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Solar energy powered smart water heating system

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Abstract. This paper proposes a smart system for controlling the temperature of a water heating system. The proposed system is powered by solar energy and it allows cooling and heating the water used in households throughout the year, particularly, when the outside temperature goes to extreme highs and lows. The system is equipped with sensors to measure the temperature of water inside the tank and show the range of water. A mobile application is developed to monitor and control the water temperature around the clock.

Introduction

Today, a country's Gross Domestic Product (GDP) is directly correlated with its energy consumption, which serves as a measure of that country's prosperity. As a result, the need for energy resources is growing every day. Energy resources come in many different forms, but they are primarily grouped into two categories: renewable energy sources (solar, air, and wind) and non-renewable energy sources (coal, petroleum).

Non-renewable energy resources speed up industrial expansion, but their supply is finite by nature. In order to meet the energy needs of the present and future generations, it is vital to find alternative energy sources due to the quick depletion of fossil fuel resources. Solar energy stands out among several options as having the best long-term prospects for supplying the world's rising energy needs. This resource's main shortcomings are its low intensity, sporadic nature, and nighttime non-availability.

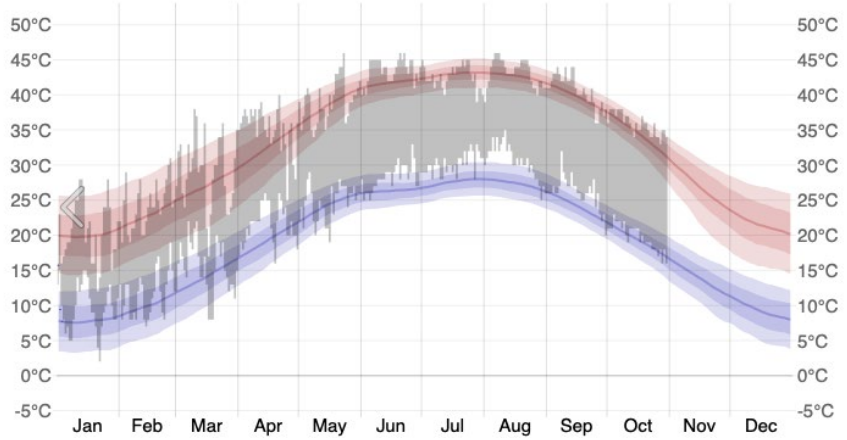

Figure 1. Temperatures throughout the year in Saudi Arabia year (2022).

Despite these drawbacks, solar energy still seems to hold the most promise of all the available renewable energy sources. Solar power is an abundant source of energy. Large amounts of renewable solar energy are produced by the sun and can be captured and used to generate heat and power. Water heating, air heating, building air conditioning, solar refrigeration, photovoltaic cells, greenhouses, photo-chemical power production, solar furnaces, and photo-biological co-versions are just a few of the many potentials uses for solar energy. The weather inside Saudi Arabia in the summer is excessively hot, which effects the water temperature inside the tanks, therefore it is difficult for people to take showers, use the toilet, do the dishes etc., therefore there is a high demand of water cooling systems, but a smart system does not exist, as a group we will design a smart system that solves this problem and make it easier for consumers to use them at home and make water more efficient which can be accessed at all times during the day.

The proposed system has several advantages over other similar systems proposed in [1] – [4]. The system in [1] is not solar powered, while the system in [2] does not have cooling feature, and it has no monitoring mechanism. The system in [3] allows heating and is solar powered, however, it has no cooling or monitoring features. In contrast, the proposed system allows both water cooling and heating. Also, it allows monitoring through a mobile application, and furthermore, it is solar powered. Details on the proposed system followed by technical specifications are demonstrated in the next section, followed by results, analysis and conclusion.

Proposed System

The block diagram of the proposed system is shown in Figure 2 below.

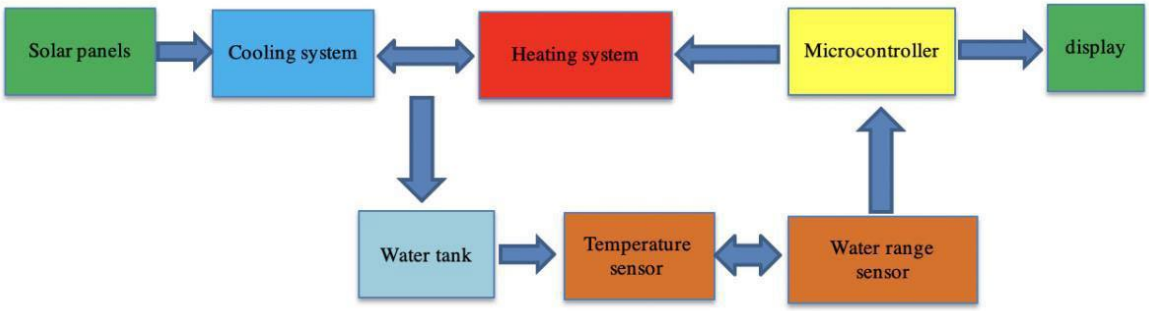

Figure 2. A block diagram of the proposed system.

