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Development of an Application-Based Water Meter Reading System for Accuracy and Stability of Customer Bills at Perumda Tirta Patriot, Bekasi City

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ABSTRACT

Inkonsistensi dalam rentang waktu pembacaan meter air, yang seringkali melebihi atau kurang dari 30 hari standar dalam satu bulan, diyakini menjadi penyebab utama lonjakan tagihan yang tidak wajar dan memicu keluhan pelanggan. Sehingga tujuan penelitian ini adalah untuk menganalisis dampak inkonsistensi periode pembacaan meter air terhadap fluktuasi tagihan pelanggan dan mengusulkan solusi upgrading system pada aplikasi pencatatan meter di PERMDA Tirta Patriot Kota Bekasi. Metode penelitian yang digunakan adalah kualitatif deskriptif dengan pendekatan studi kasus, didukung oleh data sekunder berupa catatan pembacaan meter dan riwayat tagihan pelanggan yang mengalami fluktuasi signifikan, serta data primer melalui wawancara mendalam dengan petugas pencatat meter, staf billing, dan perwakilan pelanggan. Hasil analisis menunjukkan bahwa penyimpangan periode pembacaan (terutama yang melebihi 30 hari) secara langsung mengakibatkan penghitungan volume pemakaian yang terakumulasi dan berdampak pada penerapan blok tarif progresif yang lebih tinggi, sehingga tagihan membengkak. Implementasi sistem yang baru diharapkan dapat meminimalkan inkonsistensi, meningkatkan akurasi billing, dan pada akhirnya mengurangi fluktuasi tagihan serta meningkatkan kepuasan dan kepercayaan pelanggan terhadap layanan PERUMDA Tirta Patriot Kota Bekasi.

Inconsistencies in water meter reading intervals, which often exceed or fall short of the standard 30 days per month, are believed to be a major cause of unreasonable bill spikes and trigger customer complaints. Therefore, the purpose of this study is to analyze the impact of inconsistent water meter reading intervals on customer bill fluctuations and to propose a system upgrade solution for the meter reading application at PERUMDA Tirta Patriot, Bekasi City. The research method used was a qualitative descriptive case study approach, supported by secondary data in the form of meter reading records and billing histories of customers experiencing significant fluctuations, as well as primary data through in-depth interviews with meter readers, billing staff, and customer representatives. The analysis shows that deviations in the reading intervals (especially those exceeding 30 days) directly result in the calculation of accumulated usage volumes and impact the application of higher progressive tariff blocks, resulting in bill inflation. The implementation of the new system is expected to minimize inconsistencies, improve billing accuracy, and ultimately reduce bill fluctuations, while increasing customer satisfaction and trust in PERUMDA Tirta Patriot, Bekasi City.

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INTRODUCTION

Water is a basic necessity managed by the Regional Water Company (PERUMDA). Tirta Patriot Kota Bekasi is the main service provider for the community in Bekasi City. To maintain the company's operational sustainability and customer trust, billing accuracy and consumption data reliability are essential (Aini et al., 2023).

The water billing process is based on the volume of water recorded on the customer's water meter, which is measured periodically, ideally in a consistent 30-day cycle each month. However, in practice, there are often inconsistencies in the water meter reading period in the field. Customers receive bills with significantly varying reading periods, ranging from 15 days to more than 30 days. This variability has several sources, namely technical and non-technical aspects or administrative factors and the discipline of meter readers. These fluctuations reach 30% to 40% per month for individual customers. Meter readers at PERUMDA Tirta Patriot work in customer service areas that are divided into several zones.

Each zone has a manager as the head of the department and three assistant managers as sub-department heads, namely marketing, water meters, and billing. The main duties and functions of meter readers are the authority and responsibility of the assistant manager of the marketing sub-department, assisted by several validators for the process of validating the data input by customer water meter readers.

Significant fluctuations in bills that are not caused by technical problems such as processing or distribution network issues give rise to two main problems, namely internal administrative issues related to inconsistencies in the reading period, reflecting weaknesses in the scheduling system, supervision, and control of meter recording data quality, which has the potential to increase *Non -Revenue Water* (NRW) from an administrative perspective (Humairoh et al., 2021). In addition, there are public service issues where unexplained bill fluctuations damage the credibility of PERUMDA Tirta Patriot in the eyes of customers, triggering complaints and potentially reducing collectability rates (Hadi, 2022).

