Developing a Solar Powered Water Purifier For Safe and Affordable Water Supply

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December 2023

Declaration

It is hereby declared that

1. The Final Year Design Project (FYDP) submitted is my or our own original work while completing a degree at Brac University.
2. The Final Year Design Project (FYDP) does not contain material previously published or written by a third party, except where this is appropriately cited through full and accurate referencing.
3. The Final Year Design Project (FYDP) does not contain material which has been accepted, or submitted, for any other degree or diploma at a university or other institution.
4. I/We have acknowledged all main sources of help.

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Ethics Statement

Our final year design project report contains 20% plagiarism. We checked the plagiarism with the help of Turnitin.

Abstract/ Executive Summary

A solar-powered water purifier is a device that utilizes solar energy to purify water, making it safe for consumption. This innovative technology combines the use of solar panels to harness energy from the sun and a purification system to remove contaminants and impurities from water sources. The solar panels convert sunlight into electricity, which powers the water purification process, making it an environmentally friendly and sustainable solution for providing clean drinking water. This sustainable solution addresses the challenges of water contamination and scarcity prevalent in many parts of Bangladesh. By harnessing the power of the sun, the purifier can effectively remove impurities, pathogens, and pollutants from water, ensuring that it meets the required quality standards for consumption. Solar-powered water purifiers are designed to address the critical issue of access to safe drinking water in areas where traditional infrastructure may be lacking or unreliable. By utilizing renewable solar energy, these systems can operate independently of grid power, making them ideal for remote or off-grid locations. The purification process typically involves filtration and disinfection methods such as reverse osmosis, UV sterilization, or distillation, ensuring that the water meets safety standards for human consumption.

Dedication

We dedicate our initiative with the sincerest gratitude and affection to you, our dear parents and teachers—the sources of our growth, wisdom, and unwavering support. Your unwavering assistance has been the wind beneath our wings, propelling us forward and understanding. You have guided us over every challenge as our shining example of brilliance. We owe our parents a debt of gratitude for shaping who we are today via their unrelenting devotion and unselfish love.

Acknowledgment

Our final year design project was made possible with the assistance of Dr. A.S. Nazmul Huda, our thesis coordinator and assistant professor in the BRAC University Department of Electrical and Electronic Engineering. His advice was crucial to our project's success as it helped with numerous paperwork-related challenges, data collection, problem-solving, system design and implementation, and numerous other areas. In addition, his understanding and encouraging demeanor throughout the year relieved a great deal of strain on us, enabling us to work more freely and effectively. Finally, we would like to express our sincere gratitude for the direction, assistance, and mentoring of Nahid Hossain Taz and Raihana Shams Islam Antara, lecturers in the Department of Electrical and Electronic Engineering at BRAC University.

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List of Acronyms

IEEE- Institute of Electrical and Electronics Engineers

IoT- Internet of Things

USB- Universal Serial Bus

PCB- Printed Circuit Board

LCD- Liquid Crystal Display

LED- Light Emitting Diode

Glossary

Solar Panel: A key element in the switch to sustainable energy is solar power. They are an essential source of clean, sustainable power since they capture sunlight and turn it into energy. It's critical to become knowledgeable about the essential vocabulary and ideas related to solar panels in order to comprehend them properly.

Reverse Osmosis: Reverse osmosis (RO) is a method of purifying water that removes a wide range of contaminants, including germs, salts, and other hazardous substances. During the procedure, water is driven across a semipermeable membrane, which traps impurities inside and only allows pure water molecules to flow through. This method is called reverse osmosis because it is the opposite of the natural osmosis process, which entails water traveling from an area with a low solute concentration to one with a high solute concentration.

Peltier Module: A Peltier module, also known as a thermoelectric cooler or TEC, is a solid-state apparatus that utilizes the Peltier effect to transfer heat from one side of the module to the other when an electric current is applied. It consists of two different types of semiconductor material (n-type and p-type, typically) that are connected in series and sandwiched between two ceramic plates. The n-type material contains surplus electrons, and the p-type material contains excess holes.

Ultrasonic Sensor: Ultrasonic sensors are electronic devices that use sound waves to recognize objects and measure distances. These sensors are used in many different disciplines, including navigation systems, robotics, and industrial automation. This is a dictionary entry for key terms related to ultrasonic sensor.

Chapter 1: Introduction- [CO1, CO2, CO1]

1.1 Introduction

Water is a vital constituent for all forms of life on earth. Fresh water comprises 3% of the total water on earth. Among all the freshwater sources, only a small percentage (less than 0.01%) is available for human use [1]. Unfortunately, this small portion of accessible drinking water sources has recently been contaminated with different groups of aquatic contaminants, like coliform, toxic metals, pesticides, and many other emerging contaminants throughout the world. It is a serious issue related to public health and has become an alarming problem in developing countries. Like many other developing countries in the world, Bangladesh is also going through a critical water pollution problem. The overgrowth rate of population, industrialization, rapid urbanization, improper sanitation, frequent flooding, and use of agrochemicals might have deteriorated the water quality of Bangladesh. The current status of water quality in Bangladesh places special emphasis on both conventional pollutants (heavy metals, pesticides, and fecal pollution) and emerging contaminants. The concentration of heavy metals is higher in the water bodies. Besides, Bangladesh needs to depend on other countries for power and gas supplies. We have already faced a huge crisis in recent times. So the target of our project is to build a purification system using renewable solar power [2].

1.1.1 Problem Statement

The most significant element on earth is water. Water is essential for human survival and a healthy lifestyle. Due to its frequent consumption, water is an extremely precious resource. Here, we draw attention to the negative consequences of tainted water on people as well as the widespread crisis of water distribution and availability in developing nations [3]. Although it is the most essential element for life and a basic human necessity, polluted water can harbor and spread diseases. According to research, an average male or female has to drink about 3.7 liters/2.7 liters) of water every day to sustain a healthy lifestyle (Sawka, Cheuvront, & Carter, 2005) [4]. Decontaminating and purifying water for daily usage must consequently be done at a reasonable cost. The process of purifying water involves eliminating unwanted chemicals, biological pollutants, suspended solids, and gasses from the water. Water purification can include the decontamination of surface and ground water from sources such as lakes and streams, but it also includes reclamation from wastewater sources. The U.S. Environmental Protection Agency (EPA) recommends that water used for the irrigation of food crops contain no more than 0.10 mg/L of arsenic. For drinking water, however, the EPA has a current standard of 50 ppb of arsenic and is issuing a new standard of 10 ppb [5].

1.1.2 Background Study

Waterborne infections are one of the top killers in developing countries, causing up to 10 million deaths and billions of illnesses every year, with half of them affecting children. Boiling water is the most commonly used method of purifying water for cooking and drinking in rural areas in developing countries [6]. However, boiling is costly, uses a large amount of fossil fuel, and the logging of wood leads to deforestation. Solar-powered water purification is one of the most viable and cost-effective solutions to address these issues [7] . There's a real and urgent need for water technology that's eco-friendly and can be used in rural areas. Water is one of the most precious and essential natural resources for the human race. The rapid development of society and the variety of human activities have contributed to an increase in pollution and damage to water resources. The lack of fresh water has forced people to look for freshwater sources. In many parts of the country, water sources are brackish water, saline water, or impure water.

In our country, clean drinking water is one of the major issues faced by tribal and rural areas. There are many ways of purifying water. Here we are making a water purifier using reverse osmosis that runs on solar energy. Solar energy is a renewable energy which is abundant and affordable [8]. In the event of power failure, this water purifier will still work as the solar energy is stored. In this case, we are using a microcontroller (8051) which stops the water from overflowing. This water purifier is suitable for remote & rural areas where electricity is not available. It is also suitable for disaster-stricken areas. It reduces the salt in sea water and provides pollution-free operation [9]. Water is essential for all kinds of life, but it's hard to get it clean, expensive to move, and can't be replaced. That's why almost half the world's population is facing a water shortage problem by 2030. Around 45 crores people are living in water-deprived regions, and 70% of freshwater is being used for irrigation.Water is essential for all kinds of life, but it's hard to get it clean and purified. According to research, an average male or female has to drink about 3.7 liters/2.7 liters of water every day to sustain a healthy lifestyle (Sawka, Cheuvront & Carter, 2005). Decontaminating and purifying water for daily usage must consequently be done at a reasonable cost. The process of purifying water involves eliminating unwanted chemicals, biological pollutants, suspended solids, and gasses from the water. The U.S. Environmental Protection Agency (EPA) recommends that water used for the irrigation of food crops contain no more than 0.10 mg/L of arsenic. For drinking water, however, the EPA has a current standard of 50 ppb of arsenic and is issuing a new standard of 10 ppb.

1.1.3 Literature Gap

The solar water purifier is an eco-friendly and sustainable water purification solution since it is an innovative technology that uses sun energy to cleanse water. There are still some gaps in the literature about its efficacy, efficiency, and potential drawbacks despite its many benefits. This essay will cover the gaps in the current body of knowledge about solar water purifiers and how credible sources might fill them. A primary deficiency in the literature is the absence of thorough investigations about the efficacy and efficiency of solar-powered water purifiers. While some studies suggest that solar water purification is a viable solution, additional investigation is required to evaluate various technologies, pinpoint the most successful and efficient systems, and ascertain the variables affecting their effectiveness. With a focus on efficiency, efficacy, and potential drawbacks, this source offers a thorough analysis of solar water disinfection processes. The most promising innovations are aided in being identified, and it offers a foundation for additional study. There is also a deficiency of information regarding the drawbacks and restrictions of solar water purifiers in the literature.

The efficiency of solar water purification systems can be impacted by various factors, including climate, location, and technology capacity. In order to improve the design and use of solar water purifiers, it is imperative to comprehend these problems. This source covers the technological, sociological, and economic elements of solar water disinfection along with its prospects and limitations. It aids in identifying the potential roadblocks to the widespread use of solar water purification devices and offers suggestions for overcoming them. Long-term cost-effectiveness of solar water purifiers is debatable, as many communities, especially those in underdeveloped nations—may find the initial outlay and ongoing maintenance costs prohibitive. Furthermore, as solar water purifiers must be scalable to satisfy the demands of expanding populations for water purification, this is an essential feature to take into account. The affordability and scalability of solar water disinfection systems are reviewed in this reference. Enhancing accessibility and adoption of these systems is recommended, and it aids in identifying the elements that affect these systems' costs and scalability.

