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Formation of Linear Programming Models of Water Price Compliant to the Regulation of Ministry of Home Affairs, Indonesia

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ABSTRACT

Regional Drinking Water Company (PDAM) Tirtanadi manages Medan City's clean water. PDAM divides its clients into seven categories, with Group I being low-income areas that require water subsidies. PDAM does not yet have a mathematical model for water rates, but it depends on Minister of Home Affairs Regulation No. 23, which gives legal guidance. Since there is no mathematical model, this research uses linear programming (LP) to establish each group's minimal water tariff. PDAM bases its water pricing on the Minister of Home Affairs Regulation No. 23 of 2006 and uses the LP model. The LP model reduces complicated computations into linear equations, making them easier to comprehend and apply. The computed water rates match PDAM pricing for six consumer categories, according to the research. One group, Group II Block I, has a higher tariff ratio of 2.3:1. Model parameters are more susceptible to changes in costs, consumption volume, and payment capability of this group, causing this disparity. This study's new goal is to minimize high-water-use clients. Other groupings remained unchanged. LP models establish PDAM's minimum water rates and optimize water tariff calculation effectively and equitably using analytical methods. PDAM may utilize the LP model to determine pricing that cover all expenditures, but Minister of Home Affairs Regulation No. 23 of 2006 continues to keep tariffs cheap and not a social burden on Medan. This research suggests that additional monopolistic enterprises and other water resource management for 37 Indonesian provinces may utilize its minimum water selling price approach. In the mathematical equation, the LP model is correct. Thus, PDAM Tirtanadi may use it to calculate the minimal water selling price by considering economic considerations. Water firms must help PDAM researchers who are willing to supply data, including polite service from each division's workers.

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A. INTRODUCTION

Water is a vital necessity for humans to sustain daily life. It is no longer a free resource provided by nature but has become a valuable commodity. As such, water must be preserved, protected, and properly managed, requiring investment in water resources to ensure their usefulness and sustainability (Raj et al., 2023). Therefore, water should be managed by institutions capable of serving the community responsibly and effectively (Siphambe et al., 2024) In Medan, PDAM Tirtanadi is responsible for managing water to meet the needs of the community. PDAM operates as a monopoly, granting it the authority to determine water tariffs

for seven customer groups, namely low tariff (L_r), basic tariff (B_r) group I block II, basic tariff (B_r) group II block I, full tariff (F_r) group II block II, full tariff (F_r) group III block I, full tariff (F_r) group III block II and special tariff (S_r).

The water tariffs set for the full tariff and special tariff groups are very high because these groups are subject to progressive tariffs, which impose higher rates on those consuming water above the basic drinking water needs standard. The implementation of progressive tariffs aims to protect raw water resources (Chapter II, Article 8, Paragraph 2) and provide subsidies to low-tariff customer groups (Chapter VI, Article 21, Paragraph 2e). The population of Medan City is approximately 2,279,894 people, comprising 569,974 households (Badan Pusat Statistik, 2016) . Therefore, PDAM must be able to meet the water needs of every resident, and the implementation of water tariffs should be appropriate to ensure it does not burden customers. Because water tariff can also optimize water usage, project collective water usage, and consider the rising costs of groundwater (An-Vo et al., 2015)

In determining water tariffs, PDAM does not have a specific mathematical model. The tariff determination by PDAM solely refers to Minister of Home Affairs Regulation No. 23 of 2006. Tariffs are defined as levies imposed on all goods crossing a country's borders, either for export or import, and are applicable at a specific time (Ząbkowski et al., 2023). Tariffs also protect domestic producers, including emerging industries, and help counteract unfair practices by foreign producers engaging in dumping or selling imported goods at prices lower than the domestic market value (Márquez-Ramos et al., 2021). In addition, tariffs can also increase government revenue through taxation. Meanwhile, price is the value of an object measured in terms of money or other means of exchange (Soares et al., 2024). According to Coelho & Castillo-Girón (2020), price is something that is sacrificed to obtain a good or service. Price is also the exchange of money to acquire goods or services, along with the sacrifice of time spent waiting to obtain those goods or services (Giunta et al., 2021). The relationship between tariffs and prices involves understanding that tariffs can be an amount or levy imposed on a good, or they can refer to a pricing structure set by an institution or service provider (Acey et al., 2019). Therefore, it is tariffs that determine the price. This study will determine water tariffs by formulating a series of equations in the form of a model consisting of PDAM revenue, total social costs, water resource costs, water treatment costs, water provision and distribution costs, as well as general and administrative expenses. From the resulting model structure, a price is generated as the unit to be paid by customers.

