Modeling Operations of CCPP Tambak Lorok, Based on Gas Fuel and Investment in CCPP Block 3

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Abstract

To support the company's growth rate which is expected to be faster and more competitive, also to support the company's vision and mission, PT Indonesia Power to support the Block 3 CCPP construction project using the latest technology with the best level of efficiency. At the time of entering the operation period, taking gas fuel for CCPP Tambak Lorok is projected with only 100 BBTUD in accordance with the Letter Minister ESDM no. 34 K / 16 / MEM / 2020, from planned design 173 BBTUD. Currently CCPP Block 3 is the construction phase and commercial operation is planned in 2022. Operations Research (OR) with a mixed integer-linear programming mathematical program is used to determine the optimization of CCPP Block 1, Block 2 and Block 3 Tambak Lorok with maximum benefits, by looking at the investment side of the Block 3 CCPP development. With limited gas availability only 100 BBTUD, the optimum profit can make with the operation of Tambak Lorok Block 3, and only operating Block 2 if any surplus gas and stand by mode for PLTGU Block 1 operating only when Block 3 off.

Keywords
Power Generation, MILP, Operation Optimization, Power Plan Investment.

1. Introduction
To support the company's growth rate which is expected to be faster and more competitive and to support the achievement of the company's vision and mission. The vision of Indonesia Power is "To be the best energy company that grows sustainably" encourages PT Indonesia Power to carry out self-development by building new generators to replace old ones. With the mission of "Providing energy solutions that are reliable, innovative, environmentally friendly, and exceed customer expectations", in 2016 it was decided to initiate a new CCPP construction project called the Block 3 CCPP project and make the CCPP Block 3 Tambak Lorok power plant construction project using the latest technology. Tomlinson and McCullough (1996) that single-shaft CCPP more efficient technology on gas turbine system. Edris (2009) that comparison of configuration of CCPP have plus and minus result for each configuration. Based on this data, analytical study of environment and can reduce the cost of producing electrical energy to satisfy customers of PT Indonesia Power. With the goal of a development project that is in line with the vision and mission of PT Indonesia Power, CCPP Tambak Lorok Block 3 is expected to be able to fulfill all these goals. By initializing the project in 2016, a feasibility study was carried out for this project. The results of the feasibility study conducted state that the power plant construction project is feasible to implement. And in 2018 as a project execution step the construction process for this power plant was carried out.
The operation of CCPP Block 3 with limited gas supply will cause the risk of an increased return on investment due to the lack of operating hours. Or it will cause maintenance burdens on CCPP Block 1 and Block 2 because they are no longer operating because there is no gas fuel supply, which in fact the machines at this CCPP still have economic value to produce profitably.