1.1.4 Relevance to current and future Industry

Due to the ability to solve urgent environmental issues and improve public health, solar water purifiers hold substantial importance for both existing and future businesses. In many metropolitan areas nowadays, water pollution is becoming a bigger concern and is a factor in a number of health issues. The solar water purifier industry is an expanding market due to its efficiency and cost-effectiveness [10]. Solar technology is becoming an increasingly attractive option for water purification in many parts of the world, especially in developing countries. Solar water purifiers offer an environmentally friendly solution to the need for clean drinking water and can be adapted to suit different contexts. Furthermore, solar purification systems are energy efficient and can help reduce the impact of climate change by reducing dependence on traditional energy sources [11]. These devices will play an even bigger role in the future as worries about ensuring pure water to local communities continue to grow. The solar water purifier industry is expected to continue to expand in the coming years as technological advancements continue to improve the efficiency and affordability of the devices. With the increased awareness of the need for clean drinking water globally, the solar water purifier industry is expected to experience steady growth. The industry is set to benefit from the increasing demand for renewable energy and the growing need for water purification solutions. As solar technology continues to mature, solar water purifiers will become even more cost-effective and efficient [12].

1.2 Objectives, Requirements, Specification and constant

1.2.1. Objectives

- **Providing clean and safe drinking water :** The primary objective is to remove contaminants, pollutants, and pathogens from water sources, thereby ensuring that the water is safe for human consumption. Solar-powered water purifiers use sunlight to remove contaminants from water, such as chemicals, oils, metals, pathogens, lead, and other contaminants. By removing contaminants, solar-powered water purifiers can provide safe drinking water, especially in remote areas or areas with contaminated or saline water resources [13].

- **Using renewable energy and Off-grid functionality :** Solar-powered water purifiers use renewable energy generated by solar panels, making them environmentally friendly and reducing reliance on non-renewable energy sources and Solar powered water purifiers are designed to operate independently of the electrical grid, making them suitable for use in remote and off-grid areas where electricity supply may be unreliable or nonexistent [14].

- **Sustainability :** By utilizing solar energy, these purifiers aim to reduce reliance on fossil fuels and minimize their environmental impact. They contribute to sustainable development by harnessing renewable energy to provide a vital resource such as clean water.

- **Being cost-effective :** Solar-powered water purifiers can be a cost-effective way to generate pure water, as sunlight is free and the materials to make the devices are low-cost and non-toxic. Solar powered water purifiers can save costs associated with electricity bills, as they utilize free solar energy for operation. This makes them financially viable, especially in areas where electricity costs are high or access to electricity is limited [15].

- **Being simple to implement :** Solar-powered water purifiers are simple to implement and can be replicated for a minimal investment cost. Many solar powered water purifiers are designed to be portable and easy to transport, allowing them to be used in various settings such as disaster-stricken areas, remote villages, or outdoor recreational activities [16].

1.2.2 Functional and Nonfunctional Requirements

Functional Requirements

- **Water Storage and Distribution:** One of the most important functions of a water purifier that is powered by solar energy is the storage capacity. This means that the purified water will always be available, even when the sun isn’t shining or when there’s a lot of demand for water. A solar water purifier may have a storage tank or a reservoir made from food grade materials to keep the water clean. A distribution system with the right valves, pipes and faucet will ensure that the purified water is delivered to our end-users quickly and easily

- **Durability and Weather Resistance:** Water purifiers powered by solar energy are usually used in places that are remote or off the grid, where the environment can be tough. That's why it's important to make sure the system is built to last, with materials that won't corrode or break down over time. It should also be able to handle extreme weather conditions like high temperatures, high humidity, dust and rain

- **Ease of Maintenance:** A functional requirement of a solar-powered water purifier is ease of maintenance. The system should be designed for easy access to filters and other components that require periodic cleaning or replacement. Clear instructions and user-friendly interfaces should be provided to guide users in maintaining the system properly.

Non-functional Requirements

- **Energy Storage and Backup:** The system should have adequate energy storage capacity, such as batteries or capacitors, to ensure continuous operation during periods of low sunlight or power outage.

- **Portability and Ease of Use:** Solar-powered water purifiers are often used in remote areas where portability is crucial. Therefore, the system should be lightweight, compact, and easy to transport. It should also be user-friendly, requiring minimal technical expertise for installation, operation, and maintenance.

- **Longevity:** Longevity is key to making sure the water purifier lasts as long as possible and doesn't need to be replaced or repaired too often. This involves using high-quality materials and components that can handle long-term use in the sun and other conditions. Additionally, regular maintenance procedures should be defined to make sure your purifier runs smoothly and doesn't break down too quickly

1.2.3 Specifications

Table 1.1: Component level specifications of our designed prototype

Sub-system	Model	Specification	Comment
Photo-voltaic solar panel	Ce ISO TUV UL Certificates Byd 12V 300W Solar Panel Camping	Solar cell: Ploy 156X156mm cell No. of cells: 72 pcs Rating: IP67 waterproof Weight: 27kg Front Cover: 3.2mm high transmission low iron tempered glass Connector: Mc4 compatible connector.	Four 300 watt solar panels supply 1000W of electricity to our water purifier a day.
UV water purifier	Puricom CP-3+UV Wall Mount 4 Stages UV Water Purifier	Filter system: Ultraviolet(UV) Filter stage: 4 stage Dimension: D15 x W37 x H36.5 cm UV Housing: Stainless Steel 304 Grade UV Lamp: Philips / TUV 6W; G6 T5 / Made in Poland Operation pressure: 15-85 PSI	Under the standard water quality and flow, this filter is capable of killing or restraining 99.9% bacteria and viruses effectively under UV lamps. This UV water filter also has 304 grade SS UV housing and polished stainless steel reactor chambers enhance the UV reflection and confirm maximum durability. Output 3.8 liter/ per minute.
Battery	GLOBATT ACE N50Z Battery	Type: Lead-acid battery Output Voltage: 12V Output Current: 60A Storage Backup: Upto 20 hours	It works as energy storage. It stores unused energy from the solar. At night when solar can not supply electric power that time this battery will supply its stored power. This battery is rechargeable.

Power supplier	3-24V 72W Speed Control Volt AC/DC Adjustable Power Adapter Supply Display	Output current: 2A Power: 48W Efficiency: 95% Total cable length: 200cm Input: AC100-240V 50/60Hz Output: DC 3-24V adjustable High quality components	Ac-Dc Smps 24V 2A Power Supply for RO Water Purifier
RO water purifier filter pipe	(¼) 6mm 10 feet pipe	Grade: Food graded pipe Size: (¼) 6mm	Flows water through pipe from one filtration process to another filtration process.
Electric wires	Water purifier wire harness	Insulated material: PVC Current rating: up-to 30 Amp Voltage rating: 12-48 VDC Working temp: -10-60*C Material: Copper	Electric wires are needed to connect solar power with a filter for supplying power to the system, RO booster pump with booster pump DC adapter, high pressure and low pressure switch with tank and booster pump etc.
Sensors	MD-L100E	Power supply:12-28V Output: 4~20mA/RS485 Rating: IP68 waterproof design Quality: Anti-electromagnetic interference design to ensure the stability of the signal.	Measures liquid level or water depth based on the principle of hydrostatic pressure
Microcontroller	Arduino Uno	Microcontroller: ATmega328P	It continuously monitors the liquid level of the overhead

		Operating Voltage: 5V Input Voltage (Recommended): 7-12V Input Voltage (Limit): 6-20V Digital I/O Pins: 14 PWM Digital I/O Pins: 6 Analog input Pins: 6 DC Current per I/O Pin: 20 mA DC Current for 3.3V Pin: 50 mA Flash Memory: 32 KB SRAM: 2 KB EEPROM: 1 KB Clock Speed: 16 MHz	tank and reservoir. It controls the pump and turns it on and off with respect to the level of the water in the tank. This auto-switching feature saves manpower. Hence no need to operate manually. Our system switches the pump when the level of water in the tank goes below the low level sensor and off when the water exceeds the high level sensor. Thus no wastage of water, stop tank overflow, save water, electricity bill, time and water charges

1.2.4 Technical and Non-technical consideration and constraint in design process

Technical considerations :

a) **Solar panel efficiency :** The efficiency of the solar panels used in the water purifier is a crucial technical consideration. High-efficiency solar panels can generate more power from the available sunlight, allowing for improved performance of the water purification system.

b) **System Monitoring and Control:** Implementing a robust system for monitoring and control is crucial to optimizing the performance of the solar-powered water purifier. This may involve sensors to measure water quality parameters, automated controls to adjust purification processes, and remote monitoring capabilities for maintenance and troubleshooting.

c) **Durability and Weather Resistance:** Solar-powered water purifiers, often deployed in remote or off-grid locations, must be designed with weather resistance, durability, and protection against dust, humidity, extreme temperatures, and potential vandalism to withstand challenging environmental conditions.

Non-technical considerations:

a) **Environmental Impact:** Designing a solar-powered water purifier should consider its environmental impact, which includes minimizing energy consumption, using environmentally friendly materials, and managing waste generated during the system's lifecycle.

b) **Cultural and Social Acceptance:** Cultural and social factors can influence the acceptance and adoption of a solar-powered water purifier in certain contexts. Understanding the local community's preferences, beliefs, and practices related to water usage can help tailor the design to ensure its acceptance and long-term use.

c) **Cost-effectiveness:** The cost of designing, manufacturing, and operating a solar-powered water purifier should be carefully evaluated. The system should offer an affordable solution compared to alternative water purification methods, considering both initial investment costs and long-term operational expenses.

1.2.5 Applicable compliance, standards, and codes

Table 1.2: Applicable standards and codes for different required devices for the system

Device	Standard	Definition
Solar Module	IEEE 1562-2021	Photovoltaic (PV) module performance testing and energy rating.
	IEEE 1562-2021	Photovoltaic (PV) module performance testing and energy rating.
	IEC 62509:2010	PV generator charging of a battery.
	IEC 61730-1:201	Photovoltaic (PV) module safety qualification Part-01:Requirement for construction
	IEC 61730-2:2019	Photovoltaic (PV) module safety qualification Part-02:Requirement for testing
	BDS IEC 61730-1:2019	Photovoltaic (PV) module safety qualification part 1: Requirements for Construction

	BDS IEC 61730-2:2019	Photovoltaic (PV) module safety qualification part 2: Requirements for testing
Battery	BDS IES 61427-1	Secondary cells batteries for renewable energy storage
	BDS IES 60086-4	Primary batteries-Part-04:Safety of lithium batteries
Solar charge controller	IEEE 1361-2003	Battery charge controllers for photovoltaic system.
Microcontroller	IEEE 1118.1-1990	The description of a serial system for connecting microcontrollers within a single site as well as between devices
Sensor	IEEE 2700-2014	A common framework for sensor performance specification terminology,units, conditions, and limits is provided.

