An Iot Based System for Improving the Solar Water Heater

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Abstract

Background: The home buildings' solar water heating systems' energy efficiency is improved.The Internet of Things (IoT) has been utilised to capture a variety of data, which is employed in this system.Determine the relevant opportunities for increasing the effectiveness of different SWH subsystems.For the overall efficient operation of the system, control techniques are also created.The operating effectiveness of a solar water heater is monitored using a variety of sensors, including TDS sensors, optical liquid level sensors, temperature sensors, and turbidity sensors. In order to reduce loss and enhance the solar water heater's efficiency during maintenance, it is continuously monitored.Using IoT, this heater data may be retrieved from any location.

Keywords: Arduino UNO, TDS Sensor, Temperature Sensor, Potentiometer, Optical liquid level sensor, Turbidity sensor, Resistor.

1. Introduction

It is utilised in renewable energy producing systems to provide real-time monitoring of the wind turbine and solar panel array infrastructure.Uncontrolled six-pulse rectifier is used to change the wind turbine's ac output voltage to dc.The hybrid system of renewable energy sources (RES) coupled uses a wind turbine to generate voltage, which is then provided to the battery bank.For each renewable energy source, a monitoring system is developed based on voltage and current measurements [1].The initiative uses an Android platform to track renewable energy sources online.Using this method, the Power Conditioning Unit's digital electronics can exchange data through Bluetooth with an Android tablet or smartphone (PCU).utilising better pictorial representation and a touch screen interface, the Low-Cost Android tablet can take the place of the graphical LCD displays and Internet modem of RES Power Conditioning Unit (PCU). [2]. A comprehensive management and remote monitoring system for telecommunications power plants has been created and put into operation. The system is used to run and manage more over 200,000 communications power plants, including air conditioning units installed in around 8,000 telecommunication buildings and equipment including rectifiers, inverters, and UPSs. [3]. This study recognizes the issue of non-intrusive load monitoring method of load disaggregation into distinct appliances, since there may be mismatch with loads changeable in time when certain local generators based on renewable energy sources are linked to the same grid. Three methods of separating out electric energy use from energy produced by local renewable energy sources are outlined. [4]. Through the use of wireless sensor boards and text message (SMS) transmission through cellular network, the project's output provides immediate access to generated electricity at the rural site. An intelligent management system built on Frontline SMS is housed in the SMS receiver at the main site and is used to host SMSs and display distant measurement trends online. [5]. After briefly introducing it, we shall analyse and investigate a linear parabolic solar power plant in this essay. According to the current parameters, a plant-specific online monitoring system has been created. We evaluate the efficiency of each Internet parameter in addition to researching various Internet dynamics as significant components in order to understand how the Internet behaves. [6]. This study examines TES technology for solar water heating systems with an emphasis on approaches for PCM integration into these systems.

These techniques include incorporating a PCM device, storage containers, and solar collectors into the solar hot water circuit.It is found that the technology employed in SDHW systems using PCMs most frequently is the integrated PCM storage vessel.The configuration of the storage unit's latent heat and heat transmission procedures are reviewed in more detail.[7].A approach based on preference selection index (PSI) has been utilised to determine the best design of the parameters that offer the greatest possible thermal performance with the least possible increase in friction inside the collector duct.

