few years industries have sprung up quickly [3], [4]. Batamindo Industrial Park is an industrial area in Batam that has so many industries. To carry out industrial activities, all industries in Batamindo Industrial Park must have electrical energy suppliers, in this case all electrical energy flowed comes from a division under the auspices of PT. Batamindo Investment Cakrawala is the Power House Division. The Power House division is a very important division to distribute electrical energy, the Power House division must keep the power plant operating and avoid power disruption and total blackout [5].

To minimize the occurrence of generation problems that result in temporary blackouts and total blackouts in all industries in Batamindo Industrial Park, Power House Division must consider the number of generating machines running every hour to balance the power load required by each industry [6], [7]. The Power House division has a power reserve called a spinning reserve [8]. Spinning reserve is a power reserve stored and prepared in the form of a running generating engine to anticipate the occurrence of gas trips on the engine and other cases that cause the engine to not work properly so that it does not produce electrical energy and there is a total blackout [9], [10] .

The power reserve limit applied by Power House Batamindo is 10-14 MW [11]. The power backup carried out by the operations team considers not only in terms of time, but also takes into account the fuel usage part. If the generating machine works with a large amount and the power released is also small, it means that there is a lot of available power reserve [12]. This results in a waste of fuel. If the generating machine works not in accordance with its operating pattern due to generation problems, it will increased emissions in a very inhospitable environment [13], [14]. Based on the above problems, it is necessary to conduct research that discusses the analysis of power backup arrangements to anticipate total blackouts and fuel use in the generating engine at the Batamindo Power House.

2. Literature Review

In generators, spinning reserve is the standby power used to start generation if it receives a dispatch signal from the grid. The purported spinning reserve uses a fuel mechanism that is standby, rotating and ready to synchronize and generate rapid power. In CASIO the backup resource must reach full level within 10 minutes of receiving the dispatch signal [15].

2.1 Power Plant

According to figure 2.1 power generation is the most important part of the electric power system, power generation has the function of generating electrical energy by converting other energy sources into electrical energy [16], [17]. Power plants are usually classified according to the working principle and energy source they use. A generating unit usually consists (1) Prime Mover, which functions to produce motion energy in the form of shaft rotation which is then intended to rotate the generator. (2) The generator functions to convert motion energy into electrical energy that is ready to be sent to the load center. (3) Substation has a function to regulate energy delivery and also adjust the voltage level to match the delivery voltage level [18].

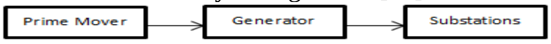

Figure 2.1. Basic components of the plant.

2.2 Oil and Gas Power Plant

Oil and Gas Power Plant generally in Indonesia uses engines with dual fuels, therefore the fuel system must be able to accommodate both fuels. Fuels commonly used are natural gas and diesel oil (B30). Diesel fuel oil is usually used for two functions, namely for pilot fuel and main fuel. The main fuel function is used if the gas engine is operated using diesel fuel as its main fuel before the switch-over of fuel to the gas system. While the function of the pilot fuel will always be used in every engine operation effort (starting and operating the engine).

2.3 Dual fuel system

Dual fuel system can use 2 (two) fuels to produce electric power. At Power House Batamindo, this dual fuel system uses natural gas fuel and diesel type B30. This gaseous fuel contains several types of chemical molecules such as Propane Gas (0.40%) and Butane Gas (0.20%) [12]. So that this dual fuel system is one of the methods being developed to get an increase in engine performance. The dual fuel system uses two types of fuel that have different characteristics. By utilizing this difference in fuel characteristics, engine performance can increase [19]. In addition, dual fuel systems can be used to reduce the level of exhaust emissions. Because basically LPG gas has a lower carbon (C) content than diesel and gasoline. Therefore, the emissions released from the combustion of LPG gas are lower than diesel and gasoline. Basically, this dual fuel system requires a lot of settings to be able to get the best performance. This is because the dual fuel system dependent on various parameters, such as workload, engine speed, injection timing, fuel fraction and also the condition of the intake manifold on the engine. [19]

2.4 Transmission line

A transmission line is part of an electric power system in the form of a number of conductors installed stretching along the distance between the center of the plant to the center of the load [20]. Its function is to transmit electrical energy from the generating center to the load center. Transmission lines are usually used to transmit electrical power for relatively long distances.