1.3 Systematic Overview/summary of the proposed project

The main target of our project is to ensure pure drinking water for mass people in our country. Bangladesh is a densely populated developing country. Like other developing countries of the world, this country is also facing serious water pollution. Water contaminated with non-biological agents such as toxic chemicals or heavy metals require additional steps to make the water safe to drink. Drinking water containing bacteria and viruses can lead to serious health issues and diseases such as diarrhea, cholera and dysentery. Unlike traditional water treatment solutions, which often depend on a consistent energy supply, solar-powered systems can operate even during power outages or other disruptions. This makes them particularly useful in areas where access to energy is unreliable, such as in remote or rural communities. Also If you live in an area where such diseases are a risk, the most effective way to protect yourself is by using reverse osmosis water purification. According to the World Health Organization, over two million die of water-borne diseases annually. One billion do not have access to safe drinking water. Solar water purification is considered an effective method of pathogen contamination purification. In our project basically we are using reverse osmosis as a purification unit. Solar panel is used for power supply to run the microcontroller and other activities. As it is a natural energy source so in our project we do not need to depend on any other source of energy which can reduce the dependency on electricity and save the bill also. And the systems do not require much maintenance. Considering all this point we are developing our project [17].

1.4 Conclusion

Water purification with solar energy is a novel concept for our nation. This project has a specific goal, however it is beneficial for those particular fields. After extensive study, it may prove to be a benefit for the country thus far even though it may not be helpful for everyone at first. An estimated 785 million people worldwide lack access to a minimal level of drinking water service [18] . This implies that people have to travel more than 30 minutes to obtain drinking water or rely on sources like lakes or rivers, which are prone to contamination. However, the quality of water services provided by solar-powered systems can be greatly improved, benefiting children's and their families' livelihoods as well as their development and health. In addition to lowering pollution from diesel systems, solar-powered water systems can maintain the health of children. Because they allow pumping from deeper levels below the ground, even during droughts or when numerous shallow wells run dry, they can lessen the effects of decreasing water levels and extreme weather occurrences. And most of all, when other electrical systems fail during a storm, they may keep on running. Solar-powered systems, in contrast to conventional handpumps, have the capacity to store water and provide it for various uses, hence expanding the population's access to water. This can make water easily available to schools, healthcare facilities, and entire communities while also cutting down on walking and waiting times.

Chapter 2: Project Design Approach [CO5, CO6]

2.1 Introduction

Solar radiation is utilized by solar water purifiers to disinfect and clean water. A solar collector, a storage tank, and a disinfection system are usually what make them up. The water in the storage tank is heated by the heat produced by the solar collector, which gathers and transforms sunlight. After being heated, the water is run through a disinfection system that kills bacteria, viruses, and other impurities using UV light or other techniques. Drinking water containing bacteria and viruses can lead to serious health issues and diseases. The importance of water filtration is that it gives people access to clean water that is free of contaminants, that tastes good, and is a reliable source of hydration. There are different methods for water purification. Among the most popular techniques for purifying water are boiling, filtration, distillation, chlorination, UV treatment, and reverse osmosis. people's needs and the impurities they are seeking to get rid of will determine the approach that they need to take.

2.2 Identify multiple design approach

All in all, we have selected two design approaches for our solar water purifier. Following is a list of the two design approaches that have been chosen:

Design Approach 01:

Reverse Osmosis System [19]**:**
Solar powered reverse osmosis water purifier is a water treatment device that uses solar energy to separate dissolved pollutants from raw water by a partially permeable membrane. It is designed to provide clean and safe drinking water at low cost and high efficiency. Here are some key points about solar powered reverse osmosis systems:

- **Solar:**
  These systems mainly use solar energy, which is considered clean and renewable energy. They use light energy to save and convert it into electricity, thus reducing the cost of electricity.

- **Portability and space saving:**
  Solar powered reverse osmosis systems are smartly configured to allow easy movement and save space. They are designed to be easily customized to specific requirements and water quality.

- **High rejection rate:**
  By using high-removal membranes, these systems can remove up to 99.7% of unwanted dissolved solids.

- **Applications:**
  Solar powered reverse osmosis systems can be used for a variety of purposes including drinking water production, irrigation, agriculture and other uses . They are suitable for treating water from sources such as rivers, wells and even seawater.

- **Efficiency and profit:**
  These systems are highly efficient, customizable and economical. They can operate with a capacity of 100 hours using solar energy, reducing operating costs compared to grid or diesel generators.

- **Ready-to-use solutions:**
  Some solar-powered reverse osmosis systems are designed as plug-and-play devices, making them easier to install and operate. They are equipped with durable components, automation, monitoring and remote control for easy maintenance and operation

- **Research and development:**
  Research and development is underway to improve solar powered reverse osmosis systems. For example, there are projects to develop small water filters using reverse osmosis and UV water treatment powered by solar energy. It is important to note that there are many different manufacturers and suppliers of solar powered reverse osmosis systems, each offering different features and specifications. Experts or manufacturers should be consulted to determine the most suitable system for specific needs and requirements.

Fig 2.1: A solar powered water purifier using reverse osmosis [20]

Design Approach 02:

Using Peltier device [21] **:**
A solar-powered water purifier using a Peltier module is a device that uses a Peltier module to purify water and can be powered by solar energy. The Peltier module is a thermo-electric device that can cool or heat a surface when an electric current is passed through it. Here are some examples of how Peltier modules can be used in solar-powered water purifiers:

- **Cooling system:** A cooling system based on the Peltier effect can be used to cool water and make it more palatable. This system uses very little power and is portable.

- **Water generation:** The Peltier module can be used to cool atmospheric air below its dew point, thereby condensing the water vapor present in the air and generating water

- **Water purification:** The Peltier module can also be used to purify water by effectively removing impurities. The efficiency of the Peltier water purification apparatus is relatively high, and better insulation and solar thermal preheating of the water can improve its performance.

- **Ultrafiltration:** Another method for purifying water is ultrafiltration, which can be combined with cooling and heating based on the Peltier effect to create a portable water purifier that can produce hot and cold water.

Overall, a solar-powered water purifier using a Peltier module can be an effective and sustainable way to purify and generate water in areas where access to clean water is limited.

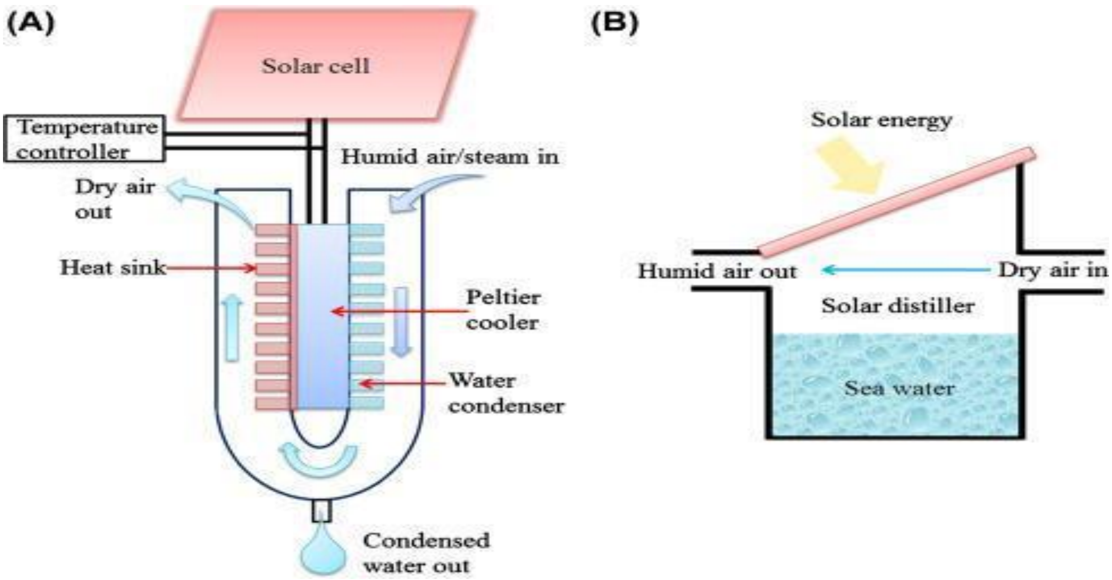


Fig 2.2: A solar powered water purifier using peltier device [22]

