Utilization of water flow for powering the internet-based water metering system household scale

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Abstract. Water is a vital element needed by humans, the use of renewable energy is a concept that is being developed at this time, one of which is the flow of water, electricity generation that utilizes water flow that uses water turbines that are placed in a rapid pipe which then turns the turbine wheel and converts the rotational power into electricity to power an Internet-based water meter system of Things. This research aims to develop PDAM water meters which are currently analog then developed into digital and can be monitored by the system and utilize the water flow to turn on the whole system. Researchers design a tool that utilizes water flow to activate and store power reserves in the system by utilizing a monitoring system that makes it easy for consumers to find out the amount of water consumption and costs to be paid at intervals of a certain period. This system includes turbines, charging circuits, microcontrollers, and water rate sensors that are developed using the Internet of Things (IoT) and a power supply system in the form of batteries. The battery will charge when the generator reaches a stable condition and will automatically activate when the water flow reaches an unstable condition.

1. Introduction
PDAM is a regional company engaged in water supply services to customers by channeling water to customers through reservoir pipes to meet the water needs of the population. In channeling water from the PDAM, a process of checking or monitoring the amount of water used is distributed to the customer's house. The method used today is still manual by sending officers to each customer's house to check the house water meter. This method is considered ineffective because it requires a lot of energy and takes a lot of time and the PDAM meter is still analog. This tool is designed by utilizing water flow in the reservoir pipe which is used to power the monitoring system for measuring the flow of water that is sent through the PDAM reservoir to customers that can be monitored via the internet. This tool also uses a sensor that is a digital water flow sensor as a detector of water discharge. Later the results of these readings will be sent to an application that the author made with the help of the Wemos microcontroller as the wifi module used, so that staff and customers can monitor the water meter without the need for checking manually.

2. Method

2.1. System power supply
Nano hydro or nano hydropower plant is a small-scale power generator device that uses water flow as a driving force in such devices as waterfalls, irrigation channels, water pipes in households to PDAM
reservoirs by utilizing high waterfalls (heads) and the flow of water that passes through them. The term Nano-hydro can be interpreted into two words, Nano which means small and hydro which means water. Nanohidro has 3 main components, namely water as a power source, turbines as modifiers of water flow to spin mechanical power and generators as converters of rotational energy to electrical energy. Nanohidro utilizes the flow velocity and flow of water vertically, so the higher the waterfall to the tool, the greater the potential energy that can be converted into electrical energy [1].

2.1.1. Water turbines. Water turbines convert the potential energy of water into mechanical energy by utilizing the water level (head) vertically. There are 2 types of water turbines, namely impulse and reaction turbines. In impulse turbines, the effective height is converted into kinetic energy before it reaches the turbine so that the influence of the water pipe height on the power generated is very high. The water turbine used for this type of person uses the speed of water flow from a certain height and water discharge to produce enough power in turning on the device [2].

2.1.2. Battery. A battery or accumulator is an electric cell in which a reversible electrochemical process takes place (can be reversed) with high efficiency. What is meant by a reversible electrochemical process, is that in a battery the process of converting chemicals into electricity (discharging) can take place, and energy from electric power to chemical power, recharging by regenerator of the electrode used, namely by passing an electric current in the direction (polarity) opposite in the cell. Each battery cell consists of two different types of electrodes, namely positive electrodes, and negative electrodes dipped in a chemical solution [3,4]. The battery used is a li-ion type with a capacity of 5000 mAh with an optimal output of 3.7 - 3.85 volts.

2.2. Power calculation
In designing a system the most important consideration that needs to be made when designing a battery-operated device in any form is power consumption. Keeping the battery working longer between changes in the battery is often the main design point. For that, we need to know how small programming changes will impact device power consumption. So the authors designed a system that can have low power, namely by using a microcontroller and choosing sensors that have low voltage and current. So as not to consume a lot of energy consumption on a battery that is used when running a system.

2.3. Application using the internet of things

2.3.1. Android studio. Android Studio is the official IDE for building Android applications based on IntelliJ IDEA. It is a Java Integrated Development Environment (IDE) developed by JetBrains to develop computer software for helping users in the world of programming in terms of navigation, supporting productivity, to intelligent code editors.

2.3.2. Antares. Antares is a Horizontal IoT Platform trying to do the service as general as possible so that the vertical IoT solution can adapt to the architecture that generally used. Many IoT cases solved using Antares services, for example, smart home, smart metering, asset tracking, smart building.