The outcomes of the proposed approach demonstrate that the streamwise specifically how the pH content varies, and to communicate this information to the appropriate authorities. This project will be implemented at drinking water reservoirs and municipal water tanks. For that, we'll be utilizing a GSM module and an Arduino board to determine the pH value [10]. In order to reduce the power consumption of a household geyser, this paper describes the design of a smart geyser controller that uses low power IEEE 802.15.4 radios to transport information between two functional units. The first operational device switches the geyser on and off as well as measures the geyser's environmental data, including water temperature, voltage, current, and power readings. In addition to connecting to a PC where environmental data is kept in a local database for historical review, the other functional unit is utilised to show information to the user. The operational optimization algorithm is based on the priority time table that is created using this database [11]. The advancement of technology is accelerating. We have a better alternative for busy workers thanks to modern technologies. In modern homes, a range of appliances, including computers, switches, doorbells, ovens, televisions, LED lights, water heaters, and HVAC, are installed (Heating, Ventilation, & Air Conditioning). At times, keeping an eye on every device becomes challenging. There are occasions when leaving some appliances running when no one is home can result in higher electricity bills. An IoT might be used to accomplish this, a modern technology. Motion and temperature sensors are both used in the proposed work. PIR (Pyro-electric Passive Infrared) is utilized for authentication, and the temperature sensor LM35 is used to determine the room's current temperature and control the appliances accordingly [12]. In a sun water heating gadget, the maximum regularly met problem is to obtain hot water at required temperature constantly because of variation within the incident solar radiation over a day or maybe in the one-of-a-kind seasons of the year. This painting deals with the designing of a manipulate mechanism based totally on sensed temperatures, together with the water waft charges from structures, primary (hot water supply) and secondary (cold water supply), which are constantly monitored. This mechanism proposes a option to problems of acquiring heat water at a desired temperature and enjoyable the temperature specific sports as it estimates the quantity of bloodless water to be provided from the secondary supply. Further, the strength intake could also be reduced by using enforcing a hybrid mode (the use of a sun water heater and an electric heater), where the water could be preheated by using the solar water heater. As a result, strength fees of the electrical heater may be curtailed [13]. An overview of solar energy use for home water heating is provided in this study. The outcomes of preliminary research to create a low-cost solar-powered water heating system, a green energy source, are also mentioned. The device described here uses a thermal collector to absorb the heat that the sun radiates. Using sensors, actuators, and a programmable logic controller, the heating and recirculation process is automatically regulated (PLC). The findings show that the system under consideration has the capacity to provide enough hot water to satisfy home consumption needs. [14]. The current work develops a solar heating system model based on the energy transfer mechanism. The solar heating system is broken down into five main parts by the model, including collectors, heat exchangers, auxiliary heat sources, pipes, hot water storage tanks, and radiation ends. From energy and exergy evaluations, it is possible to calculate the system's primary components' thermal and exergy efficiencies. A real-world example is used to apply the analysis, and a schematic showing the system's energy flow is also included. The example shows that the majority of heat loss takes place in collectors. The amount of energy distributed to customers only makes up 4.3% of the total energy entering the system. Exergy loss mostly happens in the radiation ends, auxiliary heat source, and collectors. The findings are of significant relevance for the solar heating system's energy-saving and optimization. [15]. In Ecuador, household hot water systems (DHW) run on electricity and liquefied petroleum gas (LPG). Ecuador is currently working to change its energy structure, which includes getting rid of LPG in the home market. In this setting, induction cooktops will take the place of gas cooktops, and electrical heaters will take the place of gas water heaters. The country's power demand curve would experience large peaks as a result, which will be a serious issue. The benefits to the economy and environment are demonstrated by a quantitative analysis of the various hybrid solar systems used for DHW to reduce the consumption of electric energy and LPG. The solar thermal system and the photovoltaic system, each of which is supported by an auxiliary heating system, are simulated in this