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SOLAR POWER SYSTEM FOR WATER PRESSURE MONITORING SYSTEM AT PERUMDA TUGU TIRTA KOTA MALANG

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ABSTRACT

The Internet of Things (IoT) connects devices to the Internet, allowing them to communicate with consumers. Embedded computer systems, sensors, and actuators are all part of it. Some IoT applications, such as Tugu Tirta Malang, have had a significant impact on water distribution. Choosing the right power supply can provide more effective real-time results in collecting and exchanging data. As in previous research on the use of solar cells for power supply, IoT devices can produce sensor reading systems with constant and accurate time delays. Some previous research on the selection of solar cells as the power supply of IoT devices and the application of the IoT device in the field of water distribution in Tugu Tirta to provide ease and speed to collect water pressure data. According to a survey, IoT devices do not yet have an independent power source, so IoT devices may lose power during a power outage at Tugu Tirta Kota Malang main power source. The results of a solar cell-based power source for a water pressure monitoring system at Tugu Tirta Malang are presented in this research. The results demonstrate that the solar panel power system as the main power plant may be accomplished utilizing the specifications of one 50 WP solar panel and one 20 Ah battery. Perum Bukit Dieng Critical Point may be monitored 24 hours a day, seven days a week utilizing a 20 Ah battery and a 50 WP solar panel. The solar power system can power the monitoring system for 24 hours with an average output power each day of 7.93 Watts, with 3.96 Watts entering the surveillance system and 4.04 Watts going into the battery.

Keywords Internet of Things; solar panel; power supply; pressure-reducing valve; district meter area; critical point;
Paper type Research paper

INTRODUCTION

The advanced technological development and the human need for ease and speed in performing daily tasks created a popular technology today, the Internet of Things (IoT). Internet of Things in general is a concept that connects things around us to the Internet network that allows it to communicate between things and with their users [1]. IoT is a technology in which users can monitor, control, and access systems or devices connected to the Internet [2]. This technology consists of embedded computer systems such as microcontrollers, software, sensors, actuators, and network connectivity capable of collecting and exchanging data [3]. Some IoT applications have had a big impact in the area of water distribution, such as Perumda Tugu Tirta. Tugu Tirta holds the key to providing clean and healthy water distribution to consumers. Water pressure sensors are sensors that measure the pressure of liquids such as water, oil, liquid gas, and so on. The type of water pressure sensor commonly used in IoT devices is a 1/4-inch water pressure sensor. In previous research on monitoring water quality in Perumda Tugu Tirta using IoT, it was found to provide ease and speed in performing access monitoring through a smartphone or website [4]. However, this study does not specifically describe how the power supply of the IoT device is used. This is because IoT devices are included in electronic devices that require electricity as a primary source. Choosing the right power supply can provide more effective results in collecting and exchanging data in real-time. As in previous research on the use of solar cells for power supply, IoT devices are able to produce sensor reading systems with constant and accurate time delays [5]. A solar cell becomes one of the alternative power sources for renewable energy. The sunlight captured by the solar cell is converted into DC electricity [6]. From some previous research on the selection of solar cells as the power supply of IoT devices and the application of the IoT device in the field of water distribution in Perumda Tugu Tirta to provide ease and speed to collect water pressure data. The research was carried out, namely “Solar

Cell as A Power Supply For Monitoring System At Perumda Tugu Tirta Kota Malang" in the hope that the data is collected constantly and there is no data loss due to the loss of power supply on the device.

Water Distribution Network and Treatment Management Tugu Tirta Kota Malang

Drinking Water Supply System (SPAM) Perumda Tugu Tirta Kota Malang uses the zoning system principle based on water supply availability in a service area. The distribution network at the inlet zone is fitted with a master meter as well as other supporting instrument equipment such as a strainer and a pressure-reducing valve (PRV) as a tool for officers in regulating SPAM in each region so that it can guarantee the continuity of the customer's water flow for 24 hours with a minimum pressure of 0.5 bar or 5 meters. The function of the PRV is to regulate the pressure that enters the system so that the water pressure does not exceed the specified limit. The transmission and distribution network installed in the Malang area and its surroundings has a total length of ± 3407.6 km. Perumda Tugu Tirta Kota Malang is equipped with a supporting building, namely a reservoir or water tank that serves as water storage during the minimum water usage hours. The existing condition of water service in the distribution network of the entire area of service of Perumda Tugu Tirta Kota Malang is currently reaching the target of 79% water pressure ≥ 0.5 bar or 5 meters of the total critical pressure point spread throughout the area of water services Perumda Tugu Tirta Kota Malang. Perumeda Tugu Tarta KotaMalang has installed almost 200 critical points to monitor water pressure at the critical point of the water service to ensure customers get water with the standards determined by the company.