2.4. Water flow sensor
This measurement gives a hint that is proportional to the total quantity that has flowed in a given time. Fluid flows through the primary element in succession in a more or less isolated quantity by alternately filling and emptying the measuring vessels of known capacity. Quantity measurements are classified according to Gravimetric or weight measurements, Volumetric gauges for liquids, and Volumetric gauges for gases.
3. Result

3.1. Diagram block
Design and diagram block system used in the whole telemetry system:

![Diagram block system](image1)

**Figure 1.** Diagram block system.

3.2. Diagram flow

![Diagram flow](image2)

**Figure 2.** Diagram flow harvesting energy.

4. Discussion

4.1. Testing turbines without load
Based on the data below, we can analyze when the water valve is closed, the flow of water does not flow. It can read the water flow reading debit air 00.00 L/min, water volume 0.00 L, in the discharge
range of debit 6.94 L/s to 10.58 L/sec; there is an electric force voltage of 10.24 volt which can start the telemetry system at the lower limit of the standard input voltage is 3.3 volt.

| Water debit (L/min) | valve 1/4 | valve 3/4 | Full valve | $I_{sc}$ (A) | $V_{oc}$ (V) |
|---------------------|-----------|-----------|------------|--------------|--------------|
| 0.00                | √         |           |            | 0            | 0            |
| 3.32                | √         |           |            | 0.009        | 2.596        |
| 3.34                | √         |           |            | 0.006        | 2.6          |
| 3.40                | √         |           |            | 0.005        | 2.581        |
| 6.94                | √         |           |            | 0.093        | 10.24        |
| 6.94                | √         |           |            | 0.092        | 10.26        |
| 6.94                | √         |           |            | 0.093        | 10.27        |
| 6.94                | √         |           |            | 0.092        | 10.24        |
| 10.82               | √         |           |            | 0.114        | 12.28        |
| 10.82               | √         |           |            | 0.113        | 12.29        |
| 10.82               | √         |           |            | 0.114        | 12.29        |

4.2. *Calibrating the sensor*

This calibration testing method compares the flow rate of manually measured water flow with data taken by the sensor. It is a method to find the error value owned by the sensor in comparing the capacity entering the reservoir. It also divided by the amount of time needed until the water level reaches the maximum point or the bucket is fully loaded with data readings from flow sensors: The analysis in this test is the percentage of error rates at calibration has a range of 12% to 0% with the highest error rate reaching 12%. Calculate the percentage of errors in sensor calibration uses, and the formula is performed:

$$
\text{error} = \frac{\text{manual debit value} - \text{flow sensor}}{\text{flow sensor}} \times 100\%
$$

Measurements made included in changing of the input voltage, which initially ranged from 12-14 volts to 7.4 volts for battery charging, and 5 volts for starting the PDAM water monitoring system. It is included Wemos microcontroller, flow sensor, and I2C LCD for manual monitoring, battery charging, and the life of the system. The charging battery made in parallel so that they can simultaneously turn on the system when charging the battery. Measurement of voltage reduction can be seen in the seven-segment display in the step-down module and after the battery measurement system is complete, changing with measurement of voltage and current entering the monitoring system, in this power measurement in the monitoring system can be considered as a turbine measurement when experiencing an electrical load.

4.3. *Testing of the power charging*

This test uses the method of charging the battery capacity through the input voltage of the turbine step-down based on the time domain so that it can be seen how much the change in battery capacity in a specific period time and the conditions of charging and discharging, with the following calculation:

$$
\text{charging time to full capacity of battery} = \frac{\text{capacity of battery (mAh)}}{\text{current from charging module}}
$$

If it is assumed that the battery capacity is 1000 mAh and the output current of the charging module is 0.8 Ampere, the charging time is $(1000 \text{ mAh}) / (800 \text{ mA}) = 1.25$ then $1.25 \times 60 \text{ minutes} = 75 \text{ minutes}$ or 1 hour 15 minutes the battery can be fully charged. Based on the assumptions above, it has been tested 15 times with a battery capacity voltage by checking the time of 5 minutes per check to see changes in
the value of the capacity stored on the battery. The measurement has been done by turning the turbine as a power supply and measuring the voltage and current in the battery within a period.

