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Analysis of Capacitor Bank Power Factor Leads to Zero kVAR Cost for PLN UP3 Pekalongan Customer

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ABSTRACT

PT Ronny Aquario Perkasa had over consumption of reactive power (kVArh) issue's in 2018, which resulted IDR 301.702.15,00 fine to PT PLN. This kVArh fine is caused by power factor below 0.85. As follow up, the company was suggested to install capacitor bank and later on showed reduction on the electrical bill. This research shows how to calculate power factor and chose the right capacity of capacitor bank to improve power factor which leads to zero kVArh Cost. This research also provides cash flow and revenue calculation that reflects capacitor benefit from financial perspective, including the feasibility of the investment analysis as a consideration for by PT Ronny Aquario Perkasa or any other PLN Customer before implementing capacitor bank.

Key words: Capacitor Bank, Reactive Power

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1. INTRODUCTION

PT PT Ronny Aquario Perkasa was fined IDR 301.702.151,00 by PT PLN, from the electrical bill, it shows that this fine caused by power factor below 0.85. Indonesian government sets the selling price of electricity based on the Minister of Energy and Mineral Resources (Energy & Mineral Resources) Regulation no. 28 of 2016 which applies to all electricity user managed by the State Electricity Company (PLN). Large-scale customers such as Industrial, Business, Government, and Social tariff groups are given a limit on reactive power usage. If the reactive power usage exceeds 62% of the active power, or cos Q $\leq$ 0.85 inductive, then the excess reactive power is charged to the consumer.

Reactive power is unused power that is developed by reactive components in an AC circuit or systems. The reactive power that is produced mostly is inductive reactive power. Inductive reactive power which produced by PLN customers, collectively can damage PLN equipment. The inductive reactive power of an electrical equipment cannot be eliminated, but it can be compensated by installing electrical equipment that has a capacitive reactive power which resulted in a less reactive power resultant. This electrical equipment is known as the Capacitor Bank.

Capacitor bank improve voltage value, voltage setting, and improve power factor. The ability of capacitor bank in improving power factor is by absorbing load reactive power. Therefore, to improve PT Ronny Aquario Perkasa power factor, it was suggested to install capacitor bank.

This research analysis uses ETAP 16.0, by incorporating data that is collected from PT Rony Aquario Perkasa. ETAP simulation produce single-line diagram, measurement data, and load flow report. Power factor is obtained from measurement data which later on used to determine the selection of capacitor bank capacity.

Capacitor bank installation may not be resulted of cost reduction in overall. There are additional items what need to be considered before implementation. They are procurement, installation cost of the capacitor bank itself, and maintenance cost post installation. Therefore, another calculation is required to see if the investment of capacitor bank is worth to the business. This calculation involves Net Present Value (NPV), Accounting Rate of Return (ARR), Payback Period (PP), and Internal Rate of Return (IRR) method. This research also provides revenue and cash flow calculation as part of capacitor installation benefit for PT Rony Aquario Perkasa.

2. RESEARCH METHODOLOGY

2.1 Research Scope

Equipment Inventory, total Installed power, maintenance personnel cost, and system drawing are obtained from PT Ronny Aquario Perkasa

Table -1 Equipment Inventory and Total Installed Power

No.	Area	Load	Total	Power (W)	Total Power (W)
1	Gerage	AC/DC National Electric Weld	1	10	10
		Mc Frais	1	4	4
		Mc Schraff	1	5.1	5.1
		Fan Wall	2	1	2
		Lighting	1	22	22
2	Well	Water Pump	1	6.6	6.6
		Groundfost boor well pump	2	2.2	4.4
		Fan & Lighting	1	34	34
3	Office	Assano Friction Testing Machine	1	1.5	1.5
		Labor Mixer Machine	1	2.2	2.2
		Assano Single Strength Machine	1	400	400
		Computer PC	1	700	700
		Split Air cond	2	400	800
		Heater	1	250	250
		Kohesen Tester	1	250	250
		Lighting	1	2	2
4	Jaw Crusher	Motor	1	132	132
5	Vibrating Feeder	Grizzly Vibrating Feeder	1	22	22
		GZG VibratingFeeder	2	3	6
6	Cone Crusher	Motor Power	2	160	320
7	Belt Conveyor	Belt Conveyor 1	1	4	4
		Belt Conveyor 2	1	22	22
		Belt Conveyor 3	1	22	22
		Belt Conveyor 4	1	11	11
		Belt Conveyor 5	1	30	30
		Belt Conveyor 6	1	24	24
		Belt Conveyor 7	1	19	19
		Belt Conveyor 8	2	20.5	41
8	Vibrating Screen	Motor	2	30	60
		Total			**809.2**

From the eight load areas at PT Ronny Aquario Perkasa, the total installed power of all areas is 809,200 W.