The embedded pipe network is rehabilitated periodically based on pipe damage priority along the pipe path. The priority of the damage can be viewed through a network map on the GIS (Geographic Information System) application with a leak repair symbol that has been performed on the pipeline network at each location. The more pipeline repair symbols there are, the more pipeline lines will become a priority for repairing the pipe network. The frequent leakage of pipes is not only a matter of material and pipe life but also depends on the quality of the pipes and the pipe accessories used. Damage to pipeline accessories is also frequent, causing community drinking water service barriers. To improve the quality of the materials used, both pipes and accessories are necessary to maintain the installed pipe network. The pipe installation and accessory quality should also be considered to extend the pipes' life and accessories to minimize the damage or leakage of the pipes.

Water Pressure Control Strategy

Stress management is one of the most fundamental elements of a strong leak management strategy. The leakage rate in the water distribution network is a function of the pump pressure or gravity. There is a physical relationship between leakage rate and pressure (Figure 1), and the frequency of new splashes is also a function of pressure:

1. The higher or lower the pressure, the higher or lower the leak.
2. The relationship is complex, but the managers of the drinking water company should initially assume a linear relationship (a lower pressure of 10% = a lower leak of 10%).
3. The level of pressure and the pressure cycle greatly influence the splash frequencies.

There are a number of methods to reduce pressure in the system, including variable speed control pumps (VSD) and elevation-based pressure zoning [7]. Nevertheless, the most common and cost-effective is the automatic pressure-reducing valve or PRV. The PRV method is the one used in Kota Malang water management in pressure management as a reduction of water loss measure. PRV are instruments installed at strategic points in the network to reduce or maintain network pressure at a specified level. The valve maintains the preset retardation pressure without paying attention to the head pressure or flow rate fluctuations. The PRV must be at the meter's height so that the turbulence from the valve does not affect the accuracy of the meter.

In operating a PRV in a DMA, the main condition is that the DMA must be perfectly formed in the sense that there is only one flow input. The formation of the DMA is then the primary condition to be done as a preliminary action in the NRW reduction action. If DMA has not been perfect, for example, if there is still another flow from the other input pipe, this will make it difficult to set the pressure in the PRV. The PRV will work well when the water flows in one direction of the flow.While in terms of human resources and personnel in operating PRV, they need to understand the basics of hydraulics and the performance of PRV, it is necessary to first give training to the personnel who will

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then serve as PRV setting operators. Before performing the first setting in a DMA, the setting operator must first know the pressure data for 24 hours in the inlet pipe, the lowest service point, and the highest point of service in the DMA (critical point).

Figure 1. PRV Manhole & DMA Mother Meter

Critical Point Analysis

In monitoring water distribution processes from the beginning to the end, a measuring tool is needed to evaluate whether the system is running as well as expected. If, at the beginning of the system, the installation of instrumentation equipment such as the mother meter and data logger that can send data to the server is carried out, then the distribution system is also obliged to install the instrumentation device as a basic reference to evaluate the presence of flow interference or flow adjustment performed by the authorized officers. Data loggers are commonly installed on SPAM instrumentation devices from front to back, for example, on transmission, distribution, or reservoir node meters. This study discussed the data on the distribution pipeline network at the critical point of the District Meter Area (DMA) service area. DMA is a system of separation of the water service area that is divided according to a smaller hydraulic zone between 500 -2000 customers with a criterion that only has one inlet and has a clear flow limit. Water pressure measurement at the critical point (CP) is intended to monitor the water pressure at the highest or most distant customer water service to stay within the company's specified limit of 0.5 bar, so that if the pressure critical point is already appropriate, then the assumption for the entire customer in 1 DMA has been guaranteed to get the appropriate water pressure. In the setting of pressure on the distribution network, there are several methods commonly used by PDAM, namely the use of PRV (pressure-reducing valve) instrumentation to reduce pressure at the minimum night flow or night hours of water use. In this setting, officers use the data logger at the critical point point to monitor and evaluate the device settings.

