PROGRESS IN ENGINEERING APPLICATION AND TECHNOLOGY
e-ISSN: 2773-5303

PEAT

Vol. 5 No. 2 (2024) p. 235-245
https://publisher.uthm.edu.my/periodicals/index.php/peat

Utilization of Solar Energy for Filtering Water System

Muhammad Khairul Anwar Abdul Rahim[1], Lilywati Bakar[1]*, Zurina Abdul Wahab[1]

[1] *Department of Electrical Engineering Technology, Faculty of Engineering Technology, University Tun Hussein Onn Malaysia, 84600 Pagoh, Johor, Malaysia.*

*Corresponding Author: lilywati@uthm.edu.my
DOI: https://doi.org/10.30880/peat.2024.05.02.024

Article Info

Received: 27 June 2024
Accepted: 11 July 2024
Available online: 25 November 2024

Keywords

Solar Energy, renewable,water filtration system, electricity, low operating cost, in-depth analysis.

Abstract

This project "Utilization of solar energy for water filtration systems" explores the potential of solar energy to power water filtration systems. Solar offers a clean and renewable alternative to traditional energy sources, reducing dependence on fossil fuels. The system offers low operating costs after initial installation, as it uses free solar energy. Furthermore, its off-grid capabilities make it ideal for remote locations that do not have access to electricity. Although cost savings can be achieved through the use of economical materials such as used solar panels or locally sourced components, the overall cost of the system depends on the specific components selected. In addition, cost savings can be applied when an in-depth analysis is done regarding the amount of electrical power required to enable this system to function. Therefore, there is no excess cost used as the goods used are excessive and consume high costs.

1. Introduction

The development and execution of a solar energy for filtering water system is challenge of the need for clean recycled water and sustainable energy solutions. In Malaysia, many regions struggle with water shortages and unclear water caused by various factors such as pollution, inadequate infrastructure, climate change and population growth. These challenges have prompted the search for innovative solutions to provide access to existing water reuse. Based on research from internet sources, the water consumption index for the previous 10 years from 2012 until 2021, shows an increase level [1]. In addition, the use of this water becomes very sensitive for some places such as Selangor, Kelantan, and Sabah [2].

In general, renewable energy is energy derived from natural sources that are replenished at a higher rate than they are consumed. Sunlight and wind, for example, are such sources that are constantly being replenished [4]. Water filtration technology has advanced throughout time to greatly purify the water from several sources. These technologies cover a wide range of techniques, including as activated carbon adsorption, membrane filtration, UV disinfection, and more, all of which are intended to efficiently target certain pollutants. Solar energy and other renewable energy sources have gained popularity as sustainability has become more of a priority. Several systems, including air filtration settings, may now be powered by solar energy because to reduce costs and technological advancements in solar panels and associated infrastructure. In a snippet of a quote sourced from a website on the internet, "Selangor Chief Minister in March 2016, Datuk Seri Mohamed Azmin Ali wants the management of mosques and suraus in the state to impose the practice of judicious use of water among the congregation to reduce the very high rate of air wastage in the state. He said Muslims need to emulate the use of water like in the mosques in Makkah and Madinah which control the production of tap water for ablution to avoid wastage " [3]. The history of solar-powered water filtration systems is essentially the result of the convergence of environmental concerns, community needs, technological advancements, and cooperative efforts to address the pressing problems of pollution and water scarcity while fostering sustainability and resilience in society. Other than that, nowadays, the cost of manufacturing for a project is quite high. This is because each scope is not studied in more depth in parallel with the manufacturing required to complete an element itself.

2. Methodology

2.1 System Block Diagram

A few essential parts enable the operation of a utilization of solar energy for filtering water system. The solar is the primary element in the block design displayed in Figure 1, utilizing photovoltaic cells to convert sunlight into direct current electricity. The battery is charged by the solar charge controller using the direct current power produced by the solar panel.