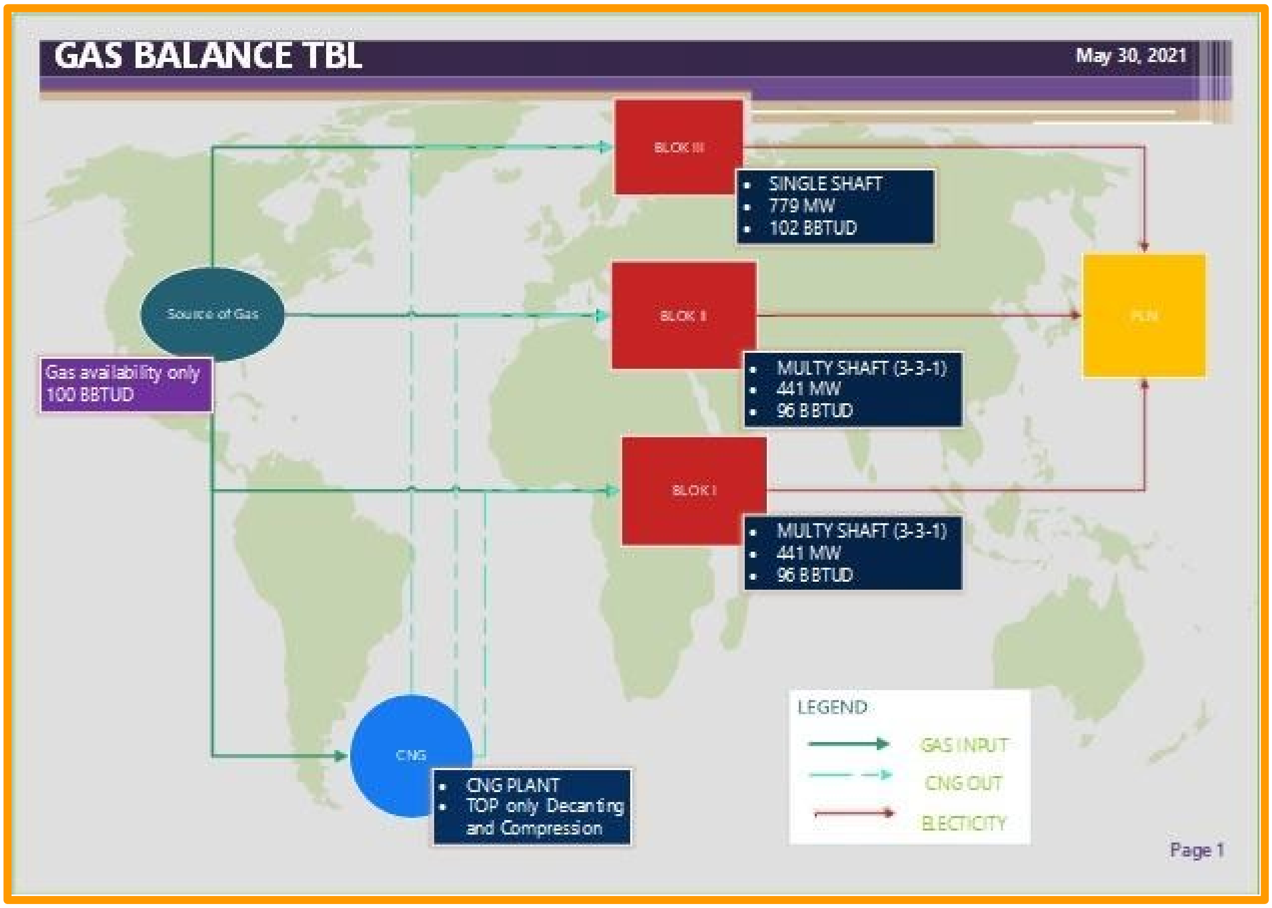

Figure 1. Flow gas consumption at Tambak Lorok

MILP-based methodology (Mixed Integer Linear Programming) has been used to solve the optimization problem of the operation of an equipment or machine (Kong et al. 2010). The application of this method is also shown in the operation of energy machines in steel companies (Liu et al. 2014). Another research that aims to develop a mathematical model to solve the optimization problem of operation on production machines based on Integer Programming has also been carried out (Kong et al. 2010). Based on these studies, the researchers tried to create a mathematical model in completing the optimization of the operation of the Tambak Lorok Block 1, Block 2, and Block 3 PLTGU plants by looking at the availability of gas fuel in Tambak Lorok. The results of this study are expected to be able to make a recommendation for the PLTGU operation pattern in Tambak Lorok to maximize investment returns and company profits.
The objectivity of this research is as follows:

a) Obtain optimal generator operating pattern modeling in Tambak Lorok.
b) Obtain optimal operating patterns to accelerate the pay back periods of CCPP Block 3 investment.
c) Utilize assets in Tambak Lorok as optimally as possible.

2. MILP

Linear Programming is concerned with the optimization (minimization or maximization) of linear functions with the limitations of the available resources. In its development Linear Programming is more interesting than other modeling in terms of computer solutions. This is because when the LP is formulated, computer software can find the most optimal value (Djati et al. 2021). When the formulation requires an integer or binary variable, the modeling changes to MILP (Mixed Integer Linear Programming). The MILP model has been developed from Method for analysis of industrial energy systems (MIND) that has been developed to solve the optimization problem for the iron and steel industry (Djati et al. 2021). The model is implemented in LINGO software. LINGO is a software for solving optimization problems developed by Lindo System, Inc., USA. It is a comprehensive tool designed to make building and solving linear, nonlinear and integer optimization models faster, easier, and more efficient (Rahmawati 2020).

