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Utilization Of Solar Energy In Iot-Based Seawater Desalination Equipment In National Energy Security

M Raafi Aqil Firdaus[1], Novky Asmoro[2], Sri Murtiana[3]

[1,2,3] Energy Security Study Program, Faculty of Defense Management, Republic of Indonesia Defense University, Indonesia

Corresponding Author: aqilfirdaus69@gmail.com

Abstract

Lack of clean water supply has become a serious problem in many coastal areas. In an effort to overcome this problem, seawater desalination is one of the possible solutions. In relation to this problem, this paper proposes an innovative approach combining seawater desalination with solar energy technology and IoT to provide clean water efficiently and sustainably. This system uses solar energy as the main power source to drive the desalination process. Sensors connected to the IoT network are used to measure important parameters such as water temperature and EC that enable real-time monitoring. However, the results of the desalination process still leave harmful waste compounds such as lead and iron, so it is necessary to re-filtrate with natural adsorbents zeolite and activated carbon. Based on the results of measurements and calculations, a solar power plant capacity of 40.821 Wp is needed and a battery capacity of 790.815 Ah.

Keywords: Solar Energy, Desalination, Iot, and energy security.

INTRODUCTION

Indonesia is one of the largest marine countries in the world. A total of two-thirds of the entire area is coastal (Djoyowasito et al. 2018). The need for clean water is increasing day by day due to industrialization, motorization, and the improvement of human living standards (Agustina 2021). In urban areas, the provision of clean water is managed by drinking water companies or carried out independently by the community by taking groundwater. However, in coastal areas far from springs, there are still many people who have not received clean water facilities. Coastal areas have the potential for seawater that cannot be consumed directly. So, there needs to be

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another solution for the provision of clean water that can be consumed (Mowaviq, Hajar, and Oktaviana Putri 2021). Indonesia as an archipelago country has a sea area of 5.8 million km2 or 70.8% of Indonesia's total area. (Remeli et al., 2019) In addition to having abundant seawater potential (Wahyudi, 2017), it also has the potential for high sunlight intensity. Both potentials can be used to produce clean water that is suitable for consumption. The method that can be used to obtain fresh water from seawater is the desalination method. Water distillation is one of the feasible solutions to overcome the freshwater crisis (Remeli et al. 2019).

Referring to the Energy and Mineral Resources Government Regulation no. 79 of 2014 concerning new renewable energy and putting the brakes on the use of fossil energy. In this government regulation, what is meant by energy management is the implementation of energy supply, business, and utilization activities, as well as the provision of strategic reserves for energy resource conservation. The purpose of energy management is expected to be utilized with energy management independence, which is a quality of energy management that is fully oriented to national interests to ensure that energy, energy sources, and energy resources can be managed as well as possible for the greatest prosperity of the people, by prioritizing the maximum possible capabilities of human resources and domestic industry. In this study, the use of solar energy is prioritized to meet energy and raw material needs and prioritizes the use of national energy resources based on a thorough consideration of capacity, continuity, and economy as well as environmental impacts. Based on Government Regulation no. 79 of 2014, article 19 concerning the environment and work safety of national energy management is aligned with the direction of sustainable national development, conservation of natural resources and control of environmental pollution.

Based on the above, the author has the idea to create an IoT-based seawater desalination device and natural adsorbents by utilizing solar energy as an alternative to providing clean water and also encouraging government programs in efforts to utilize renewable energy.

METHOD

In this study, a quantitative data collection method is used, where data collection is carried out by direct testing and measurement. The following is a flow chart of research processes which can be seen in figure 1.