METHOD

In the research method there are five stages that need to be done, namely the preliminary stage which consists of field studies, problem identification, problem formulation, research objectives and literature study. The next stage is the data collection stage. Then analysis and discussion. And the final stage is the conclusion and Suggestion.

Survey

The initial stage of this research is to conduct a study of the latest technology of Solar Power System devices on the platform providing the latest journals and research, as well as conducting a direct survey of the location, namely in Perumda Tugu Tirta Kota Malang. It was found that there are IoT devices to determine water pressure. However, existing devices have a power source directly connected to the main system or do not have an independent power source.

In order to get accurate and real-time monitoring results, IoT devices must have connectivity and qualified electrical resources to power devices for 24 hours without stopping. IoT devices do not yet have an independent power source so that it has the possibility that IoT devices will lose power during a power outage in the main power source of the PerumdaTugu Tirta Kota Malang. From these problems [8], this research was held in order to be a solution to the problems that exist in the Tugu Tirta Perumda Kota Malang. Use solar panels is combined with IoT devices that will be installed on Perumda Tugu Tirta as an independent power solution and to make energy savings of IoT device.

Solar Cell

Figure 2. Solar Cell

Solar cells or solar panels are devices capable of generating a direct electric current by converting the energy of sunlight into electricity. Sunlight releases a particle called a photon, which will subsequently collide with the semiconductor on the solar panel so that the electron on the semiconductor flows and forms an electric current [9]. The large size of the current generated by the solar panel is influenced by the manufacturer's material, load resistance, sunlight intensity, temperature, and shadow [10]. Solar cells have several advantages, including ease of installation, being environmentally friendly, and being noise-free. Generally, the installation of solar panels requires three main components: a solar cell, a solar charge controller, and a battery or accumulator. Usage on devices with DC voltage requires additional step-down or step-up controllers to adjust to the specifications of the device, whereas in devices with AC voltage, an inverter is required to convert the DC voltage on the battery to AC 220V [11].

Solar Charge Controller

Figure 3. Solar Charge Controller

Solar charge controllers are the main components for performing voltage controls on solar panel installations. The voltage in the solar cell ranges from 16 volts to 20 volts, so the voltage needs to be normalized to 12 volts in order to fit the battery specifications [12]. This device has some features,

1. The solar charge controller is able to divide the voltage and provide power from the solar cell directly to the load and battery.
2. Solar charge controllers are able to decide the current that enters the battery when the batteries are detected as full charge.

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3. Solar charging controllers can switch power from a solar cell to a battery if the solar cell does not provide sufficient current.

DC5V ¼ inch Pressure Sensor

Figure 4. Pressure Sensor [13]

It is a sensor that measures the pressure of water, oil, and non-corrosive gases. It has a working voltage of 5 volts, so it can be directly connected to an Arduino microcontroller. The material of this sensor is carbon steel alloy, or carbon steel alloy. The size of the hole on this sensor is 14 mm or 0.55 inch, with a thread diameter of 13 mm or 0.51 inch. This sensor is capable of measuring pressure from 0 to 1.2 MPa. In this study, the sensor serves as a water pressure gauge on Perumda Tugu Tirta Kota Malang for further processing of the Arduino Uno [14].

Internet of Things

The Internet of Things (IoT) is a system designed to make it easier and faster to access data or control electronic devices via the Internet [15]. IoT is very closely related to machine-to-machine (M2M) communication without human or computer intervention, better known as the smart term. (smart). The term IoT (Internet of Things) was introduced in 1999 and was first mentioned in a presentation by Kevin Ashton, co-founder and executive director of the Auto-ID Center at MIT [16]. This technology consists of embedded computer systems such as microcontrollers, software, sensors, actuators, and network connectivity capable of collecting and exchanging data [3].

Tool Design and Manufacturing

The output of the solar charge controller will be divided into batteries and Arduino as shown in Figure 1 Solar Charge Controller can switch automatically with conditions:

1. When the solar cell power decreases, the solar charge controller switches the load power supply from the solar cell to the battery.
2. When the solar cell power is high enough, the solar charge controller switches the load power supply from the battery to the solar cell.