3. Methods Model Development

The modeling in this study is used to determine the operation strategy of the Tambak Lorok CCPP plant by developing a mixed-integer programming model using lingo software with a data approach:

a) Availability of natural gas
b) Cost of production of generators (Fixed or variable costs)
c) The level of reliability and efficiency of the generator
d) Use of the CNG Plant Facility

In making this model, the condition that occurs must be observed is the operation per hour. This is done by dividing the two modeling areas using CNG and without using CNG. If we use CNG, the operating pattern in one day is two operating zones. The one operation zone is the peak load zone which is between 5 pm and 10 pm. Meanwhile, the two-operation zone is a zone where the load of low power requirements is 10 pm to 5 pm. Meanwhile, if we do not use the CNG facility, the time zone we use is one zone. To make mathematical modeling on this problem, in this study using the following notation.

Input Index

i	: variable assigning unit to i
t	: variable timepiece
v	: iterative variable for 1 - 12 to describe Blocks 1 and 2
l	: variable price indicator for Block 1, Block 2 and block 3

Parameter

A, B, C, D	: The cost component of generation
DT	: Installed Power
FC	: Fixed cost which is the calculation of component A.
VC	: Variable cost for calculating.
Q	: The ith generating power at time t
Cq	: The gas consumption of the i-th generator at the t-time
Qmax	: Maximum power of the i-th generator
Qmin	: The minimum power of the i-th generator
Gas	: Minimum gas consumption at time t
PO	: Binary for the operation status of the i-th generator at the t-time

Variables

Qit	: The total of the electrical energy from the i-th generator in the t-hour
POit	: the status of the i-th generator at the t-hour

Table 1. Variable of generators

No	Power Plant Name	Configuration	Variable
1	Gas Turbin 1.1	Open Cycle	*P* 1
	Gas Turbin 1.2	Open Cycle	*P* 2
	Gas Turbin 1.3	Open Cycle	*P* 3
	Combine Cycle 1.1.1	Combine cycle 1 GT, 1 HRSG, 1 ST	*P* 4
	Combine Cycle 2.2.1	Combine cycle 2 GT, 2 HRSG, 1 ST	*P* 5
	Combine Cycle 3.3.1	Combine cycle 3 GT, 3 HRSG, 1 ST	*P* 6
2	Gas Turbin 2.1	Open Cycle	*P* 7
	Gas Turbin 2.2	Open Cycle	*P* 8
	Gas Turbin 2.3	Open Cycle	*P* 9
	Combine Cycle 1.1.1	Combine cycle 1 GT, 1 HRSG, 1 ST	*P* 10
	Combine Cycle 2.2.1	Combine cycle 2 GT, 2 HRSG, 1 ST	*P* 11
	Combine Cycle 3.3.1	Combine cycle 3 GT, 3 HRSG, 1 ST	*P* 12
3	Combine Cycle Power Plant Blok 3	Combine Cycle 1 GT, 1 HRSG, 1 ST Single Shaft	*P* 13
4	CNG Plant		*CNG*

Objective Function:
Maximize Z = (Tariff x Total Production) - (Fixed Cost + Variable Cost + Cost Gas Consumption)

$$Max\ Z = (Tariff \times \sum_{i=1}^{13} \sum_{t=1}^{24} Qit) - \left(\sum FC + \sum VC + \sum GC\right) \qquad (1)$$

There is a constraint also to get an optimum operating cost by modelling the operation strategy of generators. The constraint of this condition is consisting of:

1. Capacity of each generators
   Capacity of all generators have limitation of minimum and maximum load. For the Q is load of generators, Qmin is minimum load, and Qmax is maximum load.
   $$Qmin \leq Qit \leq Qmax \qquad (2)$$
   The other constrain about load of generators must be validated with status of the generators and multiply the output with the big variable there is M with Binary variable. This function also called if logic at mathematics.
   $$Qit \leq POit \times M \qquad (3)$$
2. Formulation of gas consumption of each generators
   For the gas consumption about each generator, we use table 4 equation on linier equation part. In here we must include binary variable for make status 0 is off and 1 is operation.
   $$Linier\ Equation\ Generator \leq M \times POit \qquad (4)$$
   For make sure the status of gas consumption, we make validation formula.
   $$CQit \leq POit \times M \qquad (5)$$
3. Fixed cost formulation
   Fixed cost for power plant is come from investment cost. This cost called as component A and part of tariff component of power plant. For to know total of fixed cost, we must multiply component A with install power capacity and how long we want to know about this cost. Why we multiply with installed power, because this cost come form investment that calculate with performance warranty when install power plant (Hakimah 2016). If component A is "A", Installed Power is "DT" and fixed Cost is FC, the formulation is
   $$FC = Ai \times DTi \times \sum t \qquad (6)$$
4. Variable cost formulation
   Variable Cost at power plant also called Operation and Maintenance cost. At the tariff component variable cost is component B and D. This cost is multiplying with production of power plant (Hakimah 2016). If VC is variable cost, B and D is component B and D, and Qit is production of Generators i at time t,
   $$VC = Qit \times (Bi + Di) \qquad (7)$$
5. Formulation of gas rules
   All gas must be used in accordance with the gas requirements of the plant. Gas consumption must be evenly distributed every hour according to existing regulations. If the gas consumption in the t hour is Gt, the total gas availability in one day is TGD, Total 24 hours during the day, and the gas consumption in the i-th hour is CQit. Then the formulation is
   $$Gt = \frac{TGD}{24} \qquad (8)$$
   $$TGD = \sum_{1}^{13} \sum_{1}^{24} CQ \qquad (9)$$
   If gas cost is GC, and price of gas is PG, the formulation is
   $$GC = PG \times Gt \qquad (10)$$
6. Formulation of CNG
   When we use CNG plant for operation model, we just modify the gas consumption rule. When the zone time low demand that is at 10 pm to 5 pm, the gas consumption must be add to filling CNG Plant. And for high demand time 5 pm to 10 pm, availability of gas must be added the CNG production. For make simple the formulation we notice the zone one, 10 pm to 5 pm, is notice with t=1 to t=19. And for zone two, 5 pm to 10 pm, notice with t=20 to t=24. For fill the CNG plant per hour is SCNG and gas from CNG is CNG, we assumption that CNG must be filling full every use because any added cost with TOP scheme for this CNG plant. the formulation
   $$t \leq 19 : Gt = \left(\frac{TGD}{24}\right) - SCNG \qquad (11)$$
   $$t > 19 : Gt = \left(\frac{TGD}{24}\right) + \left(\frac{CNG}{5}\right) \qquad (12)$$
   If the cost for Gas and CNG is GC, the formulation is
   $$GC = (PG \times Gt) + (PCNG \times CNG) \qquad (13)$$

We are programming this formulation at lingo and divided at 4 steps. Step with CNG and without CNG and for all steps we divided with 24 hours steps for see profit one day, pattern operation of the day, validated the large simulation and 7 years steps for see the pattern of operation at 7 years. Why we use multiple programming this is for make lingo run easier and reduce error from limited device computer and lingo software.

4. Data Collection

Reliability data from CCPP Tambak Lorok Block 1 and Block 2 is obtained from the data from the performance unit test. This data is sufficient to represent the actual operating conditions of the Tambak Lorok Block 1 and Block 2 CCPP units. Then the data collection of the performance test for the Tambak Lorok Block 1 and Block 2 CCPP units uses the *Heat Loss Method*. Heat Loss Method is methods to calculate the efficiency of power plant with operation parameter (Masruri 2016).

Table 2. Performance power plant block 1 and block 2 Tambak Lorok

CCPP Blok	Power Plant Name	Operation Configuration	LOAD Nett (MW)	Minimum Load (%)	NPHR Performance Test			
					Performance Test Report	30 % (kCal/kWh)	80% (kCal/kWh)	100% (kCal/kWh)
1	GT 1.1	Open Cycle	94	30	23-Apr-20	4532,92	3581,11	3353,09
	GT 1.2	Open Cycle	93	30	23-Apr-20	4443,31	3696,89	3469,51
	GT 1.3	Open Cycle	93	30	23-Apr-20	4463,31	3674,57	3449,70
	CC 1.1.1	Combine cycle 1 GT, 1 HRSG, 1 ST	125	NA	23-Apr-20	NA	2667,82	2527,58
	CC 2.2.1	Combine cycle 2 GT, 2 HRSG, 1 ST	279	NA	23-Apr-20	NA	2486,02	2397,81
	CC 3.3.1	Combine cycle 3 GT, 3 HRSG, 1 ST	419	NA	23-Apr-20	NA	2466,07	2320,30
2	GT 2.1	Open Cycle	95	30	23-Apr-20	4401,92	3477,21	3101,64
	GT 2.2	Open Cycle	94	30	23-Apr-20	4343,31	3194,22	3108,13
	GT 2.3	Open Cycle	94	30	23-Apr-20	4363,31	3196,84	3119,53
	CC 1.1.1	Combine cycle 1 GT, 1 HRSG, 1 ST	125	NA	23-Apr-20	NA	2567,82	2498,59
	CC 2.2.1	Combine cycle 2 GT, 2 HRSG, 1 ST	279	NA	23-Apr-20	NA	2376,02	2318,59
	CC 3.3.1	Combine cycle 3 GT, 3 HRSG, 1 ST	411	NA	23-Apr-20	NA	2356,07	2298,59