An explanation of the energy conversion, distribution, and integration process with the broader electrical infrastructure may be found in a block diagram that depicts the workflow of a Solar-Powered Water Filtering Rotation. While undergoing monitoring, control, and environmental factors to ensure sustainability and optimal operation, it highlights the important role that solar panels and water filter with pump, it is because the use of this system can indirectly control the rate of water and electricity usage in addition to the efficient use of use of solar systems.

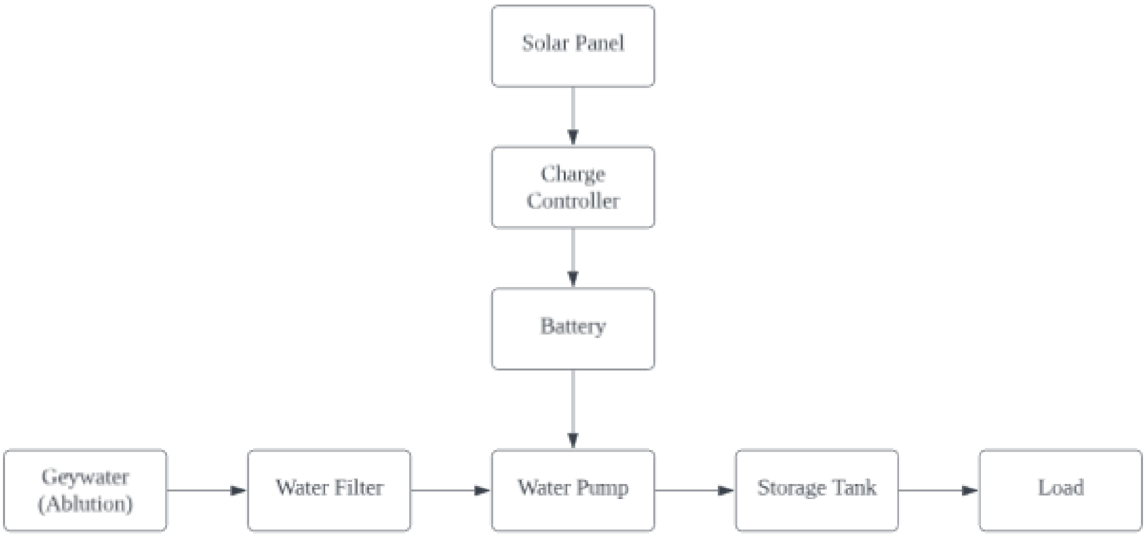

Fig. 1 *System block diagram*

2.2 Flowchart System

As demonstrated in Figure 2, a flow chart system is created based on logical operations. At first, greywater from ablution flows through the filter and then at the water pump, the water pump will pump the water to the storage tank. Water pumps take energy from the solar system. And then, the water from the storage tank will be channeled to other uses such as toilet cistern, hydroponic nursery and washing the floor.

Fig. 2 *Flowchart water pump system*

As shown in Figure 3, the solar system as provider energy to water pump. Water pumps take energy from the solar system. The solar PV input collects solar energy continuously and is fed to the solar charge controller. If solar power is available, the battery takes power from the sun through a solar charge controller, if solar power is not available then it takes power from the grid. Otherwise, the battery will continue to charge until it is full. And from this source the water pump works.

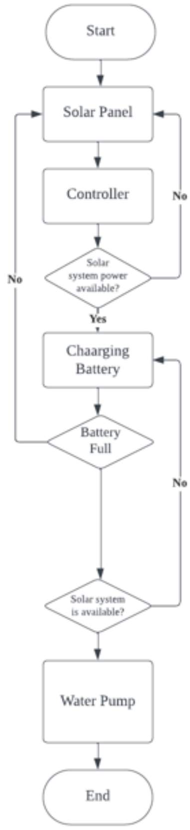

Fig. 3 *Flowchart solar system*

3. Result and Discussion

3.1 Actual Design

Figure 4 shows the actual model of solar energy for filtering water system. The model is made on a small scale to facilitate analysis. This small-scale model is also a model for in-depth analysis in terms of power reading elements generated, power used, current value, voltage value and every reading when the system is running.

