Feasibility Study of Micro Hydropower Plants in High-Rise Buildings in Indonesia By Utilizing A Working Scheme for AC Condenser Water Pumps (Ventilation & Air Conditioning System)

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Abstract. In Indonesia the number of high-rise buildings above 150 m tends to increase, according to CTBUH (Council on tall building and urban habitat) in 2018 there are 85 buildings and those that are under construction are 26 buildings, Super tall buildings with a height above 300 meters are 4 buildings and proposed mega tall building with a height of more than 600 meters is 1 building. All these buildings have very large electrical loads. The percentage of electricity consumption in the building that is the object of research is 30-50% coming from the Ventilation & Air Condition (VAC) system, 20% - 30% lighting systems, 10% computers and the rest from other utilities. Several papers and journals discussing the simulation or feasibility study of micro-hydropower plants in high-rise buildings have not yet been discussed how to utilized kinetic energy from the working scheme of the water condenser pump in the VAC system. in general, the existing papers discuss how to utilized gravity potential energy through the working scheme of the building's clean water tank which is on the roof (rooftop) when distributing water which is not optimal because of the flow of water from the clean water system is not continuous or steady-state. Research Object by taking a case study of a high-rise building in Jakarta with a height of 157 meters. The data was taken from the report on utility use for the 2018 period in the building. From the simulation, the potential of water flow rate (Q) is 0.499 m3 / sec and the electrical power that can be generated (P) is 733.83 kW and this is a Micro-hydro Power Generation category. Economic analysis for building energy savings of Rp. 541,765,714.29 / month and finally roughly Return on Investment (ROI) can be achieved in 3 years and 6 months.

1. Introduction

In Indonesia, the number of high-rise buildings above 150 m continues to increase, according to CTBUH (council on tall building and urban habitat) in 2018 there are 85 buildings and those that are being built are 26 buildings while buildings with a height above 300 meters there are 4 buildings under construction in the super tall category and a building with a height of more than 600 meters that is in the mega tall category has 1 building. In the future, it is estimated that the number of skyscrapers will increase [1-3].

All of these buildings have very large electrical loads. The percentage of electricity consumption in a building is 30%-50% coming from the HVAC system, 20%-30% from the lighting systems, 10% from the computers and the rest from other utilities. Some papers and journals that discuss the simulation of the utilization of micro-hydropower plants in high-rise buildings have not yet discussed the use of condenser water pump work schemes in general, the papers discuss the use of work schemes from building clean water tanks on roofs (rooftop) when distributing water floor below it [4- 9]. This paper focus on a case study of a high rise building in Jakarta with a height of 157 meters which illustrated in Figure 1 and the schematic diagram of the micro hydropower was shown in Figure 2 below.