Block diagram of real-time water pressure monitoring design plan shown in the Fig. 5:

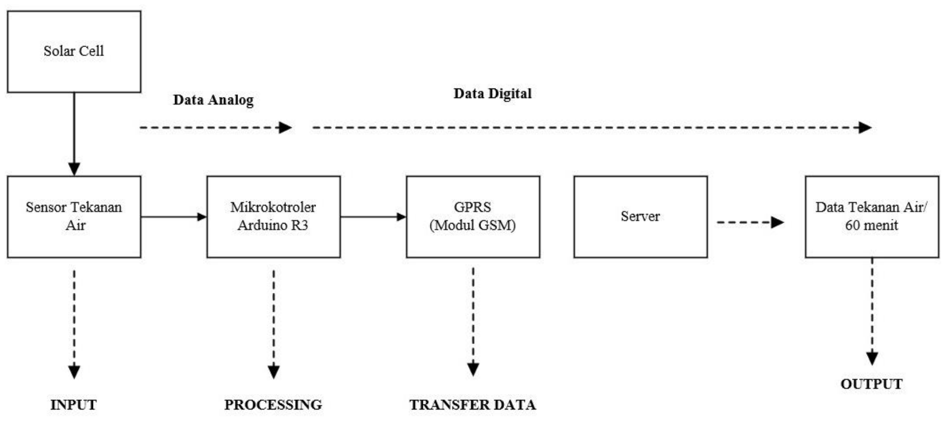

Figure 5. Hardware Design Block Diagram

Determines the power supply required by the IoT device

The power on the IoT device component supplied by the Solar Panel is shown in the Table I.

TABLE I. POWER SPECIFICATIONS ON DEVICES [17]

Type of Device	Voltage (V)	Current (A)	Power (Watt)	Output Power (Watt)
Arduino Uno R3	12	0,4	4,8	115,2
Pressure Sensor	1	0,4	0,4	9,6
SIM800L	4,2	0,3	1,26	30,24

To determine the total power required for 24 hours or a day is required the following formula [17],

$$Power(24\ Hour) = Total\ Power / (Hour \times 24\ Hours) \quad (1)$$

From this specification, the hypothetical power required in 24 Hour is as follows, when based on the average power of the device then the value is obtained:

$$Total\ Power = Arduino\ Power + Pressure\ Sensor\ Power + SIM800L \quad (2)$$

$$Total\ Power = 4.8\ W + 0.4\ W + 1.26\ W = 6.46\ W$$
$$Total\ Power\ in\ 1\ day = 115.2\ W + 9.6\ W + 30.24\ W = 155.04\ W$$

From this calculation the total energy required in one day is as much as 155.04 W. However, since the solar panel power is only effective as 60% [8].

So the power needed in a single day is 155.04 : 60% = 258.4 W

Determines the need for solar panels

In Indonesia, the optimal energy generated by solar panels for only 5 hours starts at 09:00–14:00, so the formula for determining solar panel needs is as follows:

$$Solar\ Panel = Total\ Power : Optimal\ Time \quad (3)$$

$$Solar\ Panel = 258.4\ W : 5\ Hours$$
$$Solar\ Panel = 51.68\ WattPeak$$

Determine battery usage

As a power storage medium, the battery must have sufficient capacity to support an IoT device. To determine the capacity of a battery, that is the total power multiplied by 95%. Considering that the batteries can only be used for 95% of the total capacity, the formula is as follows:

$$Reserve = Total\ Power : 95\% \quad (4)$$

$$Reserve = 155.04\ Watt : 95\%$$
$$Reserve = 163.2\ Watt$$

After obtaining the large total power reserve required, battery calculations are obtained with the formula as follows:

$$Battery\ Capacity = Total\ Power\ Output / Battery\ Voltage \quad (5)$$

$$Battery\ Voltage = 163.2\ Watt / 12\ Volt$$
$$Battery\ Capacity = 13.6\ Ah$$

So the required battery has a minimum capacity of 13.6 Ah.

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Determine Solar Charge Controller

To determine the Solar Charge Controller required specification data Isc (short circuit current),

$$SCC = Isc / Number\ of\ solar\ panels \qquad (6)$$

$$SCC = 2.97\ A \times 1 = 2.97\ A$$

Based on the results obtained from these calculations, the author prepared solar panels with a minimum capacity of 51.68 WattPeak. The battery prepared for a day's backup was a battery with a capacity of 13.6 Ah, and the solar charge controller prepared was a 2.97 ampere controller.

DISCUSSION

Results Solar Panel

In the first phase, tests were conducted to determine the quality and power efficiency of solar panel modules using ampere meters and avo meters. The tests were carried out for a week and monitored the voltage and output current of solar modules in real time. The test results were shown based on average power per hour.