Table -2 Maintenance Personnel Cost

Year	Employee salary		Damage Costs	Amount of capital
	Person	Rupiah		
2018	1	Rp 62.400.000	Rp 10.141.533	Rp 72.541.533

2.2. PT PLN (Persero)

Electrical Bill data, procurement and installation cost of capacitor bank, and material replacement cost are obtained from PT PLN Standard Material Price.

Electrical bill Month of July 2017 until September 2020 from PT. PLN on September 23rd, 2020

Table -3 Monthly Electrical Bill PT Rony Aquario Perkasa

No.	Month	Power (VA)	Previous Power Consumption (kVARh)	Current Power Consumption (kVARh)	kVARh Bill (IDR)
1	Sep-20	690000	1020.91	1041.55	0
2	Aug-20	690000	998.29	1020.91	0
3	Jul-20	690000	984.39	998.29	0
4	Jun-20	690000	973.07	984.39	0
5	May-20	690000	956.1	973.07	0

6	Apr-20	690000	930.03	956.1	0
7	Mar-20	690000	901.44	930.03	0
8	Feb-20	690000	884.46	901.44	0
9	Jan-20	690000	874.81	884.46	0
10	Dec-19	690000	867.93	874.81	0
11	Nov-19	690000	852.8	867.93	0
12	Oct-19	690000	844.29	852.8	0
13	Sep-19	690000	839.48	844.29	0
14	Aug-19	690000	833.24	839.48	0
15	Jul-19	690000	829.46	833.24	0
16	Jun-19	690000	819.05	829.46	0
17	May-19	690000	802.2	819.05	0
18	Apr-19	690000	764.48	802.2	0
19	Mar-19	690000	739.36	764.48	0
20	Feb-19	690000	715.63	739.36	0
21	Jan-19	690000	696.18	715.63	0
22	Dec-18	690000	678.87	696.18	0
23	Nov-18	690000	659.96	678.87	0
24	Oct-18	690000	643.73	659.96	0
25	Sep-18	690000	625.89	643.73	0
26	Aug-18	690000	604.88	625.89	0
27	Jul-18	690000	594.78	604.88	0
28	Jun-18	690000	562.93	594.78	11,993,488
29	May-18	690000	523.12	562.93	22,813,154
30	Apr-18	690000	474.37	523.12	26,693,564
31	Mar-18	690000	435.02	474.37	23,956,877
32	Feb-18	690000	400.95	435.02	21,392,975
33	Jan-18	690000	363.07	400.95	23,707,176
34	Dec-17	690000	320.24	363.07	26,490,681
35	Nov-17	690000	275.45	320.24	28,304,363
36	Oct-17	690000	233.32	275.45	26,673,499
37	Sep-17	690000	180.57	233.32	33,258,268
38	Aug-17	690000	131.96	180.57	30,715,546
39	Jul-17	690000	90.59	131.96	25,702,560
Total Bill					**301,702,151**

Procurement and installation cost of capacitor bank is about IDR 240,000,000, with capacitor lifetime is 10 years. This data is for capacitor bank with 700 kVAr capacity.

Table -4 Annual Material Replacement Cost

Year	**Annual Material Replacement**						
	Kapasitor		**Contactor**		**MCCB**		**Total Cost (Rupiah)**
	Vol	**Rupiah**	**Vol**	**Rupiah**	**Vol**	**Rupiah**	
2018	0,3	9.530.058	0,5	402.679	0,25	208.796	10.141.533

2.3 Data Collection Techniques

Calculation Power Factor Using ETAP 16.0

ETAP PowerStation 16.0 is an application that widely used to simulate electric power systems. In this research, ETAP 16.0 is used to perform CosQ1 calculation which later on will be used to determine which capacitor bank should be installed. ETAP also produce measurement data which is the power factor and also single-line diagram. Table 1 data is entered into ETAP to get power factor calculation. Below are steps to calculate the power factor using ETAP 16.0:

a. Draw a load plan
b. Enter total load power
c. Design single line diagram
d. Calculate the load flow (load flow report)
e. Do simulation using several alternatives of load power or the network used.