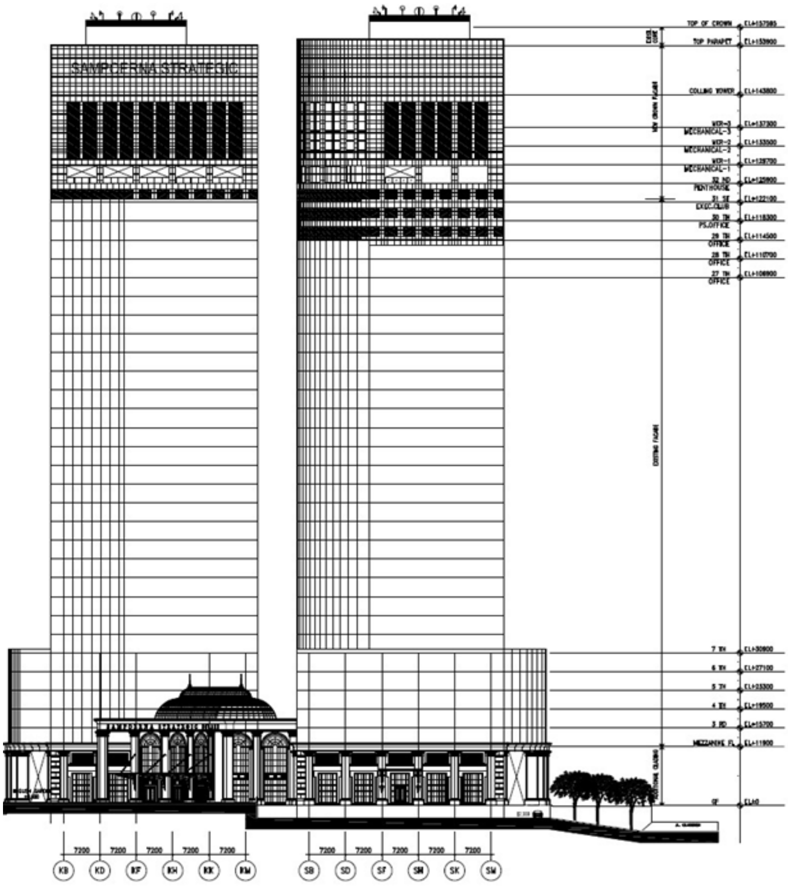

Figure 1. Sampoerna Strategic Square Building

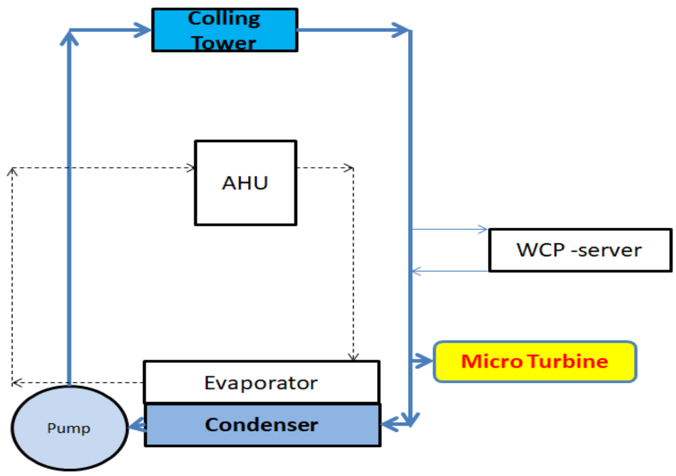

Figure 2. Micro Hydro Scheme by utilizing a condenser pump

2. Building's Electricity Consumption

2.1. Building's Electricity Consumption in 2018

The average electricity consumption in 2018 was tabulated in Table 1. It can be seen that the average electricity consumption in 2018 was 2,083,714.29 kWH / month or electricity payments per month on average was Rp2,354,609,724.57.

Table 1. Electricity Consumption in 2018 years

Month	PLN		Total (Rp)	Eletricity Bills (Rp)
	LWBP (kWH)	WBP (kWH)		
January	1,932,360.00	283,200.00	2,215,560.00	2,500,101,165.00
February	1,688,400.00	252,840.00	1,941,240.00	2,193,040,256.00
March	1,878,120.00	287,520.00	2,165,640.00	2,449,439,060.00
April	1,887,960.00	286,200.00	2,174,160.00	2,457,775,681.00
May	1,839,600.00	285,480.00	2,125,080.00	2,405,337,702.00
June	1,572,960.00	236,880.00	1,809,840.00	2,045,208,432.00
July	1,878,720.00	275,760.00	2,154,480.00	2,431,365,776.00
August	1,840,080.00	281,160.00	2,121,240.00	2,398,973,869.00
September	1,785,840.00	277,320.00	2,063,160.00	2,335,335,546.00
October	1,948,680.00	278,520.00	2,227,200.00	2,509,959,105.00
November	1,818,480.00	270,960.00	2,089,440.00	2,359,836,300.00
December	1,773,240.00	265,080.00	2,083,320.00	2,302,498,172.00
Total	12,678,120.00	1,907,880.00	14,586,000.00	16,482,268,072.00
Average	1,811,160.00	272,554.29	2,083,714.29	2,354,609,724.57