The proposed system is divided into three subsystems as illustrated in Figure 3. Each of the subsystems are described in detail below.

A. Subsystem I: (Heating and Cooling System)

The majority of hot water systems include a central boiler where water is heated to a temperature between 60 and 83 °C (140 to 180 °F) before being routed through pipes to various rooms' coil units, such as radiators. Both pressure and gravity may circulate hot water, but forced circulation with a pump is more effective since it offers flexibility and control.

Hot-water systems circulate heated water using either a one-pipe or a two-pipe system. Compared to a two-pipe system, the one-pipe method utilizes fewer pipes; therefore, to accomplish the proper water temperature, we will be using the two-pipe system with cool water to achieve the water temperature that the user chose.

This system is also focused on finding the right size of cooling AC for water tanks; a cool water system should operate at a temperature between 5 to 40 °C (41 to 140°F), also finding a system that consumes the least amount of power that works on solar panels and combining this system to heating system; for finding the right water temperature that is needed. Major components used: Heating system, Cooling system, Water tank, Pipes

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B. Subsystem II: (Photovoltaic System)

A photovoltaic (PV) system is made up of one or more solar panels, an inverter, and other mechanical and electrical components that harness solar energy to produce electricity. PV systems come in a wide range of sizes, from small rooftop or portable units to enormous utility-scale power plants. Although PV systems can function independently as off-grid PV systems, this article concentrates on grid-tied PV systems, which are PV systems that are linked to the utility grid.

The photovoltaic effect is the mechanism through which sunlight, composed of energy packets called photons, strikes a solar panel and generates an electric current. Each panel generates a very small quantity of electricity, but when connected to other panels, a solar array may generate much more energy.

To use all the systems on solar energy, we will need to calculate and test each system on how much power is being used; therefore, we will do the calculations and work out how many solar panels are needed and connect them to the system. Major components used: Solar panels, Inverter, Batteries, Charge controller.

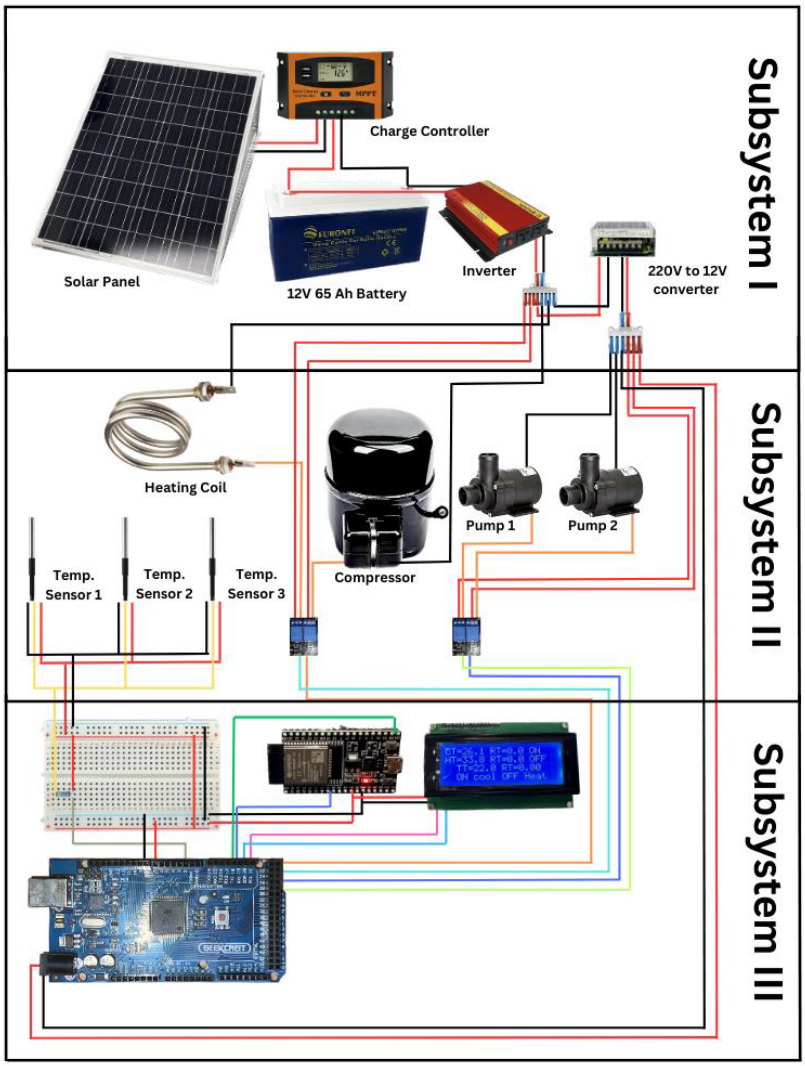

Figure 3. Project subsystems, components, and their interconnections.

C. Subsystem III: (Microcontroller and Communication System)

Information exchange between two points is described by the communication system. Communication is the process of sending and receiving information. The information transmitter,

the channel or medium of communication, and the information receiver are the three main components of communication.

