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Study of Treatment Alternative of Water Pressure Requirement Fulfillment in Piping Networks in Bajuin District Capital Service of Pelaihari City

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ABSTRACT: *Clean water is a main need, and it is an obligatory issue for the Government to provide access to clean water for all citizens. In Pelaihari City itself, clean water is one of the strategic issues, where clean water services are still lacking, due to the lack of clean water infrastructure. The problem of lack of water pressure during peak hours often occurs, thus affecting services.*

This research aims to (1) determine the causes of not achieving water pressure in several areas in the piping networks in Bajuin District Capital Service of Pelaihari City; (2) determine and also analyze the financial performance of a treatment alternative that can be developed in order to produce optimal service.

This research is a descriptive research with a quantitative approach aiming to describe a situation or a phenomenon that occurs in a company active in the field of clean water services. The criteria for selecting alternative development phases include economic analysis of NPV, IRR, BCR, and, finally, incremental rate of return analysis.

The results of this research indicate that (1) based on the IRR indicator both the treatment and the existing projects are all smaller than the MARR of 3.75%; the NPV of the treatment project is positive while the existing NPV is negative; the BCR of the treatment project is > 1 while the existing project BCR is not calculated; (2) therefore, the water pressure fulfillment treatment project in Bajuin District Capital Service of Pelaihari City is feasible for implementation to improve and advance the performance of the water company, PDAM Tanah Laut Regency.

KEYWORDS: *piping networks, study of treatment alternatives, water pressure*

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I. INTRODUCTION

Pelaihari City is currently developing rapidly economically, especially in the mining, plantation, and of course fisheries sectors. Thus, many investors and workers come about, followed by the number of buildings that emerge, such as shopping malls, offices, and housings. This has certainly resulted in an increased need for clean water.

Optimization of the drinking water supply system must be done to meet the increasing need for clean water, either by using the existing infrastructure system, or by building a new infrastructure system. Naturally, considering the costs that will be incurred and what will be obtained.

Based on data obtained from the local water company (PDAM Tanah Laut Regency), where the Bajuin Water Treatment Installation is located, namely in the Bajuin District Capital, Tanah Laut Regency, South Kalimantan Province, Indonesia, in one year there is a leakage rate of 37.08%. Therefore, if an inspection is not carried out through field observation to find the cause of the high level of leakage, certainly meeting the increasing water demand will be difficult to achieve.

This research aims to study the comparison, regarding the financial performance, between the existing infrastructure system and the proposed replacement infrastructure system of the Bajuin Water Treatment Installation at PDAM Tanah Laut Regency.

II. LITERATURE REVIEW

The physical components of clean water infrastructure consists of the water source, transmission, processing, distribution, and consumers. Sources can consist of only sources and an accumulation of system or they can also be equipped with a processing system. Sources that can be used include surface water (rivers and reservoirs), ground water (springs, wells), seawater, and rainwater. The source quantity will determine the amount of extraction that can be done, while the quality of the source will determine whether or not processing is needed for the source.

Loss of water or non-revenued water (NRW) can also be an important element in drinking water supply infrastructure, in which according to the Ministry of Public Works Regulation No. 20 of 2006 the maximum level for water losses is 20%, while according to the 2004 Ministry of Public Works Department Drinking Water Service Standards, the water leakage tolerance is 25%. Therefore, PDAM is considered to be healthy if it has a leakage rate of below 20%, and it is considered poor if the leakage rate is above 25% (Ministry of Public Works, Republic of Indonesia, 2006). The formula for calculating water loss is as follows:

$$\%\ \mathrm{NRW} = \frac{\mathrm{D} - \mathrm{K}}{\mathrm{D}}\ x\ 100\%$$

where % NRW is water loss (%), D is the amount of water distributed (m^3), and K is the amount of water recorded in the account (water sold, m^3).

Water pressure itself has a minimum pressure standard or criterion, based on the Ministry of Public Works Regulation No.18/PRT/M/2007, namely with a minimum pressure of 0.5 atm, which when converted to units of water meters becomes 5.16 meters of water (Ministry of Work General of the Republic of Indonesia, 2007).

In making a decision on the feasibility of an engineering project or the feasibility of using resources, an engineer needs knowledge or expertise, not only relating to the feasibility of engineering or technical aspects but also the feasibility of financial aspects.