2.2. Monthly Electric Power / Load Trend

2.2.1. Daily Electricity Load in 1 month

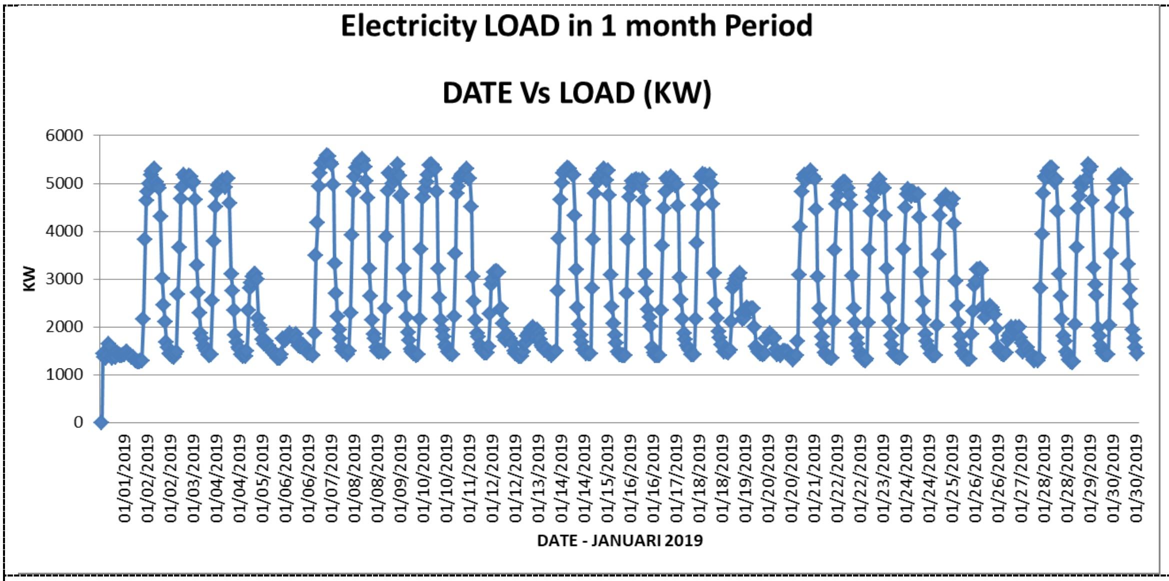

Figure 3. Electricity Load in 1 month Period

2.2.2. Daily Electricity Load on Hourly Bases in 1 Month

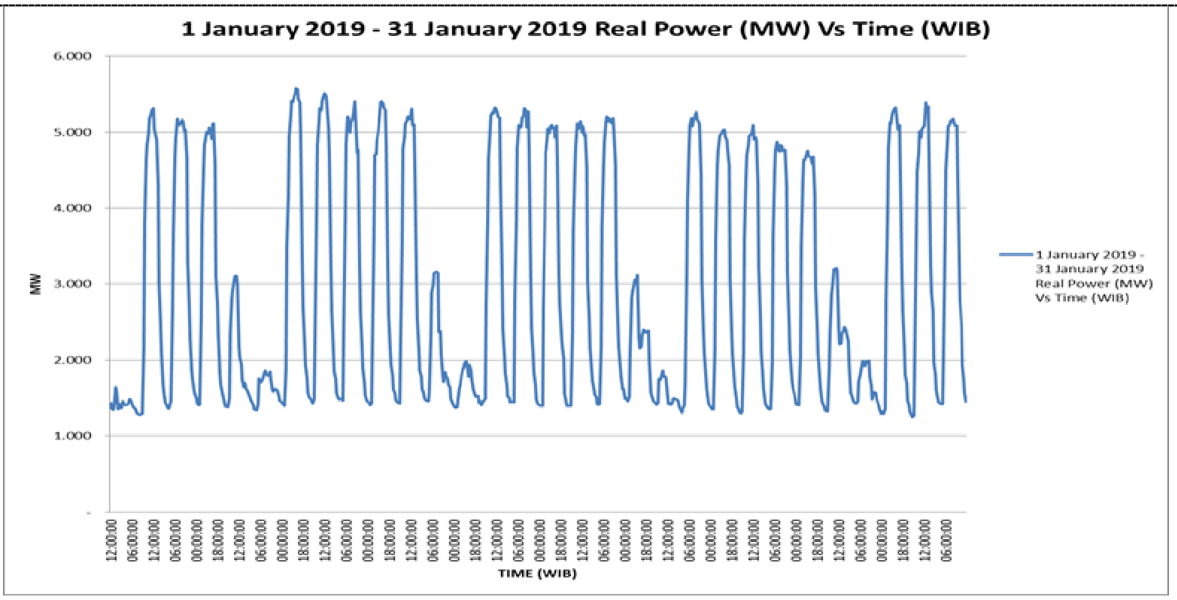

Figure 4. Daily load for 1 month of building electricity

2.3. Daily Electricity Load on Hourly Bases in 24 Hours

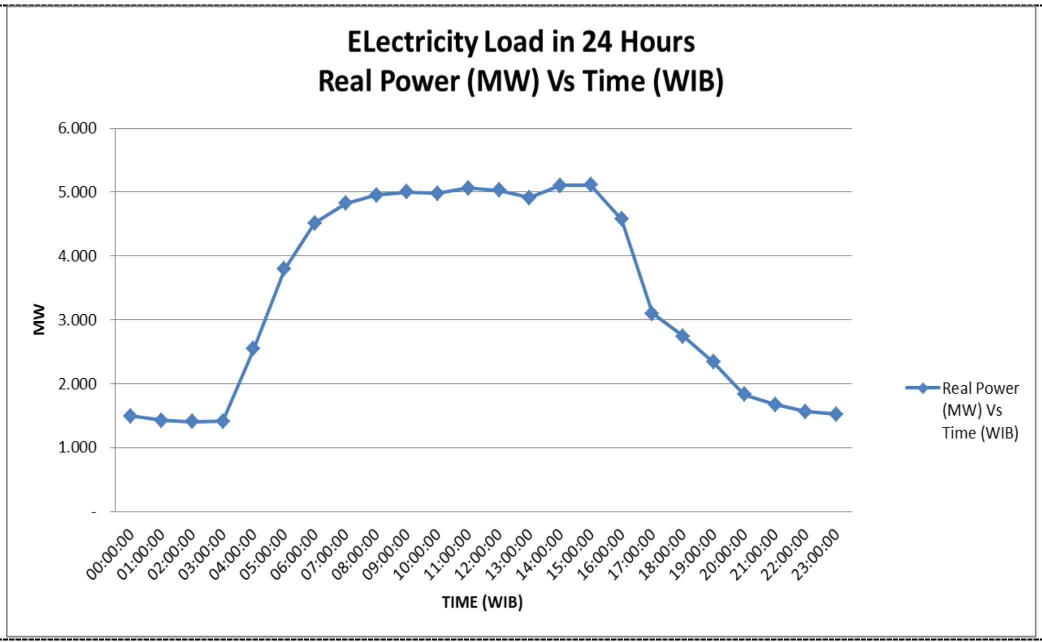

Figure 5. Building Electricity load for 24 hours

3. Research Methodology

3.1. By extracting data from the Building Automation System (BAS) from the control metasys system by Johnson controls

Figure 6. Utility control system, *Metasys* by Johnson control

4. Potential Use of VAC system water flow as a power plant

4.1.1. Potential Utilization

Building data, Average Pressure of the condenser water system pump 7,909 gpm or 0.499 m3 / second, the height of the 150 meters building consists of 33 floors and 3 basements, PLN subscription 8.3 MVA and the highest usage 6.1 MVA

$$P = \rho \times Q \times g \times H \times \eta \quad (1)$$

Where:
ρ = water density (kg / m3)
Q = water discharge (m3 / sec)
H = high waterfall effective (m)
η = overall efficiency of the hydropower plant

Power (P) = Flow Rate (Q) × Head (H) × Gravity (g)×Water Density (ρ)
P = 0.4989×150 × 9.8 × 1
= 733,383 kW or 0.733 MW

Based on its output capacity, the Classification of Hydroelectric Power Plants (PLTA) shown in Table 2. Potential Generators can be classified as Micro Hydro Power Plants (100 kW to 1 MW).

Table 2. Classification of Hydropower Plants (PLTA) [4]

No.	Classification of PLTA	Capacity
1	PLTA – Big Scale	>50 MW
2	PLTA - Medium	10 – 50 MW
3	PLTM (Mini hydro)	>1 MW – 10 MW
4	PLTMH (Micro hydro)	100 kW – 1 MW
5	Pico Hydro	< 100 kW

The Potential of Electrical Power from Utilizing Condenser Water Pump can be seen in Figure 4, where the highest Power can be generated on 11.00 PM and lowest Power can be generated on 20.00 PM to 03.00 AM.