Fig. 4 *Actual Model of solar energy for filtering water system*

3.2 Data Collection

Based on the Utilization of solar energy for filtering water system, data collection has been collected. The collection data which is the tilt angle, irradiance, temperature, the voltage and ampere of solar charge controller, battery reading, and water pump and the time taken for a 9 liters water to be pumped to the tank. Table 1 shows the table of data collected related to the single solar panel with water pump 24W.

Date: 30 May 2024 Azimuth: 249 Altitude:45 Time:9.00 A.M.

Table 1. *Data collection of single solar panel with water pump 24W*

No	Tilted Angle (°)	Irradiance (W/m^2)	Temperature (°C)	Solar Charger Controller		Battery Reading			Water Pump			Time taken for a 9 liters water to be pumped to the tank (s)
				Voltage (V)	Current (A)	Voltage (V)	Current (A)	Power Output (W)	Voltage (V)	Current (A)	Power Output (W)	
1	34	669	46	13.15	0.3	13.04	6.5	84.76	13.05	6.85	89.39	66
2	20	662	47	13.13	0.4	13.03	6.4	83.39	13.03	6.8	88.60	66
3	9	605	47	11.4	0.3	11.3	6.2	70.06	11.2	6.6	73.92	66

Table 2 shows the table of data collected related to the parallel solar panel with water pump 24W.

Date: 30 May 2024 Azimuth: 249 Altitude:45 Time:9.30 A.M.

Table 2. *Data collection of parallel solar panel with water pump 24W*

No	Tilted Angle (°)	Irradiance (W/m^2)	Temperature (°C)	Solar Charger Controller		Battery Reading			Motor Pump			Time taken for a 9 liters water to be pumped to the tank (s)
				Voltage (V)	Current (A)	Voltage (V)	Current (A)	Power Output (W)	Voltage (V)	Current (A)	Power Output (W)	
1	34	953	44	11.86	0.7	11.65	6.18	71.99	11.5	6.5	74.75	65
2	20	613	40	11.80	0.6	11.60	6.20	71.92	11.5	6.7	77.05	65
3	9	429	44	11.4	0.7	11.30	6.10	68.93	11.2	6.5	72.78	66

Table 3 shows the table of data collected related to the single solar panel with water pump 19W.

Date: 30 May 2024 Azimuth: 249 Altitude:45 Time:10.00 A.M.

Table3. *Data collection of single solar panel with water pump 19W.*

No	Tilted Angle (°)	Irradiance (W/m²)	Temperature (°C)	Solar Charger Controller		Battery Reading			Motor Pump			Time taken for a 9 liters water to be pumped to the tank (s)
				Voltage (V)	Current (A)	Voltage (V)	Current (A)	Power Output (W)	Voltage (V)	Current (A)	Power Output (W)	
1	36	778	43	12.30	0.30	12.17	1.30	15.82	12.14	1.6	19.42	64
2	21	612	41	12.30	0.30	12.20	1.50	18.30	12.10	1.6	19.36	66
3	10	978	41	12.42	0.34	12.32	1.60	19.71	12.25	1.2	14.70	65

Table 4 shows the table of data collected related to the parallel solar panel with water pump 19W.

Date: 30 May 2024 Azimuth: 249 Altitude:45 Time:10.30 A.M.

Table 4. *Data collection of parallel solar panel with water pump 19W.*

No	Tilted Angle (°)	Irradiance (W/m²)	Temperature (°C)	Solar Charger Controller		Battery Reading			Motor Pump			Time taken for a 9 liters water to be pumped to the tank (s)
				Voltage (V)	Current (A)	Voltage (V)	Current (A)	Power Output (W)	Voltage (V)	Current (A)	Power Output (W)	
1	33	751	49	12.75	0.7	12.60	1.0	12.60	12.50	1.7	21.25	68
2	19	879	50	12.80	0.7	12.70	1.0	12.70	12.60	1.6	20.16	69
3	9	836	52	12.90	0.8	12.73	0.9	11.46	12.68	1.6	20.29	65