article. An average Ecuadorian family of four is taken into account when calculating the demand for hot water. TRNSYS software was utilised to assess system behaviour throughout the course of a full year, and an analytical approach was employed to compare the outcomes. The findings imply that because solar thermal systems are more efficient than photovoltaic systems, they are more economic. The price of solar collectors and photovoltaic panels, on the other hand, has a significant impact on the economic survey. Economic study reveals that a system based on LPG is more profitable than an electrical auxiliary system when it comes to auxiliary systems since it saves 17.04 percent of the total amount needed. The analysis also demonstrates that the user and the Ecuadorian government will benefit economically and environmentally. [16]. It is effective to combine computing with water heating to recycle the lost energy. We introduce a scheduling system for computing water heaters based on the collection of computing water heaters that serve as a distributed supercomputer and has been verified by simulation under heavy workloads. On a complicated steady state, these simulations enable us to achieve an approximate CPU utilisation of around 60% while minimising the thermal resistance usage to 10% (only when necessary) [17]. Concentrating solar power (CSP) facilities with thermal energy storage (TES) could offer ancillary services (AS) in the reserve and regulation markets in addition to energy. On the one hand, offering AS helps to make the power systems more flexible and boosts the revenue of CSP plants. On the other hand, an improper offering strategy, such as supplying high AS, may considerably reduce the flexibility of CSP plants to accommodate solar energy, which is of tremendous uncertainty. Lack of flexibility could result in drastic reductions in solar energy production and lower potential earnings. In the integrated day-ahead energy, reserve, and regulation markets, this study presents a generic model framework on the best offering strategy for CSP plants that is stochastic for market pricing uncertainty and robust to solar energy uncertainty. The offering curves to supply an additional AS capacity in the supplemental AS markets are further deduced on the basis of the opportunity cost given the best day-ahead offering strategy. To construct the trade-off of the CSP plants between supplying AS to system and reserving the flexibility for solar energy accommodation, a new index called the maximum tolerable curtailment rate is introduced. The outcomes of the case study show that the suggested model is valid [18]. Systems for converting solar energy into thermal energy and storing it in hot water are known as solar water heating (SWH) systems. The effectiveness of SWH systems is mostly dependent on the use of properly engineered solar collectors and operating mechanisms. A small number of studies have been done to improve the working mechanism, even though the majority of the literature to far has concentrated on improving the efficiency of solar collectors. As a result, the goal of this paper's investigation into the SWH system's control mechanisms is to assist the building manager in achieving certain energy management objectives. In specifically, three control strategies are described for enhancing the SWH system's operational effectiveness through the management of circulation pumps and auxiliary heaters such heat pumps and electric heaters. The suggested methods were designed in response to several informational needs, including hot water demand, weather, and electricity pricing. Additionally, three different energy management goals are investigated while taking into account several hypotheses regarding the actual weather pattern and the hot water demand of a commercial facility. The outcomes demonstrate that the suggested methods can enhance SWH system performance in accordance with different operational goals [19]. This study examines how a solar thermal system operates in a building and aims to provide a solution that would lower the building manager's electricity costs while also guaranteeing that water demand and temperature requirements are met by building occupants. Two energy management strategies in particular are being studied for managing the numerous heat pumps connected to solar thermal systems to supply heat when there is insufficient solar energy. Two control systems are suggested in this situation: on-demanding control (ODC) and optimal day-ahead scheduling (ODS), both of which use varying degrees of information, such as water demand, weather, and other factors. Additionally, three distinct types of scenarios are taken into account based on the hot water demand and solar energy generation pattern of a commercial building, and the best quantity and timing of heat pumps are found for each situation. If information about the weather and heat demand is available for the next 24 hours, it is demonstrated that the ODS strategy is more effective at conserving energy and related costs than systems using the ODC technique. The performance improvement is also quantitatively supported [20].