2.4 Investment Feasibility Analysis Tools

Investment feasibility analysis is done using customized tools that is set to process quantitative data from section 2.2. The result of the investment feasibility analysis is used as basis indecision making for future business expansion. Investment feasibility analysis tools consist of below formula that is set in the Microsoft Excel using macros:

a. Forecast Earnings After Tax (additional revenue)
b. Accounting Rate of Return (ARR)

$$ARR = \frac{(Net\ Income\ Per\ Year)}{(Investment\ Cost)}\ x100\%$$

c. Payback Period (PP)

$$PP = n + \frac{total\ cash\ flow\ the\ first\ n\ year}{cash\ flow\ year\ n+1}\ x\ 1\ year$$

n = estimated period of capital return

d. Internal Rate of Return (IRR)

$$IRR = rk + \frac{NPVrk}{NPVrk - NPVrb} x(rb - rk)$$

rk = 25%
rb = 30%
NPV rk = IDR 52,525,085.09
NPV rk = - IDR 73,379,120,58

e. Net Present Value (NPV)

$$NPV = -Initial\ investment\ cost + \sum_{t=1}^{life\ time} \frac{Cash\ Flow\ t}{(1 + return\ percentage)^t}$$

t = year (1, 2, 3…)

2.5 Research Variable

There are 2 types of research variable. The first one is obtained from PT Rony AquarioPerkasa for ETAP 16.0 calculation. Below are variables:

1. Cable variable of installed system on customer premises: approximate installed underground cable length, type and size. This variable is used to produce single-line diagram.
2. Equipment installed power. This variable is used to get measurement data.

The second variable is used in feasibility investment study to determine the advantages and feasibility investment of capacitor bank. Other than calculation of power factor that will determine which is the most suitable capacitor bank to be chosen, below are some cost variable that is used in this research:

1. kVARh monthly bill. This variable is used to get load flow report.
2. Capacitor bank price and Installation cost
3. Maintenance cost post installation
   a. Consumable part
   b. Maintenance costs for bank capacitors
4. Feasibility investment analysis
   a. Net Present Value (NPV)
   b. Accounting Rate of Return (ARR)
   c. Payback Period (PP)
   d. Internal Rate of Return (IRR)

3. RESULT AND DISCUSSION

3.1 Single-line Diagram

Single-line diagram as a result from ETAP 16.0 calculation is used to determined installation location of capacitor bank. It will determine capacitor bank set up, either in serial or parallel.

The following is a single line diagram from PT Ronny Aquario Perkasa:

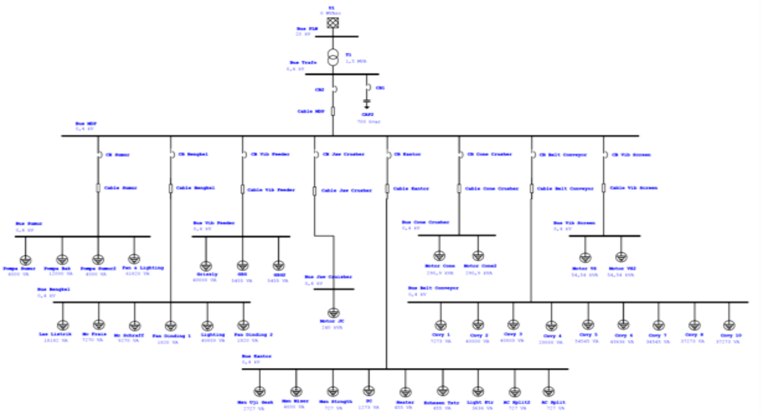

Fig. 1 Single line diagram of PT Ronny Aquario Perkasa

3.2 Measurement Data and Capacitor Bank Selection

The following table is measurement data from ETAP calculation based on data PT Ronny Aquario Perkasa total installed power (Table 2). The result shows that the power factor is 0.58.

Table -5 Measurement results at PT Ronny Aquario Perkasa

Item	Phase R	Phase S	Phase T	Total
Voltage (V)	57.10	57.40	57.40	
Voltage Angle	0.00	-119.70	119.60	
Voltage Angle Conversion	0.00	240.20	119.60	
Current (A)	1.50	1.70	1.60	
Current Angle	-52.60	-170.90	62.60	
Current Angle Conversion	-52.60	-51.20	-56.90	
Power Factor	0.00	0.00	0.00	-0.58
Active Power (kW)	54.50	62.00	51.50	172.30
Active Power Dir				
Reactive Power (kVAr)	71.40	77.30	79.20	226.70
Reactive Power Dir				
Apparent Power (kVA)	89.90	99.20	94.50	283.40

Base on the fact that the power factor is below0.85, PT Ronny Aquario Perkasa needs to install capacitor bank. Below is the calculation of capacitor bank capacity selection to ensure the power factor above 0.85.