TABLE II. SOLAR PANEL TESTING FOR 7 DAYS

Parameters	Average						
	Day 1	Day 2	Day 3	Day 4	Day 5	Day 6	Day 7
Daya (Watt)	6.78	9.27	6.74	6.92	7.07	6.59	6.85
Temperature (°C)	28	27.73	27.91	28.09	27.55	28.27	27.91

On the first day of the test, the average power was 6.78 watts and the temperature was 28 Celsius, with the highest power at 12 o'clock in the afternoon being 8.73 watts.

Results Battery Capacity

The capacity of the battery to see how long it can power the device. The battery capacity tested is a 20Ah battery. Within seven days the pressure on Perum Bukit Dieng was monitored and updated in 24 hours. With a minimum pressure of 0.9 bar and a maximum of 1.67 bar. The data can be assured that the solar cell system as the power supply on the logger Critical Point is satisfied. The results of the power test showed that using a 20Ah battery, get an average of 24 hours.

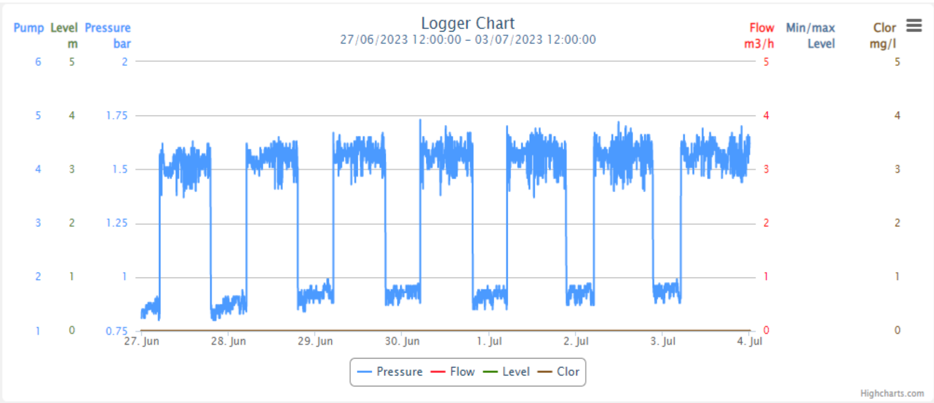

Figure 6. Critical Point Pressure Chart

Results Battery Charging System

The battery charging system is tested using the power supply from the solar panels and batteries. The test will be performed by monitoring the voltage and current coming into the IoT device and battery.

TABLE III. AVERAGE TEST FOR 7 DAYS

Parameters	Average						
	Day 1	Day 2	Day 3	Day 4	Day 5	Day 6	Day 7
Solar Panel (Watt)	6.93	6.33	6.63	6.63	7.20	7.23	7.53
Battery (Watt)	3.99	3.45	3.99	3.69	4.34	4.29	4.55
System Monitoring	3.92	3.35	3.89	3.55	4.28	4.24	4.48

Average power at a load of 3.96 W. With real-time use for 24 hours. Then the total power used is 95.04 Wh in 24 Hours. The battery serves to store the electricity generated by the solar panels for use at night refers to the battery charging system calculation formula in the method. So that the accu can be used for a long time, only 50% of the acetic capacity can be utilized. So it takes twice as many aces as $0.396 \times 2 = 0.79$ and rounded up into one battery. In Indonesia on average, the sun can shine brightly for 5 hours every day from 09:00 to 14:00. By using a solar panel that specifies 50 WP refers to the solar panel capacities calculation formula in the method. With this formula, 0.38 solar panels (rounded up to 1 panel) are produced.

From the above calculations, using the specification of a 50WP solar panel and a 20Ah battery. The solar cell system as the power supply on the critical point pressure logger can run in real time 24 hours.

CONCLUSION

The design of the solar panel power system as the main power plant can be implemented using the specification of one solar panel 50 WP and one battery with a capacity of 20 Ah. The proposed solar power system, using the selected devices, can provide power to the monitoring system with an average daily output power of 7.93 Watts with a distribution of 3.96 Watts into the system monitoring and 4.04 Watts in the battery, so reliable in providing the power supply of the systems monitoring for 24 hours. On the pressure graph, the Perum Bukit Dieng Critical Point data can be monitored up to 24 hours a week using the 20 Ah battery and 50 WP solar panel capacities. The power entering the system will not be the same as the power output because of the system power losses caused by the power consumption of each component on the network.

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