This issue needs to be studied in depth because a fair and accurate billing system is highly dependent on the timeliness and consistency of the reading cycle. Based on the above background, this study aims to analyze how inconsistencies in water meter reading periods significantly affect fluctuations in customer bill volume and value, and to analyze what strategic and technical efforts PERUMDA Tirta Patriot should undertake, particularly in the development of application systems and employee discipline, to ensure consistency in water meter reading periods that are close to 30 days.

This will enable the analysis and measurement of the level of deviation from the ideal 30-day period for water meter readings taken by PERUMDA Tirta Patriot customer water meter recording officers. Identify and measure the correlation and direct impact between inconsistencies in meter reading periods and fluctuations in volume and bill amounts received by customers, and provide strategic recommendations on implementing an *absolute date lock system based on a dashboard* and developing additional features in the meter reading application to enhance staff discipline, thereby achieving a stable and accurate reading cycle.

METHOD

This study uses a qualitative approach by collecting information through interviews with meter readers, IT staff, operations managers, and direct field observations to obtain data from customer representatives and analyze data and documents related to the PDAM customer water meter recording process.

RESULT AND DISCUSSION

The Effect of Inconsistent Water Meter Reading Periods on Volume Fluctuations and Customer Bill Amounts

The issues of bill fluctuations and increasing NRW are common problems in all public water companies in Indonesia, but not many pay attention to administrative aspects, especially the inconsistency of meter reading periods, which is actually an operational challenge that must be resolved systematically and continuously. Extreme fluctuations in the monthly water consumption records of individual customers can be attributed to several main factors, namely:

1. Changes in Customer Water Usage Patterns (Demand Factor)

This is a change in the amount of water actually used by PERUMDA Tirta Patriot customers, which is often triggered by seasonal, social, or behavioral factors, namely: First, Seasonal/Climate Factors. The city of Bekasi, as one of the main satellite cities of Jakarta, has a tropical monsoon climate with two seasons, dry and rainy. The city experiences significant changes between the dry and rainy seasons, which affect various aspects, including infrastructure and the environment. During the dry season, changes in customer water usage can occur due to activities that require more water, such as more frequent watering of gardens or plants, filling or adding water to swimming pools (if any). Meanwhile, during the rainy season, Bekasi City has historically been highly vulnerable to flooding, especially in areas crossed by the Bekasi River, tributaries, and areas with dense or obstructed drainage. This causes flooding in many locations in Bekasi City. During flooding, water usage decreases, but after flooding, water usage increases due to its use for cleaning purposes.

Second, the factor of changes in the number of residents. The phenomenon of increases and decreases in the number of residents in each house in Bekasi City from time to time is very natural and is influenced by the characteristics of Bekasi City as a dynamic, densely populated metropolitan satellite city dominated by high population mobility. Several factors that cause changes in the number of residents include the arrival/departure of family members, inter-city mobility because many houses in Bekasi serve as residences for workers who work in Jakarta or vice versa, marriage and the formation of new families, and changes in residential status, where houses that were originally vacant or rented to one family are now divided into boarding rooms, especially near industrial areas, increasing the number of individuals living at that address. Houses are converted from private residences to non-permanent offices/warehouses, resulting in a drastic reduction in the number of residents consuming water.

2. Technical Issues (Supply Factors)

These technical constraints are often the root cause of problems in terms of the quality, quantity, and continuity of water services, and contribute significantly to the high rate of technical Non-Revenue Water (NRW), which also directly affects fluctuations in customer water usage. There are two sources of technical constraints, namely constraints originating from the production and distribution of PERUMDA Tirta Patriot and constraints originating from the network within the customer's home.

The constraints originating from PERUMDA Tirta Patriot include raw water contamination. PERUMDA Tirta Patriot obtains its raw water from secondary rivers that do not meet the government's raw water standards, causing the quality of raw water to decline dramatically. If the treatment and distribution processes are not optimal, PERUMDA Tirta Patriot is forced to stop water production and distribution, which has a significant impact on the decline and increase in customer water usage, as well as the technical life of the IPA and conventional systems. Sludge issues: Ineffective management of sludge left over from the coagulation and flocculation processes can become an environmental and operational issue.

Problems originating from the customer's internal network, such as damage to the pipe network after the water meter, are the full responsibility of the customer to repair, even though the water is supplied by PERUMDA Tirta Patriot. Hidden leaks, loose pipe connections. Connections (*fittings*) between pipes, especially at corners or T-junctions, are not installed tightly or the glue (for PVC pipes) does not adhere perfectly.