CCPP Block 3 is currently still in the construction phase. At this stage, the operating data is not yet available. At this stage we have data in the form of operational design data which becomes a performance contract between the contractor and PT Indonesia Power as the Owner in this project. CCPP Block 3 is different configuration with Block 1 and Block 3. Edris (2009) write that we can use calculation of efficiency CCPP multi-shaft to single-shaft efficiency. Based on this we can calculate efficiency of Block 3 with parameter operation on design of this project.

Table 3. Performance power plant block 3 Tambak Lorok

No	**Power Plant**	**Gas Parameter**		**NPHR**	
		Gas consumption	**Load**	**Unit**	
		BBTUh	**MWh**	**BTU/MWh**	**kcal/kwh**
1	PLTGU Block 3	4,28	779	5497,20	1,386

From the reliability data of CCPP Block 1, Block 2 and Block 3, we can take a graph of the equation to obtain a mathematical model of the relationship between fuel consumption and power generated by each generator. From the available data, we can find that the relationship between these two parameters is uniform in the CCPP-style power plant. The fuel relationship equation table according to the data and our linear approach is shown in the Table 4.

Table 3. Equation gas consumption

CCPP Blok	**Generator Name**	**The equation of the load function (x) on gas fuel consumption (y) is based on operating data**	**The equation of the load function (x) on gas fuel consumption (y) is based on a Linear Approach**
1	GT 1.1	$y = -0{,}0343x^2 + 15{,}493x + 97{,}649$	$y = 11{,}3x + 188{,}62$
	GT 1.2	$y = -0{,}042x^2 + 17{,}19x + 45{,}038$	$y = 12{,}112x + 154{,}02$
	GT 1.3	$y = -0{,}0397x^2 + 16{,}764x + 57{,}336$	$y = 11{,}966x + 160{,}32$
	CC 1.1.1	$y = 7{,}8042x + 278{,}26$	$y = 7{,}8042x + 278{,}26$
	CC 2.2.1	$y = 8{,}1151x + 390{,}65$	$y = 8{,}1151x + 390{,}65$
	CC 3.3.1	$y = 6{,}8938x + 969{,}5$	$y = 6{,}8938x + 969{,}5$
2	GT 2.1	$y = -0{,}0821x^2 + 20{,}389x - 26{,}532$	$y = 10{,}097x + 210{,}08$
	GT 2.2	$y = 0{,}0156x^2 + 8{,}3264x + 238{,}87$	$y = 10{,}233x + 197{,}46$
	GT 2.3	$y = 0{,}0189x^2 + 7{,}9548x + 248{,}93$	$y = 10{,}264x + 198{,}84$
	CC 1.1.1	$y = 8{,}8163x + 137{,}36$	$y = 8{,}8163x + 137{,}36$
	CC 2.2.1	$y = 8{,}2893x + 254{,}34$	$y = 8{,}2893x + 254{,}34$
	CC 3.3.1	$y = 8{,}2091x + 374{,}99$	$y = 8{,}2091x + 374{,}99$
3	TBL Blok III	$y = 0{,}0008x^2 + 4{,}0615x + 615{,}35$	$y = 5{,}0069x + 370{,}08$

From the above comparisons, we perform some validation of the above mathematical model by taking several comparative values for equations from the table above, and we present them in the Table 5.