2.1. Net Present Value (NPV)

The present value of the project that is carried out by discounting the difference between the amount of cash in and the amount of cash out each year with a predetermined interest rate (MARR).

2.2. Internal Rate of Return (IRR)

A method for measuring the level of investment, namely the interest rate at which all net cash flows are multiplied by the discount factor.

2.3. Benefit Cost Ratio (BCR)

The ratio between positive value net benefits and negative value net benefits. A project will be feasible if BCR > 1 and will not be feasible if otherwise.

$$\mathrm{BCR} = \frac{\text{(PV from benefit)}}{\text{(PV from cost)}}$$

2.4. Incremental Rate of Return Analysis

This method is the RoR which is used to select and compare 2 alternative designs or projects by calculating the entire differences in cash flows. If IRR > MARR, choose the design or project alternative that has the highest cost, and if otherwise, choose the design or project alternative that has the lowest cost.

III. RESEARCH METHOD

The stages in this study can be outlined in the form of a flowchart as shown in Figure 1.

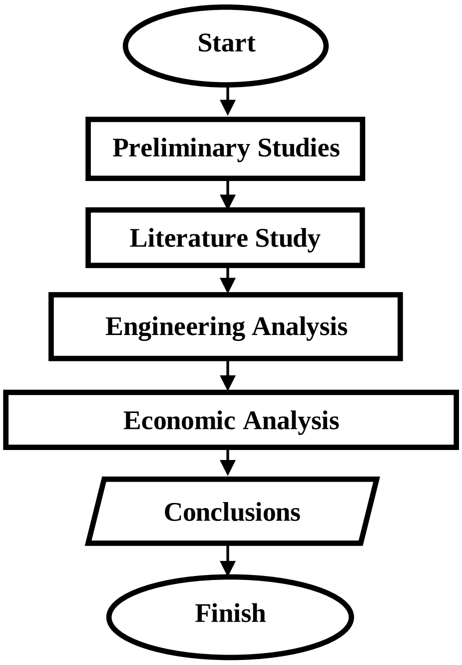

Figure 1. Research flowchart

IV. RESULT AND DISCUSSION

4.1. Field Observation

To obtain the problems that exist in the piping network, field observations are done for calibration at several points of the piping network which will then be used in hydraulic analysis for the EPANET application (Figure 2).

Figure 2. Calibration at several junctions

4.2. Data Plotting

For data plotting through simulation into the EPANET application, there are 7 occasions where negative pressures occured as well as data during peak service hours (17.00) as shown in Figure 3 and Figure 4.