3. Inconsistency in Customer Water Meter Recording (Administrative Factors)

The task of recording water meters (meter reading) is a job that faces many challenges, both in terms of physical aspects in the field and the administrative processes that must be fulfilled (Hadi, 2021). The results of the customer water meter recording process contribute significantly to fluctuations in the amount of water used by customers in a month, which also affects the amount of bills. The following are the main obstacles experienced by PERUMDA Tirta Patriot meter reading officers: First, Physical Obstacles in the Field (Access & Environment). Several physical obstacles in the field that are directly related to customer access and environmental conditions include closed house access, which prevents officers from accessing meters, forcing them to provide estimates based on weather conditions, resulting in officers choosing not to record water meters.

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Second, Administrative and Procedural Challenges. Administrative challenges that are problems related to the work system and data recording include data input errors. Officers make mistakes when entering numbers into the recording application, or incorrectly encode the meter status (for example, normal status but made unreadable). Tight recording times and a large number of customers mean that officers have a target number of meters to record in a very short period of time. This encourages officers to rush their recording or make estimates when they encounter obstacles in the field in order to meet their targets. In addition, the use of outdated technology, even though PERUMDA Tirta Patriot already has a meter recording application, the implementation is still semi-conventional because it still requires the full force of water meter recording officers to obtain data (Pratama et al., 2024). Some examples of the results of PERUMDA Tirta Patriot customer water meter recording input by meter recording officers:

Figure 1. Validator Application

Table 1. Customer History

Date Recorded	Month	Start	End	Original Cubic	Cubic	Correction	Nominal
21-10-2024	202410	259	323	64	64	0	880,000
06-11-2024	202411	323	395	72	72	0	996,000
07-12-2024	202412	395	526	131	131	0	1,851,500
10-01-2025	202501	526	702	176	176	0	2,504,000
11-02-2025	202502	702	916	214	214	0	3,055,000
12-03-2025	202503	916	1046	130	130	0	1,837,000
14-04-2025	202504	1046	1140	94	94	0	1,315,000
13-05-2025	202505	1140	1271	131	131	0	1,851,500
13-06-2025	202506	1271	1395	124	124	0	1,750,000
14-07-2025	202507	1395	1455	60	60	0	822,000
14-08-2025	202508	1455	1478	23	23	0	285,500
13-09-2025	202509	1478	1496	18	18	0	215,600
14-10-2025	202510	1496	1505	9	10	0	110,000

Strategic Application System Development and Employee Discipline

The results of the study found that inconsistencies in meter reading schedules were a significant factor causing fluctuations in water bills (in addition to *Demand*, *Supply*, and *Human Error*). Significant fluctuations caused by variations in customer water meter reading days due to physical and administrative constraints in the recording process are logical, because the total monthly usage will be divided unevenly into different billing periods and also directly contribute to NRW from an administrative aspect due to unrecorded cubic meters in the current month.

The following are the main variables that can be measured as improvement efforts that can be made to overcome this problem. First, Meter Reading Officer Discipline. This variable focuses on the performance and compliance of field officers with the established schedule.

Table 2. Time Discipline

Variable	Measurement	Improvements
Compliance Percentage Date of Reading	The number of customers read from the reading schedule date, divided by the total number of customers to be read.	Ensure that the billing period is consistently close to 30 days.

Average Number of Reading Days	The average number of days between this month's reading date and the previous month's reading date (e.g., 29.8 days).	Minimize deviations of 29-31 days. Fluctuations of 15 or 35 days should be detected as outliers.
Daily Completion Rate	The percentage of meters that should be read per day by officers vs. meters that were actually read.	Identify employees who delay work or have unrealistic workloads.
Average Customer Wait Time	The average time required for officers to move from one customer to the next (measured via GPS in the application).	Identify route efficiency and identify obstacles in the field.
Employee Attendance/Absence Rate	The number of days officers were present and performed their duties according to schedule.	Measure basic discipline regarding work commitments.

Table 3. Accuracy and Procedure Discipline

Variable	Definition	Objectives
Accuracy of Number Recording (Input Accuracy)	The number of input errors (numbers entered differ from verified meter readings) divided by the total number of recordings.	Minimize human error in entering numbers that result in incorrect billing.
Percentage of Meter Photo Quality	The number of meter photos that meet quality standards (clear, not blurry, showing 7-8 digits) divided by the total number of recordings with photos.	Ensure valid physical evidence and prevent manipulation or false estimates.
Percentage of Labeling Compliance Status	Number of meters labeled as abnormal according to SOP	Avoid lazy employees
Estimation Usage Rate	Number of recordings using the estimation method divided by the total number of customers in the officer's route.	Limit discretion

Table 4. Ethical Discipline Responsibility

Variables	Measurement	Objectives
Number of Customer Complaints Related to Employee Ethics	Number of customer reports of rude behavior, abuse of authority, or allegations of data manipulation.	To maintain the image of PERUMDA Tirta Patriot and ensure that officers act professionally.
Compliance with Work Attributes	Percentage of officers wearing uniforms, ID cards, and PPE while on duty.	To uphold professional identity and appearance discipline.