$Ptotal$ = 809,2 kW

$PF\,Initial$ = 0,58

$PF\,Opposite$= 0,85

$Qc = P[tan(cos^{-1}(PF\,Initial)) - tan(cos^{-1}(PF < opposite))]$

$Qc = 809{,}2\ x[tan(cos^{-1}(0{,}58)) - tan(cos^{-1}(0{,}85))]$

$Qc = 809{,}2\ kW x\ [tan(54{,}55) - tan(31{,}79)]$

$Qc = 809{,}2\ kW x(\ 1{,}4 - 0{,}62)$

$Qc = 809{,}2\ kW x\ 0{,}78$

$Qc = 631{,}2\ kVAr$

Based on power factor improvement calculation result from 0.58 to 0.85, the power required by the capacitor bank is 631.2 kVAr. However, in the capacitor bank design process which is 631.2kVAr is not available in the market. Therefore, in bank capacitors design process, the selected bank capacitor capacity is 700kVAr.

3.3. Power Factor Calculation Scenario using ETAP

Power factor from ETAP calculation is presented in the form of load flow report. Previously, PT Rony Aquario Perkasa worked on its 25% of overall load (without the capacitor bank) with the power factor is 0.58. At this section, this research will show power factor is improved post installation of capacitor bank at the same load, even if the load is increase up to 100% using the same capacitor bank capacity, the power factor is still above 0.85, which ideally, if the load is increased, the company will need more capacitor bank capacity. Below are two scenarios to calculate power factor using ETAP post capacitor bank installation.

3.3.1 Scenario 25% Equipment Load

By using 700 kVAr capacitor bank and 25% load enter into ETAP simulation, the resulting power factor is 0.98.

Table -6 load flow report 25% load condition

Bus	Voltage			Generation		Load		Load Flow				
ID	kV	% Mag.	Ang.	MW	Mvar	MW	Mvar	ID	MW	Mvar	Amp	%PF
* 1 Bus PLN	20.000	102.750	0.0	0.204	0.042	0	0	2 Bus Trafo	0.204	0.042	5.8	98.0
2 Bus Trafo	0.400	99.926	-0.4	0	0	0.000	-0.245	3 Bus MDP	0.203	0.285	505.9	58.1
								1 Bus PLN	-0.203	-0.041	299.5	98.1
3 Bus MDP	0.400	99.517	-0.3	0	0	0	0	Bus Belt Conveyor	0.043	0.061	108.0	58.0
								Bus Bengkel	0.011	0.015	26.8	58.1
								Bus Cone Crusher	0.080	0.113	200.4	58.0
								Bus Jaw Cruisher	0.033	0.046	82.6	58.0
								Bus Kantor	0.002	0.003	5.0	58.2
								2 Bus Trafo	-0.202	-0.284	505.9	58.0
								Bus Sumur	0.011	0.016	28.0	58.1
								Bus Vib Feeder	0.007	0.010	17.5	58.1
								Bus Vib Screen	0.015	0.021	37.5	58.1
Bus Belt Conveyor	0.400	99.421	-0.3	0	0	0.043	0.061	3 Bus MDP	-0.043	-0.061	108.0	58.0
Bus Bengkel	0.400	99.439	-0.3	0	0	0.011	0.015	3 Bus MDP	-0.011	-0.015	26.8	58.0
Bus Cone Crusher	0.400	99.355	-0.3	0	0	0.080	0.112	3 Bus MDP	-0.080	-0.112	200.4	58.0
Bus Jaw Cruisher	0.400	99.436	-0.3	0	0	0.033	0.046	3 Bus MDP	-0.033	-0.046	82.6	58.0
Bus Kantor	0.400	99.371	-0.2	0	0	0.002	0.003	3 Bus MDP	-0.002	-0.003	5.0	58.0
Bus Sumur	0.400	99.412	-0.3	0	0	0.011	0.016	3 Bus MDP	-0.011	-0.016	28.0	58.0
Bus Vib Feeder	0.400	99.383	-0.2	0	0	0.007	0.010	3 Bus MDP	-0.007	-0.010	17.5	58.0
Bus Vib Screen	0.400	99.436	-0.3	0	0	0.015	0.021	3 Bus MDP	-0.015	-0.021	37.5	58.0

3.3.2 Scenario 100% Equipment Load

By using 700 kVAr capacitor bank and 25% load enter into ETAP simulation, the resulting power factor is 0.869.