2.5 Spinning reserve

Spinnig reserve is the maximum generation capacity reserve available to anticipate a sudden increase in electricity demand and also minimize the occurrence of total outages. The number of spinning reserves is obtained from the maximum capacity that can be provided by the generating machine and the power released Eq 2.1 [21].

$$spinning\ reserve = max.available - \ total\ output \tag{2.1}$$

During a sudden generation failure process or an increase in electricity demand, the power output of the spinning reserve is increased to balance the electrical power supply with the existing demand. All synchronous generators consisting of rotating mass have an effect on the inertial system of the engine. If the system's inertia is very low, the rate of frequency change will be higher due to sudden events, making the system's frequency exceed the permissible frequency limit within a few seconds, before the generator can increase its power output [19].

At Power House Batamindo, when 19 generating machines were complete, namely in 2006, the available spinning reserve was 8-12 MW because at that time the fuel used was still black oil fuel (HFO). In 2016 the spinning reserve arrangement was at 12-18 MW due to changes in fuel which originally used HFO and then replaced with dual fuel (Gas and Solar B30). In 2017, when Power House Batamindo leased the MaxPower Indonesia plant, the spinning reserve arrangement was at 10-15 MW. The latest change is in 2021, the spinning reserve setting is 10-14 MW to save fuel. Changes in spinning reserve provisions are influenced by several things [22], [23], namely (1) The condition of the grouping system in Power House Batamindo. If the generation machine group system changes, then this will affect the spinning reserve. (2) History of power output in Power House Batamindo. If the load distributed each year increases, then this will affect the spinning reserve that is set to remain in safe condition. (3) The number of generating machines working in Batamindo Power House. The addition of the number of existing plants in the Power House will affect the spinning reserve, such as the addition of MaxPower Indonesia machines in 2017.

2.6 Fuel System

In diesel engine fuel systems, the diverter pump sucks fuel from the fuel tank. The fuel is then filtered by a fuel filter and the water content contained in the fuel is separated by a fuel sedimeter before flowing to the fuel injection pump. This injection pump assembly consists of an injection pump, governor and diverter pump [24]. By being driven by the engine, the injection pump compresses fuel and flows into the injection nozzle and injected into the cylinder to the ignition order. Then distribution to the combustion chamber with certain conditions, a fuel system is needed, fuel system function, (a) Fogging the fuel so that it is easily mixed evenly with air so that it is flammable. (b) Set the same amount of fuel per cylinder intake at each requirement the power in all cylinders is the same. (c) Set the time when spraying starts and the duration of spraying. To calculate the amount of fuel used in the generating engine is as follows equation (2.2). When enerating engine runs on 98.5% gas and 1.5% diesel fuel Eq (2.3)

$$\textit{LFO Consum} = \text{Output x power consumption pilot fuel} \quad (2.2)$$

$$\textit{Gas Consum} = \text{Output x gas consumption} \quad (2.3)$$

Where, the ability of pilot fuel consumption is 0.005 L / KWh and gas consumption is 10,900 BTU / KWh. As for calculating the amount of plant fuel consumption when the plant works with 100% diesel fuel, then Eq (2.4);

$$\textit{LFO Consum} = \text{Power x 0,260 L/ KWh} \quad (2.4)$$

2.7 Generation Problem

Some of the problems that occur in the generating machine the failure of electricity generation are as follows.

(a) Engine trip / Shutdown is an event where a machine stops automatically because there is an abnormality that occurs in the engine. The existence of safety equipment in the form of sensors installed in each system on the machine serves to detect when the engine is in an abnormal state then the machine will stop sequentially so that the engine will be maintained. According to the Instruction Manual Book of Wartsila DFDE 50DF Type, in shutdown mode the engine will stop automatically in a sequential manner. Shutdown mode will only be replaced with emergency stop, shutdown mode can be active for various reasons. WECS security installed on DFDE will request shutdown mode when the machine is in an abnormal state and is detected by sensors on machine [25].