2. System parameters

TDS stands for Total Dissolved Solids in Liquid, which includes both organic and inorganic compounds that are suspended as molecular, ionic, or microgranular particles. TDS is often measured in milli grammes per litre (mg/L) or parts per million (ppm). TDS and water quality are intimately correlated; the purer the water, the lower the TDS value. TDS in reverse osmosis filtered water, for instance, ranges from 0 to 10, while tap water, depending on where you live in the world, ranges from 20 to 300. Minerals, salts, anionic and cationic compounds, as well as other substances, make up the dissolved solids in water.

Fig.1. Node MCU

They may also contain other chemicals, such as organic materials that may have leaked into your water supply system, as well as contaminants like heavy metals. In general, the more soluble solids that are dissolved in water, the higher the TDS value, and the less pure the water is. Consequently, one benchmark for measuring the water's cleanliness can be that TDS number. This could be used in the testing and monitoring of water quality in hydroponics, residential water, and other areas. A TDS metre is essentially an electrical charge (EC) metre that measures charge by inserting two electrodes into water that are equally spaced apart. The TDS metre interprets the result and converts it to a ppm value.

TDS Specification:

1. Input Voltage: 3.3 ~ 5.5V
2. Output Voltage: 0 ~ 2.3V
3. Working Current: 3 ~ 6mA
4. TDS Measurement Range: 0 ~ 1000ppm
5. TDS Measurement Accuracy: ± 10% FS (25 ℃)
6. TDS probe with Number of Needle: 2

Maxim Integrator's DS18B20 is a 1-wire programmable temperature sensor. In extremely harsh settings, such as chemical solutions, mines, or soil, it is frequently employed to gauge temperature. The sensor's enclosure is strong and has the option to be waterproof, which makes installing it simple. A range of temperatures between -55°C and +125°C may be estimated. The DS18B20 temperature sensor operates similarly to a temperature sensor. The sensor's resolution ranges from 9 to 12 bits. The pin configuration of the DS18B20 discussed below.

Pin2 (Vcc): This pin is used to give the power to sensor which ranges from 3.3V or 5V

Pin3 (Data): The data pin supplies the temperature value, which can communicate with the help of the1-wire method.

DS18B20 Temperature Sensor Applications:

• This sensor is extensively used to calculate temperature within the rigid environments which includes mines, chemical solutions, otherwise soil, etc.

• This sensor can be used to measure the liquid temperature.

• We can use it in the thermostat controls system.

• It can be used in industries as a temperature measuring device.

• This sensor is used as a thermometer.

DS18B20 Sensor Specifications

• Programmable Digital Temperature Sensor

• Communicates using 1-Wire method

• Operating voltage: 3V to 5V

• Temperature Range: -55°C to +125°C

• Accuracy: ±0.5°C

This study examines TES technology for solar water heating systems with an emphasis on approaches for PCM integration into these systems.These techniques include incorporating a PCM device, storage containers, and solar collectors into the solar hot water circuit.It is found that the technology employed in SDHW systems using PCMs most frequently is the integrated PCM storage vessel.The configuration of the storage unit's latent heat and heat transmission procedures are reviewed in more detail.[7].A approach based on preference selection index (PSI) has been utilised to determine the best design of the parameters that offer the greatest possible thermal performance with the least possible increase in friction inside the collector duct.The outcomes of the proposed approach demonstrate that the streamwise dependent on the wiper's position. The term "rotary potentiometer" or simply "POT" is another name for these potentiometers. You can only apply up to 100 volts to a potentiometer rated at 1 Watt. i.e 10 mA. That was true for the entire 10000 ohms of the voltage. Additionally, this means that you are only able to pass 10 mA into the wiper. The numerical value conveys the importance of resistance. According to 1k, the pot will be able to withstand resistance up to 1000 ohms. It will provide ten times and one hundred times, respectively, higher resistance than one thousand. The pot draws more current when the resistance value is lower. A resistor is a passive two-terminal electrical component used in circuits to implement electrical resistance. Resistors have a variety of purposes in electronic circuits, including lowering current flow, adjusting signal levels, dividing voltages, biassing active components, and terminating transmission lines. Resistor of 4.7K ohms

Colour codes: Yellow, violet, red, and golden.

Power Rating: 1 Watt,

Approximate Maximum Current: 14.59mA,

Resistance: 4.7K Ohm.

The pull-up and pull-down resistors are frequently made of 4.7K ohm resistors. A specified voltage can be supplied via resistors to an active device like a transistor.

Solar water heating (SWH) is the process of employing a solar thermal collector to heat water using the sun's energy. For solutions in various climates and latitudes, a range of designs are offered at differing costs. For household and some industrial applications, SWHs are frequently employed. A working fluid enters a storage system after being heated by a sun-facing collector for later use. SWH are both passive and active (pumped) (convection-driven). They either use water alone, water and a working fluid, or both. They are heated either directly or with the use of light-focusing mirrors. They can run on their own or in combination with electric or gas heaters. Mirrors may concentrate sunlight into a smaller collector in large-scale setups. Global solar hot water (SHW) thermal capacity is 472 GW as of 2017, and China, the US, and Turkey are the market leaders. By capacity per person, Barbados, Austria, Cyprus, Israel, and Greece are in first place. Simple ideas include a straightforward glass-topped insulated box with a flat sheet metal solar absorber attached to dark-colored copper heat exchanger pipes, or a group of metal tubes encircling a glass cylinder that has been evacuated (near vacuum). A parabolic mirror can focus sunlight on the tube in industrial applications. A hot water storage tank holds heat.