Table -7 load flow report 100% load condition

Bus	Voltage			Generation		Load		Load Flow				
ID	kV	% Mag.	Ang.	MW	Mvar	MW	Mvar	ID	MW	Mvar	Amp	%PF
* 1 Bus PLN	20.000	102.750	0.0	0.836	0.475	0	0	2 Bus Trafo	0.836	0.475	27.0	86.9
2 Bus Trafo	0.400	100.546	-1.2	0	0	0.000	-0.708	3 Bus MDP	0.828	1.155	2039.7	58.2
								1 Bus PLN	-0.828	-0.447	1350.4	88.0
3 Bus MDP	0.400	98.898	-1.2	0	0	0	0	Bus Belt Conveyor	0.173	0.242	434.5	58.1
								Bus Bengkel	0.043	0.060	106.9	58.3
								Bus Cone Crusher	0.322	0.452	810.7	58.0
								Bus Jaw Cruisher	0.133	0.186	333.3	58.1
								Bus Kantor	0.008	0.011	20.2	58.6
								2 Bus Trafo	-0.812	-1.137	2039.7	58.1
								Bus Sumur	0.045	0.062	112.3	58.4
								Bus Vib Feeder	0.028	0.039	70.4	58.5
								Bus Vib Screen	0.060	0.084	151.5	58.2
Bus Belt Conveyor	0.400	98.510	-1.1	0	0	0.172	0.242	3 Bus MDP	-0.172	-0.242	434.5	58.0
Bus Bengkel	0.400	98.587	-1.0	0	0	0.042	0.060	3 Bus MDP	-0.042	-0.060	106.9	58.0
Bus Cone Crusher	0.400	98.243	-1.1	0	0	0.320	0.450	3 Bus MDP	-0.320	-0.450	810.7	58.0
Bus Jaw Cruisher	0.400	98.571	-1.1	0	0	0.132	0.185	3 Bus MDP	-0.132	-0.185	333.3	58.0
Bus Kantor	0.400	98.311	-0.7	0	0	0.008	0.011	3 Bus MDP	-0.008	-0.011	20.2	58.0
Bus Sumur	0.400	98.476	-0.9	0	0	0.044	0.062	3 Bus MDP	-0.044	-0.062	112.3	58.0
Bus Vib Feeder	0.400	98.358	-0.8	0	0	0.028	0.039	3 Bus MDP	-0.028	-0.039	70.4	58.0
Bus Vib Screen	0.400	98.570	-1.0	0	0	0.060	0.084	3 Bus MDP	-0.060	-0.084	151.5	58.0

3.4. Capacitor Bank EconomicValue

Initial cost in capacitor banks investment consist of costs for purchasing and installing bank capacitors as well as costs for maintaining bank capacitors themselves and consumable parts.

From section 2, procurement and installation cost of capacitor bank with 700 kVAr capacity is about IDR 240.000.000,00

The following is consumable part costs (Material replacement caused by damaged) for 700 kVArcapasitor bank capacity within 10 years with the assumption of prices of goods and services increase 5% per year.

Table -8 Consumable Part

Year	Annual Material Replacement						
	Kapasitor		Contactor		MCCB		Jumlah Rupiah
	Vol	Rupiah	Vol	Rupiah	Vol	Rupiah	
2018	0,3	9.530.058	0,5	402.679	0,25	208.796	10.141.533
2019	0,3	10.006.561	0,5	422.812	0,25	219.236	10.648.610
2020	0,3	10.506.889	0,5	443.953	0,25	230.198	11.181.040
2021	0,3	11.032.234	0,5	466.151	0,25	241.708	11.740.092
2022	0,3	11.583.845	0,5	489.458	0,25	253.793	12.327.097
2023	0,3	12.163.038	0,5	513.931	0,25	266.483	12.943.452
2024	0,3	12.771.189	0,5	539.628	0,25	279.807	13.590.624
2025	0,3	13.409.749	0,5	566.609	0,25	293.797	14.270.155
2026	0,3	14.080.236	0,5	594.940	0,25	308.487	14.983.663
2027	0,3	14.784.248	0,5	624.687	0,25	323.912	15.732.846
Total							127.559.112

Note: Assuming 5% price increase of goods & services per year

The bank capacitor that has been installed requires maintenance costs to maintain its reliability. The bank capacitors maintenance cost (personnel and spare part / consumable part) within 10 year can be found in the following table with assumption price of goods and services increase 5% per year.