(b) Fuel gas trip is a failure to move from fuel gas where the sensor will detect the cause of the failure and then the system will sequentially stop supplying fuel gas automatically and sequentially. At the time of Fuel gas trip a quick step that must be done by the operation team is to change the engine system that was originally Gas mode to Diesel mode. Diesel mode is the condition of the engine using diesel fuel, where this fuel is injected into the combustion chamber at the end of the compression stroke assisted by an injection pump (injector). [26]

(c) Black outis a complete blackout / collapse of the electrical power grid caused by an imbalance between the generation of electrical power and its consumption or other electrical disturbances. [26]

3. Research Method

3.1. Design

The implementation method to answer the problems in this final project is starting from collecting literature sources, then taking data related to the number of generating machines running, the number of spinning reserves that can be produced in one day and the amount of fuel used in one day including unexpected situations and conditions, taking data on the average consumption of diesel fuel use on one generating machine, Comparison of the results of data processing is carried out. After comparison, write down the results of data processing according to figure 3.1.

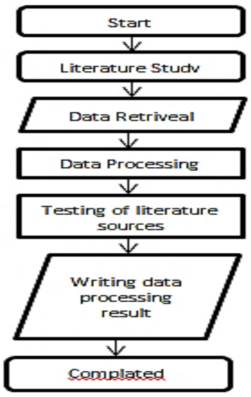

Figure 3.1. Research flow chart

3.2. Design the whole document.

Based from figure 3.2 the design of the analysis of the amount of power reserve (spinning reserve) against a total outage is to compare the amount of power reserve against unexpected problems that will occur in one day.

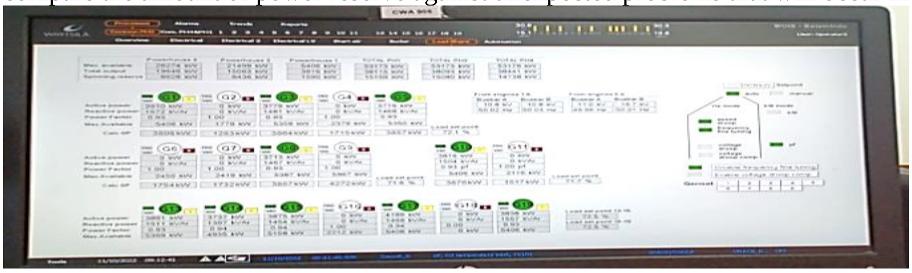

Figure 3.2. sWOIS screen display - Number of working generating machines

3.3. Design Analysis of the amount of fuel use

The design of the analysis the amount of fuel use ofthe generating engine a comparative analysis of the amount of power engine operating at one time to the amount of fuel needed to drive the generating engine.

3.4. Testing

Testing in this final project is carried out with several processes, namely:

1. Testing spinning reserves against black out

In this test, it will be tested whether the lower the number of spinning reserves, the more vulnerable it will be to total blackouts or vice versa. Setting the number of spinning reserves in the Batamindo Power House is a minimum of 10 MW and a maximum of 14 MW like in the figure 3.3.

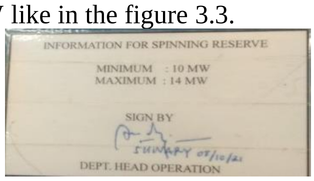

Figure 3.3. Setting the number of spinning reserves at Power House Batamindo

2. Testing of spinning reserves against fuel use.

In this test it will be seen whether the higher the engine speed, the higher the fuel consumption used, the greater the torque and power produced, the higher the fuel needed [23]

4. Result and Discussions

4.1. Spinning reserve analysis of black outs

The maximum capacity of an engine when working using diesel fuel can reach 5.2 MW and when using gas fuel can reach 4 MW. But to extend the life of the engine, these generating machines are charged only about ±70% of their maximum capacity. So, a generating machine can produce 2.8-3.8 MW of power and MaxPower Indonesia produces 15 MW based on figure 4.1.