Therefore, this study employs a Linear Programming (LP) model to determine the minimum water tariff. This model is derived from a clause-by-clause translation of the Minister of Home Affairs Regulation No. 23 of 2006 into structured mathematical equations. This LP model is used to formation the water tariffs determine. The implementation of (LP) in water management offers a promising path toward sustainable and efficient solutions due to its ability to address complex optimization problems with various constraints (Freire-González, 2019). According to Song et al. (2024), this (LP) model has two functions: maximizing profit and minimizing production costs (output functions). Every problem to be expressed in (LP) model must be formulated as a mathematical equation, incorporating parameters of predetermined decision variables and establishing a relationship between the objective function and the constraint functions (Grové et al., 2023). This study seeks to address this gap

by developing an advanced LP model specifically designed to comply with the regulatory guidelines of the Ministry of Home Affairs in Medan. By incorporating a comprehensive analysis of cost structures, environmental impacts, and socio-economic factors, this study aims to offer a robust framework for determining air pricing strategies that can ensure equitable access to air, encourage desirability, and support the objectives of the Indonesian government's air pricing regulations (An-Vo et al., 2015). The application of LP for water pricing has been explored in various countries, reflecting a global interest in optimizing water resources management to achieve economic efficiency, environmental sustainability, and social equity. Each country's approach to using LP for water pricing is shaped by its unique water resource challenges, regulatory frameworks, and socio-economic contexts. Here's an overview of how LP has been used for water pricing in different countries, highlighting the diverse applications and objectives: (1) Australia: has utilized LP models to manage its scarce water resources, especially in the Murray-Darling Basin. The country focuses on maximizing water use efficiency in agriculture while ensuring environmental flows are maintained (Coelho & Castillo-Girón, 2020); (2) China: Studies have focused on optimizing water supply systems in cities like Beijing, where LP models help determine water tariffs that encourage conservation and ensure the financial viability of water utilities, while also considering the social impact of pricing policies (Li et al., 2019); (3) Egypt: LP models have been used to optimize the allocation of Nile water for different uses, with water pricing serving as a mechanism to promote efficient use and distribution of water resources among agricultural, industrial, and domestic sectors (Wahba et al., 2018); and (4) Spain: The models have been used to assess the economic value of water in agriculture, inform water pricing policies, and optimize the allocation of water resources among users to balance economic, environmental, and social objectives (Kouriati et al., 2024). LP is a set of linear equations, where each linear equation consists of one dependent variable and several independent variables (Shamieh et al., 2018). The dependent variable is a function of the independent variables, governed by the following equation: $y = f(X_i) = a_1x_1 + a_2x_2 + a_3x_3 + \cdots a_nx_n$, Where: y = dependent variable; x_i = independent variable; a_i = coefficient, $a_i \in R$.

B. METHODS

The design of this study begins with the problem of the different selling prices of water set by PDAM Medan for the seven groups. Two groups have to pay high water prices, while one group gets a subsidy, which causes injustice in the use of water for customers. In addition, PDAM sets the selling price of water only based on the Regulation of the Minister of Home Affairs Number 23 of 2006 and does not yet have an accurate mathematical model. For this reason, this study created a model to determine the minimum selling price of water for the seven groups of PDAM customers. The methodology of this study is divided into four research objectives (RO), with RO-1 translating the law of the Regulation of the Minister of Home Affairs Number 23 of 2006 into a mathematical equation in the form of an LP model. By translating the law verse by verse into an LP model in a mathematical equation. In translating the water law, it is necessary to study each chapter in depth so that it can be formed into an LP model with the mathematical equation that has been developed. RO-3 determines the minimum selling price of water for the seven groups with the LP model that has been formed. The price

obtained is called the new water tariff. Water tariffs or tariffs are used interchangeably throughout the thesis to refer to a structure or mechanism that controls water prices. To ensure the accuracy of the tariff obtained from the confirmation, it is compared with the water price set by PDAM. The confirmation was carried out from 2018 to 2022. As a contribution to this research, the LP model can be used by PDAM in determining the minimum selling price of water because it has achieved a mathematically accurate model. Therefore, this research model can provide good information in determining the minimum selling price of water for PDAM. The description above is illustrated in Figure 1 below.