To control a single device function, a microcontroller is integrated into the system. It accomplishes this by utilizing its core CPU to evaluate data that it receives from its I/O peripherals.

The microcontroller receives temporary data that is stored in its data memory, where the processor accesses it and employs program memory instructions to interpret and apply the incoming data. It then communicates and takes the necessary action via its I/O peripherals. Major components used: Sensors, Transmitter, Receiver, Arduino mega

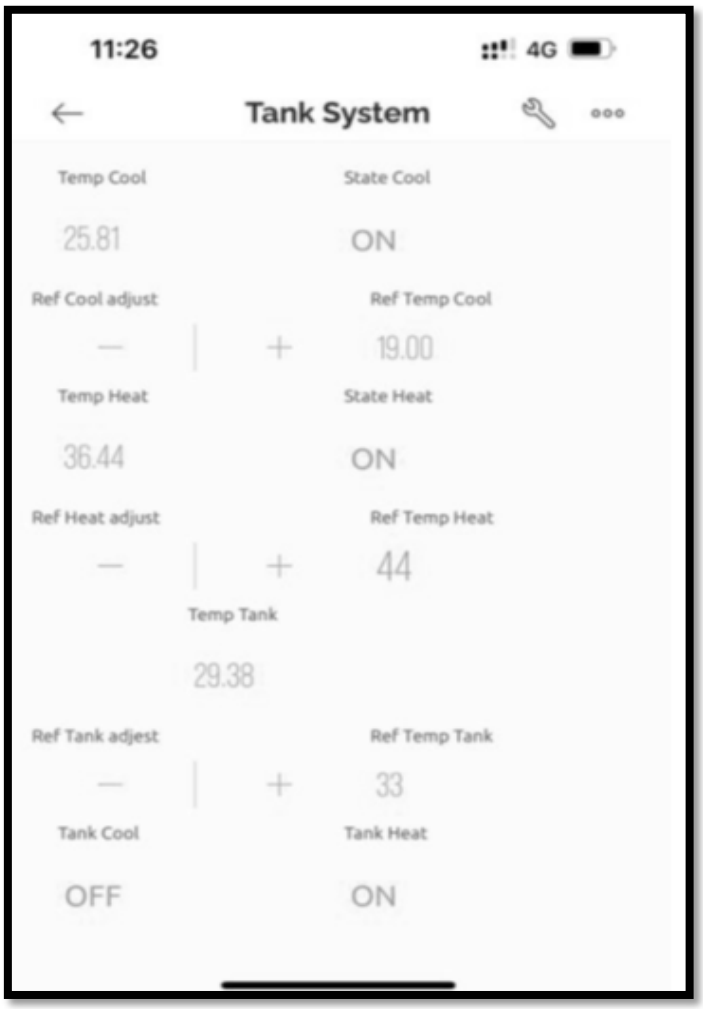

Figure 4. Mobile app UI for temperature monitoring and control.

Summary

This paper proposed a smart and efficient system for controlling and maintaining the temperature of water heating systems in residential units. It uses a renewable energy source to power the system making it environmentally friendly and sustainable. Since water-heating systems consume a lot of energy, the proposed system can help in significantly reducing the energy footprint and thus reduce the energy bills paid by the consumers.

References

[1] Water Tank System Using System Identification Method, International Journal of Engineering and Advanced Technology (IJEAT), Malaysia, 2013.

[2] Solar Water Heater Design, Al Akhawayn University, Morocco, 2019.

[3] Solar Water Heater Geyser, Undergraduate Senior Design Project, Prince Mohammed Bin Fahd University, Saudi Arabia, 2020.

[4] Powerful Tank Water Cooling Device, Global consumer bureau, Saudi Arabia, 2022.

[5] Choudhary, M., & Singh, R. (2018). Smart Water Heating System Using Internet of Things. In Proceedings of the International Conference on Information Systems Design and Intelligent Applications (pp. 573-582). Springer, Singapore.

[6] Li, X., Chen, X., & Li, M. (2018). Smart Water Heater Control System Based on Internet of Things. In 2018 International Conference on Computer, Information and Telecommunication Systems (CITS) (pp. 1-5). IEEE.

[7] Nikolic, I., & Nikolic, D. (2017). Smart Water Heating Systems—A Review. In 2017 5th Mediterranean Conference on Embedded Computing (MECO) (pp. 1-4). IEEE.

[8] Kumar, A., & Garg, R. (2019). Design and Implementation of a Smart Water Heating System Using IoT. In 2019 4th International Conference on Internet of Things: Smart Innovation and Usages (pp. 1-5). IEEE.

[9] Dervisoglu, E., & Karakose, M. (2020). Design and Implementation of a Smart Water Heating Control System Based on IoT. In 2020 5th International Conference on Computer Science and Engineering (UBMK) (pp. 1-5). IEEE.

[10] Chen, G., Zhang, X., & Liu, J. (2019). Design and Implementation of a Smart Water Heater Control System Based on IoT. IOP Conference Series: Earth and Environmental Science, 242(1), 012067.