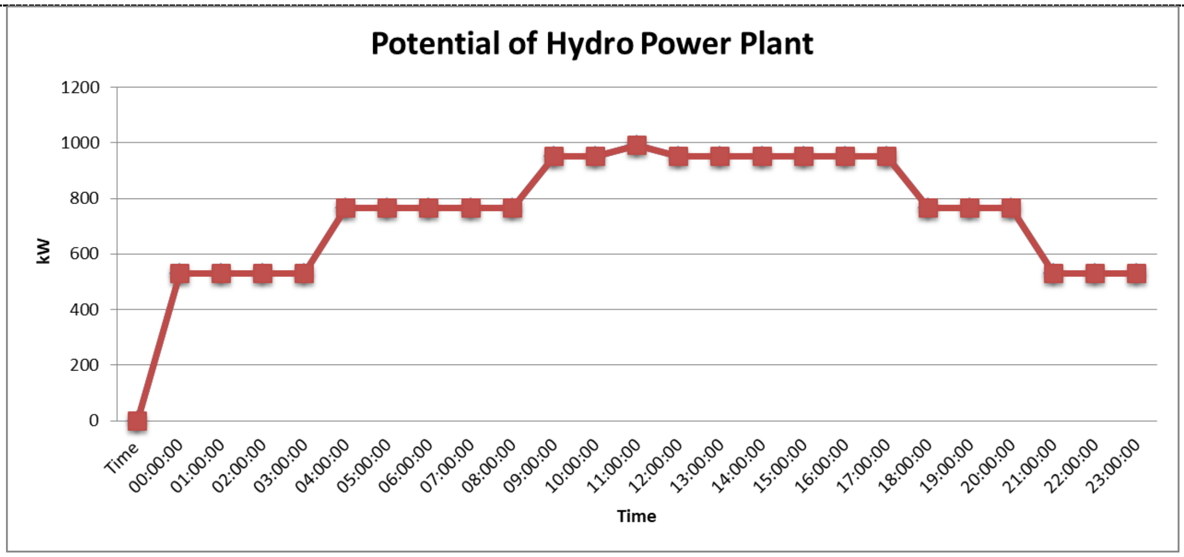

Figure 7. Potential of Power Plant from Utilizing Condenser Water Pump

4.1.2. Potential Power Plants from Utilizing Condenser Water Pump to replace daily electricity consumption

Potential Power Plants from Utilizing Condenser Water Pump to replace daily electricity consumption can be seen on Figure 8 & 9, which can replace the building's power source from 15 %to 40 %.

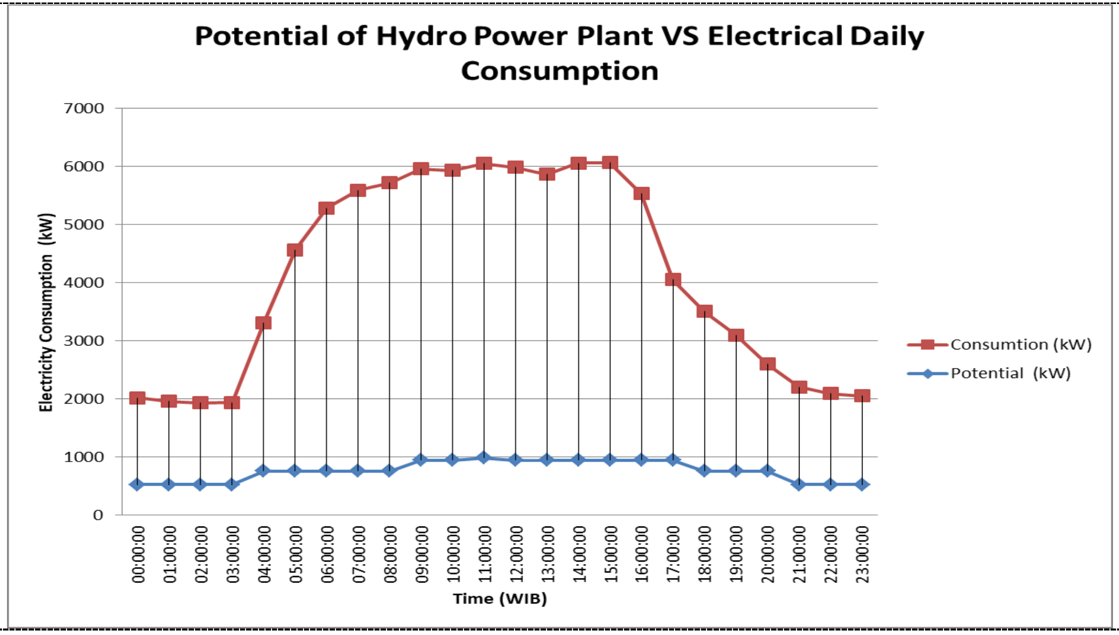

Figure 8. Potential of the Power Plants Versus Actual Electricity Consumption of Buildings