Fig.2. Solar water heater

With solar heating systems, the volume of this tank must be larger to account for inclement weather and the fact that the solar collector's ideal ultimate temperature is lower than that of a normal immersion or combustion heater. Water can serve as the heat transfer fluid (HTF) for the absorber, but in active systems, a separate loop of fluid containing anti-freeze and a corrosion inhibitor often heats the tank via a heat exchanger (commonly a coil of copper heat exchanger tubing within the tank). Due to its excellent thermal conductivity, resistance to air and water corrosion, ability to seal and join by soldering, and mechanical strength, copper plays a significant role in solar thermal heating and cooling systems. Copper is used both in receivers and primary circuits (pipes and heat exchangers for water tanks).

Solar thermal collectors use heat from the sun to heat a liquid and heat a roof. Using evacuated tube collectors (ETC), one can lessen the heat loss that flat plates inevitably experience. Convection serves as an effective isolation technique to maintain heat inside the collector pipes because it cannot traverse a vacuum. The vacuum is formed between two concentric tubes as two flat glass sheets are typically not robust enough to withstand the vacuum. The two concentric glass tubes that surround the water pipework in an ETC are often separated by a vacuum that allows heat from the sun to enter while limiting heat loss. The heat absorber is coated on the inner tube. Vacuum life varies from 5 to 15 years depending on the collection. In full sunlight, flat plate collectors are typically more effective than the ETC. However, in foggy or severely cold situations, flat plate collectors' energy production is somewhat lowered more than that of ETCs. The majority of ETCs are constructed with annealed glass, which can break when exposed to hailstones the size of golf balls.

Efficiency of collector can be calculated by the ratio between the rates of useful heat (QU) transferred by solar radiation on the cover plate.

It can be shown by the equation:

$\eta =$ (Heat energy out)/(Heat energy in) = Qout/Qin

The heat removal factor is the ratio of energy computed using (Ti-Ta) to that calculated using (Tpm-Ta) (Fr).

If the usable energy is divided by a "heat removal factor," the average absorber surface temperature could be substituted by the temperature of the fluid entering the collector (Ti) (Fr). The flow rate of the heat transfer fluid affects the heat removal factor (Struckmann, 2008).

The photovoltaic (PV) panel is one technique to power an active system. The (DC) pump and PV panel need to be compatible with each other in order to ensure optimal pump performance and lifespan. Despite the fact that a pump driven by solar energy does not run at night, the controller must make sure that the pump does not run when the sun is out but the collection water is not sufficiently heated. PV pumps provide the following benefits: simpler/less expensive installation and upkeep Extra PV energy can be used for household needs or returned to the grid. Can work during a power outage and dehumidify a living environment reduces the carbon footprint of using pumps powered by the grid.

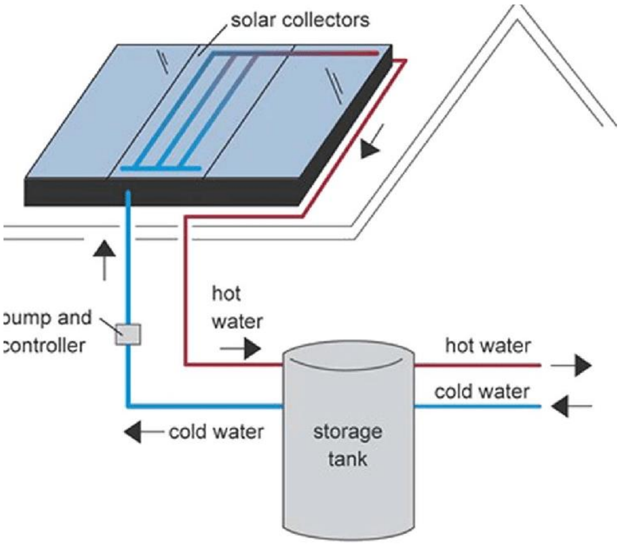

Fig.3. Componenents Of Solar Water Heater

Water exiting the solar collector and water in the storage tank close to the heat exchanger are both monitored by a differential controller for temperature variances. The pump is started by the controller when the temperature difference between the water in the tank and the water in the collector is less than or equal to 3°C. This guarantees that heated water in storage always warms up when the pump runs and stops the pump from frequently turning on and off. (In direct systems, since there is no heat exchanger, the pump can be activated with a difference of about 4°C.)