Second, the Meter Recording Application Quality Variable. This variable focuses on application features that utilize technology (digitization) and data integration to support disciplined meter recording and prevent data manipulation.

Table 5. Application Quality Variables Meter Reading

Variables	Measurement	Objectives
GPS Feature Usage Rate Timestamp	Percentage of readings that have GPS data and a valid timestamp that corresponds to the meter location.	Measure Location and Time Discipline. Discipline officers must be physically present at the meter location at the time of recording to prevent fictitious or off-route recordings.
Photo Meter Validity (%)	Percentage of meter photos that were uploaded and passed verification	Measure Procedural Discipline and Evidence. Discipline officers must comply with SOPs to take clear photos as evidence, rather than simply photographing random objects (to prevent manipulation of figures).
Anomaly Reading Ratio (RPA)	Number of readings that are outside the normal range and require re-verification.	Measuring Accuracy Discipline. If RPA is high, it may indicate that officers are careless (incorrectly inputting numbers) or manipulating data, which leads to anomalies, thus requiring double verification.

The author suggests several specific measures to address fluctuations in the number of days of water meter readings for PERUMDA Tirta Patriot customers within a one-month period or a minimum

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of 30 days of usage due to inconsistencies in the reading period through an application system that focuses on strengthening the integrated administrative control system between the mobile application and web dashboard, namely:

1. Application with an Absolute Date Lock System (*ADLS)*

The Absolute Date Lock System (ADLS) is a functionality feature designed in the digital meter recording application (mobile application) and billing system (server) to ensure that the meter reading period for customers is always consistent and uniform every month (Pratama et al., 2024).

The absolute date lock system, also known as the fixed meter recording period, is a mechanism in the water meter recording application that limits the time range in which customer water meter readings can be taken and entered into the system. This ensures that the application only allows data input on scheduled dates, for example, only on the 1st to 3rd day of the target month. Officers cannot force input outside this range. If there are exceptions, such as closed/empty meters or holidays, input must be transferred to "Revisit" mode, which automatically requires the approval of the zone manager or marketing assistant manager and has an audit trail log. The main purpose of this system is to ensure consistency, accuracy, and fairness in determining water usage and billing. Some of the reasons for this include: First, Period Consistency. To ensure that each customer is billed based on an *almost* uniform usage period, ideally close to 30 days each month. This avoids bills that are too high or too low due to recording periods that are too short or too long.

Second, Data Integrity. This prevents officers or customers (in the case of self-meter reading) from entering data outside the predetermined schedule, which can cause chaos in the monthly billing cycle. And third, Billing Cycle Security. By locking in the date, PERUMDA Tirta Patriot can ensure that the billing process (calculation and issuance of bills) can begin on time after the recording period ends, so that the payment due date can also be predicted

2. Application with an Optimized Routing System

The optimized routing system is a feature that utilizes intelligent algorithms integrated with a GIS (Geographic Information System) program to determine the most efficient visit sequence for meter readers based on the geographical location of each customer. The system must automatically create efficient daily routes based on the customer's GPS (Global Positioning System). This helps officers complete all meters in a zone or route on the targeted day.

The main objective of implementing this system is to improve the overall effectiveness and efficiency of meter readers' work processes. Through more systematic route and workflow arrangements, this system is able to reduce the total distance traveled and the time needed for meter readers to complete all readings in their work area, thereby directly reducing operational costs in terms of both fuel consumption and working time. In addition, this system encourages increased productivity by enabling officers to complete more readings in a single working day, which ultimately speeds up the billing cycle. The implementation of this system also contributes to the creation of fairness in the distribution of workloads, as the distribution of tasks between officers in various recording zones becomes more balanced. On the other hand, clear routes and structured work procedures help minimize the potential for human error and the risk of missed meter readings, thereby ensuring greater accuracy of the data produced.