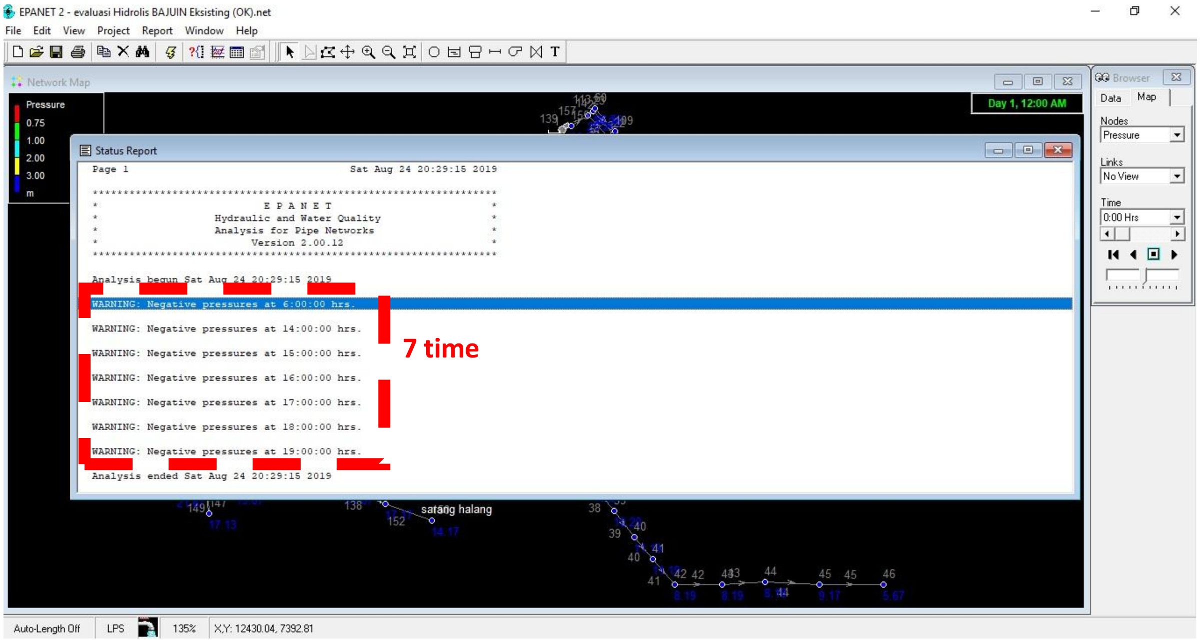

Figure 3. Data plotting through simulation into the EPANET application

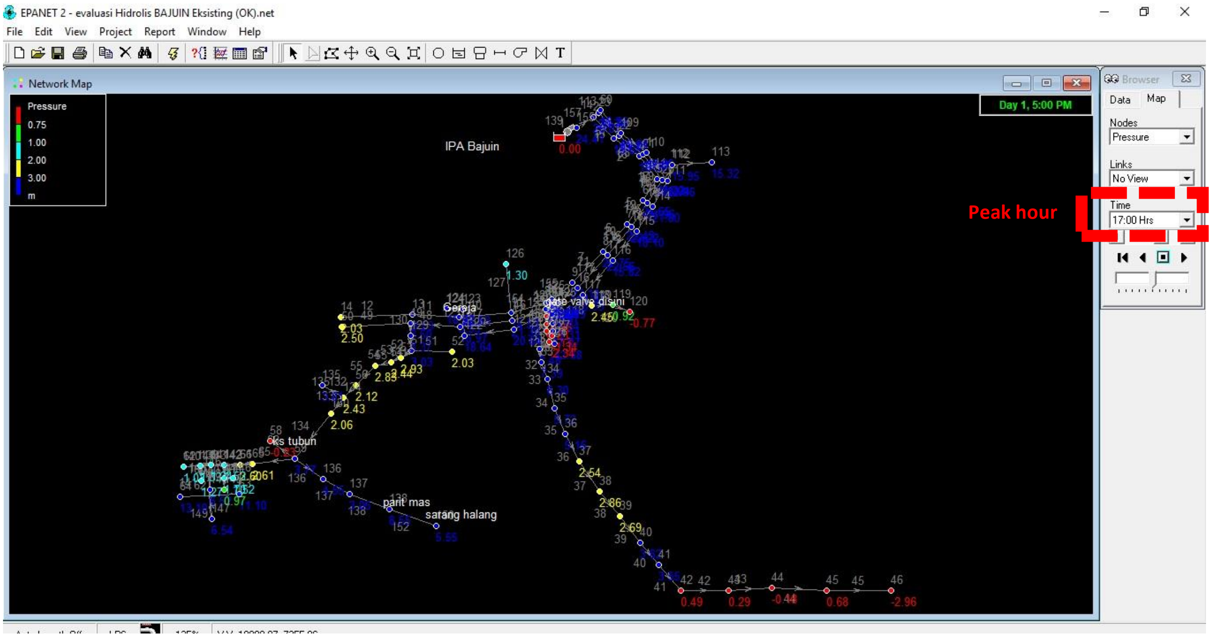

Figure 4. Data plotting through simulation into the EPANET application during peak service hours (17.00)

4.3. Treatment Design

Based on the data obtained from the results of field observations, a simulation will be carried out on the EPANET application for treatment design by changing the water distribution system, namely adding a booster reservoir before the water is distributed to customers' houses, therefore the required pressure can be met at all service points. This can be seen in Figure 5.