The most basic collector is a metal tank with water that is placed in a sunny area. A tank is heated by the sun. The initial systems operated in this manner. Due to the equilibrium effect, which occurs as soon as the tank and water start to heat up and continues until the water in the tank reaches room temperature, this configuration would be inefficient. Keeping heat loss to a minimum is difficult. It is possible to build the system more freely and use existing storage tanks by placing the storage tank lower than the collectors. One option is to conceal the storage tank. Heat loss can be decreased by placing the storage tank in an air-conditioned or partially-air-conditioned area.

3. System Implemenatation

In this project, we will connect an Arduino microcontroller to a gravity analogue TDS sensor and read the value from a 16x2 LCD display. Because TDS Value is temperature-dependent. To measure the temperature of the water, I will also add a DS18B20 Waterproof Temperature Sensor. The TDS Sensor uses the recorded temperature to make very accurate and calibrated reading corrections. The excitation source is an AC signal, which effectively shields the probe from polarisation and increases the probe's lifespan while also enhancing output signal stability. Waterproof, the TDS probe can be submerged for extended periods of time measurement. In water that is hotter than 55 degrees Celsius, the probe cannot be utilised.

The reading will be impacted if the probe is too close to the container's edge. The probe's head and cord are waterproof, but the connector and the circuit board that houses the signal transmitter are not. The connection between a TDS sensor and an Arduino is made using the circuit diagram provided below, which is quite straightforward.The Connect the VCC to Arduino 5V & GND to GND. Connect its Analog pin to any analog pin of Arduino. Here, Analog pin (A1) of Arduino.

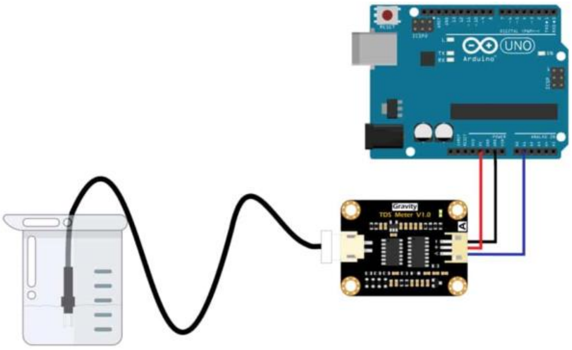

Fig.4. TDS sensor to an Arduino and add an additional NodeMCU

Let's now connect a TDS sensor to an Arduino and add an additional NodeMCU. The TDS value will be shown in NodeMCU, and if the temperature rises or falls, the reading will be erroneous because conductivity varies with temperature. Therefore, the temperature coefficient must be included to the code in order to resolve this problem. There is no temperature sensor in this sensor. Consequently, we must include a temperature sensor outside. Due to its simple interface and great accuracy, the DS18B20 Waterproof Temperature Sensor is a good choice in this situation.

Connect any digital pin to the output pin of the DS18B20 Waterproof Temperature sensor. We used Arduino's Digital Pin 7 in this instance. Pull the output pin to 5V supply using a 4.7K resistor. The code is available here. As the DS18B20 requires gravity tds, one wire, and Dallas library, we need additional libraries for this code. Consequently, we must download it and then add it to the library folder.Once the code is uploaded you can now measure the TDS of water and display in the node MCU