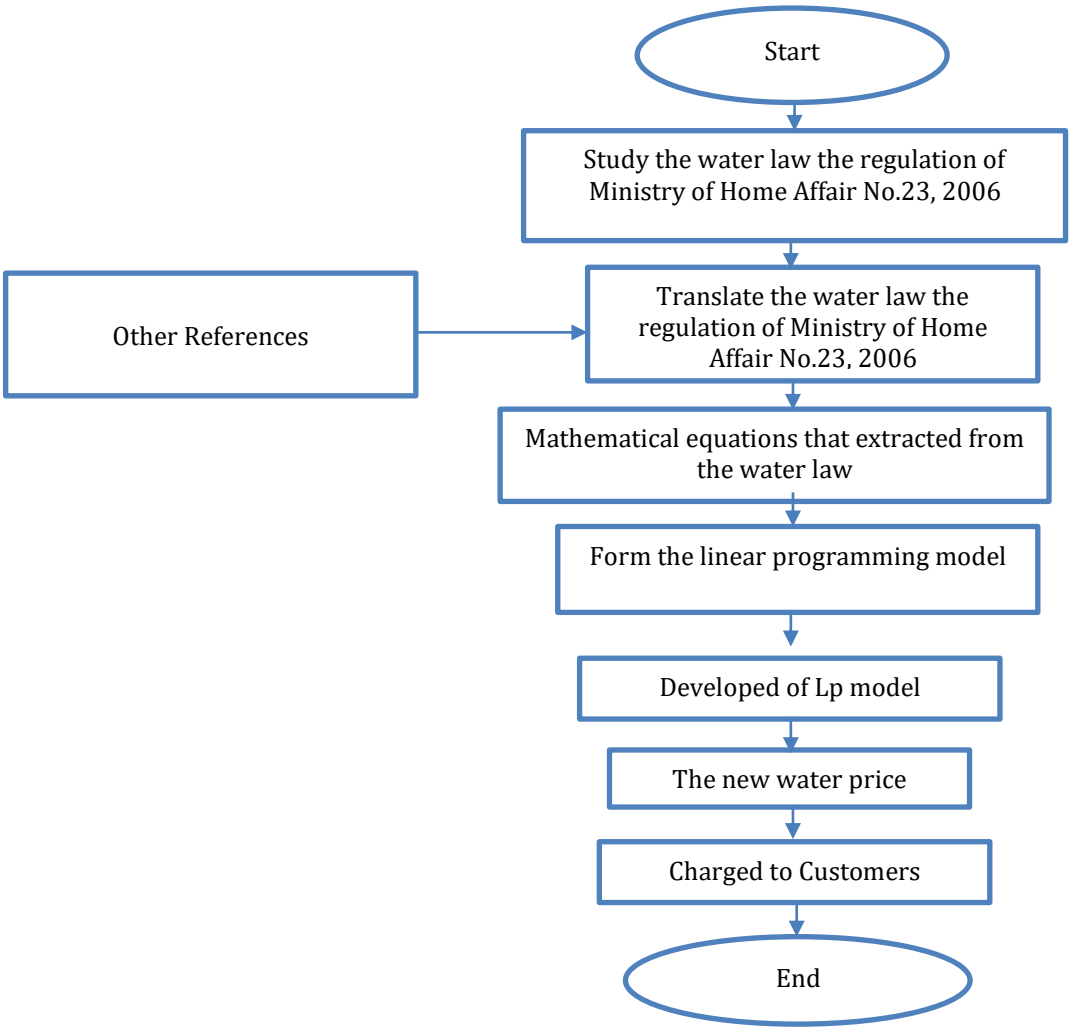

Figure1. Research Methodology

This study briefly explained the state of the PDAM, including revenue, customers, cost of water resources, water treatment, water supply and distribution, cooperation and administrative costs, and the selling price of water determined by the company. Then mathematical equations were formed, containing revenue, customers, total cost of production and the selling price of water. Known that PDAM is a regional company that distributes water to the people of Medan. It is a monopoly company because only PDAM provides water in the city of Medan. According to (Bergaentzlé et al., 2019), monopolists will go bankrupt because the tariffs paid by consumers are inversely proportional to the lowprice elasticity. To translate the Regulation of the Ministry of Home Affairs Indonesia, No. 23, 2006, the first step was to

reading Chapter I. The chapter contained generalisation with sub-sections from 1 to 15. Nevertheless, only a few paragraphs were used in translating the water law because they were adapted to the needs of this research. In Chapter I, paragraphs 9 to 14 were translated and defined mathematically. The part translated from Government Regulation No. 23 of 2006 begins with production costs, basic costs, low tariffs, basic tariffs, full tariffs, and special tariffs up to the formation equation selling price of water. The purpose of translating these variables is to formulate mathematical equations, ultimately deriving the equation for the selling price of water in a linear programming model. Thus, the translation is as follows:

1. Production Cost: In Chapter I, article-1, paragraph-9, production cost is defined as the total production cost (V) to produce clean water that includes the costs of water resources (V_1), cost of water treatment (V_2), cost of water supply and distribution (V_3), general and administrative costs (V_4). Therefore, mathematically, it is written as:

$$V = V_1 + V_2 + V_3 + V_4 \tag{1}$$

2. Basic Cost: In Chapter I, article-1, paragraph-10, basic cost, B_c is defined as production cost, V divided by produced water volume, w_v minus the volume of standard water loss, w_L. Therefore, it is written as:

$$B_c = \frac{V}{w_v - w_L} \tag{2}$$

3. Low Tariff: In Chapter I, article-1, paragraph-12, low tariff, L_r is defined as a subsidised tariff. Its value is lower compared to basic cost, B_c. Therefore, it is written as:

$$L_r < B_c \tag{3}$$

4. Basic Tariff: In Chapter I, article-1, paragraph-13, basic tariff, B_r is defined as a tariff that is equivalent with basic cost, B_c. It is written as:

$$B_r = B_c \tag{4}$$

5. Full Tariff: In Chapter I, article-1, paragraph-14, full tariff, F_r is defined as a tariff with a value higher than basic cost, B_c because it includes profit generation and contra cross-subsidies. It is written as:

$$F_r > B_c \tag{5}$$

6. Special Tariff: According to Chapter V, article-17, paragraph-5, the agreed tariff as referred to in paragraph (1) letter d, is based on the agreement between PDAM and the customer. In this case, an agreement exists between the director of the PDAM and the customer with a bond stipulated in the agreement with the approval of the management board, and voluntary communication is required that is mutually beneficial to both parties.

C. RESULT AND DISCUSSION

In determining the water prices for the seven customer groups, data obtained from the PDAM was used. This data had been processed, averaged, and rounded. The data was then structured into an LP equation using symbols as the objective function and constraint functions. The data was collected from the years 2007 to 2016, can be seen in Table 1, as follows:

Table 1. Data from $U_1, U_2, U_3, V_1, V_2, V_3, V_4$ (in IDR/m³) in 2007 to 2016

Average of	Low tariff	Basic tariff group I block II, with water usage ≤ 10.000 m³	Basic tariff group II block I, with water usage > 10.000 m³	Full tariff group II block II, with water usage ≤ 10.000 m³	Full tariff group III block I, with water usage > 10.000 m³	Full tariff group III block II, with water usage ≤ 10.000 m³	Special tariff, with water usage ≤ 10,000 m³ dan > 10,000 m³
Water price (U_1 in IDR/m³)	1,623.8	2,405.4	5,134	5,634	6,915.1	12,572.9	53,821.9
PDAM revenue (U_2 in IDR/m³)	7,627.1	8,516.1	15,654	17,192	18,811.5	33,623.1	65,818
Total social cost (U_3 in IDR/m³)	3,616.5	8,044.6	12,423.4	33,653.6	7,275.42	6,256.4	50,779.4
The cost of water resource (V_1 in IDR/m^3)	2,479.1	2,958.3	3,997.5	4,361.03	4.797,38	4.797,38	7,589.03
Cost of water treatment (V_2 in IDR/m³)	139.4	112.57	278.91	562.67	1,066.8	2,133.7	4,469
Cost of water supply and distribution (V_3 in IDR/m³)	170.2	137.96	362.51	521,92.8	1,086.3	2,629.06	4,511.119
General and administrative costs (V_4 in IDR/ m³)	1,221.9	2,443.9	2,292.79	4,635.1	9,370.6	18,779.2	35,218.59

By substituting the coefficient $U_1, U_2, U_3, V_1, V_2, V_3, V_4$ taken from Table 2, the equation is formulated into a linear programming model consisting of seven equations. Since the variables consist of seven, the equation cannot be solved manually using the simplex method. Therefore, to determine the water price for each group, statistical tools are used. In this study, LINDO was employed, and the same approach was applied to all groups until all seven groups were completed, as shown in the equation below.