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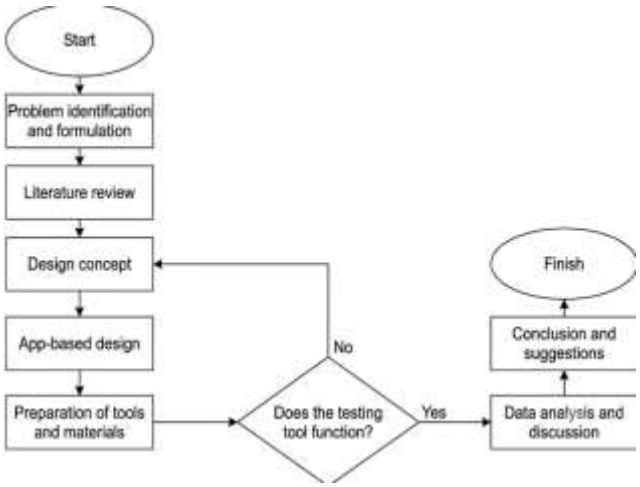


Figure 1. Research Method Flowchart

Research Tools and Materials

In this study, the tools and materials used for power supply or solar power to run the desalination equipment system are, panels, batteries, inverters, Solar Charge Controller (SCC), wattmeters and cables. (Question 2020) The components used in the desalination equipment are water pumps, heating elements, stainless steel tubes, stainless steel pipes, water taps, pipes, ESP 32, the ThingSpeak website, TDS meter sensors and DS18B20 temperature sensors (Munir, Rahman, and Rahmalina 2023). The tools used to measure power, current and voltage use a digital multimeter.

RESULTS AND DISCUSSION

Desalination Equipment Design

The following is the design design that will be used as a desalination tool:

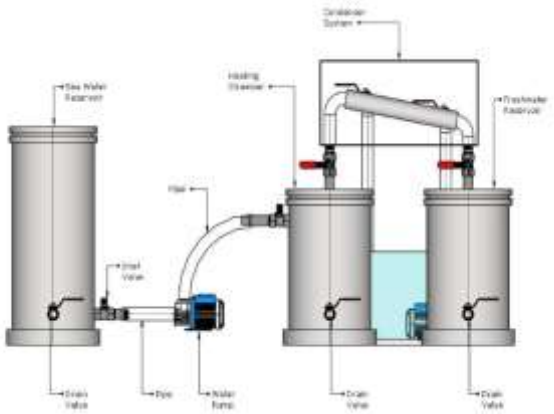


Figure 2. Desalination Equipment Design

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Data Collection Techniques

In data collection, there are three processes carried out to obtain data, namely data collection of solar power plants, data collection of desalination equipment and. The method used in this study is the quantitative method. The following are the working steps of data collection of testing tools, namely:

a. Solar Power Plant Data Collection

The first step is to prepare the solar panel and digital multimeter, the solar panels are assembled according to the procedure. Then installation with Solar Charge Controller (SCC), Wattmeter and battery battery. Next, dry the solar panels in direct sunlight at sunrise. The purpose of determining the current and voltage power produced by the solar power system. Digital multimeters and wattmeters will be used to measure the DC current and voltage from the solar panel to the battery pack. Then data collection is done by connecting the output of the solar panel with a multimeter and reading from the wattmeter display. Data collection is carried out every 30 minutes until sunset.

b. Data Collection of Desalination Equipment

First, prepare a multimeter and wattmeter. Furthermore, the desalination device system series is connected to the battery pack. Then calculate the time it takes for the water pump to fully fill the seawater heating tube. Record the accuracy of temperature sensors in the water that has been desalinated. Then a multimeter is used to record the voltage, power and current requirements required by each component in the desalination device.

c. Adsorbent Filtration Data Collection

The first step is to set up the TDS meter sensor device. The adsorbent filtration is connected to the desalinated water collection tube. Then record the results of the TDS meter sensor readings to find out the water quality on the ThinkSpeak website.

Data Analysis

At this stage, an analysis is carried out from the data that has been obtained from the test results. The data is used to determine the planning of solar power plants and also to determine the planning of desalination equipment.

Solar power plant planning data is used to calculate the voltage and current flow generated by the solar panels into the battery. Solar power plant data will be used dalam perencanaan kebutuhan daya dari alat desalinasi.

The desalination equipment planning data is used to find out how much power the

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desalination tool needs to be able to carry out the desalination process using the battery energy source that has been supplied by the solar power plant and to find out how the sensors can work in the system of this test tool.

Natural adsorbent filtration device planning data to find out what the water conductivity level, lead content and iron content are to ensure that the desalinated water is suitable for consumption.