2.3 Describe multiple design approach

1. Using Reverse Osmosis:

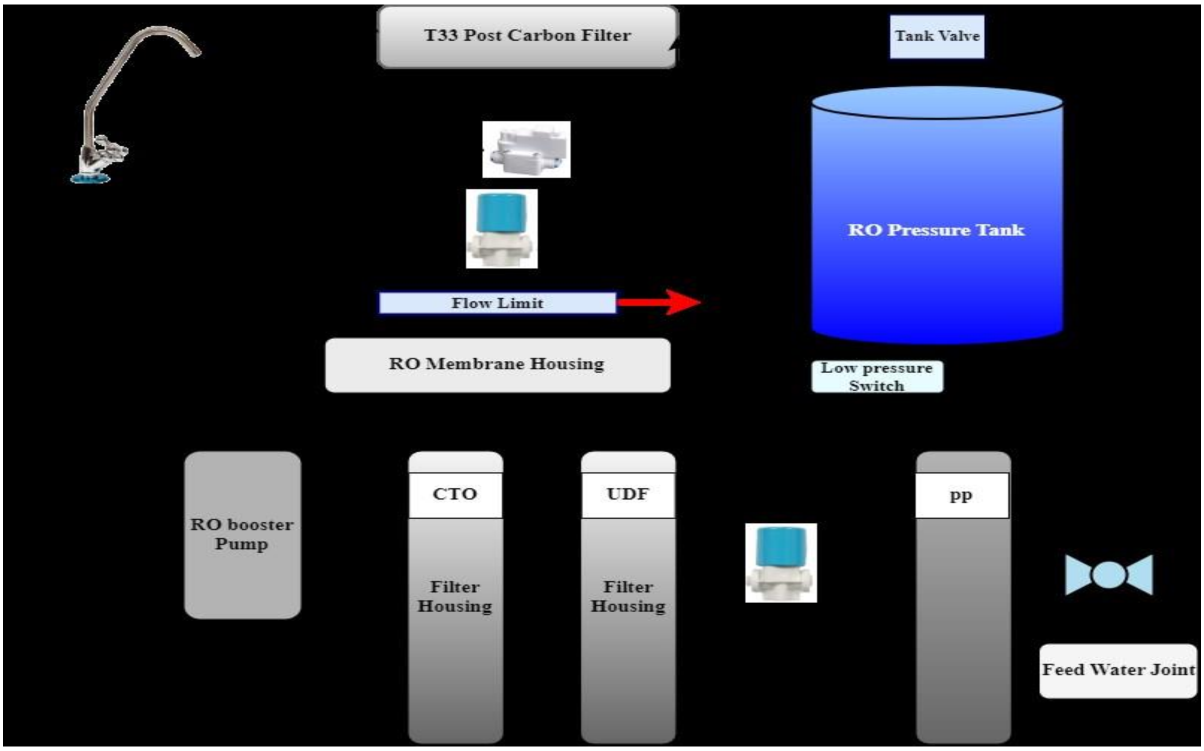


Fig 2.3: Block diagram of reverse osmosis system

2. Using Peltier:

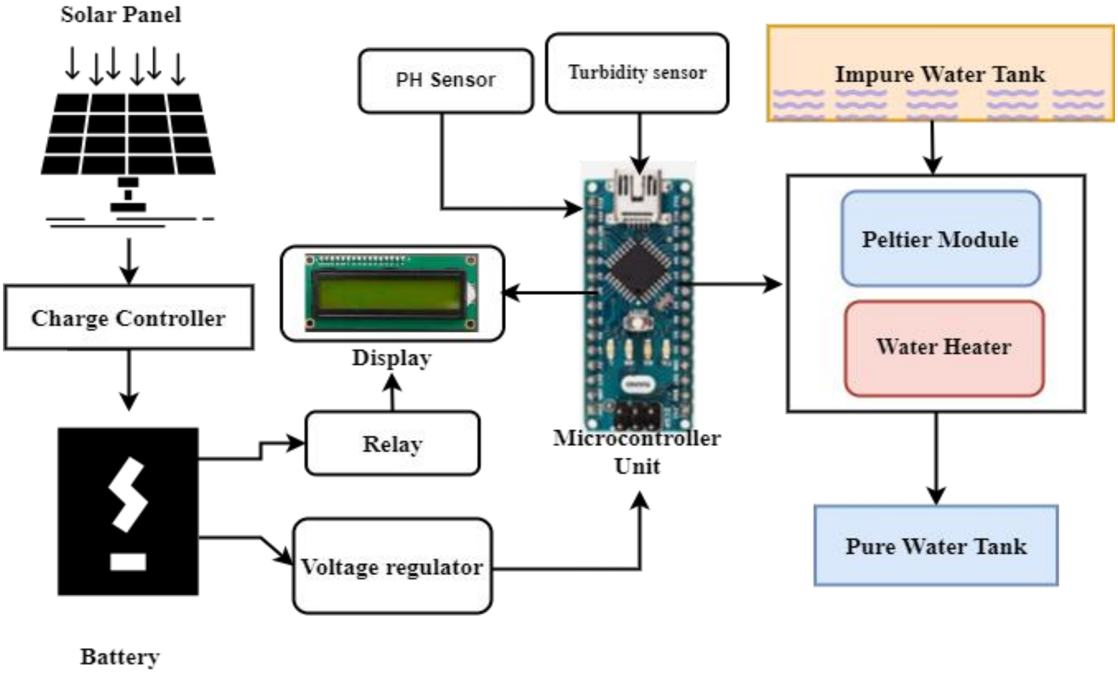


Fig 2.4: Block diagram of peltier device

2.4 Analysis of multiple design approach

Table 2.1: Analysis on multiple design approaches of the system

Multiple Design Approaches	**Design Approach-01**	**Design Approach-02**
Cost	Moderate	Low
Usability	Fast Working	Time Consuming
Parts Accessibility	Easily Available	Moderate
Size	Big Size	Compact
Maintainability	Simple	Complex

We followed some criterias for the design approaches 1 and 2 and by analyzing these criterias we have come to a conclusion that the Design Approach-1 which is the reverse osmosis system is suitable for better results in our project.

Firstly in design 1, the estimated cost is 12900 taka which is higher than design 2. This can be considered because we will not compromise the water quality for our budget.

Secondly, The usability of our design approach 1 which is the RO system is fast working compared to our Design approach 2 which is the Peltier module. Because it will take a few minutes to heat up the U shaped heater and cooling process by the Peltier module. Whereas the Reverse Osmosis System takes a few seconds to process the water and convert into pure water.

Thirdly, the availability of the parts of both of our design approaches is decent. In some research and market analysis we found that sometimes the Peltier module goes out of market.
But there is very less possibility of shortage of the Reverse Osmosis membrane because it is widely used in various works including water purifications.

Moreover, The size of the design approach 1 will be bigger than design approach 2 because the size of the RO membrane is bigger than the Peltier module. That is a negative side of design approach 1 .

2.5 Conclusion

Solar power water purification is a very unique concept for our country. There is no market created till now on it. Solar energy can be a major source of power. Its potential is 178 billion MW which is about 20,000 times the world's demand. But it cannot be developed on a large scale. Sun's energy can be utilized as thermal and photovoltaics. The solar power where the sun hits the atmosphere is 1017 watts, whereas the solar power on earth's surface is 1016 watts. The total world – wide power demand of all needs of civilization is 1013 watts. Therefore, the sun gives us 1000 times more power than we need.The energy radiated by the sun on a bright sunny day is approximately 1 kw/m2 , which may be used in driving the prime movers for the purpose of generation of electrical energy [23].

Chapter 3: Use of Modern Engineering and IT Tool. [CO9]

3.1 Introduction

Before creating the project prototype, we need to do some testing and find the optimal solution for the design among the two design approaches. We have to do some simulation work to ensure that the device provides valuable data and relevant results. Furthermore, the design that provides a better result and has good precision has to be identified. There is a lot of software on the market which depends on several categories, such as availability, whether it is free or not, whether the software interface is complex or easy to use, etc. There are several simulation software programs available on the market for simulation purposes. We need to make a selection taking into account the availability of the components in the library that we should use. For simulation, there are software programs like Proteus, Matlab, etc. After doing some research on it, we found that Proteus is easy to use and offers almost all the features in the library content that are necessary. And for preliminary 3D designs,there are several 3D designs available. However, since we are still very new to this field, we need to choose a tool that is easy to use, has the functions of a professional 3D tool, and is available.

3.2 Select appropriate engineering and IT tools

There are numerous software programs available that can be used as IT tools. For simulation, there are multiple softwares from which we have selected Proteus, as we are familiar with the interface and have used it previously. For Matlab, which is familiar to us, we could not utilize this software as all the needed components for the simulation are not available in Matlab, and it is more complex in Matlab to simulate this type of simulation. So considering all this, we think Proteus is a better choice for simulation. For 3D design purposes, we have used sketchup software.

3.3 Use of modern engineering and IT tools

At the beginning of any project, it is essential to select the appropriate tools. The process of selecting the appropriate project management software begins with a thorough and honest evaluation of the requirements. Following this, we will select alternatives and the appropriate ones. Additionally, we will test-trialize and evaluate against the requirements. Finally, the evaluation of the costs and the implementation of all steps will ensure a successful outcome in structuring a project. Therefore, in our project, we will require the assistance of Proteus and Arduino to ensure a successful outcome

Proteus:

Through the Proteus software, we have simulated the two design approaches and checked whether they are working or not, giving us value. For the design approaches, the simulation process was done seamlessly. All the simulations were done using the Arduino Nano.

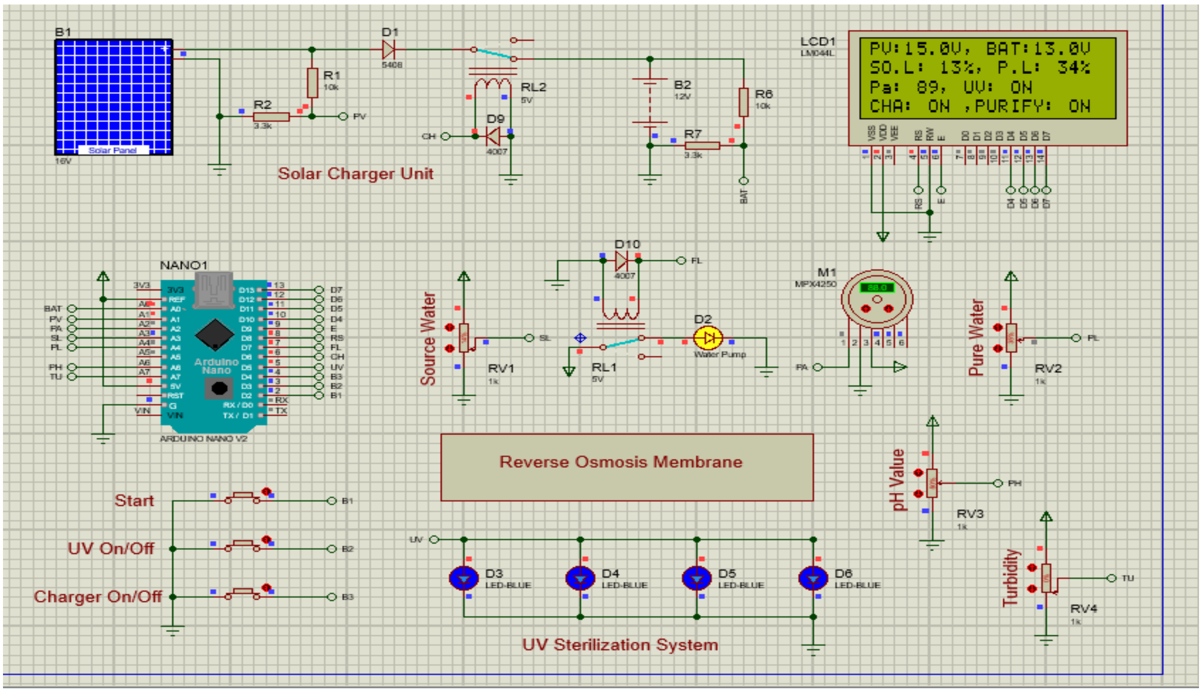


Fig 3.1: Proteus design of Approach 01

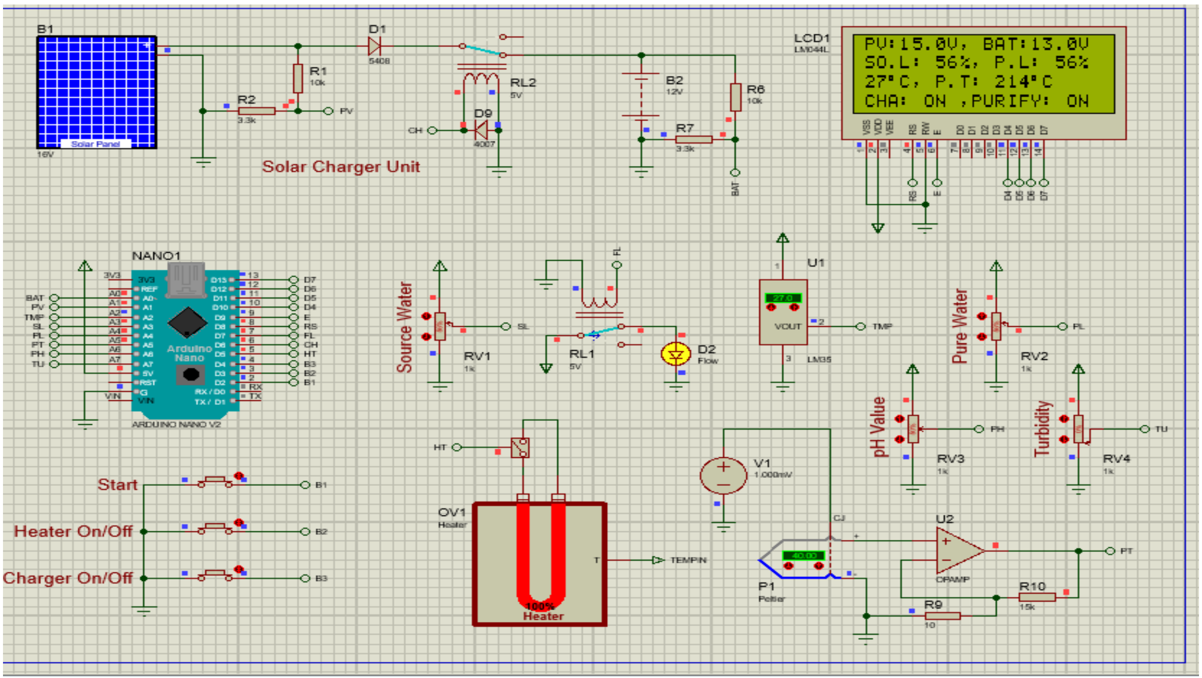


Fig 3.2: Proteus design of Approach–02

Arduino:

Arduino is a free, open-source microcontroller that lets you run a program to make a display. It's a single chip device that can do multiple tasks at once, and can be programmed with the help of the Arduino IDE. It's the perfect way for students from all over the world to get their hands on a microcontroller and learn about it. Plus, you can use it to work with sensors, modules, shields, and a bunch of different communication options like WiFi, Bluetooth etc.