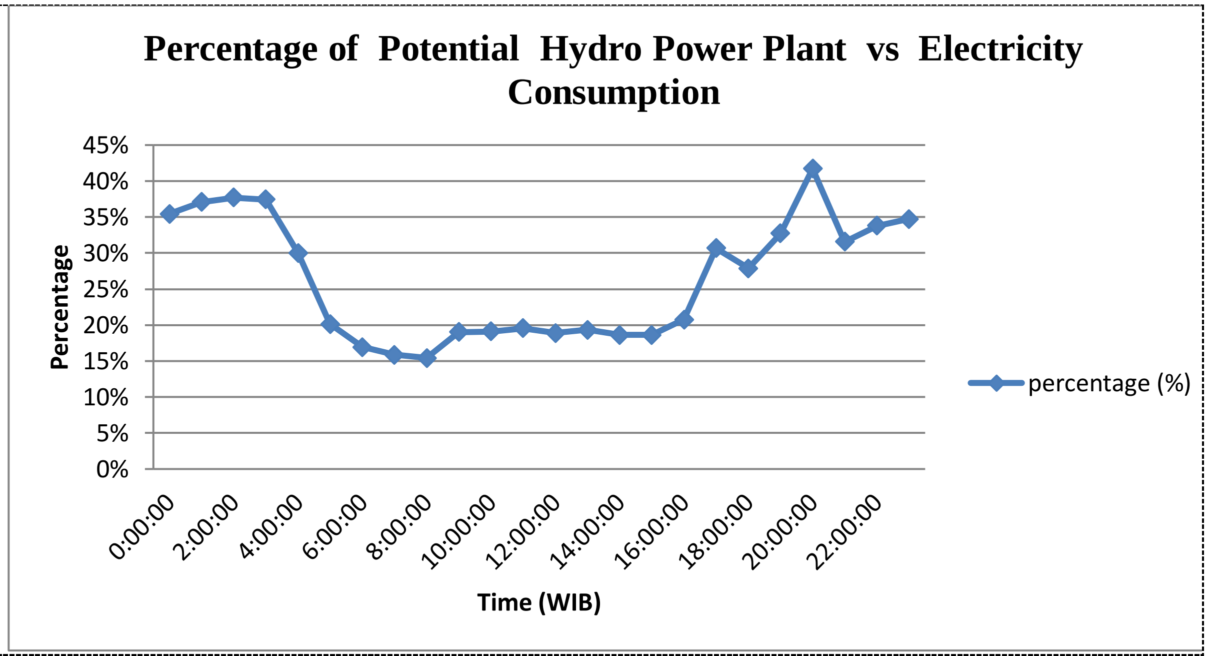

Figure 9. Percentage of Potential Generators vs Building Electricity Consumption

From the figure above, the average potential utilization of the CWP pump system for micro hydro power plants can save electricity consumption by 26% or an average savings per month of Rp541,765,714.29 or savings every year Rp.6,501,188,571.43

4.1.3. Potential Savings

Savings Potential use benchmark data for the cost of making micro-hydro power plants in Indonesia is 1500 USD/kW. At 1000 kW Planning costs around 1,500,000USD or around Rp22,500,000,000 (exchange rate 1USD = Rp15,000,000) So that the savings potential is obtained roughly before considering operational costs, plant efficiency, bank interest or other cost components, then: 26% x Rp2,354,609,724.57 = Rp541,765,714.29 / month

$$\text{Return On Investment} = \frac{22.500.000.000}{541.765.714{,}29} = 42 \text{ months or 3 years and 5 months}$$

5. Conclusion

It is found that The Potential of Electrical Power from Utilizing Condenser Water Pump can be obtained that the highest Power can be generated on 11.00 PM and lowest Power can be generated on 22.00 PM to 03.00 AM, It is obtained that the average potential utilization of the CWP pump system for micro hydro power plants can save electricity consumption by 26% or an average savings per month of Rp541,765,714.29 or savings every year Rp6,501,188,571.43 and roughly, the ROI or payback period can be achieved in 3 years and 5 months.

6. Further Research

Scope of Further research can be modelled a complete hydro power plan system from a condenser pump (VAC) water flow and simulated by MATLAB [10].

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