RESULTS AND DISCUSSION

The design of the desalination device system in this study was realized to find effective experimental results to convert seawater into fresh water. To get effective results, this system is realized by utilizing the following desalination technology.

Capacity Requirements of Solar Power Systems for IoT-Based Desalination Equipment

The solar panels used are 300 Wp with a capacity of 100 Wp for each solar panel consisting of 3 units connected by a parallel circuit. The solar panels are positioned facing north with a 15-degree inclination. This test was carried out for 25 days from November 6, 2023 to April 30, 2023 starting at 05:30 to 18:00.

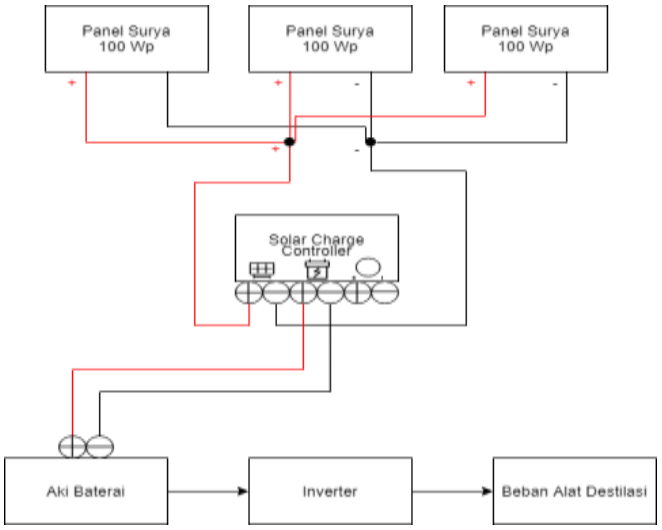


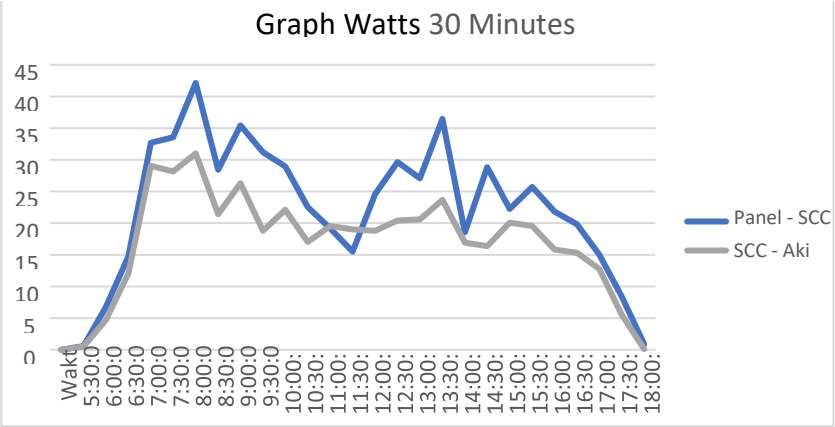
Figure 3. Solar Panel Network Scheme

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Gambar 4. Graph Watts

Below is a table of solar panel results to Ampere Hour (Ah) and Watt Hour (Wh) generated solar panels to the battery battery.

Tabel 1. Production Ampere Hour and Watt Hour per Day

No.	Date	Panel - SCC		SCC - Aki	
		Ah	Wh	Ah	Wh
1	6 November 2023	14,335	242,000	12,374	174,500
2	7 November 2023	15,098	256,700	13,260	186,500
3	8 November 2023	16,446	294,500	14,273	201,600
4	9 November 2023	14,537	271,000	13,345	183,500
5	10 November 2023	15,432	281,900	13,081	185,100
6	11 November 2025	29,224	468,100	27,138	381,000
7	12 November 2025	16,298	286,600	14,139	200,000
8	13 November 2025	14,521	255,600	13,003	177,500
9	14 November 2025	15,309	266,800	13,185	185,800
10	15 November 2025	15,742	282,500	13,470	190,400
11	16 November 2025	17,932	316,900	15,904	224,400
12	17 November 2025	16,062	296,200	14,308	196,100