1. Determining the Water Price for Low Tariff

Based on the average data obtained from Table 2, a linear programming equation was formulated, consisting of an objective function that minimizes the selling price of water. The constraint function includes seven customer groups in a linear mathematical equation. To determine the water price for these seven customer groups, the LINDO software was used, the data can be formulated into an LP equation for low tariff as shown below:

$Min\ 7627.1U_2 - 3616.5U_3 - 2479.1V_1 - 139.4V_2 - 170.2V_3 - 1221.9V_4$

Subject to

$7627.1U_2 - 3616.5U_3 - 2479.1V_1 - 139.4V_2 - 170.2V_3 - 1221.9V_4 \geq 1623.8$

$8516.1U_2 - 471.5U_3 - 2997.5V_1 - 112.57V_2 - 137.96V_3 - 2443.9V_4 \geq 2405.4$

$15654U_2 - 12423.4U_3 - 3997.3V_1 - 278.91V_2 - 363.51V_3$-$2292.79V_4 \geq 5134$
$17192U_2 - 33653.6U_3 - 4361.03V_1 - 562.67V_2 - 521.92V_3 - 4635.1V_4 \geq 5643$
$18811.5U_2 - 7275.42U_3 - 4797.38V_1 - 1066.8V_2 - 1086.3V_3 - 9370.6V_4 \geq 6915.1$
$33623.1U_2 - 6256.4U_3 - 4962.3V_1 - 2133.7V_2 - 2629.06 - 18779.2V_4 \geq 12572.9$
$65818U_2 - 50779.4U_3 - 7589.03V_1 - 4469.0V_2 - 4511.1V_3 - 3521.8V_4 \geq 53821.9$
$U_2, U_3, V_1, V_2, V_3, V_4 \geq 0$
End

The same approach was utilised to calculate the water price for tariff group I block II, basic tariff group II block I, full tariff group II block II, full tariff group III block I, full tariff group III block I and special tariff.

2. Establishing the Water Price for Basic Tariff Group I Block II

In establishing the minimum water selling price for the basic tariff group I block II, the calculations were carried out in the same way as low tariff.

Min $8516.1U_2 - 471.5U_3 - 2997.3V_1 - 112.57V_2 - 137.96V_32 - 2443.9V_4$
Subject to
$7627.1U_2$- $3616.5U_3$-$2479.1V_1$-$139.4V_2$-$170.2V_3$-$1221.9V_4 \geq 1623.8$
$8516.1U_2$-$471.5U_3$-$2997.5V_1$-$112.57V_2$-$137.96V_3$-$2443.9V_4 \geq 2405.4$
$15654U_2$-$12423.4U_3$-3997.53-$278.91V_2$-$363.51V_3$-$2292.79V_4 \geq 5134$
$17192U_2$-$33653.6U_3$-$4361.03V_1$-$562.67V_2$-$521.92V_3$-$4635.1V_4 \geq 5634$
$18811.5U_2$-$4797.38U_3$-$4797.38V_1$-$1066.8V_2$-$1086.3V_3$-$9370.6V_4 \geq 6915.1$
$33623.1U_2$-$6256.4U_3$-$4962.3V_1$-$2133.7V_2$-$2629.06V_3$-$18779.2V_4 \geq 12572.9$
$65818U_2$-$50779.4U_3$-$7589.03V_1$-$4469.0V_2$-$4511.1V_3$-$3521.8V_4 \geq 53821.9$
$U_2, U_3, V_1, V_2, V_3, V_4 \geq 0$
End

3. Calculating the Water Price for Basic Tariff Group II Block I

Based on the calculations, it can be arranged in a linear equation as follows:

Min $15654U_2 - 12423.4U_3 - 3997.3V_1 - 278.91V_2 - 363.51V_3 - 2292.79V_4$
Subject to
$7627.1U_2$ -$3616.5U_3$ -$2479.1V_1$-$139.4V_2$-$170.2V_3$-$1221.9V_4 \geq 1623.8$
$8516.1U_2$-$35674.4U_3$-$2997.5V_1$-$112.57V_2$-$137.96V_3$-$2443.9V_4 \geq 2405.4$
$15654U_2$-$12423.4U_3$-$3997.3V_1$ -$278.91V_2$-$363.51V_3$- $2292.79V_4 \geq 5134$
$17192U_2$-$33653.6U_3$-$4361.03V_1$-$562.67V_2$-$521.92V_3$-$4635.1V_4 \geq 5634$
$18811.5U_2$-$7275.42U_3$-$4797.38V_1$-$1066.8V_2$-$1086.3V_3$-$9370.6V_4 \geq 6915.1$
$33623.1U_2$-$6256.4U_3$-$4962.3V_1$-$2133.7V_2$ -$2629.06V_3$-$18779.2V_4 \geq 12572.9$
$65818U_2$-$50779.4U_3$-$7589.03V_1$-$4469.0V_2$-$4511.1V_3$-$3521.8V_4 \geq 53821.9$
$U_2, U_3, V_1, V_2, V_3, V_4 \geq 0$
End

4. Setting the Water Price for Full Tariff Group II Block II

In setting the minimum water selling price for the full tariff group II block II, the calculations for each variable and variable coefficient were done the same way as for low tariff. With the calculated variables, it can be arranged into a linear equation as follows:

Min $17192U_2 - 33653.6U_3 - 4361.03V_1 - 562.67V_2 - 521.92V_3 - 4635.1V_4$

Subject to

$7627.1U_2$ -$3616.5U_3$-$2479.1V_1$-$139.4V_2$-$170.2V_3$-$1221.9V_4 \geq 1623.8$

$8516.1U_2$-$471.5U_3$-$2997.5V_1$-$112.57V_2$-$137.96V_3$-$2443.9V_4 \geq 2405.4$

$15654U_2$-$12423.4U_3$-$3997.3V_1$-$278.91V_2$-$363.51V_3$-$2292.79V_4 \geq 5134$

$17192U_2$-$33653.6U_3$-$4361.03V_1$-$562.67V_2$-$521.92V_3$ -$4635.1\ V_4 \geq 5634$

$18811.5U_2$-$7275.42U_3$ -$4797.38V_1$-$1066.8V_2$-$1086.3V_3$-$9370.6V_4 \geq 6915.1$

$33623.1U_2$-$6256.4U_3$-$4962.3V_1$-$2133.7V_2$-$2629.06V_3$-$18779.2V_4 \geq 12572.9$

$65818U_2$-$50779.4U_3$-$7589.03V_1$-$4469.0V_2$-$4511.1V_3$-$3521.8V_4 \geq 53821.9$

$U_2, U_3, V_1, V_2, V_3, V_4 \geq 0$

End

5. Pricing the Water Price for Full Tariff Group III Block

Based on the calculations for each variable, it can be arranged into a linear equation as follows:

Min 18811.5U2−7275.42U3−4797.38V1−1066.8V2−1086.3V3−9370.6V4

Subject to

7627.1U2-3616.5U3-2479.1V1 -139.4V2-170.2V3-1221.9V4≥1623.8

8516.1U2-471.5U3-2997.5V1-112.57V2-137.96V3-2443.9V4≥2405.4

1565.4U2-12423.4U3-3997.3V1-278.91V2 -363.51V3-2292.79V4≥5134

17192U2-33653.6U3-4361.03V1-562.67V2-521.92V3-4635.1V4≥5634

18811.5U2-7275.42U3-4797.38V1-1066.8V2-1086.3V3-9370.6V4≥6915.1

33623.1U2-6256.4U3-4962.3V1-2133.7V2 -2629.06V3-18779.2V4≥12572.9

65818U2-50779.4U3-7589.03V1-4469.0V2-4511.1V3-3521.8V4≥53821.9

U2, U3, V1, V2, V3, V4≥0

End

6. Estimating the Water Price for Full Tariff Group III Block II

With the calculated variables, it can be arranged into a linear equation as follows:

Min 33623.1U2−6256.4U33−4962.3V1−2133.7V22−**2**629.06V3−18779.2V4

Subject to

7627.1U2- 3616.5U3-2479.1V1 -139.4V2-170.2V3 -1221.9V4≥1623.8

8516.1U2-471.5U3-2997.5V1-112.57V2-137.96V3-2443.9V4≥2405.4

15654U2-12423.4U3 -3997.3V1 -278.91V2 -363.51V3 -2292.79V4≥5134

17192U2-33653.6U3-4361.03V1-562.67V2-521.92V3 -4635.1V4≥5634

18811.5U2-7275.42U3-4797.38V1-1066.8V2 -1086.3V3 -9370.6V4≥6915.1

33623.1U2-6256.4U3-4962.3V1 -2133.7V2-2629.06V3-18779.2V4≥12572.9

65818U2-50779.4U3-7589.03V1-4469.0V2-4511.1V3-3521.8V4≥53821.9

U2, U3, V1, V2, V3, V4≥0
End

7. Figuring the Water Price for Special Tariff

With the calculated variables, it can be arranged into a linear equation as follows:

Min $65818U_2 - 50779.4U_3 - 7589.03V_1 - 4469.0V_2 - 4511.1V_3 - 3521.8V_4$
Subject to
$7627.1U_2$-$3616.5U_3$-$2479.1V_1$-$139.4V_2$-$170.2V_3$-$1221.9V_4$≥1623.8
$8516.1U_2$-$471.5U_3$-$2997.5V_1$ -$112.57V_2$ -$137.96V_3$-$2443.9V_4$≥2405.4
$1565.4U_2$-$12423.4U_3$-$3997.3V_1$-$278.91V_2$-$363.51V_3$ -$2292.79V_4$≥5134
$17192U_2$-$33653.6U_3$-$4361.03V_1$-$562.67V_2$-$521.92V_3$ -$4635.1V_4$≥5634
$18811.5U_2$-$7275.42U_3$ -$4797.38V_1$-$1066.8V_2$-$1086.3V_3$ -$9370.6V_4$≥6915.1
$33623.1U_2$-$6256.4U_3$-$4962.3V_1$ -$2133.7V_2$ -$2629.06V_3$-$18779.2V_4$≥12572.9
$65818U_2$-$50779.4U_3$-$7589.03V_1$-$4469.0V_2$-$4511.1V_3$-$3521.8V_4$≥53821.9
U_2, U_3, V_1, V_2, V_3, V_4≥0
End

Based on the results of the data analysis by LINDO software for the seven PDAM customer groups, the water selling price obtained can be seen in Table 2.

Table 2. Water selling price (U_1) obtained using LP model in 2017

No	Customer	Optimal state with iteration	(Price/m³)
1	Low tariff	4	1,623.8
2	Basic tariff group I block II	2	2,405.4
3	Basic tariff group II block I	4	12,045.6
4	Full tariff group II block II	3	5,634.0
5	Full tariff group III block I	2	6,915.1
6	Full tariff group III block II	2	12,572.9
7	Special tariff	1	53,821.9

Table 2, reveals that the minimum water price for low tariff was low tariff was equal to IDR 1,623.8/m³. This outcome is because the low tariff group is subsidised between groups, so the price of water is very low and in accordance with the 1945 Constitution article-33 paragraph-3 which states that all of Indonesia's natural wealth is for the welfare of the Indonesian people. Therefore, if subsidies between groups do not meet, the government must provide subsidies from the state and regional budgets for revenue. This research result at Table 7 showed that the minimum selling price of water for basic tariff group I block II was equal to IDR 2,405.4/m³. Determination the low selling price of water is undoubtedly detrimental to PDAM. The water company covers financial difficulties from non-sales of water revenue, for example connecting new pipes, fines, installation leases and so on. The research results revealed that the price of water for the basic tariff group II block I was IDR 12,045.6/m³, while the price set by PDAM for this was only IDR 5,134.5/m³. There is a significant price difference of 2.3: 1. From Appendix J, basic tariff group II block I is a group of households with

a higher amount of water usage, namely > 10,000 m^3 and with more customers, from the research show that PDAM a loss of 57.3%,, the higher prices obtained in this study were intended so that the PDAM could achieve the target full cost recovery which is beneficial for the development and continuity of PDAM of its services, and become a source of local revenue as a concrete manifestation of the implementation of regional autonomy. According to (Lu, L., Deller, D., & Hviid, 2019), the aim of increasing water prices for customer groups is to limit high water demand, increase block rates, balance incentives for savings with fair distribution of costs across households and instill responsive intervention behavior to conserve water. Nevertheless (Ashoori, N., Dzombak, D. A., & Small, 2016) stated that a