Sketchup:

SketchUp is a versatile 3D modeling software that enables users to create, modify, and share 3D models with ease. Its intuitive interface, interoperability, and active community make it a popular choice among professionals and beginners alike.

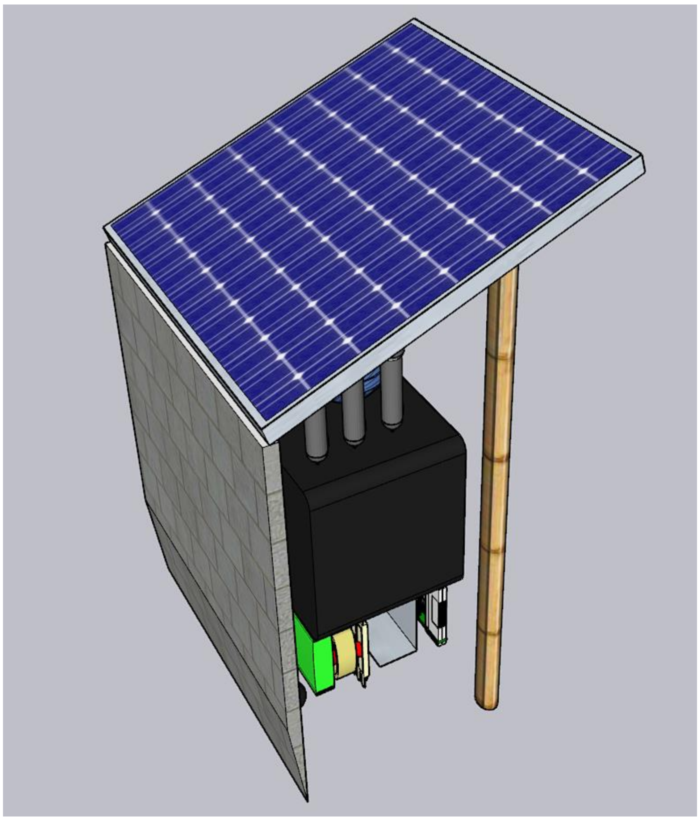


Fig 3.3: The outer part of the reverse osmosis system

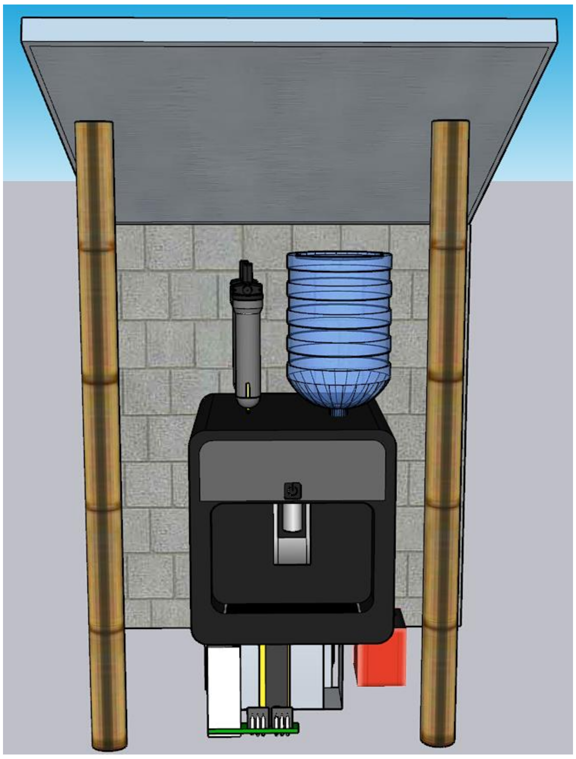


Fig 3.4: The inner part of the reverse osmosis system

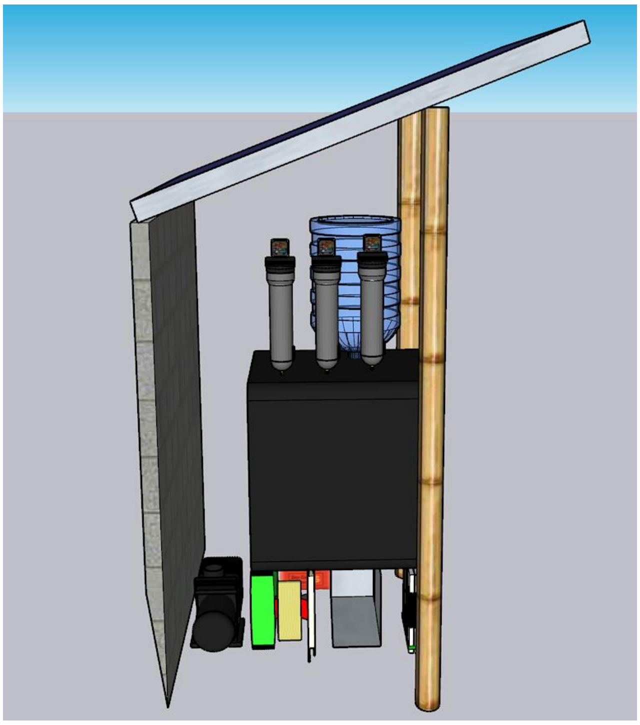


Fig 3.5: The side view of the reverse osmosis system

Canva: Canva is an adaptable graphic design tool that makes it simple for users to produce visually appealing content. Drag-and-drop capability, an extensive template library, and an easy-to-use interface make it suitable for both novices and experts. With the versatility of Canva's mobile app and web platform, users can design while on the go. Canva makes the design process easier for everyone who wants to bring their creative ideas to life, be they a business owner, marketer, student, or hobbyist. Our poster was created using Canva.

3.4 Conclusion

Our project requires software that allows us to obtain all the necessary information and components for the design approaches. We have selected software that is familiar and easy to use. And as far as the data result is concerned, the sensors are mostly analog, so the values can be determined in the simulation process using a potentiometer. All design approaches were tested for two test cases, as shown in the previous parts. And in Proteus, the availability of all parts makes it easier to use and run the simulation. Also, the 3D design was implemented through software named Sketchup .And the formation of the poster for poster presentation was done through online software named ‘ Canva’.

Chapter 4: Optimization of Multiple Designs and Finding the Optimal Solution. [CO7]

4.1 Introduction

The project proposal is the basis for turning the idea into a prototype. After the proposal, several designs are assigned. This will lead to the main idea of the project. However, the main challenge is finding the optimal solution. So the answer to which design is the most optimal can only be found after optimizing every design. Therefore, we examined every possible design strategy for our project. In our project, the primary goal is to get the optimum design. We simulate the designs and check if the components are available or not, if they are cost-effective, if they can be replaced, etc. After doing some research, we concluded that a design approach must be implemented in real-life.

4.2 Optimization of Multiple Design Approach

The project involves the exploration of two distinct design approaches, with the goal of identifying the optimal solution for showcasing as a prototype. Extensive research was conducted, including simulations and the utilization of new software to gain a deeper understanding. Proteus was employed for simulation across all design approaches, allowing for the assessment of their outcomes in alignment with the project's core concept. Various analyses, including evaluations of requirement fulfillment and data accuracy, were carried out to pinpoint the most effective solution.

Design-01:

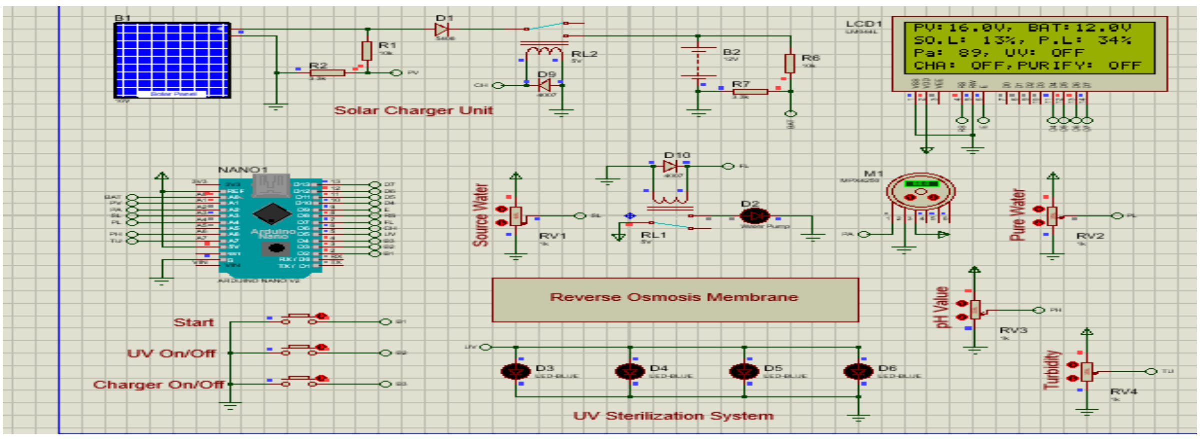


Fig 4.1: Simulation Approach of design-01

Basically, we're using Proteus software to design our simulation model. In this design, we've used a solar charger unit that is connected with multiple relays to charge the solar controller. Additionally, we also used an Arduino Nano to control the whole unit. Here, a sterilization system is also included with the reverse osmosis membrane in the source water. We also used a PH sensor and Turbidity sensor to measure the purity of the water.