3.3 Data Analysis

A single solar panel delivers a fixed voltage (usually 12V-24V) but can vary its current output depending on sunlight. Parallel connections of multiple panels maintain the same voltage but significantly increase the total current available. This is useful for powering devices with high current demands, like a 24W water pump, as long as the solar charge controller's current rating can handle the combined output. As demonstrated in Figure 5, value of voltage is at the average value which is don't have any increasement at the voltage aspect. While the current that produce is increase while the solar panel is connected parallel from the single condition at innitial.

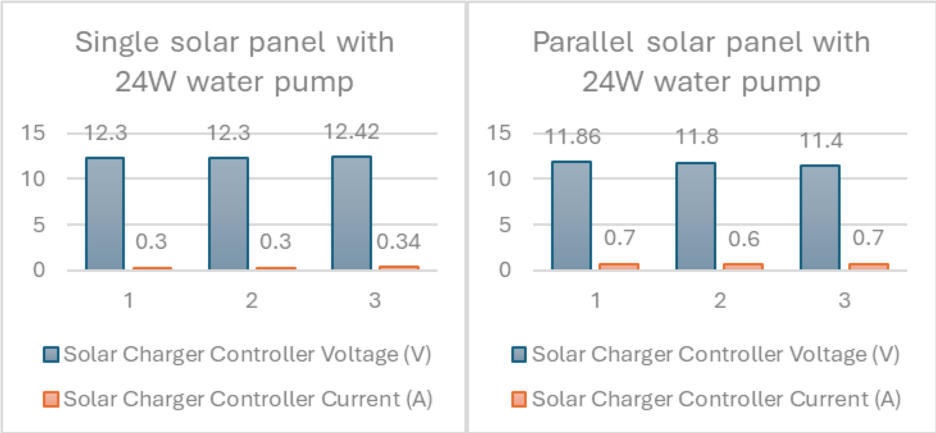

Fig. 5 *Comparison voltage and current between single solar panel and parallel solar panel with 24W water pump at solar charge controller*

Figure 6 illustrates that connecting solar panels in parallel maintains a constant voltage, similar to a single panel. However, the overall current output significantly increases compared to a single panel setup. Even though the water pump power still not the same rating, the laws of single circuit and parallel circuits state that voltage will maintain and current will increase in series circuit and the voltage increase and current will be maintained according to the series-parallel circuit rules.

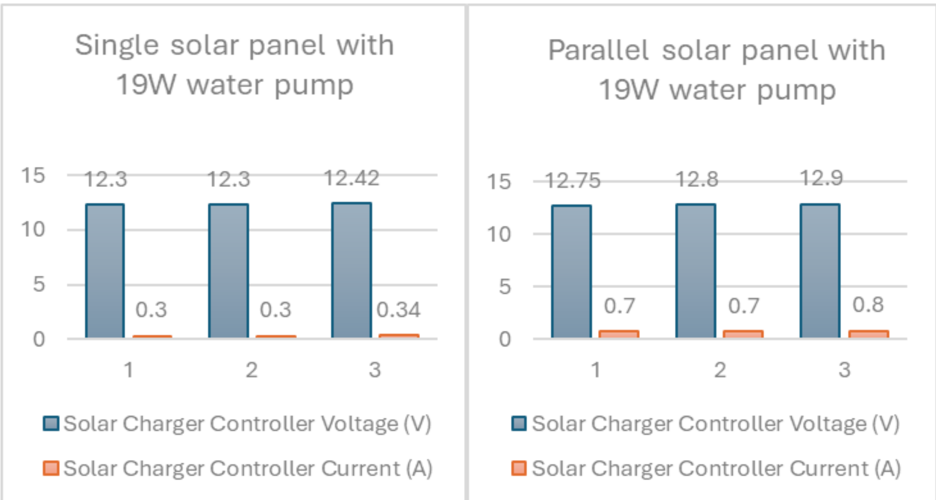

Fig. 6 *Comparison voltage and current between single solar panel and parallel solar panel with 19W water pump at solar charge controller*