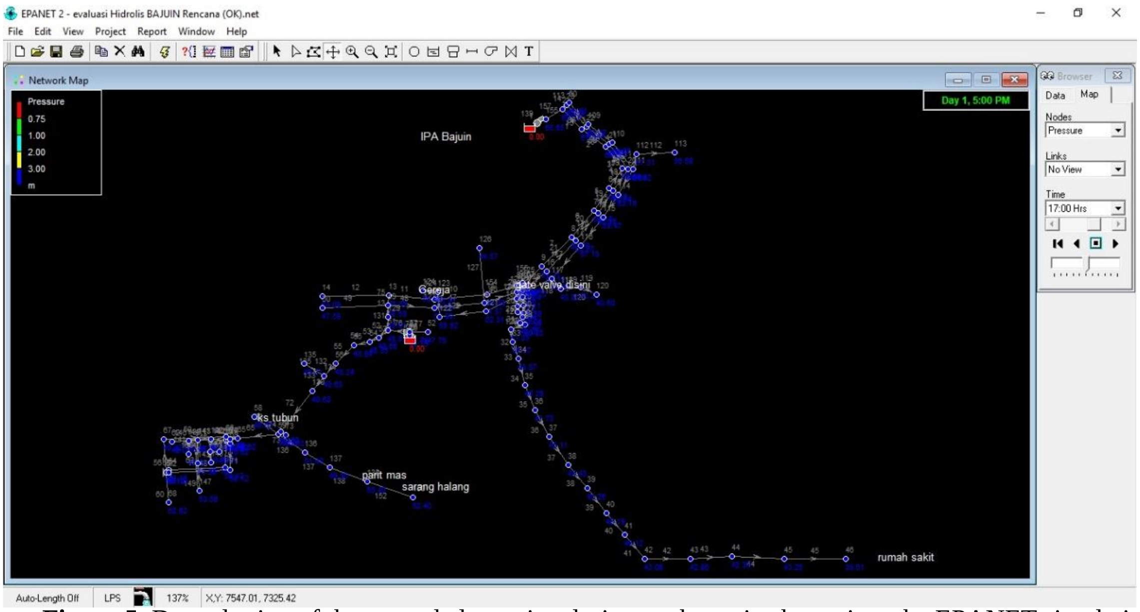

Figure 5. Data plotting of the second alternative during peak service hours into the EPANET simulation

4.4. Value Engineering

Value engineering is carried out to determine the investment cost of the treatment design using a budget simulation as given in Table 1.

Table 1. Total investment cost analysis

No	Unit	Activity Proposal	Cost Estimation
1	Production	Development of water treatment installation 20 L/s along with support, and water treatment installation optimization 20 L/s in 2013	Rp 10,109,286,436.93
2	Transmission	Optimization of main distribution piping network (pipe change)	Rp 17,354,442,722.12
3	Reservoir	Reservoir booster distribution to customers	Rp 6,078,399,657.46
4	Management system	Health and safety at work	Rp 173,871,372.00
		Total (rounded)	Rp 33,716,000,000.00

4.5. *Economic Analysis*

Economic analysis is made with several calculation assumptions, including the following:
- The treatment design has been determined based on the results of hydraulic analysis through simulations on the EPANET application;
- Total production capacity 40 L/s;
- Year 0 in 2019;
- Inflation rate (MARR) 3.75% according to the 2020 Bank of Indonesia Decree.

4.6. *Net Present Value* (NPV)

In this study, the economic life for the analysis is assumed to be 20 years designed to operate up to 50 years for the new installation distribution network to replace the ACP distribution network which will be added to the old production unit (2013) with a remaining economic life of 14 years. Also, optimization of the fluxation basin will be carried out to increase its economic life to 20 years, while the remaining life of the distribution network for the old installation which currently does not have any operational issues is assumed to be 30 years.

- *Discount factor*

  In the first year of 2020, the *discount factor* is

$$\text{df} = \frac{1}{(1+3.75\%)^1} = \frac{1}{1.0375} = \mathbf{0.963855}$$

- *Present value* of revenue and expenditure

  From the revenue that occurred in 2020, with an amount of Rp 3,725,000,000.00 which is multiplied by the discount factor, the present value is Rp 3,590,361,446.00. In addition, the total expenditure incurred in 2020 amounted to Rp 1,979,000,000.00 which is multiplied by the discount factor. Therefore, the present value of the expenditure is Rp 1,907,469,880.00. The results are given in Tables 2 and 3.