TIME	PH 1		PH 3					PH 3 Ext.				PH 4							MAX POWER		Maximum Available	Total Load	Spinning Reserve
	D/G 10	D/G 11	D/G 1	D/G 2	D/G 3	D/G 4	D/G 5	D/G 6	D/G 7	D/G 8	D/G 9	D/G 13	D/G 14	D/G 15	D/G 16	D/G 17	D/G 18	D/G 19	INC 1	INC 2			
	Mega Watt (MW)																				(MW)	(MW)	(MW)
01:00	3,7	**	*	**	*	3,7	3,7	3,7	***	3,7	**	3,8	3,8	*	*	4,0	***	*	6,0	9,0	56,2	45,1	11,1
02:00	3,6	**	*	**	*	3,6	3,6	3,7	***	3,6	**	3,7	3,7	*	*	4,0	***	*	6,0	9,0	56,2	44,5	11,7
03:00	3,6	**	*	**	*	3,6	3,6	3,6	***	3,6	**	3,7	3,7	*	*	4,0	***	*	6,0	9,0	56,0	44,4	11,6
04:00	3,5	**	*	**	*	3,6	3,6	3,5	***	3,5	**	3,6	3,6	*	*	4,0	***	*	6,0	9,0	56,0	43,9	12,1
05:00	3,4	**	*	**	*	3,4	3,4	3,4	***	3,4	**	3,5	3,6	*	*	4,0	***	*	6,0	9,0	56,0	43,1	12,9
06:00	3,5	**	*	**	*	3,6	3,6	3,6	***	3,6	**	*	3,8	*	*	4,0	***	*	6,0	9,0	51,0	40,7	10,3
07:00	3,8	**	*	**	*	3,8	3,8	*	***	3,8	**	*	3,6	*	*	4,0	***	**	6,0	9,0	47,8	37,8	10,0
08:00	3,5	**	*	**	*	3,6	3,6	*	***	3,4	**	*	3,3	3,3	*	4,0	***	**	6,0	9,0	51,5	39,7	11,8
09:00	3,5	**	3,6	**	*	3,6	3,6	*	***	3,6	**	*	3,5	3,5	*	*	***	**	6,0	9,0	51,4	39,9	11,5
10:00	3,6	**	3,6	**	*	3,6	3,6	*	***	3,7	**	*	3,5	3,5	*	*	***	**	6,0	9,0	51,4	40,1	11,3
11:00	3,6	**	3,4	**	*	3,4	3,4	*	***	3,7	**	*	3,4	3,4	*	*	***	**	6,0	9,0	51,2	39,3	11,9
12:00	3,6	**	3,4	**	*	3,4	3,4	*	***	3,7	**	*	3,4	3,4	*	*	***	**	6,0	9,0	51,4	39,3	12,1
13:00	3,5	**	3,4	**	*	3,4	3,4	*	***	3,6	**	*	3,4	3,4	*	*	***	**	6,0	9,0	51,2	39,1	12,1
14:00	3,4	**	3,4	**	*	3,4	3,4	*	***	3,4	**	*	3,2	3,2	*	*	***	**	6,0	9,0	51,4	38,4	13,0
15:00	3,1	**	*	**	*	3,1	3,1	*	***	3,2	**	*	3,2	3,2	*	3,2	***	**	6,0	10,0	51,4	38,1	13,3
16:00	3,2	**	*	**	*	3,2	3,2	*	***	3,2	**	*	3,2	3,2	*	3,2	***	**	6,0	9,0	51,4	37,4	14,0
17:00	*	**	*	**	*	3,7	3,7	*	***	3,5	**	*	3,6	3,6	*	3,6	***	**	6,0	9,0	47,3	36,7	10,6
18:00	*	**	*	**	*	3,5	3,5	*	***	3,5	**	*	3,6	3,6	*	3,6	***	**	6,0	9,0	47,3	36,3	11,0
19:00	*	**	*	**	*	3,2	3,2	*	***	3,4	**	*	3,2	3,2	*	3,2	***	**	6,0	9,0	47,3	34,4	12,9
20:00	*	**	*	**	*	3,2	3,2	*	***	3,2	**	*	3,2	3,2	*	3,2	***	**	6,0	9,0	47,3	34,2	13,1
21:00	*	**	*	**	*	3,1	3,1	*	***	3,2	**	*	3,1	3,1	*	3,1	***	**	6,0	9,0	47,3	33,7	13,6
22:00	*	**	*	**	*	3,5	3,5	*	***	3,5	**	*	3,4	3,4	*	3,4	***	**	6,0	6,0	44,4	32,7	11,7
23:00	*	**	*	**	*	3,4	3,4	*	***	3,4	**	*	3,3	3,3	*	3,3	***	**	6,0	6,0	44,4	32,1	12,3
24:00	*	**	*	**	*	3,3	3,3	*	***	3,3	**	*	3,3	3,3	*	3,3	***	**	6,0	6,0	44,4	31,8	12,6