Figure 7 shows the data while using single solar panel which is also use water pump 24W output and water pump 19W output which is value of voltage (V), current (A), and power output (W). Based on this collection, the voltage (V), current (A), and power output (W) from the 24W water pump produces greater value compared to 19W water pump. The values that produce from 24W water pump which is for first reading is 89.39W, 6.85A, and 13.05V while the 19W water pump produces 19.42W, 1.6A, and 12.14V for the first reading.

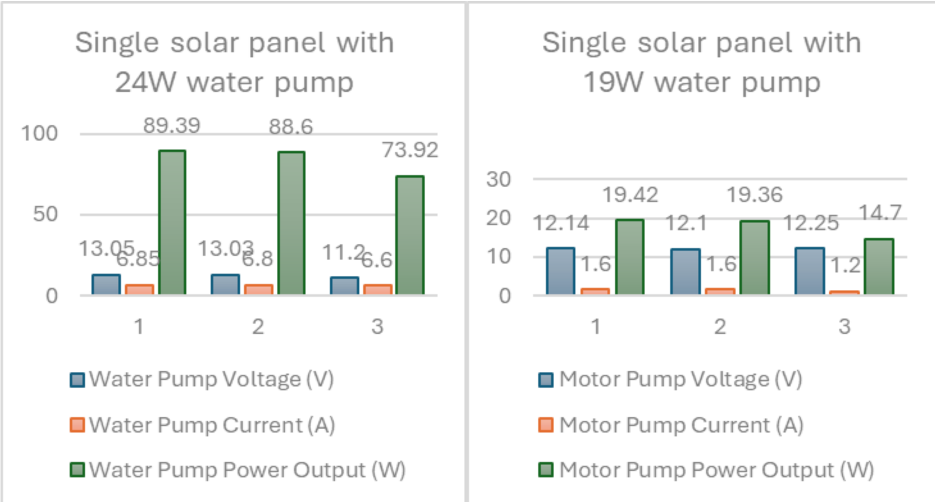

Fig. 7 *Comparison voltage, current and power output between single solar panel 24W water pump and single solar panel 19W water pump*

Figure 8 shows the data while using parallel solar panel which is also use water pump 24W output and water pump 19W output which is value of voltage (V), current (A), and power output (W). Based on this collection, the voltage (V), current (A), and power output (W) from the 24W water pump produces greater value compared to 19W water pump. The values that produce from 24W water pump which is for first reading is 74.74W, 6.5A, and 11.5V while the 19W water pump produces 21.25W, 1.7A, and 12.5V for the first reading.