Table 2. N*et present value* (NPV) calculation for the second treatment alternative

Year	Revenue	Expenditure	Revenue PV	Expenditure PV	Cash Flow
0	0	(28,169,803,155.00)	0	(28,169,803,155.00)	(28,169,803,155.00)
1	3,725,000,000.00	(1,887,000,000.00)	3,590,361,445.78	(1,818,795,180.72)	1,838,000,000.00
2	5,405,000,000.00	(2,188,000,000.00)	5,021,338,365.51	(2,032,689,795.33)	3,217,000,000.00
3	5,084,000,000.00	(2,270,000,000.00)	4,552,408,501.77	(2,032,645,023.41)	2,814,000,000.00
4	5,546,000,000.00	(2,355,000,000.00)	4,786,603,386.16	(2,032,537,139.27)	3,191,000,000.00
5	5,479,000,000.00	(2,715,000,000.00)	4,557,857,820.51	(2,258,547,907.04)	2,764,000,000.00
6	6,027,000,000.00	(2,816,000,000.00)	4,832,507,749.71	(2,257,896,436.57)	3,211,000,000.00
7	6,027,000,000.00	(2,922,000,000.00)	4,657,838,794.90	(2,258,205,568.06)	3,105,000,000.00
8	6,027,000,000.00	(3,032,000,000.00)	4,489,483,175.81	(2,258,522,148.51)	2,995,000,000.00
9	6,630,000,000.00	(3,145,000,000.00)	4,760,149,360.91	(2,258,019,568.64)	3,485,000,000.00
10	6,630,000,000.00	(3,263,000,000.00)	4,588,095,769.55	(2,258,062,819.92)	3,367,000,000.00
11	6,630,000,000.00	(3,386,000,000.00)	4,422,260,982.70	(2,258,488,037.32)	3,244,000,000.00
12	7,293,000,000.00	(3,513,000,000.00)	4,688,662,246.72	(2,258,504,109.79)	3,780,000,000.00
13	7,293,000,000.00	(3,644,000,000.00)	4,519,192,526.96	(2,258,047,109.31)	3,649,000,000.00
14	7,293,000,000.00	(3,781,000,000.00)	4,355,848,218.75	(2,258,256,151.80)	3,512,000,000.00
15	8,022,000,000.00	(3,923,000,000.00)	4,618,076,010.94	(2,258,378,483.04)	4,099,000,000.00
16	8,022,000,000.00	(4,070,000,000.00)	4,451,157,600.91	(2,258,316,060.30)	3,952,000,0000.00
17	8,022,000,000.00	(4,223,000,000.00)	4,290,272,386.42	(2,258,516,615.29)	3,799,000,000.00
18	8,825,000,000.00	(4,381,000,000.00)	4,549,134,916.35	(2,258,329,752.81)	4,444,000,000.00
19	8,825,000,000.00	(4,545,000,000.00)	4,384,708,353.10	(2,258,186,908.20)	4,280,000,000.00
20	8,825,000,000.00	(4,716,000,000.00)	4,226,224,918.65	(2,258,456,285.14)	4,109,000,000.00
			90,342,182,532.12	**(72,219,204,255.46)**	
IRR	**9.42%**	**NPV**	**18,122,978,276.66**		

Table 3. *Net present value* (NPV) calculation for existing infrastructure

Year	Revenue	Expenditure	Revenue PV	Expenditure PV	Cash Flow
0	0	(5,546,196,845.00)	0	(5,546,196,845.00)	(5,546,196,845.00)
1	1,919,000,000.00	(1,467,000,000.00)	1,849,638,554.22	(1,413,975,903.61)	452,000,000.00
2	2,174,000,000.00	(1,671,000,000.00)	2,019,683,553.49	(1,552,387,864.71)	503,000,000.00
3	2,391,000,000.00	(1,733,000,000.00)	2,140,993,062.10	(1,551,794,636.81)	658,000,000.00
4	2,631,000,000.00	(1,798,000,000.00)	2,270,745,313.56	(1,551,805,425.23)	833,000,000.00
5	2,631,000,000.00	(2,137,000,000.00)	2,188,670,181.74	(1,777,722,606.76)	494,000,000.00
6	2,894,000,000.00	(2,217,000,000.00)	2,320,437,602.07	(1,777,612,357.91)	677,000,000.00
7	2,894,000,000.00	(2,300,000,000.00)	2,236,566,363.44	(1,777,506,093.96)	594,000,000.00