Figure 4.1. *Generator Load* at Oktober 1, 2022

Power House Batamindo has a group system, namely PH1 has 2 generating machines, PH 3 has 5 generating machines, PH 3 extention has 4 generating machines, PH 4 has 3 generating machines and PH 4 extention has 3 generating machines. Each PH is set the number of machines that will work. The amount of power on the engine running at each PH should not exceed the available power reserve, because if there is an unexpected problem in one group, the other engines will affect each other for load sharing. The power backup management system is also made to anticipate generating machines that experience sudden or sudden generation problems, such as a surge in load and loss of load due to carelessness of tenants.

4.2. Analysis of spinning reserve provisions applied by Power House Batamindo.

Based on data collected for one month from the table 4 Power House Batamindo has very well implemented the established power backup regulations. In that month Power House Batamindo had a Spinning reserve at a safe level of 84.7%, at an unsafe level of below 10 MW was 5.1% and the installed spinning reserve exceeded its maximum limit so that fuel waste was 10.2%. The use of a large enough spinning reserve is caused by gas rationing.

Table 4.1. Spinning reserve percentage during October 2022

	Information	Hours	Percentage
(red)	< 10,00 MW	38	5,1%
(green)	10,00-14,00 MW	630	84,7%
(purple)	> 14,00 MW	76	10,2%
Total (24 Jam x 31 Hari)		744	100,0%

4.3. Analysis of spinning reserve provisions on fuel usage

1. Calculate the amount of fuel usage when working normally.

Using equations 2.2 and 2.3 can be calculated the amount of fuel consumption as long as the generating engine works in 98.5% gas and 1.5% diesel. Data writing is done randomly and only pays attention to the order of increase of the spinning reserve following table 4.2.

Table 4.2. Calculation of the use of gas and diesel fuel during normal operation

Date	Time	Max Available	Total Load	Spinning	LFO Consum			Gas Consum		
					Max. Available	Load	Spinning	Max. Available	Load	Spinning
		Mega Watt (MW)			Liter (L)			British Thermal Unit		
08/10	15.00	32,7	26,1	6,6	163,5	130,5	33,0	356.430.000	284.490.000	71.940.000
08/10	23.00	32,8	25,2	7,6	164,0	126,0	38,0	357.520.000	274.680.000	82.840.000
30/10	04.00	40,0	31,3	8,7	200,0	156,5	43,5	436.000.000	341.170.000	94.830.000
16/10	12.00	38,7	29,1	9,6	193,5	145,5	48,0	421.830.000	317.190.000	104.640.000
19/10	20.00	60,0	49,2	10,8	300,0	246,0	54,0	654.000.000	536.280.000	117.720.000
21/10	07.00	62,3	50,7	11,6	311,5	253,5	58,0	679.070.000	552.630.000	126.440.000
22/10	16.00	51,8	39,0	12,8	259,0	195,0	64,0	564.620.000	425.100.000	139.520.000
20/10	03.00	60,9	47,7	13,2	304,5	238,5	66,0	663.810.000	519.930.000	143.880.000
21/10	19.00	62,4	48,4	14,0	312,0	242,0	70,0	680.160.000	527.560.000	152.600.000
25/10	08.00	65,9	50,5	15,4	329,5	252,5	77,0	718.310.000	550.450.000	167.860.000
28/10	18.00	68,0	48,5	19,5	340,0	242,5	97,5	741.200.000	528.650.000	212.550.000

Based on figure 4.2 & the calculation of diesel fuel consumption against power reserve (spinning reserve) shows that the greater the installed power reserve, the more diesel fuel consumption.