The route optimization mechanism is based on solving a complex problem, often referred to as the Travelling Salesperson Problem (TSP), in which the system must find the shortest route to visit a series of customer locations and return to the starting point. This requires initial data input or geolocation for each zone according to the capacity of the meter reading officer. Each zone will be allocated to one or more officers. The optimized route system is also equipped with visualization and navigation. The optimization results are displayed to officers in the form of a list of visit sequences and map visualizations integrated with Google Maps or similar applications. Customer water meter readers can follow step-by-step navigation from one meter location to the next according to the optimal sequence

3. Application with *Real-Time* Alert System

This system works by comparing the newly entered meter readings with the customer's historical data stored on the server. If there is a deviation from the normal pattern, the application will immediately

trigger an alert. The application will trigger an alert immediately after the meter reader enters the readings and clicks the "submit" button, for the following cases:

Table 6. Anomaly Cases

Anomaly Categories	Warning
Zero Usage (Low Consumption)	A warning appears if the new meter reading is the same as the previous month's meter reading, i.e., usage of 0 m^3.
Extreme Usage (High Consumption)	A warning appears if this month's usage exceeds a certain threshold.
Reverse Meter (Negative Usage)	A critical warning appears if this month's meter reading is less than the previous month's meter reading.
Unusual Numbers (Outlier)	A warning appears if the officer enters incorrect data (for example, the number entered is illogical, or there is a significant jump in the number from the normal limit).
Blurry/Dark Photo Quality	The application can perform a simple image analysis to ensure that the meter reading is legible. If it is blurry, a warning appears.

4. Web Management Dashboard (Control Center)

The dashboard is a visual display on a layer, presenting web-based data used by zone service management or directors to monitor all meter recording activities carried out by all officers in the field in real time, covering the following components:

Table 7. Dashboard Components

Components	Description & Control Functions
Daily Progress Summary	A graph showing the percentage of daily achievement displays the daily target alongside the actual results Control Function: See whether the target for that day has been achieved, and how many meters remain to be recorded.
Live Tracking of Officers (Geolocation Map)	Displays an interactive map showing the last GPS location of all officers currently active in the field, including the location of meters recorded today. Control Function: Verifies whether officers are in their assigned zones and ensures that the route sequence is optimal.
Anomaly & Exception Reports	Displays a list or real-time count of meters recorded with anomaly warnings, such as zero usage, high usage, reverse meters, or blurry photos. Control Function: Main focus. Zone service management can click on anomaly data to view photos and notes from officers in the field, and decide whether to send a team to verify.
Photo Verification (Image Gallery)	Display thumbnails of recently uploaded meter photos, with complete metadata including Customer ID, Time, and Location. Control Function: Management can perform random visual audits to ensure photo quality and that the numbers entered match the numbers in the photos.
Timestamp & Period Alerts	Displays a list of customers whose recording period deviates from the schedule. For example, recorded on a locked date or outside the optimal day range Control Function: Monitors compliance with the Absolute Date Locking System and ensures consistency of the billing cycle.
Officer Performance (Leaderboard)	Display a table or graph ranking officers based on daily productivity, i.e., the number of meters recorded and data quality such as the anomaly ratio. Control Function: Used for performance evaluation, identification of high-performing officers, and providing additional training for officers who are slow or make frequent mistakes.
Billing Cycle Progress	The total percentage of customers recorded from all regions in that month.

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Every time data is sent, the server instantly processes and updates the recording status. This ensures that the data viewed by management on the Dashboard is always up-to-date.

The discipline of meter readers to record consistently according to the dates set each month for each customer and the quality of the meter reading application equipped with a web-based dashboard are efforts to address the issue of inconsistency in the recording period, which is the root cause of administrative problems and can improve the accuracy of customer water bills.

The customer water meter recording application system currently used by PERUMDA Tirta Patriot has accommodated some of the administrative recording needs but has not addressed the issue of inconsistent recording periods. The technical specifications of the *Hard Lock* reading schedule feature must be supported by three technical pillars, namely central data, real-time validation, and manipulation prevention.

First, Central Data and Database, which covers two things, including: 1) Reading Schedule Table (*Reference Table*), where each customer must have a *record* in the central database that determines the Customer ID, customer name and address, mandatory reading date for the current month, tolerance range for the permitted start date, and tolerance range for the permitted end date. This tolerance range must be very strict, ideally 1-2 days or even the same day for the highest level of discipline. And 2) Reading Log (*Audit Trail*), which means that every reading action must be recorded in detail, including the input time, server time, GPD coordinates of the officer, water meter number, and even the Officer ID.