8	3,054,000,000.00	(2,387,000,000.00)	2,274,909,842.20	(1,778,064,765.33)	667,000,000.00
9	3,360,000,000.00	(2,476,000,000.00)	2,412,383,386.52	(1,777,696,805.07)	884,000,000.00
10	3,360,000,000.00	(2,569,000,000.00)	2,325,188,806.29	(1,777,800,608.14)	791,000,000.00
11	3,360,000,000.00	(2,665,000,000.00)	2,241,145,837.39	(1,777,575,493.05)	695,000,000.00
12	3,696,000,000.00	(2,765,000,000.00)	2,376,154,622.77	(1,777,615,674.23)	931,000,000.00
13	3,696,000,000.00	(2,869,000,000.00)	2,290,269,515.92	(1,777,809,318.50)	827,000,000.00
14	3,696,000,000.00	(2,977,000,000.00)	2,207,488,690.05	(1,778,055,690.01)	719,000,000.00
15	4,065,000,000.00	(3,088,000,000.00)	2,340,124,530.60	(1,777,688,696.31)	977,000,000.00
16	4,065,000,000.00	(3,204,000,000.00)	2,255,541,716.24	(1,777,799,670.07)	861,000,000.00
17	4,065,000,000.00	(3,324,000,000.00)	2,174,016,112.04	(1,777,719,448.07)	741,000,000.00
18	4,472,000,000.00	(3,449,000,000.00)	2,305,238,679.42	(1,777,899,867.02)	1,023,000,000.00
19	4,472,000,000.00	(3,578,000,000.00)	2,221,916,799.44	(1,777,732,179.88)	894,000,000.00
20	4,472,000,000.00	(3,712,000,000.00)	2,141,606,553.68	(1,777,648,373.72)	760,000,000.00
			44,592,719,723.18	**(40,0601,08,323.39)**	
IRR	**10.72%**	**NPV**	**4,532,611,399.79**		

In both the treatment and the existing alternatives, a positive NPV is obtained. Therefore, the two alternatives above are feasible to implement.

4.7. Internal Rate of Return (IRR)

As seen in Table 2, after calculating the cash flow on the treatment alternative, the NPV obtained is Rp 18,122,978,276.66 and the IRR value obtained is 9.42% which is greater than the MARR value of 3.75%. Whereas in the calculation of cash flow in the existing conditions in Table 3, the NPV is Rp 4,532,611,399.79 and the IRR value is 10.72% which is also greater than the MARR value of 3.75%. Thus, these two alternatives can be considered feasible.

4.8. Benefit-to-Cost Ratio (BCR)

Benefit-to-cost ratio is the ratio between revenue (benefit) to cost. In this study, PV is calculated based on a discount rate of 3.75% and the amount of benefit calculated is the company's revenue, or the benefit value of PDAM itself, while costs are incurred for maintenance. In the treatment design project, the ratio between revenue and expense is calculated as follows:

$$\text{BCR} = \frac{\text{Revenue PV}}{\text{Cost PV}} = \frac{90{,}342{,}182{,}532.12}{72{,}219{,}204{,}255.46} = \mathbf{1.25}$$

Whereas in the existing condition, the calculation of the ratio between revenue and expenses is as follows:

$$\text{BCR} = \frac{\text{PV Penerimaan}}{\text{PV Biaya}} = \frac{44{,}592{,}719{,}723.18}{40{,}060{,}108{,}323.39} = \mathbf{1.113}$$

From the results of the above calculation, the values of BCR are greater than 1 (BCR> 1). Hence, these two alternatives can be considered economically efficient.

4.9. Incremental Rate of Return Analysis

After analyzing using the NPV and IRR methods, it is discovered that both the treatment alternative and the existing conditions provide feasible and efficient results through the BCR method, therefore the calculation will be carried out using the incremental internal rate of return analysis method. The calculation in question is shown in Table 4.