100% price increase at several user levels would have little impact on the price index, sectoral output and employment opportunities and would not affect economic fluctuations or economic instability. From the research results in Table 7, the minimum water price for the full tariff group II block II is equal to IDR 5,634.0/m^3. This is because the group contains a component of a reasonable profit rate and counter-subsidies. This means that full tariff customers pay progressive water prices to provide cross-subsidies to customers who pay low tariff. Based on the research results in Table 7, the minimum selling price of water for full tariff group III block I was equal to IDR 6,915.1/m^3. Full tariff group III block I is a group that provides cross-subsidies and consists of the industrial sector. PDAM is obliged to gain profit from the services provided to this group for the company to be in a healthy condition in terms of financial, managerial and personnel aspects to make a profit. From the research results, the minimum selling price of water for full tariff group III block II was equal to IDR 12,572.9/m^3. It does not mean that the water price set by PDAM has reached the minimum water price. Instead, the price of water is low, so it cannot guarantee the interests of PDAM as a business entity and water operator for benefit the community. From the research results, the selling price of water for special tariff ws equal to IDR 53,821.9/m^3. For this group, PDAM sets a high selling price for water because this group consists of large, medium and small traders. Therefore, this group can provide benefits for PDAM and also provide cross-subsidies.

D. CONCLUSION AND SUGGESTIONS

Conclusion of this research the results of this study indicate that the profits obtained by PDAM are still low (Minister of Home Affairs Regulation Number 23 of 2006, Chapter VI Article 24 Paragraph 1). The findings of the analysis reveal that PDAM has a deficit if money is exclusively collected from water sales and the PDAM operational area is only in zone 1. To cover the deficit, the company uses non-water sales income and water from zone 2 which are not discussed in this study. The LP model can also confirm the selling price of water carried out, namely from 2018 to 2022. So that the explanation of the affirmation is not too long, this paragraph only writes the results of the affirmation for 2021 and 2022 and the results of the study are also the same as in 2018. The results of the study show that the affirmation for low tariffs in 2021 is IDR 5,434.51 / m3 and the price of water in 2022 is IDR 5,434.51 / m3. For basic tariff group I block II in 2021 it is IDR2,405.4/m3 and water price in 2022 is IDR2,405.4/m3. For basic tariff group II block I in 2021 it is IDR12,045.6/m3 and water price in 2022 is IDR12,045.6/m3. For full tariff group II block II in 2021 it is IDR5,634/m3 and air price in 2022 is IDR5,634/m3. For full tariff group III block I in 2021 it is IDR6,915.1/m3 and

water price in 2022 is IDR6,915.1/m3. For full tariff group III block II in 2021 it is IDR12,572.9/m3 and water price in 2022 is IDR12,572.9/m3. For the special tariff group in 2021, it is IDR 53,821.9/m3 and the water price in 2022 is IDR 53,821.9/m3. It can be seen that the water price for each customer group obtained from affirmations in 2021 and 2022 has not changed.

This shows that the air price has reached the minimum limit. With this affirmation, PDAM can improve the operation and maintenance of the drinking water supply system effectively and efficiently in the future, improve PDAM performance and drinking water services for the community, and plan efficient funding source implementation activities for the implementation of PDAM's termination. Based on the confirmation findings of this research, the water price for the low tariff group is IDR 5,434.5/m3 and the price established by PDAM is only IDR 1,623.8/m3. The baseline tariff group II block I is IDR 12,045.6/m3, however the price established by PDAM is just IDR 5,134.5/m3. There is a considerable price disparity in this research, which is three times the amount established by PDAM. It is known that the price of water in the two groups, namely the low tariff group and the basic tariff group II block I, has grown from 2017 to 2022, while the other groups stay the same as the price established by PDAM. This shows that the novelty of the findings has been achieved. The results of this study indicate that the prices obtained in this study are the actual prices and the prices that must be applied by PDAM in the low tariff group. Thus, PDAM can increase revenue and become more sustainable, while the basic tariff group II block I also gets high prices. Although PDAM is socially oriented, PDAM is also a company that seeks profit with the aim of maintaining the company's life and developing its business. In this case, the company needs to increase the selling price of water according to the price obtained in this study in order to cover its costs in full. In addition, the LP model is mathematically accurate, while PDAM uses regulations set by the government and the tariffs set are valid for up to five years. This research suggests that monopolistic enterprises and other water resource management for 37 Indonesian provinces utilize the minimum water selling price approach. In the mathematical equation, the LP model is correct. Thus, PDAM Tirtanadi may use it to calculate the minimal water selling price by considering economic considerations. Water firms must help PDAM researchers who are willing to supply data, including courteous service from each division.

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