Table 5. Data validation for the linear approach

CCPP Blok	Power Plant Name	60% Load			Error	85% Load			Error	95% Load			Error
		Load	Gas Consumption Based on Operation Data	Gas Consumption Based on Linier Approach		Load	Gas Consumption Based on Operation Data	Gas Consumption Based on Linier Approach		Load	Gas Consumption Based on Operation Data	Gas Consumption Based on Linier Approach	
		MW	MMBTUh	MMBTUh		MW	MMBTUh	MMBTUh		MW	MMBTUh	MMBTUh	
1	GT 1.1	56,4	862,347272	825,94	4,22%	79,9	1116,568157	1091,49	2,2%	89,3	1207,648893	1197,71	0,8%
	GT 1.2	55,8	873,46712	829,8696	4,99%	79,05	1141,453595	1111,4736	2,6%	88,35	1235,934155	1224,1152	1,0%
	GT 1.3	55,8	869,155692	828,0228	4,73%	79,05	1134,448771	1106,2323	2,5%	88,35	1228,548217	1217,5161	0,9%
	CC 1.1.1	75	863,575	863,575	0,00%	106,3	1107,45625	1107,45625	0,0%	118,75	1205,00875	1205,00875	0,0%
	CC 2.2.1	167,4	1749,11774	1749,11774	0,00%	237,2	2315,145965	2315,145965	0,0%	265,05	2541,557255	2541,557255	0,0%
	CC 3.3.1	251,4	2702,60132	2702,60132	0,00%	356,2	3424,72687	3424,72687	0,0%	398,05	3713,57709	3713,57709	0,0%
2	GT 2.1	57	868,8981	785,609	9,59%	80,75	1084,541569	1025,41275	5,5%	90,25	1144,865619	1121,33425	2,1%
	GT 2.2	56,4	758,000416	774,6012	2,19%	79,9	1003,596096	1015,0767	1,1%	89,3	1106,658824	1111,2669	0,4%
	GT 2.3	56,4	757,700864	777,7296	2,64%	79,9	1005,176309	1018,9336	1,4%	89,3	1110,011501	1115,4152	0,5%
	CC 1.1.1	75	798,5825	798,5825	0,00%	106,3	1074,091875	1074,091875	0,0%	118,75	1184,295625	1184,295625	0,0%
	CC 2.2.1	167,4	1641,96882	1641,96882	0,00%	237,2	2220,147495	2220,147495	0,0%	265,05	2451,418965	2451,418965	0,0%
	CC 3.3.1	246,6	2399,35406	2399,35406	0,00%	349,4	3242,839085	3242,839085	0,0%	390,45	3580,233095	3580,233095	0,0%
3	Blok III	467,4	2688,465308	2710,30506	0,81%	662,2	3655,426323	3685,398835	0,8%	740,05	4059,202277	4075,436345	0,4%

From the results of these comparisons, it is known that there is a difference between the linear approach and the operating data. With the difference value below 10% and only occurs at the mid load value, with the R value on the graph close to 1 and seeing the purpose of this modeling is to find the value of profit optimization which focuses on global operations, the approach is can still represent linearly to be used in Linear Programming (Ahmadyaningrat et al. 2018).

5. Results and Discussion

5.1 Numerical Results

The results of this research we get are the operating patterns of CCPP Block 1, Block 2 and Block 3 with the availability of existing gas and utilization of CNG facilities. In addition to this operating pattern, we also get the value of profit per day to year with the assumptions in Table 6.

Table 6. Assumption for input value at programming

Assumption	Block 3	Block 1&2
Tariff	Rp 1.444,00	Rp 1.444,00
Gas Cost	7 USD/mmBTU	7 USD/mmBTU
Component A (Rp/Kwh)	271	181,15
Component B (Rp/Kwh)	30	74,96
Component D (Rp/Kwh)	48	1,75
Intalled Capacity (KW)	779000	830000
Duration when maintenance	3 bln	1 bln

The results of the first modeling we get the operation pattern of Tambak Lorok Block 1, Block 2 and Block 3 without using CNG in 24 hours at Table 7.

Table 7. Result 24 hours without CNG

Gas	Block 1	Block 2	Block 3
BBTUD	MW	MW	MW
100	0	0	771
150	0	223	765

And if the Tambak Lorok plant operates using the CNG plan facility, the pattern obtained is at Table 8.

Table 8. Result 24 hours with CNG

Gas	Block 1		Block 2		Block 3	
BBTUD	Zone time 1 (MW)	Zone time 2 (MW)	Zone time 1 (MW)	Zone time 2 (MW)	Zone time 1 (MW)	Zone time 2 (MW)
100	0	0	0	408	570	779
150	0	336	0	223	779	779

The third result we get is the plant operation pattern within seven years by looking at the maintenance data of each plant. By operating without CNG, the Block 3 plant will experience one maintenance period according to the factory's recommendation, which is 32,000 operating hours. When Block 3 is undergoing maintenance, the Block 1 and 2 generators are fully operational. Meanwhile Block 1 did not undergo any maintenance period and Block 2 underwent one major maintenance period.

