Study of commercial water losses in PDAM Maja Tirta, Mojokerto City

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Abstract. Water losses is a problem that often occurs in PDAM (Perusahaan Daerah Air Minum), including PDAM Maja Tirta, Mojokerto City. Water meters at customer connections installed for a long time and have never been calibrated can decrease in accuracy, causing commercial water losses. This study starts with a literature study about water losses. It then collected secondary data from PDAM Maja Tirta Mojokerto City in the form of service maps, the number and address of customers, the volume of water input that enters the distribution system, the system output volume, and tariffs or prices water. An analysis can be done from the secondary data to determine the number and location of sampling using the method described in SNI 05-0666 of 1997. The primary data that will be taken is the accuracy of the customer's water meter measurements. From the study results, the level of commercial water loss due to the accuracy of the water meter was 8.52% from input system volume (total distributed water) or 148.160 m$^3$. Control of commercial water losses can be done by periodically measuring the customer's water meter, replacing damaged water meter, and adding an input system water meter.

1. Introduction

In operating, there are various problems that occur in local water company (PDAM), one of the problems that often occur is water losses [1]. Water losses in the PDAM or Non-Revenue Water is water produced by the PDAM that does not generate revenue, causing losses [2]. The rate of water loss in Indonesia is still quite high at an average of 37% and even in some PDAM's the water loss rate reaches 70% [3]. This can result in losses for the PDAM because lost water will reduce revenue [4]. Water losses can occur at several points in the drinking water supply system, including the Water Treatment Plant (WTP), the main network, reservoirs, water meters, and payment systems [5]. Water meter is a tool for measuring the amount of water flow continuously through a working system equipment that is equipped with a sensor unit, a counting unit, and a measuring indicator unit to state the volume of water that passes [6]. The water meter level is influenced by pressure, the age of the water meter, and the starting flow [7]. One way to check water losses is to use a water balance. Water balance is a tool for calculating water losses that function to check and control at three main points which are indicators of the health of the drinking water supply system, namely: system input, consumption, and water losses [2]. The purpose and objective of this study is to calculate the amount of commercial water losses in PDAM Maja Tirta, Mojokerto City to determine the amount of commercial water losses that occur.
2. Methodology

2.1. Number and sampling location
The number of samples taken refers to SNI 05-0666-1997 and with customer data grouping into domestic and non-domestic in each district as shown in the figure below.

![Location map for water meter sample.](image)

Figure 1. Location map for water meter sample.

2.2. Sampling technique
Sampling was carried out using a simple tera instrument, as shown in the figure below.

![Simple water tera meter instrument for sampling the water meter accuracy test.](image)

Figure 2. Simple water tera meter instrument for sampling the water meter accuracy test.

The sampling steps are:
- Installing the water hose from the customer's faucet to the inlet of tera instrument
- Open the customer’s faucet
- Records the customer’s water meter
- Records the initial tera meter instrument’s water meter
- Calculating the water meter on the tera meter instrument after taking 100 L of water (initial meter + 100 L)
• Turning the faucet on tera meter instrument
• Close the faucet on tera meter instrument when the water meter shows the previously calculated number
• Records the customer’s water meter after sampling
• Calculating the customer’s water meter accuracy
• Doing retest
• Calculating the average of customer’s water meter accuracy

2.3. Water balance calculation
Water balance calculation steps are:
• Calculating volume input system
• Calculating billed authorized consumption
• Calculating unbilled authorized consumption
• Calculating NRW using the following equation [8]:

\[ NRW = Volume\ Input - Billed\ Authorized\ Consumption \]  

(1)

• Calculating water losses using the following equation [8]:

\[ Water\ Losses = NRW - Unbilled\ Authorized\ Consumption = Physical\ Water\ Losses + Commercial\ Water\ Losses \]  

(2)

• Calculating commercial water losses using the following equation [2]:

\[ Commercial\ Water\ Losses = \%KAK \times Water\ Losses\ (m^3/time-months\ or\ years) \]  

(3)

• Calculating physical water losses using equation (2)
• Calculating average water prices tariff using the following equation [9]:

\[ Average\ Tarif (Rp./m^3) = Total\ income\ in\ a\ year\ (Rp.) / water\ consumption\ in\ a\ year\ (m^3) \]  

(4)

3. Results and discussion

3.1. Volume input system
The volume input of treated water that enters into the drinking water network is calculated in the water balance [4]. In this case, the system input volume intended is the total volume of distributed water in PDAM Maja Tirta in 2019 that is 1.739.614 m³.

3.2. Billed authorized consumption
Authorized consumption is the volume of metered or unmetered water taken by registered or official customers, water suppliers and other parties who, implicitly or explicitly, receive official permission to collect water, whether for residential, commercial, or industrial purposes. Authorized consumption can also include water use such as firefighting or extinguishing drills, washing of PDAM pipes or drains, cleaning streets, watering city parks, and water used for construction [4].

Billed authorized consumption is the components of authorized consumption which are subject to payment and become revenue (also known as billed water or income water). Equivalent to metered billed consumption plus unmetered billed consumption [4]. At PDAM Maja Tirta, billed authorized consumption consists of water sold to customers and water tank delivery. The water sold to customers is the authorized consumption with meter, while the water tank's delivery is considered unmetered. The total volume of authorized billed consumption in 2019 is 924.382 m³ with Rp.3.660.048.755 income.