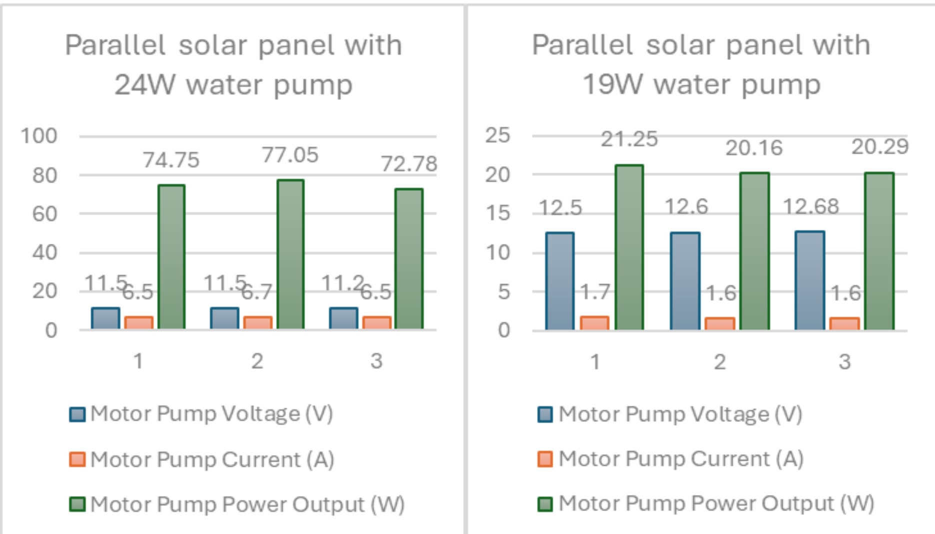

Fig. 8 *Comparison voltage, current and power output between parallel solar panel 24W water pump and parallel solar panel 19W water pump*

Progress in Engineering Application and Technology Vol. 5 No. 2 (2024) p. 235-245

Irradiance which is the amount of sunlight hitting a solar panel, has a direct but not perfectly proportional relationship with the voltage it produces. As shown in the Figure 9, while the irradiance is at 953 W/m2, the voltage is at 11.86V and while irradiance is at 429 W/m2, the voltage is at 11.4V. Based on this data, we know that the higher irradiance produces more voltage because when the irradiance increases, the output of voltage also increase.

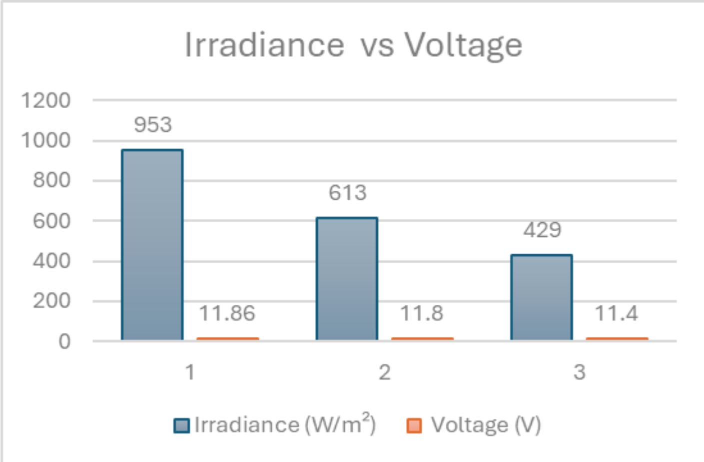

Fig. 9 *Relationship between irradiance and voltage*

3.4 Discussion

Based on the data collection and data analysis that produces above, the first aspect is about the voltage and parallel connections. A single solar panel produces a fixed voltage (typically 12V-24V) that remains constant regardless of how many panels are connected in parallel (Figures 4.3 & 4.4). However, the key benefit of parallel connections is that the total current available significantly increases (Figures 4.3 & 4.4). This is ideal for powering devices with high current demands, like a 24W water pump, as long as the solar charge controller can handle the combined current.

Other than that, power output and water pump load. The data in Figures 4.5 and 4.6 highlights that a 24W water pump draws more current and produces more power compared to a 19W pump, even under the same voltage. This demonstrates that the water pump's power rating directly affects the current it draws.
Besides, the next aspect is parallel panels and power increase. While both single and parallel panel setups deliver higher power output for the 24W pump compared to the 19W pump (Figures 4.5 & 4.6), parallel connections offer the advantage of potentially reaching higher overall power output due to the increased current.

Next is about irradiance and voltage. There's a direct, but not perfectly proportional, relationship between irradiance (sunlight intensity) and the voltage produced by a solar panel (Figure 4.7). As irradiance increases, voltage generally increases as well. However, this rise slows down at higher irradiance levels, eventually reaching a plateau. Temperature also is the main aspect that effect the output of the system. Higher temperatures can slightly decrease voltage output, even with constant irradiance. Also about the panel characteristics. The specific design and materials of the solar panel can influence the voltage response to irradiance changes.

In essence, understanding voltage behavior, parallel connections for increased current, and the impact of irradiance is crucial for optimizing solar panel performance in powering devices like water pumps. So that, for this system, the water pump of 24W is suggested to use and the number of solar panel that recommended is greater than 24W in order to get the smooth running system.