The solar powered water purifier with reverse osmosis and UV radiation is an ingenious system designed to provide safe and clean drinking water using renewable energy. Here's how it works:

Firstly, the device harnesses the power of the sun through solar panels, which convert sunlight into electrical energy. This clean energy is then used to power the water purifier without relying on external power sources—it's eco-friendly and cost-effective!
The purification process begins by drawing water from a contaminated source, such as a river or well, using a pump. The water is then filtered through a series of pre-filters to remove larger particles, sediments, and impurities. The reverse osmosis system comes into play next.

In the reverse osmosis (RO) stage, the water is passed through a semipermeable membrane, which acts as a barrier against unwanted contaminants, including bacteria, viruses, dissolved salts, and heavy metals. The membrane allows only pure water molecules to pass through while denying the passage of impurities. As a result, the end product is significantly cleaner and safer water.

But the purification process doesn't stop there! To ensure absolute sterilization, UV radiation is employed. The purified water moves through an ultraviolet (UV) chamber, where powerful UV-C rays penetrate and destroy any remaining microorganisms, including harmful bacteria and viruses. The exposure to UV radiation effectively purifies the water, leaving it free from pathogens and other potential health hazards. The final step involves storing the purified water in a clean, secure tank or container, ready for consumption. The entire mechanism, from solar energy to reverse osmosis and UV treatment, functions seamlessly, providing a continuous supply of safe drinking water.

Overall, this solar-powered water purifier utilizing reverse osmosis and UV radiation offers a sustainable and reliable solution to address the vital need for clean water in areas without access to centralized water treatment facilities or reliable electricity.

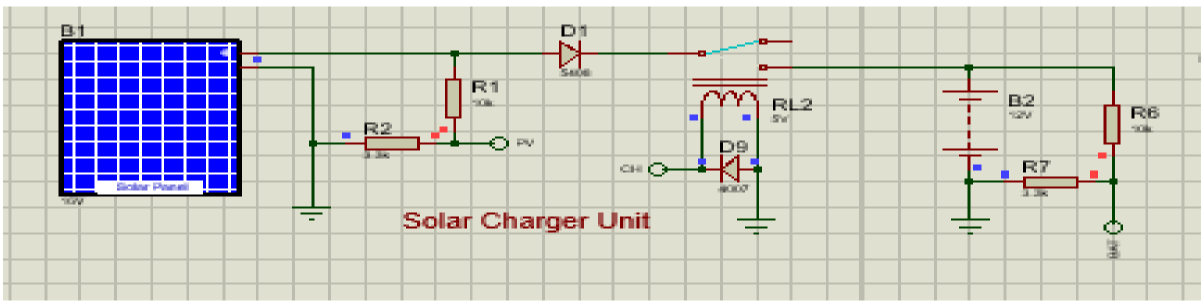


Fig 4.2: Schematic diagram of charging unit of design-01

Charging Unit: The solar panel will charge the battery because the whole project is based on solar-power. Here, the photovoltaic effect is used by the solar panel to convert solar energy to electrical energy. DC energy is produced and passes through the solar charge controller and charges the battery.

Result:

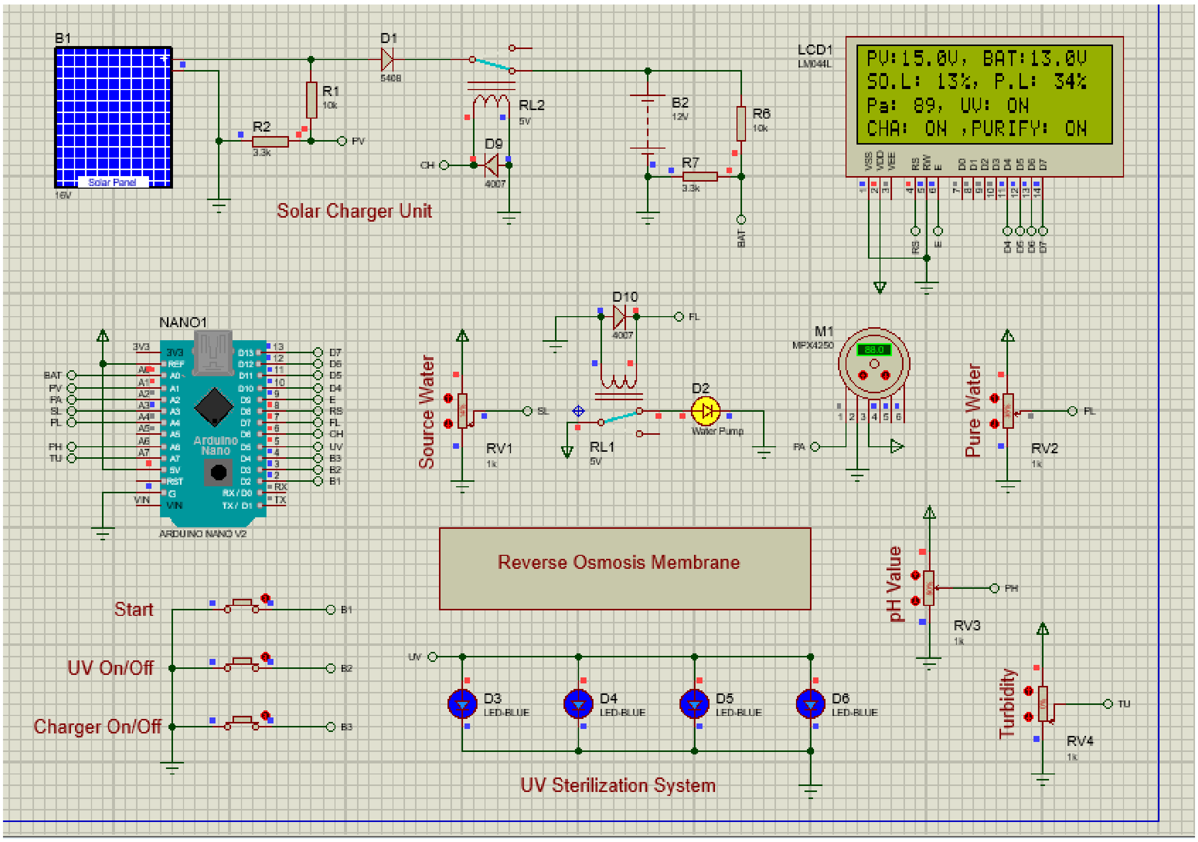


Fig 4.3: Output results of the design approach-01 simulation

In the simulation, the source water mode is on and the UV ray lights are also on which helps to kill the dirty mechanisms from water. The battery is being charged with the help of solar power. We also used sensors like turbidity and pH which helps us to identify the purity of the water and its being shown on display.

Design-02:

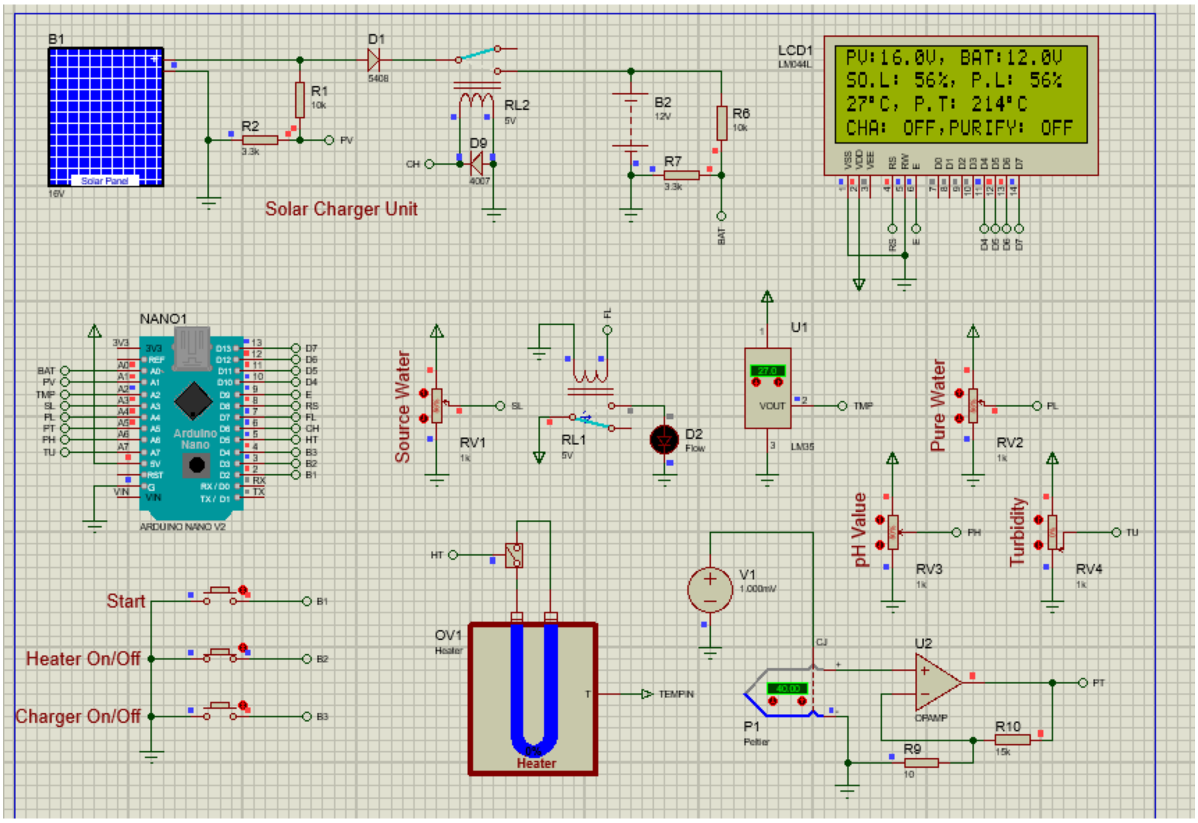


Fig 4.4: Simulation Approach of design-02

The solar powered water purifier, equipped with a Peltier module, pH sensor, and turbidity sensor, combines innovative technologies to provide a reliable and efficient method of water purification. Let's dive into its mechanism:

To begin, the device harnesses solar energy through solar panels, converting sunlight into electricity. This sustainable power source is utilized to operate the purifier, eliminating the need for external electricity and reducing carbon footprint.

The purification process starts by drawing water from a source such as a well or river, using a pump. The water passes through the system, and the first step involves monitoring its turbidity level through a turbidity sensor. This sensor measures the amount of suspended particles or impurities present in the water, providing real-time data on its clarity and cleanliness.

Next, the water flows into a chamber, where the pH sensor comes into play. The pH sensor measures the acidity or alkalinity of the water by detecting the concentration of hydrogen ions. This data helps determine the water's quality and ensures proper balance for human consumption.

Now, the water reaches the core component of the purification process – the Peltier module. The Peltier module utilizes the Peltier effect, which utilizes the temperature difference created by an electrical current passing through two dissimilar materials. As the electrical current passes through the module, it creates a temperature gradient, causing one side to cool down and the other side to heat up. This thermoelectric cooling effect is crucial for the purification process.