The fourth result is using CNG, so Block 3 only experiences major maintenance once, Block 2 has one major maintenance time and Block 1 must be maintained after the gas is back at 100 BBTUD. In the operation pattern, there is no significant difference in the 24-hour operation simulation and the long-term operation pattern, which is seven years, but we know and can plan scheduled maintenance of each plant.

From the four results that have been mentioned, we can calculate the profit value of each of the operating patterns obtained. We can see the profit yield data in the following Table 9.

Table 9. Profit operation without CNG plant

Years Operation	Gas Volume	Profit (Billion Rupiah)
2022	100 BBTUD	2,31
2023	100 BBTUD	2,31
2024	100 BBTUD	2,31
2025	150 BBTUD	2,15
2026	150 BBTUD	3,05
2027	150 BBTUD	3,07
2028	100 BBTUD	2,31

In 2025, when it operates with 150 BBTUD gas fuel, there will be a decrease in profit because Block 3 is undergoing maintenance for three months. The same thing happens to the advantages when using CNG at Table 10.

Table 10. Profit operation with CNG plant

Years Operation	Gas Volume	Profit (Billion Rupiah)
2022	100 BBTUD	0,90
2023	100 BBTUD	0,90
2024	100 BBTUD	0,90
2025	150 BBTUD	1,36
2026	150 BBTUD	2,47
2027	150 BBTUD	2,33
2028	100 BBTUD	0,90

From the modeling results and the benefits obtained, we can analyze the role of the CCPP Block 3 development project. Based on the assumptions we input and the results from maximizing the profits we have done; we get two economic analyzes from the Tambak Lorok Block 3 Project with the additional assumption of the project value. CCPP Block 3 is IDR 7,29 trillion.

Table 11. Economics analysis if block 3 operation without CNG

Asummption									
		2021	2022	2023	2024	2025	2026	2027	2028
Investment		-7,29							
Project Cash Flows			2,31	2,31	2,31	2,15	3,05	3,07	2,31
Total Cash Flows		-7,29	2,31	2,31	2,31	2,15	3,05	3,07	2,31
Discount Rate		6,1%							
Calculation									
Timeline		2021	2022	2023	2024	2025	2026	2027	2028
Year		0	1	2	3	4	5	6	7
Discount Factor		1,00	0,94	0,89	0,84	0,79	0,74	0,70	0,66
Discounted Cash Flows		-7,29	2,18	2,05	1,94	1,70	2,27	2,15	1,53
Net Present Value									
NPV 1st way	**7**								
NPV 2nd way	**7**								
Internal Rate of Return									
IRR	**27,1%**								
Payback Period									
Cumulative Cash Flows		-7	-5	-3	0	2	5	8	10
Payback Flag		0	0	0	0	1	0	0	0
Payback Calculation		0	0	0	0	3,16	0	0	0
Payback Period (Years)	**3,16**								

Table 12. Economics analysis if block 3 operation with CNG

Assumption									
		2021	2022	2023	2024	2025	2026	2027	2028
Investment		-7,29							
Project Cash Flows			0,90	0,90	0,90	1,36	2,47	2,33	0,90
Total Cash Flows		-7,29	0,90	0,90	0,90	1,36	2,47	2,33	0,90
Discount Rate		6,1%							
Calculation									
Timeline		2021	2022	2023	2024	2025	2026	2027	2028
Year		0	1	2	3	4	5	6	7
Discount Factor		1,00	0,94	0,89	0,84	0,79	0,74	0,70	0,66
Discounted Cash Flows		-7,29	0,85	0,80	0,76	1,07	1,83	1,63	0,60
Net Present Value									
NPV 1st way	**0**								
NPV 2nd way	**0**								
Internal Rate of Return									
IRR	**7,0%**								
Payback Period									
Cumulative Cash Flows		-7	-6	-5	-5	-3	-1	2	2
Payback Flag		0	0	0	0	0	0	1	0
Payback Calculation		0	0	0	0	0	0	5,32	0
Payback Period (Years)	**5,32**								

From table 11 we can see that with limited gas fuel, with optimization using MILP it is found that the Pay Back Periods can be achieved at 3.16 years after operating. While table 12 shows that the use of assets in the form of a CNG plant can affect the income. However, with the modeling carried out, it was found that the optimal utilization of the CNG plant can still reach a Pay Back Period of 5.32 years.