4. Conclusion

The solar energy water filtration device demonstrates the viability and usefulness of implementing Islamic precepts. Installing and removing the grey water recycling system is a straightforward task that reduces air waste, saves clean water supplies, and can reduce power use. Estimated models, extensive applications suggested because of quality checks as well as energy sources supplied by solar panels to generate water pumps, all show a feasible system.

Utilizing solar energy for water filtration systems offers a sustainable and reliable method for clean water, particularly in remote locations. Sunlight is captured by solar panels and converted into electricity. This electricity can then power pumps that draw water through various filtration stages, or even directly run specific methods like UV disinfection. The major advantages include reduced dependence on fossil fuels and a significant decrease in operating costs after the initial investment. However, successful implementation requires careful planning. Sunlight availability in the target area is crucial, and battery storage may be necessary to ensure operation during low-light periods. Additionally, the chosen filtration method needs to be compatible with solar power, as some purification processes may require more electricity than solar panels can consistently produce.

For this system, there are several aspects that need to be improved in order to get a superior system in line with the passage of time. One of the elements that need to be improved is the cutoff system water pump while the water in the tank reaches it limit. This cut off system also can link with mobile phones to control the running or data of the water pump. Other than that, the solar supply also can transfer to others usage which is to turn on the lights and so on. So that, its pushing towards saving the cost of electricity because it uses solar energy or known as one of renewable energy sources.

Acknowledgement

This research was supported by Universiti Tun Hussein Onn Malaysia (UTHM). Acknowledgment also goes to the staff and personnel of the Johor State Forestry Department for the technical assistance extended throughout the study.

References

[1] Statista Research Department. (May 23, 2023). Domestic metered water consumption in Malaysia from 2012 to 2021. https://www.statista.com/statistics/796354/domestic-metered-water-consumption-malaysia/

[2] Pusat, negeri perlu bertekad selesai segera isu air. (2023, May22). BH Online. https://www.bharian.com.my/kolumnis/2023/05/1104346/pusat-negeri-perlu-bertekad-selesai-segera-isu-air

[3] MStar. (2016, March 27). Masjid, surau di Selangor diarah kurangkan pembaziran air. https://www.mstar.com.my/lokal/semasa/2016/03/27/masjid-surau-kurang-bazir-air

[4] United Natio. What is renewable energy. https://www.un.org/en/climatechange/what-is-renewable-energy#:~:text=Renewable%20energy%20is%20energy%20derived,that%20are%20constantly%20being%20replenished.

[5] Lund, H. (2007). Renewable energy strategies for sustainable development. Energy, 32(6), 912–919. https://doi.org/10.1016/j.energy.2006.10.017

[6] Sharma, S., Jain, K. K., & Sharma, A. (2015). Solar Cells: In Research and Applications—A Review. Materials Sciences and Applications, 06(12), 1145–1155. https://doi.org/10.4236/msa.2015.612113

[7] El-Harbawi, M., Azwana, A., Sabidi, B. T., Kamarudin, E. B., Abd Hamid, A. B., Harun, S. B., Nazlan, A. B., & Yi, C. X. (2010). DESIGN OF A PORTABLE DUAL PURPOSES WATER FILTER SYSTEM. In Journal of Engineering Science and Technology (Vol. 5, Issue 2).

[8] Sreewirote, B., Suttisinthong, N., & Ngaopitakkul, A. (2019). The Application of Solar Cells for Water Filtration System. MATEC Web of Conferences, 260, 03002. https://doi.org/10.1051/matecconf/201926003002

[9] Lewis M. Fraas, Larry D. Partain. (2010). Solar cells and their application. Published by wiley.

[10] Suratkon, A., Chan, C. M., & Tuan Ab Rahman, T. S. (2014). SmartWUDHU': Recycling ablution water for sustainable living in Malaysia. Journal of Sustainable Development, 7(6), 150–157. https://doi.org/10.5539/jsd.v7n6p150