Table -9 Maintenance costs for bank capacitors

Year	Employee salary		Consumable Costs (IDR)	Amount of capital (IDR)
	Person	IDR		
2018	1	62.400.000	10.141.533	72.541.533
2019	1	65.520.000	10.648.610	76.168.610
2020	1	68.796.000	11.181.040	79.977.040
2021	1	72.235.800	11.740.092	83.975.892
2022	1	75.847.590	12.327.097	88.174.687
2023	1	79.639.970	12.943.452	92.583.421
2024	1	83.621.968	13.590.624	97.212.592
2025	1	87.803.066	14.270.155	102.073.222
2026	1	92.193.220	14.983.663	107.176.883
2027	1	96.802.881	15.732.846	112.535.727
Total				912.419.607

Note: Assuming 5% price increase of goods & services per year

The total costs incurred for the capacitor bank components maintenance is IDR 784,860,494 for 10 years period. If the damaged capacitor bank components replacement being added, the total maintenance cost is IDR 912,419,607, - within 10years.

Based on above calculation, it can be calculated initial investment cost is Rp. 1.152.419.607,00

3.4 Etap 16.0 Load FlowSimulation

3.4.1 Additional Revenue from Zero kVAr Cost

PT Rony Aquario Perkasa obtained its additional revenue by eliminating excess usage of kVAr has a result of installing the capacitor bank. From table 3, excess kVArh data year 2018 until 2019 was obtained from average current reactive power consumption at 0.58 power factor (before capacitor installed based on PLN historical billing in Oct 2020). Data from 2020 until 2027 is assumed as average rupiah excess kVArh usage in 2018 to 2020. Below is the table of forecast revenue post bank capacitors installation at PT Ronny Aquario Perkasa.

Table 10 Revenue post capacitor bank installation

Year	**Excess kVArh**	**Rupiah Excess kVArh / month**	**Rupiah Excess kVArh**
2018	247.033	Rp 22.948.172	Rp 275.378.066
2019	317.049	Rp 29.452.286	Rp 353.427.429
2020	206.352	Rp 25.558.702	Rp 306.704.421
2021	279.739	Rp 25.986.387	Rp 311.836.639
2022	279.739	Rp 25.986.387	Rp 311.836.639
2023	279.739	Rp 25.986.387	Rp 311.836.639
2024	279.739	Rp 25.986.387	Rp 311.836.639
2025	279.739	Rp 25.986.387	Rp 311.836.639
2026	279.739	Rp 25.986.387	Rp 311.836.639
2027	279.739	Rp 25.986.387	Rp 311.836.639
Total			Rp 3.118.366.387

Note: 1 kVArh = Rp. 1.115,00

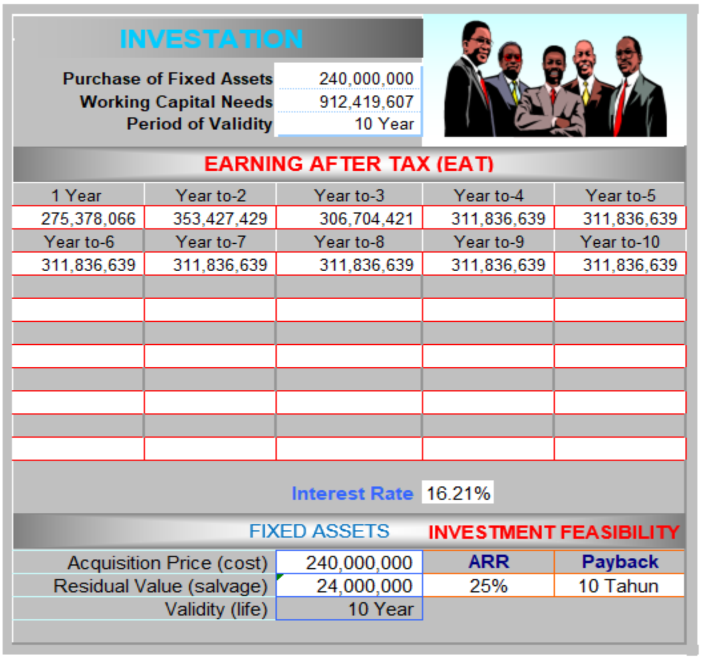

Fig. 2 Investment Feasibility Analysis Tools - EAT
Note: assumed AAR PT Ronny Aquario Perkasa sets in 25%