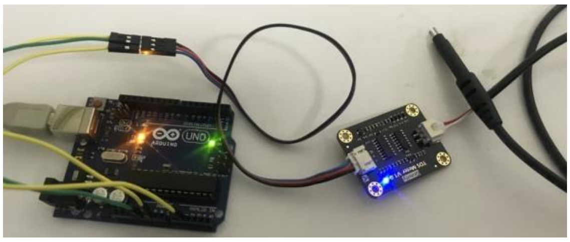

Fig.5. Hardware Implementation of SWH-1

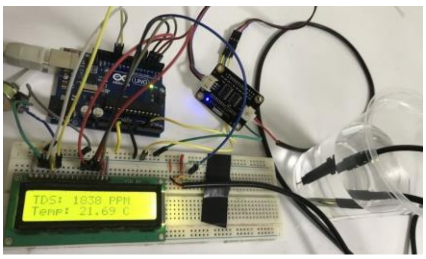

Fig.6. Hardware Implementation of SWH-1

Program-Source Code:

```
#include <EEPROM.h>

#include <GravityTDS.h>

#include <LiquidCrystal.h>

#include <Onewire.h>

#include <DallasTemperature.h>

LiquidCrystal lcd(12, 11, 5, 4, 3, 2);

#define ONE WIRE BUS 7

#define TdsSensorPin A1

OneWire oneWire(ONE WIRE BUS);

GravityTDS gravityTds;

DallasTemperature sensors(&oneWire);

float tdsValue = 0;

void setup()

{

Serial.begin(115200);

lcd.begin(16, 2);

sensors.begin();

gravityTds.setPin(TdsSensorPin);

gravityTds.setAref (5.0); //reference voltage on ADC, default gravityTds.setAdcRange (1024);

gravityTds.begin();

//initialization

}

void loop()

sensors.request Temperatures();

gravityTds.setTemperature(sensors.getTempCByIndex(0)); //ses

gravityTds.update(); //sample and calculate
```

```
tdsValue = gravityTds.getTdsValue(); // then get the value
Serial.print(tdsValue, 0);
Serial.println("ppm");
Serial.print("Temperature is: ");
Serial.print(sensors.getTempCBy Index (0));
lcd.setCursor(0, 0);
lcd.print("TDS: ");
lcd.print (tdsValue, 0);
lcd.print(" PPM");
1cd.setCursor(0, 1);
lcd.print("Temp: ");
lcd.print (sensors.getTempCByIndex (0)); lcd.print(" C");
delay(1500);
lcd.clear();
}
```

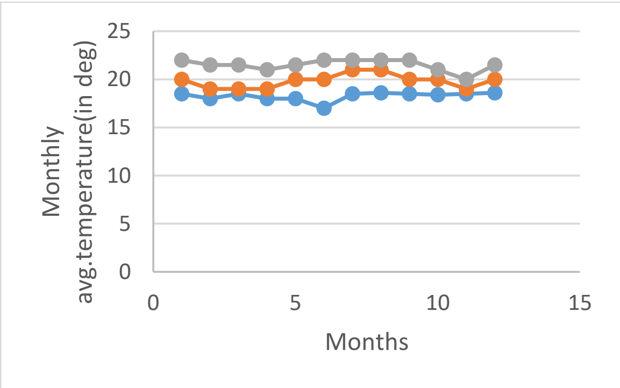

Fig.7. Monthly average temperature over months taken in instituteof SWH

5. Conclusion

The findings demonstrate that the design and composition of the absorber plate have a significant impact on the solar collector's efficiency. The thermal conductivity of the absorber plate material also affects how well it works. It has been shown that both the collector and tank function well in areas with high levels of solar radiation. Due to insufficient sun radiation, solar water heaters operate slightly less well in colder climates. Efficiencies of the solar water heaters produced in Rwanda at Tumba College of Technology range from 60 to 76 percent. Due to its high efficiency and well-thought-out design, which prevents system oversizing, the payback period of 2 years is less than that in other literature (2.5–3.5 years). It has been observed that the thickness of the insulating materials should be increased for the coldest regions so that the solar water heater's tank can maintain hot water for an extended amount of time.One of the most advantageous ways to heat shower water is with a solar water heater. And this is a fantastic chance for us to reevaluate their way of life and adjust to this new technology, which will help them save a tonne of money that they can invest in other crucial things. In general, factors affecting a solar system's economic feasibility include the quantity of annual sunshine, the amount of heating energy needed, the cost of the solar, the required temperature of the hot water, financing and incentives, as well as the annual costs of operation and maintenance.The efficiency of an evacuated tube collector solar water heater is assessed in this study. At the RMK Engineering College campus, an experimental setup was established, and the measured provided solar energy was successfully compared with software. The potential of several areas throughout the state was then evaluated using the software.

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