On the cool side of the Peltier module, the water is exposed to low temperatures, prompting condensation. This condensation causes impurities and contaminants to solidify and separate from the water, facilitating their removal. The purified water then moves toward the module's hot side, where it starts to evaporate due to the increased temperature. This evaporative process further eliminates any remaining impurities, leaving behind clean water vapor.

The water vapor then condenses back into its liquid form, forming purified water droplets. These droplets are collected in a separate chamber, ensuring that only the clean water is stored for consumption. The Peltier module continues to cycle and purify the incoming water, maintaining a continuous supply of clean water.

In summary, the solar powered water purifier employing a Peltier module, pH sensor, and turbidity sensor provides an efficient and eco-friendly solution for water purification. By combining solar energy, real-time monitoring of water quality, and the thermoelectric cooling effect, it guarantees the delivery of safe and clean drinking water, even in locations without reliable access to electricity or centralized water treatment facilities.

Result:

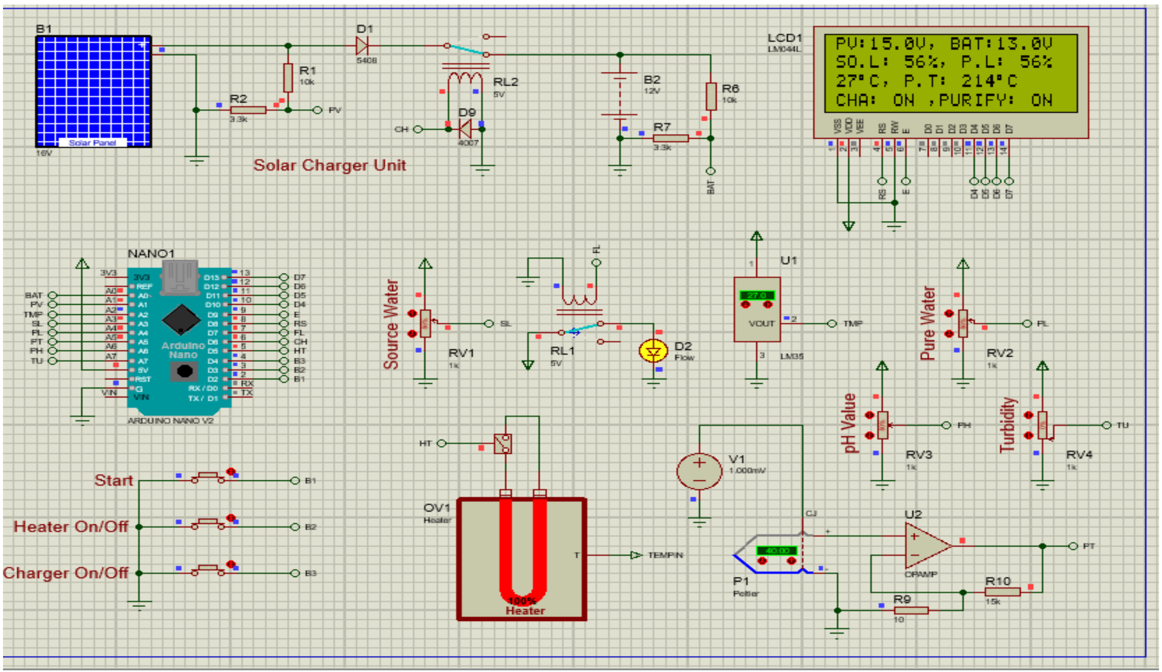


Fig 4.5: Output of design-02

In the simulation, the source water mode is on. Here, we have used a U shaped funnel heater to heat the water and kill the microorganisms present. Then, with the help of a Peltier device, we used the cooling module part to cool down the boiled water. The battery is being charged with the help of solar power. We also used sensors like turbidity and pH which helps us identify the purity of the water and its being shown on display

4.3 Identify Optimal Design Approach

Based on our simulation, we have some features to compare between the designs-

Table 4.1: Comparison of the designs

Multiple Design Approaches	**Design Approach - 01**	**Design Approach - 02**
Cost	Moderate	Low
Usability	Fast Working	Time Consuming
Parts Accessibility	Easily Available	Moderate
Size	Big Size	Compact
Maintainability	Simple	Complex
Efficiency	Higher (96.6)	Less(72.4)
Power(P=VI)	56 watt	80 watt
Battery Life	Higher	Lower

We followed some criteria for design approaches 1 and 2, and by analyzing these criteria, we have come to the conclusion that design approach Approach-1 which is the reverse osmosis system, is suitable for better results in our project.

Firstly, in design 1, the estimated cost is 12900 taka, which is higher than in design 2. This can be considered because we will not compromise the water quality for our budget.

Secondly, The usability of our design approach 1 which is the RO system, is fast compared to our design approach 2 which is the Peltier module. Because it will take a few minutes to heat up the U shaped heater and cool the Peltier module. Whereas the reverse osmosis system takes a few seconds to process the water and convert it into pure water,.

Thirdly, the availability of the parts for both of our design approaches is decent. In some research and market analysis, we found that sometimes the Peltier module goes out of market.
But there is very little possibility of a shortage of the reverse osmosis membrane because it is widely used in various projects, including water purification.

Moreover, the size of design approach 1 will be bigger than design approach 2 because the size of the RO membrane is bigger than the Peltier module. That is a negative side of Design Approach 1 .

4.4 Performance evaluation of developed solution

Table 4.2: Power Consumption

Parameters	Reverse Osmosis	Peltier module
Total Power Consumption	(12.5 × 4.5) = 56 Watt	80 Watt

Table 4.3: Analyzing the testing methods Reverse Osmosis

Parameter	During Purification	After Purification
TDS Sensor	500 ppm	200 ppm
pH	10	7.2
Iron	0.03 mg/L	0.01 mg/L
BOD	5.0 mg/L	4.5 mg/L

Reverse Osmosis:

Efficiency: The project's primary objective is to supply pure water by using solar power rather than electricity. Here, we have seen after simulation that the RO system has the highest efficiency, which is 96.6%.

Battery charging time: Charge time = (Battery capacity in Ah) ÷ (Solar panel current in A) To find the solar panel current, we need to divide the solar panel wattage by the solar panel voltage. In our case, that would be: Solar panel current = 50W ÷ 12V = 4.17A Then, we can plug in the values of your battery capacity and solar panel current into the formula: Charge time = 15Ah ÷ 4.17A = 3.6 hours This means that it will take about 3.6 hours of direct sunlight for our solar panel to fully charge our battery from 0% to 100%.

Power Consumption: In this approach, total power consumption was 56 watts, which is much better than approach-02.

pH Value : The acidity or alkalinity of a solution is determined by its pH value. It is measured in a range of 0 to 14, where 7 is regarded as neutral. Less than 7 is the pH of an acidic solution, and more than 7 is the pH of an alkaline solution. In the RO system, we get better and more pure water, as it has a value of 7.2.

TDS sensor : Total Dissolved Solids, or TDS, is a measurement of the total amount of organic and inorganic materials present in a liquid in suspended molecular, ionized, or microgranular form.TDS is commonly represented in terms of parts per million (ppm) or milligrams per liter (mg/L) when referring to water.

Minerals, salts, metals, and other contaminants are included in the TDS value of water, which serves as a measure of its cleanliness. Lower TDS readings typically correspond to purer water, while higher readings might point to a higher concentration of dissolved solids. After purification, we get a fair value of 200 ppm.

Moreover, we also checked Iron and BOD.

Table 4.4: Analyzing the testing methods Peltier module

Parameter	During Purification	After Purification
TDS Sensor	100% ppm	40% - 60% ppm
pH	10	7.8
Iron	0.05 mg/L	0.02 mg/L
BOD	7.0 mg/L	5.5 mg/L

Peltier Module:

Battery charging time: Charge time = 20Ah ÷ 4.17A = 4.7 hours This means that it will take about 4.7 hours of direct sunlight for our solar panel to fully charge our battery from 0% to 100%.

Efficiency : The efficiency of a Peltier module is directly proportional to the temperature difference between its hot and cold sides. A larger temperature difference results in a higher heat transfer rate, which in turn increases the module's efficiency(72.4)

Preventing overcharging and extending battery lifespan: The main function of solar charge controllers is to prevent batteries from overcharging. Though this system is not suitable for all kinds of weather, its importance in preventing batteries from overcharging is beyond description. By doing so, the lifetime of the batteries becomes longer and ensures that the deep cycle batteries aren't overcharged during the day and that the batteries aren't drained at night by power running back to the solar panels.

4.5 Conclusion

Our undertaking is planned so that we underscore the new idea of a water purifier that is consolidated with an effectively utilizable sustainable power structure called solar powered energy. Conserving natural energy resources and increasing reliance on renewable energy sources to meet ever-increasing energy demands were the primary motivations behind our concept. Through our examination work, we discovered that there are numerous approaches to carrying out a solar based controlled water purifier. There are multiple ways of purifying water, for instance, reverse osmosis, peltier purifying devices, and the utilization of sun powered stills. By installing the water purifier, the community as a whole is treated like a single customer, and a single generating site is established. The total burden requested by every one of the members is basic in deciding the size of the office. The final method we have chosen is to use a reverse osmosis system to purify the water. We have calculated manually the power consumption and the amount of time it takes to fully charge the battery. The pH and TDS were also measured manually to identify the purity of the water.

Chapter 5: Completion of Final Design and Validation. [CO8]

5.1 Introduction

Following a more thorough comparison of the published design approaches, the hardware prototype for the optimized design of Design Approach 01 which is reverse osmosis system, has been fabricated. On the hardware prototype, there are some modifications. The software design is implemented in Proteus, and it is only to observe certain connections to see if they are working properly or not. On the other hand, a hardware prototype system is also developed as per our project plan to make sure it works and be able to satisfy consumers.

5.2 Completion of final design

First, we implemented the project through software simulation with the help of Proteus. It is shown below.