3.4.2 Cash Flow

PT Ronny Aquario Perkasa cash flow is obtained from total income and Investment cost depreciation. Refer to section 3.5, it was mentioned that Procurement and installation cost of capacitor bank with 700 kVAr capacity is about IDR 240,000,000, and from table 8, it is known that the maintenance cost post installation is 912,419,607. With assumption capacitor bank lifetime is 10 years and incorporating provided cost using Investment feasibility analysis tools, the following is cash flow table post capacitors bank installation investment at the PT Ronny Aquario Perkasa factory:

Investation	1,152,419,607	Lifetime	10 Year
CASH FLOW			
Information	**EAT**	**Depreciation**	**Cash Inflow**
Year to-1	275,378,066	49,440,000	324,818,066
Year to-2	353,427,429	39,255,360	392,682,789
Year to-3	306,704,421	31,168,756	337,873,177
Year to-4	311,836,639	24,747,992	336,584,631
Year to-5	311,836,639	19,649,906	331,486,544
Year to-6	311,836,639	15,602,025	327,438,664
Year to-7	311,836,639	12,388,008	324,224,647
Year to-8	311,836,639	9,836,078	321,672,717
Year to-9	311,836,639	7,809,846	319,646,485
Year to-10	311,836,639	6,201,018	318,037,657

Fig. 3 Investment Feasibility Analysis Tools - Cash Flow

3.4.3 Economic Analysis of Investment Feasibility Technique

The principles of technical economics application is used both in the economic viability analysis of engineering projects and assisting in decision making, based on the following economic parameters

1. Accounting Rate of Return (ARR)

From the data table, total investment costs and income per year can be used to calculate Accounting Rate of Return (ARR) value of at PT Ronny Aquario Perkasa as follows:

INVESTMENT ASSESSMENT WITH ACCOUNTING RATE OF RETURN

Investation	1,152,419,607	Lifetime	10 Year
CASH FLOW			
Information	EAT	Depreciation	Cash Inflow
Year to-1	275,378,066	49,440,000	324,818,066
Year to-2	353,427,429	39,255,360	392,682,789
Year to-3	306,704,421	31,168,756	337,873,177
Year to-4	311,836,639	24,747,992	336,584,631
Year to-5	311,836,639	19,649,906	331,486,544
Year to-6	311,836,639	15,602,025	327,438,664
Year to-7	311,836,639	12,388,008	324,224,647
Year to-8	311,836,639	9,836,078	321,672,717
Year to-9	311,836,639	7,809,846	319,646,485
Year to-10	311,836,639	6,201,018	318,037,657

Average Profit After Tax (EAT)	311,836,639
Investment Average	576,209,803
Accounting Rate of Return	27.06%
investment worth running	

Fig. 4 Investment Feasibility Analysis Tools - ARR

From the calculation, the value of the Accounting Rate of Return (ARR) of bank capacitor development at PT Ronny Aquario Perkasa is 27.06%. Refer to section 3.5.1 (assumed AAR PT Ronny Aquario Perkasa sets in 25%), the ARR eligibility standard that is feasible to be implemented is greater than 25%. So, based on the ARR data calculation, it can be concluded that the investmentin installing bank capacitors isfeasible.

2. Payback Period (PP)

Payback period (PP) is the time required to return the investment value. The method of calculating PP is to calculate the time required (years) so that the estimated cumulative net cash flow will as same as the initial investment. From the investment feasibility analysis tools calculation, the Payback period (PP) calculation of the capacitor bank development investment at PT Ronny Aquario Perkasa is the following:

Investment Appraisal with Payback PerioD

Investatition	1,152,419,607	Interest rate	16.21%
Lifetime	10 Year		
CASH FLOW			
Information	EAT	Depreciatition	Cash Inflow
Year to-0	0	0	(1,152,419,607)
Year to-1	275,378,066	49,440,000	324,818,066
Year to-2	353,427,429	39,255,360	392,682,789
Year to-3	306,704,421	31,168,756	337,873,177
Year to-4	311,836,639	24,747,992	336,584,631
Year to-5	311,836,639	19,649,906	331,486,544
Year to-6	311,836,639	15,602,025	327,438,664
Year to-7	311,836,639	12,388,008	324,224,647
Year to-8	311,836,639	9,836,078	321,672,717
Year to-9	311,836,639	7,809,846	319,646,485
Year to-10	311,836,639	6,201,018	318,037,657

PAYBACK PERIOD	3 Year 4 Month
CONCLUSION	
investment worth running	

Fig. 5 Investment Feasibility Analysis Tools –PP

Based on the results of these calculations, it can be concluded that the investment in the expansion of bank capacitors at PT Ronny Aquario Perkasa is feasible.