Table 2. Sensor calibration.

| Time (min) | Voltage input (V) | Ampere input (mA) | Measured battery capacity (mA) |
|------------|------------------|-------------------|-----------------------------|
| 15.00      | 7.7              | 0.215             | 200                         |
| 15.05      | 7.5              | 0.211             | 210                         |
| 15.10      | 7.1              | 0.221             | 217                         |
| 15.20      | 7.63             | 0.3               | 270                         |
| 15.25      | 7.45             | 0.33              | 320                         |
| 15.30      | 7.4              | 0.15              | 350                         |
| 15.35      | 7.2              | 0.152             | 370                         |
| 15.40      | 7.3              | 0.152             | 410                         |
| 15.45      | 7.25             | 0.153             | 440                         |
| 15.50      | 7.5              | 0.152             | 470                         |
| 15.55      | 7.4              | 0.303             | 550                         |
| 16.00      | 6.67             | 0.302             | 610                         |
| 16.05      | 6.82             | 0.401             | 670                         |
| 16.10      | 6.92             | 0.402             | 720                         |
| 16.15      | 6.9              | 0.4               | 800                         |

4.4. Battery discharge testing

In this test, the 18650 battery is arranged in series and serves to provide power to the microcontroller and also the flow sensor as a sensor to detect how much discharge and the amount of water usage that passes through the pipe flow, after that the microcontroller will run the command to send data and display it using a 2 x LCD 16 and I2C for manual monitoring.

4.5. Test delivery of data to Antares

In this test, the module used is the wemos D1 Mini module; this test carried out in a closed room. This test is to see data loss and delay for data sent on the Antares internet of things platform. For the result of the data can be seen in Table 3 as follows:

Table 3. Data delivery to Antares test.

| No | Time   | Delay (s) | Loss | Condition |
|----|--------|-----------|------|-----------|
| 1  | 18:56:14 | 21       | No   | Sent      |
| 2  | 18:56:53 | 21       | No   | Sent      |
| 3  | 18:57:19 | 21       | No   | Sent      |
| 4  | 18:57:45 | 21       | No   | Sent      |
| 5  | 18:58:11 | 21       | No   | Sent      |
| 6  | 18:58:37 | 21       | No   | Sent      |
| 7  | 18:59:03 | 21       | No   | Sent      |
| 8  | 18:59:29 | 21       | No   | Sent      |
| 9  | 18:59:58 | 21       | No   | Sent      |
| 10 | 19:00:24 | 21       | No   | Sent      |

Based on the results of the test data above, it can be seen that the delay of sending data to the Antares platform is an average of 21 seconds, and all data sent without loss.

4.6. Testing application

Beta testing is to find out the extent of the quality of the application being built, and whether it is in line with expectations or not, beta testing is filling out by the survey page from the user. The conclusion of Beta Testing: After all, the questions for the requested variable are calculated. Make the comparison
with $r$ table according to the number of respondents surveyed. The steps to discuss $r$ table with $r$ arithmetic (count) are as follows: 1). Calculate df (degree of freedom). In this case, a survey of 33 respondents was carried out, so to find out the value, the formula $df = n - 2$ used. Then the value of df (degrees of freedom) was $df = 33 - 2$ or $df = 31.2$. Take $r$ table and look for the number 31 with a significance of 0.05 or 5%. From the table below, it is known that $r$ table 31 is 0.355. 3). Compare it with all results Calculations that have been done before. If the question asked is valid if $r$ table $< r$ count or $r$ table is smaller than $r$ count. In this case, it is known that there are no invalidation questions because $r$ table is smaller than $r$ arithmetic (count).

**Table 4.** Test application.

| Test Case | Scenario Testing                                                                 | Purpose of Testing                          | The Results of Testing |
|-----------|----------------------------------------------------------------------------------|---------------------------------------------|------------------------|
| Main Page | Adjust the sensor read value and press the category button                       | Showing consumption of water in meter cubic value | Successful            |
| Category  | The sensor readings are converted into the price of water tokens for each class. | Showing the prices token’s water per-category | Successful            |

5. Conclusion

Based on the results of research and testing, the use of a turbine as a power supply monitoring system for the PDAM air meter and charging battery can work optimally if it is placed on a flow source that has a tremendous airflow, the use of turbines and batteries as an internet-based water meter power supply system is an alternative solution to the current digital water monitoring system power reserve, and the use of water debit monitoring equipment and the price of water tokens should be available in every home for advancing the smart house applications.

References

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