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No.	Date	Panel - SCC		SCC - Aki	
		Ah	Wh	Ah	Wh
13	18 November 2025	17,005	295,100	14,935	211,100
14	19 November 2025	21,844	376,100	19,412	274,000
15	20 November 2025	18,853	181,778	18,693	53,965
16	21 November 2025	19,109	181,422	16,850	48,175
17	22 November 2025	18,987	153,034	14,474	58,723
18	23 November 2025	16,194	187,664	17,058	59,653
19	24 November 2025	17,500	184,000	12,923	276,450
20	25 November 2025	14,730	266,800	22,096	202,400
21	26 November 2025	16,621	188,113	16,571	194,269
22	27 November 2025	18,024	196,171	16,703	264,096
23	28 November 2025	18,678	188,363	12,963	240,309
24	29 November 2025	18,471	179,701	13,743	132,082
25	30 November 2025	16,819	172,029	18,459	147,810
Average Production Daily Energy		17,4	250,763	15,7	185,977
Total		433,8	6269,076	392,4	4649,433

The following is the data generated in the form of the time required in one desalination process. This data capture is used as a reference to determine the optimal capacity for solar panels and battery packs.

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Tabel 2. Testing the Energy Requirements of Desalination Equipment

No	Types of processes	Operating components	Quantity	Power unit	Amount of power	Old Operation	Total Energy
				(W)	(W)	(Jam)	(Wh)
1.	Filling seawater into a tube heater by water pump.	Pompa air 12 V DC	1	55	55	1 Minutes	0,916
2.	Water Desalination Process sea in the heating tube.	Heating elements 220V AC	1	660	660	10 Hour 37 Minutes	7007
		Water Pump Kondensor 12 V DC	1	55	55	10 Hours 37 Minutes	583,916
Total energy required							7591,832

Based on the results of the tests that have been carried out, namely testing solar power plants and testing desalination equipment. Data were obtained showing that the power needs of desalination equipment, which is 7,591 kWh per day, cannot be met by the production of electrical energy produced from solar power plants that produce the most average electrical energy per day, which is 185,977 Wh per day. In order to meet the power needs needed to supply electrical energy to the desalination equipment. Therefore, adjustments were made to the design of the solar power plant to the power needs of the desalination equipment to maximize the desalination process every day.

$$\text{Number of Solar Panels} = \frac{Power\ Prototype\ Desalination}{Production\ Power\ of\ The\ Day}$$

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$$\text{Number of Solar Panel} = \frac{7{,}591\ kWh}{185{,}977\ Wh}$$

Number of Solar Panel = 40,821~41 Buah Panel 300 Wp

Based on the calculation above, it is obtained that the number of solar panels that must be installed to meet the power needs of the desalination equipment in one day is 41 panels of 300 Wp. To find out the battery capacity needed to accommodate the production of electrical energy produced by solar panels, it is necessary to calculate the amount of battery capacity.

$$\text{Capasity battery} = \frac{Power\ Prototype\ Desalination}{Voltage\ Baterry\ \times\ DoD}$$

$$\text{Capasity battery} = \frac{7591{,}832\ Wh}{12V\ \times 80\%}$$

Capasity battery = 790,815 Ah

CONCLUSION

Based on the results and discussions obtained, it can be concluded as follows:

This Desalination tool system is designed using stainless steel materials as heating tubes, condensers and storage tubes that can accommodate a seawater capacity of up to 10 liters. The solar power generation system needed to optimize the desalination system equipment is as many as 41 panels of 300 Wp per panel with a total solar power capacity of 40,821 Wp and the required battery capacity of 790,815 Ah.

It can be seen that the results of the measurement of iron and lead levels in seawater before filtration are 0.25 mg/liter for iron, and for lead levels of 0.0012 mg/liter. For measurement results based on TDS meter sensors and temperature sensors, it is known that the average results of seawater EC and temperature before desalination and filtration of natural adsorbents is 15.37 mS/liter and temperature is 31.4 °C, while the results of EC and temperature after desalination and filtration with natural adsorbents are 0.288 mS/liter and temperature is 30.75 °C.

For further research, the author suggests the design of desalination equipment to increase water storage capacity and also water heaters, so that clean water production can increase, in addition, it is recommended to increase the capacity of solar power plants so that the desalination process is more optimal.

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