Second, *Real-Time* Input Validation in the Application. This system is the main mechanism that must be implemented on the mobile application side for officers and re-verified on the server side.

Table 8. Real-Time Meter Reading Validation Features

Technical Mechanism	Implementation Description
Absolute Date Validation	When an officer attempts to enter meter data, the application server will check the real-time date of the officer's device. Data input is only permitted if the date falls within the Initial Tolerance Range and Final Tolerance Range specified in the Schedule Table. If outside the range, the following message appears: "Reading for this Customer ID is out of schedule. Valid date: DD/MM/YYYY."
GPS and Time Validation	Reading input is only valid if the technician's GPS location matches the customer's coordinates, and the technician's device timestamp is synchronized with the Central Server timestamp, to prevent time tampering.
Delay Check (Late Reading Flag)	If a reading is entered outside the tolerance range, for example, due to a previous administrative error, the system must automatically assign a "Late Reading" flag. This flag notifies the Billing System that this month's bill may have a period of less than 30 days or even longer.

Third, Data Manipulation Prevention Feature. Undisciplined officers will look for ways to bypass the lock system. This feature prevents such attempts.

Table 9. Anti-Manipulation Features

Anti-Manipulation Features	Prevention Mechanism
Mandatory Geotagging (GPS Lock)	The application must record GPS coordinates when the submit button is pressed. Data is only accepted by the server if the GPS is within a certain tolerance radius, for example, 1–5 meters from the customer's coordinates stored in the database.
Automatic Timestamp Recording	The application records the server's real-time time and date, not the smartphone's local time, which can be easily changed, when the reading is input. This prevents recording outside of working hours or outside of the locked period.
GPS Access Approach (Hardware Access)	The application must strictly request GPS access permission, and some applications will refuse to work if mock location or fake location settings are enabled on the device.
Mandatory In-App Photo Capture	Officers are not allowed to upload photos from the device's gallery.
Automatic Time and Location Overlay	Meter photos must be taken directly through the camera feature within the application.

Image Analysis (OCR or AI/ML)	Advanced applications use Optical Character Recognition (OCR) or Machine Learning technology to: a) Automatically detect and read meter numbers from photos. b) Compare the numbers read by the system with those manually entered by the officer. If there is a significant discrepancy, an alert will appear..
Old/Duplicate Photo Detection	The system can detect and reject photos that appear identical to photos from previous months or blurry photos (using image hash analysis or image quality).

If the application supports offline mode, data input must remain locked based on the last synchronized schedule. All data entered offline must include the device timestamp and be validated by the server immediately after the device comes online to check time consistency. The use of modern technologies such as Optical Character Recognition (OCR) is highly relevant to minimize data manipulation by automatically reading meter readings through a mobile phone camera (Sanjaya & Sugiarto, 2023).

By integrating these technical specifications, known as the *Absolute Date Lock* system, it is possible to ensure that the established schedule is authoritatively implemented in the field, minimizing billing fluctuations due to inconsistent reading periods, and ultimately increasing customer confidence in the accuracy of PERUMDA Tirta Patriot's billing.

A crucial question arises: although the *Hard Lock* system is designed to enforce discipline, there will always be cases where readings cannot be conducted as scheduled, such as locked gates, aggressive dogs, vacant houses, flooded meters, or technical issues. This is referred to as *Exception Handling*.

Technically and procedurally, exception handling must be structured so as not to compromise the accuracy of the billing period and to remain in line with the regulations and administrative procedures established by PERUMDA Tirta Patriot management.

CONCLUSION

Inconsistent water meter reading periods that deviate from the standard 30 days have been identified as the main cause of spikes in customer bills, triggering complaints at Perumda Tirta Patriot in Bekasi City. These time deviations, whether due to physical constraints in the field or administrative factors involving staff, have led to an accumulation of usage volume that pushes calculations into higher progressive tariff blocks.

In addition to financially harming customers, this problem has impacted the company's credibility and increased the amount of Non-Revenue Water (NRW) from an administrative perspective due to inaccurate monthly consumption data. As a strategic solution, this study proposes the development of an application system equipped with an Absolute Date Lock System feature to lock the reading schedule and an Optimized Routing System for officer route efficiency.

Controls are also strengthened through a *Web Management Dashboard* that monitors officer movements in *real-time* (Jefri & Huda, 2025) and the implementation of anti-manipulation features such as mandatory *geotagging* and direct photo capture in the application. The implementation of this technological integration is expected to ensure a stable billing cycle, improve billing accuracy, and realize more transparent and accountable public services.

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