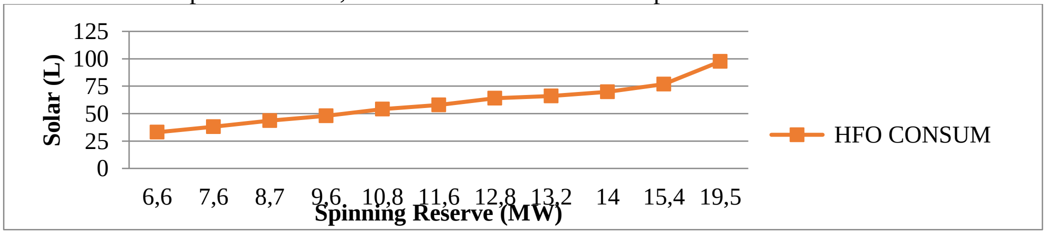

Figure 4.2. Graph of the relationship of spinning reserve to solar consumption

Likewise from figure 4.3, the use of gas based on the calculation of gas fuel consumption against power reserves shows that the greater the installed power reserve, the more gas fuel consumption.

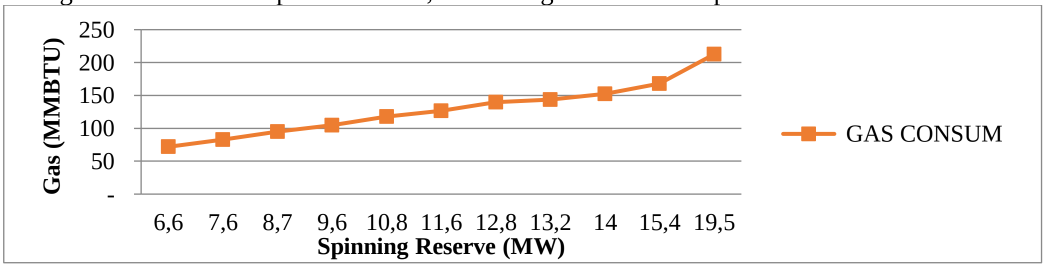

Figure 4.3. Graph of the relationship of spinning reserve to gas consumption

2. Calculate the amount of fuel used when a generation problem occurs.

Using equations (2.3) and (2.4) can be calculated the amount of diesel consumption as long as the generating machine works 100% solar, following the table 4.3.

Table 4.3. Calculation of the use of diesel fuel at the time of generation problems

DATE	RESON	POWER (MW)	DURATION (Min)	LFO CONSUM (L)
04/10/2022 10.00-11.00	*Fuel Gas Trip*	66,4	60	332
	DG#13	4,2	8	145,236
	DG#03	3,8	4	66,196
	DG#03	3,4	4	59,228
	DG#03	3,2	3	41,6

	TOTAL		79	644,26
10/10/2022 15.00-16.00	Backup DG#14 *shutdown*	64,3	60	320
	DG#01	4,2	7	127,44
	DG#04	4,3	22	410,306
	DG#08	4,1	10	177,667
	DG#17	4,4	10	127,44
	TOTAL		109	1.162,85
13/10/2022 16.00-17.00	Gas Rationing	66	60	330
	DG#04	4,2	60	1.092
	DG#05	4,2	60	1.092
	DG#09	4,2	46	837,2
	DG#10	3,8	60	988
	DG#13	2	60	251,33
	DG#15	4,1	29	514,878
	TOTAL		375	5.374,08
19/10/2022 08.00-09.00	Gas Rationing	71,3	60	356,5
	DG#03	4,1	60	1.066
	DG#04	4,1	60	1.066
	DG#08	4,1	60	1.066
	DG#10	4,2	60	1.092
	DG#17	4,2	60	1.092
	TOTAL		360	5.738,50
29-Oct 15.00-16.00	Alrm. Low Exhaust Gas	50,9	60	254,5
	DG#03	3,3	17	243,1
	TOTAL		77	497,6

Based on the calculation of fuel consumption at the time of the generation problem that requires the generating machine to run 100% diesel is because the generating engine works with 100% diesel fuel and the greater the power released when it works 100% diesel, the greater the consumption of diesel fuel in the generating engine. Diesel fuel is a fuel for generating engines that can emit a lot of emissions. For this reason, its use is highly recommended to be reduced. According to figure 4.4 the amount of diesel fuel consumption is not influenced by the type of generation problem, be it during gas rationing, gas trip, or when the engine is turned on to backup other generating machines but is only influenced by the amount of load and duration of operation.