Table 4. Incremental rate of return analysis calculation

Year	Revenue Differences	Expenditure Differences	Incremental Cash Flow
0	-	(22,623,606,310.00)	(22,623,606,310.00)
1	1,806,000,000.00	(420,000,000.00)	1,386,000,000.00
2	3,231,000,000.00	(517,000,000.00)	2,714,000,000.00
3	2,693,000,000.00	(537,000,000.00)	2,156,000,000.00
4	2,915,000,000.00	(557,000,000.00)	2,358,000,000.00
5	2,848,000,000.00	(578,000,000.00)	2,270,000,000.00
6	3,133,000,000.00	(599,000,000.00)	2,534,000,000.00
7	3,133,000,000.00	(622,000,000.00)	2,511,000,000.00
8	2,973,000,000.00	(645,000,000.00)	2,328,000,000.00
9	3,270,000,000.00	(669,000,000.00)	2,601,000,000.00
10	3,270,000,000.00	(694,000,000.00)	2,576,000,000.00
11	3,270,000,000.00	(721,000,000.00)	2,549,000,000.00
12	3,597,000,000.00	(748,000,000.00)	2,849,000,000.00
13	3,597,000,000.00	(775,000,000.00)	2,822,000,000.00
14	3,597,000,000.00	(804,000,000.00)	2,793,000,000.00
15	3,957,000,000.00	(835,000,000.00)	3,122,000,000.00
16	3,957,000,000.00	(866,000,000.00)	3,091,0000,00.00
17	3,957,000,000.00	(899,000,000.00)	3,058,000,000.00
18	4,353,000,000.00	(932,000,000.00)	3,421,000,000.00
19	4,353,000,000.00	(967,000,000.00)	3,386,000,000.00
20	4,353,000,000.00	(1,004,000,000.00)	3,349,000,000.00
IRR 9.09%			
(> MARR) --> FEASIBLE)			

This calculation is done by calculating the entire difference in the cash flow projection between the two alternatives for comparison. In this calculation, the treatment alternative can be considered better than continuing to rely on the existing conditions if the IRR value is greater than the MARR value. Otherwise, if the IRR value is smaller than the MARR value, then the existing condition is more feasible to continue. Based on Table 4, it is discovered that the IRR value is 9.09% which is greater than the MARR value of 3.75%. This means that a treatment alternative must be chosen.

V. CONCLUSION

From the results of the previous analysis in this study, several conclusions can be made as follows:

4.1. The Cause of Not Achieving Pressure

From the results of the field observation, by performing calibration at several points, observing the existing conditions of the production unit and distribution unit, as well as utilizing data obtained from the PDAM, it can be concluded that the causes of not achieving water pressure in the Bajuin District Capital Service piping network are:

a. The water treatment unit is not optimal, the Water Treatment Installation (IPA) along with the supporting facilities that were built in 1983, and the IPA which was built in 2013 are currently operating less than optimal.

b. The distribution unit, namely the piping network with asbestos cement pipe (ACP) material is not efficient due to it being more than 35 years old and can easily break if pressure is increased. This is discovered based on the EPANET simulation using data calibration. In addition, ACP pipes are currently not included in the food grade standard for producing safe drinking water.

Some of the above are the main causes of not achieving the pressure according to the needs during peak service hours, hence it will affect customer satisfaction.

4.2. Financial Performance Analysis Results

Furthermore, after analyzing the financial performance, several points can be concluded as follows:

a. The investment program for the IPA construction project, reservoir booster, replacement of ACP pipes by HDPE, and optimization of the existing IPA at Bajuin District Capital which will be proposed through the National Urban Water Supply Program (NUWSP) funded by the World Bank or APBN has a total cost of Rp 33,716,000,000, and based on the analysis of financial performance which has been projected in the next 20 years it is found to be feasible and profitable, and will increase revenue for PDAM. The performance of PDAM is, therefore, expected to improve. With an NPV of Rp 18,122,978,276.66, the IRR value is 9.42% which is greater than the MARR set at 3.75%, and the BCR value is 1.25 which is greater than 1.

b. Meanwhile, if the treatment project is not implemented, by continuing to rely on the existing conditions, the analysis in the next 20 years can also be considered feasible with an NPV of Rp 4,532,611,399.79, an IRR of 10.72% which is greater than the MARR set at 3.75%, and a BCR of 1.113 which is also greater than 1.

Furthermore, based on calculations using the incremental internal rate of return analysis method, an IRR of 9.09% which is greater than the MARR of 3.75% is obtained. This means that the treatment alternative can be considered feasible when compared to continuing with the existing condition.

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