5.2 Graphical Results

Operation with CNG will be lost profit then operation without CNG plant. This is because not any different tariff on time zone 1 and zone 2. So, if we use the CNG plan we only add cost for gas consumption. On the other hand, CNG can be used to absorb the remaining gas in time zone one and used in time zone two. This is in line with the electricity production of CCPP Tambak Lorok, that electricity production must be balanced with the load demand (Kautsar et al. 2017).

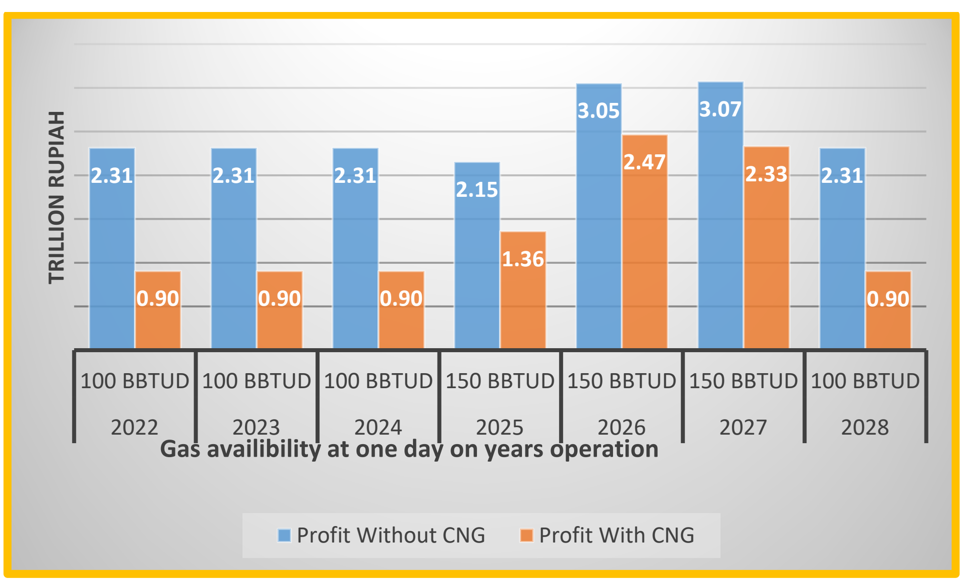

Figure 2. Profit operation Tambak Lorok CCPP in every one-year operation

5.3 Proposed Improvements
For future improvements, the assumption value of this study must be close to the value in the field with the smallest possible error value.

5.4 Validation
In this study, using many assumptions that have an influence on the decision making of the model created. Modeling is made with an objective function in the form of maximizing profits with fixed variables. In fact, variables such as tariffs, prices for components A, B, C, D are dynamic (Febrian et al. 2018). In this simulation experiment, we conducted several experiments by changing the tariff value and it was found that the tariff value was very influential in determining profits and losses. For components A, B, C, and D, if we change the value according to the portion of each generator, this does not show a significant change to the modeling results. Because components A, B, C, D have been studied to determine and the values rarely shift when the power generating unit is operational phase (Ismail and Supriono 2013). The biggest shift of components A, B, C, D is in component C where fuel prices tend to be dynamic (Hakimah 2016). To solve this problem, for improvement in future research, using optimization to predict the value of tariffs, fuel prices and bank interest during the research period will produce a more precise simulation output, when the output predictions are used as input for the modeling that has been made.

6. Conclusion
In the optimization study, the optimization of the Tambak Lorok plant has been carried out based on the results of the sequence of operating patterns that must be run. With limited availability of gas, we get the optimal operating pattern to generate maximum profit. This modeling results in a priority order of operations, that is Tambak Lorok Block 3, Block 2 and then Block 1. This priority order becomes the basis for the distribution of gas fuel to achieve maximum profit. The optimization results from this operating pattern can accelerate the achievement of BEP (Break Event Point) from the investment in the construction of the Tambak Lorok PLTGU Block 3, from 12 years of BEP according to the feasibility study to 3.16 years from the optimization results. Utilization of CNG assets will result in lower income. With the optimization carried out, CNG can still be utilized and does not interfere with the investment value in the Block 3 PLGU Project.

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Biography

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