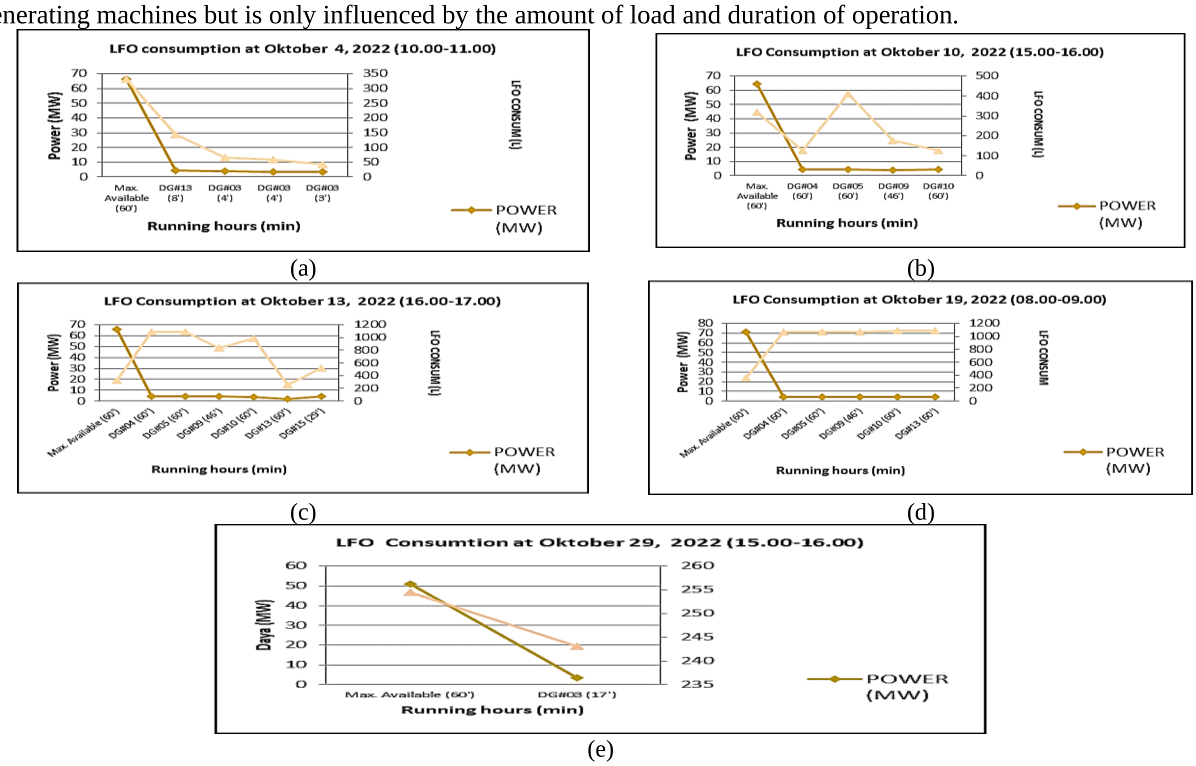

Figure 4.4 Graph of MFO Consumption Over Time

5. Simpulan

To anticipate a total black out, Batamindo Power House has a spinning reserve regulation, namely a minimum of 10 MW and a maximum of 14 MW with a running system for each group of generator engines not to exceed the set limit. If the power backup is not made in accordance with the power backup regulations and unwanted things occur, such as a fuel gas trip, this will result in power disruption and even a black out. When using fuel, when the spinning reserve is set below 10 MW, the loss of gas or diesel fuel will be small compared to the spinning reserve which is set above 14 MW. The higher the installed load and the longer the generating machine runs 100% diesel, the higher the diesel fuel consumption will be. If the use of diesel fuel increases, the emissions released by the generating machine will be higher, this will have a negative effect on the environment.

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