3.3. Unbilled authorized consumption
Unbilled authorized consumption is a legally used component of authorized consumption but is not subject to payment and therefore does not become income. Equivalent to metered unbilled consumption
plus unmetered unbilled consumption [4]. This component is used for PDAM operations such as pipe washing (washout), pipe testing, road cleaning, etc. [10]. At PDAM Maja Tirta, the recorded water volume for authorized unbilled consumption in 2019 for washing pipes (washout) is 6054 m³.

3.4. Non-revenue water (NRW)

NRW is water produced by PDAM’s that do not generate income so that the PDAM loses money [2]. By using the authorized billed input volume and consumption data, NRW calculations can be performed using equation (1). So, the NRW volume is input system volume 1.739.614 m³ minus billed authorized consumption volume 924.382 m³ equal to 815.232 m³.

3.5. Water losses

Water losses is the difference between system input and authorized consumption. Water losses can be considered as the total volume for the entire network, or parts of a network such as transmission or distribution, or restricted zones. Water losses consist of physical losses and non-physical or commercial losses [11]. The volume of water losses can be calculated by equation (2). So, the water losses volume is NRW volume 815.232 m³ minus unbilled authorized consumption volume 6.054 m³ equal to 809.178 m³.

3.6. Commercial water losses

Non-physical (commercial) water losses is water losses that are not physically visible but can be known from calculations or records of the amount of water distributed to customers. Commercial water losses include all kinds of inaccuracies related to customer meters, data mishandling (both meter reading and dipping), and unauthorized consumption (water theft or illegal use of water) [4]. In this study, commercial water losses data is only calculated from the customer water meter results because there is no data on commercial water losses due to water theft and administrative errors.

A total of 126 sampling plans, 68% of the samples were taken, and 86 samples. Then performed calculations to find the deviation value (P). The deviation value can be calculated by finding the difference between the volume of water recorded on the customer meter and the meter reference meter to find out the deviation value using the equation below [2]:

\[ \text{Deviation}(P) = \sum (Mr - Mc) \] (5)

With:
\( Mr = (\text{Meter Reference}) \) the number is shown by the water meter for reference
\( Mc = (\text{Meter Customer}) \) the number shown by the customer's water meter

| Result          | Amount | \( \Sigma \) Deviation (L) |
|-----------------|--------|---------------------------|
| Accurate        | 2      | 0                         |
| Negative deviation | 58   | -356.55                   |
| Positive deviation | 26   | 372.3                     |
| Total           | 86     | 15.75                     |

The amount of commercial water losses due to water meters (KAK) can be calculated using the following equation [2]:

\[ KAK(\%) = (\frac{P}{n}) \times 100\% \] (4)

With:
\( KAK = \) Water meter commercial losses (%)
P = deviation result from water meter accuracy analysis
n = the number of samples

So that the percentage of KAK in PDAM Maja Tirta is 18.31%. The volume of commercial water losses can be calculated using equation (3). Commercial water losses volume is 18.31% times water losses volume 809.178 m³ equal to 148.160 m³.

3.7. Physical water losses
Physical water losses are the physical loss of water from the pressure system and water storage tanks/reservoirs to the customer's point of use. In a network where the customers are installed with a water meter, the customer's point of use is the customer's water meter [4]. The volume of physical water losses can be calculated using equation (2). Physical water losses volume is water losses volume 809.178 m³ minus commercial water losses volume 148.160 m³ equal to 661.017 m³.

3.8. Average water prices tariff
The water price tariff at PDAM Maja Tirta is classified into 10 groups. These groups are small trade, large trade, small industry, large industry, household A, household B, government agencies, tank, general social and special social. Based on equation (4), the average tariff is total income in a year Rp.3.660.048.755 divided by water consumption in a year 924.382 m³ equal to Rp.3.959,45/m³.

3.9. Water balance

| Input system | Authorized consumption | Billed | Unbilled | Revenue water |
|--------------|------------------------|--------|----------|---------------|
|              | 53,14% 924.382 m³      | 53,10% 923.657 m³ | 0,04% 725 m³ | 53,14% 924.382 m³ |
|              | Rp 3.660.048.755       | Rp 3.623.798.755  | Rp 36.250.000 | Rp 3.660.048.755 |
|              |                        | Unmetered          |          |               |
|              |                        | 46,86%             |          |               |

| Water losses | Commercial | Physical |
|--------------|------------|----------|
|              | 8,52% 148.160 m³ | 38,00% 661.017 m³ |
|              | Rp 586.633.794   | Rp 2.617.264.588  |
|              | 815.232 m³       |               |
|              | Rp 3.227.868.759 |               |

Figure 3. PDAM Maja Tirta’s water balance.

3.10. Commercial losses controls
Based on the findings in PDAM Maja Tirta and literature studies on commercial water losses control that can be carried out are as follows:
- Conducting a technical audit of water meter readings
- Conducting regular exchange of meter reading officers
- Using an adequate water meter reading system (digital)
- Verifying the results of customer water meter readings
- Conducting customer water meter tera meter regularly (at least once every 3 years)
- Conducting a survey to customers' homes where the water meter number is indicated by a decrease (water meter is reversed)
- Replacing the water meter that blocks the reading (damaged/mossy)
- Replacing/repairing main water meter for more accurate determination of system input volume
4. Conclusion
Based on the analysis results, the amount of commercial water losses in PDAM Maja Tirta in 2019 is 8.52% of the system input volume (total water distributed) or equal to 148,160 m$^3$. Control of commercial water losses can be done by periodically carrying out customer water meters, replacing damaged/interfering water meters with reading, and conducting main meter installations.

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