3. ***Net Present Value (NPV)***

From the investment feasibility analysis tools calculation with assumption of the reference interest rate is above 16.21%, the Net Present Value (NPV) of the capacitor bank development investment at PT Ronny Aquario Perkasa can be calculated as following:

Investation Review using NET PRESENT VALUE

Investasi	1,152,419,607	Suku bunga	16.21%
Usia Ekonomis	10 Year		

CASH FLOW

Information	EAT	Depreciation	Cash Inflow
Year to-0	0	0	(1,152,419,607)
Year to-1	275,378,066	49,440,000	324,818,066
Year to-2	353,427,429	39,255,360	392,682,789
Year to-3	306,704,421	31,168,756	337,873,177
Year to-4	311,836,639	24,747,992	336,584,631
Year to-5	311,836,639	19,649,906	331,486,544
Year to-6	311,836,639	15,602,025	327,438,664
Year to-7	311,836,639	12,388,008	324,224,647
Year to-8	311,836,639	9,836,078	321,672,717
Year to-9	311,836,639	7,809,846	319,646,485
Year to-10	311,836,639	6,201,018	342,037,657
		0	

Net Present Value (NPV)	409,499,416
investment worth running	

Fig. 6 Investment Feasibility Analysis Tools - NPV

Based on the results of these calculations, it can be concluded that the investment in the expansion of bank capacitors at PT Ronny Aquario Perkasa is feasible

4. Internal Rate of Return (IRR)

Internal Rate of Return, abbreviated as IRR, is an indicator of an investment efficiency level. The IRR value is the value of the interest rate when the NPV is 0. Therefore, the IRR value is calculated based on the interpolation of the NPV value when it is negative and the NPV value when it is positive.

From the investment feasibility analysis tools calculation, the IRR interpolation value from the bank's capacitor expansion investment at PT Ronny Aquario Perkasa.

PENILAIAN INVESTASI DENGAN INTERNAL RATE OF RETURN

Investation	1,152,419,607	Interest Rate	16.21%
Lifetime	10 Year		

CASH FLOW

Information	EAT	Depreciatition	Cash Inflow
Year to-0	0	0	(1,152,419,607)
Year to-1	275,378,066	49,440,000	324,818,066
Year to-2	353,427,429	39,255,360	392,682,789
Year to-3	306,704,421	31,168,756	337,873,177
Year to-4	311,836,639	24,747,992	336,584,631
Year to-5	311,836,639	19,649,906	331,486,544
Year to-6	311,836,639	15,602,025	327,438,664
Year to-7	311,836,639	12,388,008	324,224,647
Year to-8	311,836,639	9,836,078	321,672,717
Year to-9	311,836,639	7,809,846	319,646,485
Year to-10	311,836,639	6,201,018	342,037,657

Internal Rate of Return (IRR)	26.89%
investment worth running	

Fig. 3 Investment Feasibility Analysis Tools - IRR

The result from investment tools is 26.89%.

From the calculation in section 2.3 (the IRR value of 25 % and 30 % has been calculated using interpolation of NPV value in MicrosoftExcel) the value of the Internal Rate of Return (IRR) from the investment of bank capacitor development at PT Ronny Aquario Perkasa is 27.08%.

So, both IRR values are greater than the reference interest rate used which is 16.21%. Therefore, based on the results of these calculations, it can be concluded that the investment of bank capacitor development at PT Ronny AquarioPerkasa is feasible.

4. CONCLUSION

From the research that has been performed, it can be concluded as following:

1. Capacitor bank improves power factor which resulted to zero kVArh cost.
2. Based on both 25% load and maximum load conditions ETAP 16.0 simulation, the power factor at PT Ronny Aquario Perkasa's factory is still above 0.85, which PT Rony Aquario Perkasa investment in capacitor bank installation able to cover 4 times business future expansion.
3. Based on the investment feasibility analysis calculation results, the value of the Accounting Rate of Return (ARR), Payback period (PP), Net Present Value (NPV), and Internal Rate of Return (IRR), it can be concluded that the investment of bank capacitor development at PT Ronny Aquario Perkasa is feasible to be implemented.

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