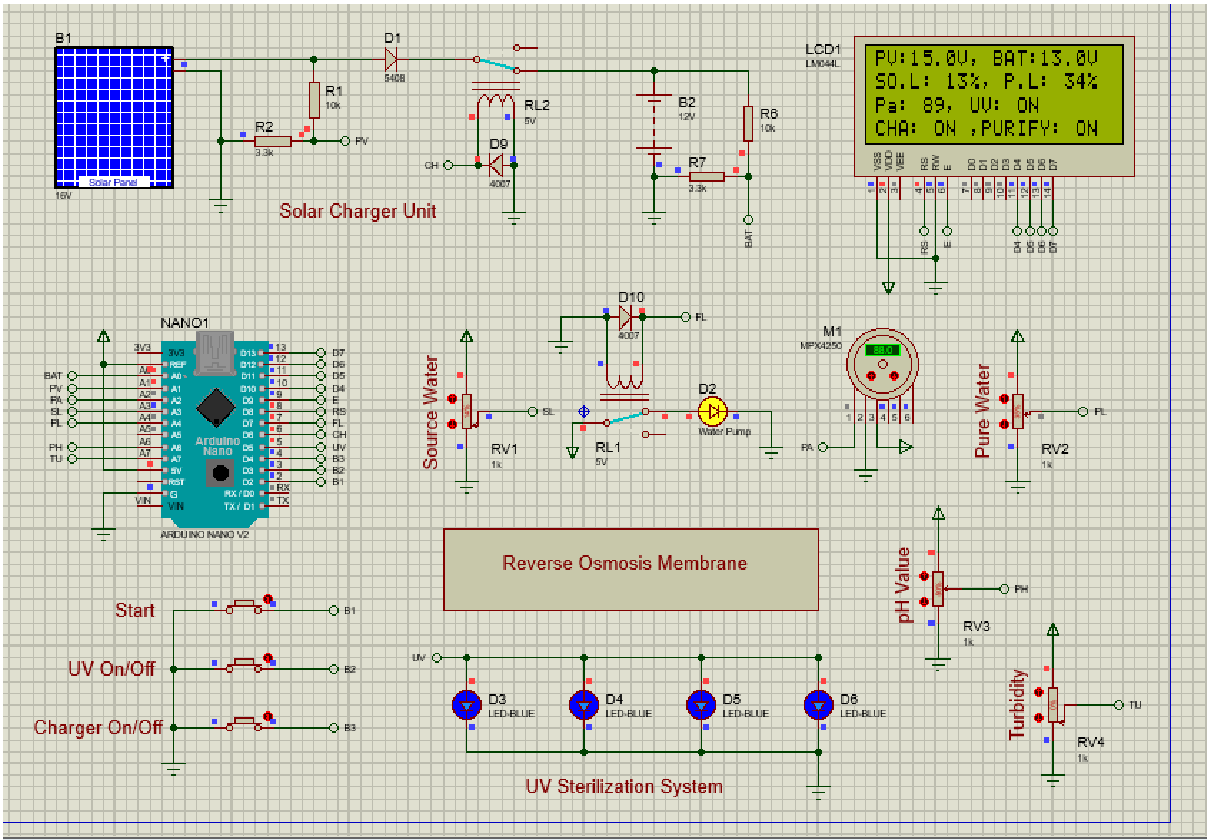


Fig 5.1: Simulation of project

In the simulation, the process was briefly described. The purification process begins by drawing water from a contaminated source, such as a river or well, using a pump. The water is then filtered through a series of pre-filters to remove larger particles, sediments, and impurities. The reverse osmosis system comes into play next. In the reverse osmosis (RO) stage, the water is passed through a semipermeable membrane, which acts as a barrier against unwanted contaminants, including bacteria, viruses, dissolved salts, and heavy metals. The membrane allows only pure water molecules to pass through while denying the passage of impurities. As a result, the end product is significantly cleaner and safer.

Also, we have drawn a schematic diagram of our proposed project for better understanding, and we have tried to construct the purifier through this method.

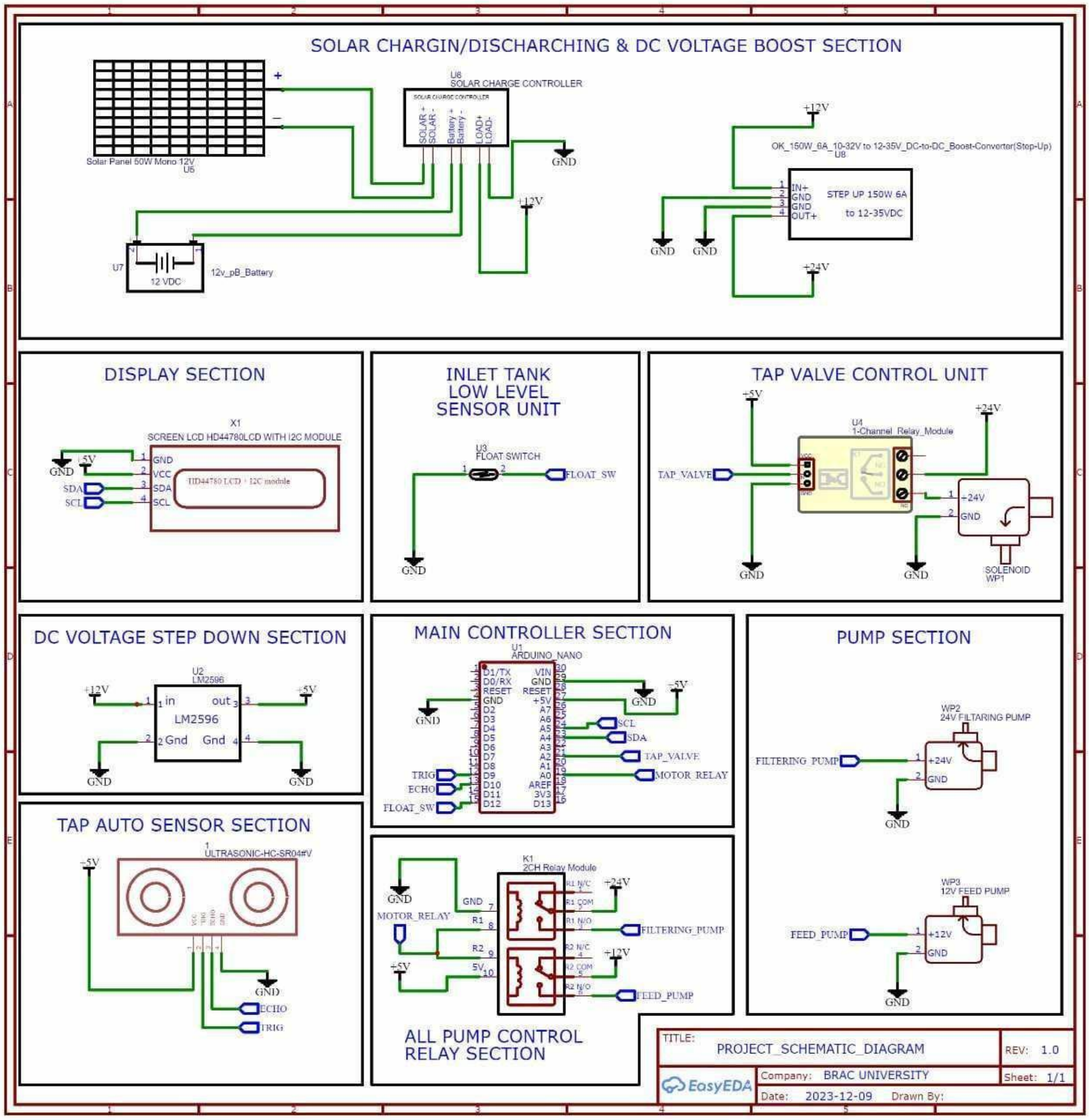


Fig 5.2: Schematic of project

Final Prototype Design

Fig 5.3: Final prototype design

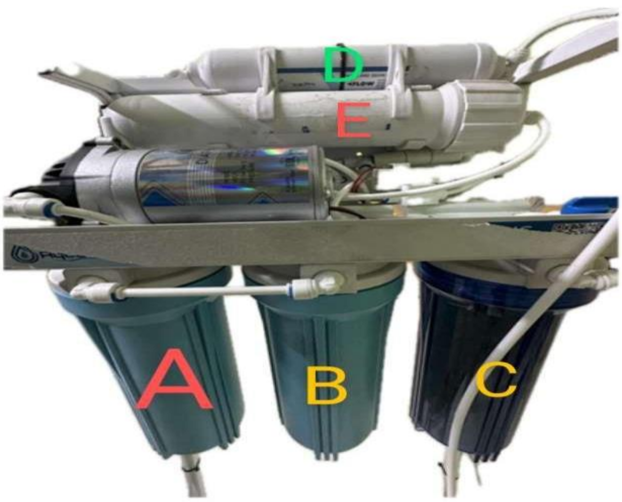


Fig 5.4: Final prototype design,reverse osmosis membrane, and other filters.

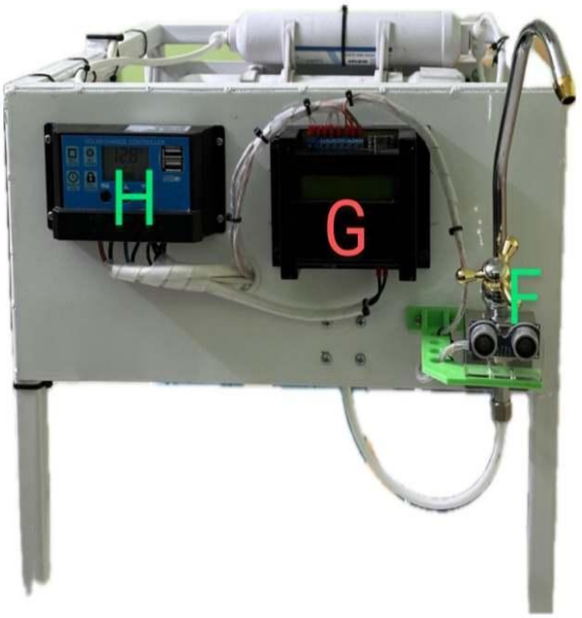


Fig 5.5: Final prototype design, charge controller and sensor module

Fig 5.6: Final prototype design with description

The detailed description of the overall design is described below:

‘A’ GAC Filter (Granular activated carbon) : A filter with granular activated carbon (GAC) is a proven option to remove certain chemicals, particularly organic chemicals, from water.

‘B’ CTO Filter(Chlorine taste and odor): CTO is an acronym for Chlorine, Taste, and Odor. A filter recommended for CTO removal will produce water that is much clearer in color with a more appealing taste and elimination of odors.

‘C’ PP Filter (Polypropylene): Polypropylene filters are non-toxic and perfectly suitable for drinking water as well as being rough and unusually resistant to many chemical solvents, acids and bases

‘D’ Water Conditioner: Most water conditioners remove the chemicals and compounds that give your water an unpleasant taste or smell.

‘E’ RO Membrane: The RO method of water purification uses the polymeric membrane, which is also called a semipermeable membrane, which allows some of the molecules or the ion to pass through the Osmosis.

‘F’ Ultrasonic sensor and faucet: Ultrasonic Sensors use high frequency ultrasonic waves to detect the levels of any medium liquid or solid. This sensor/transmitter is mounted at the top of a tank and aimed downward. It transmits waves and measures the time it takes to receive the return signal from the water to the sensor.

‘G’ Smart controller: It works as a control unit

‘H’ Solar charger: A solar charger is a device that converts sunlight into electrical energy to charge electronic devices

‘I’ 50 watt solar module: It collects the energy from sunlight.

‘J’ Waste water tank: Stores the wasted water

‘K’ Storage tank: Reserves the purified water.

‘L’ Battery: It stores solar energy for further use.

‘M’ Inlet tank: Basically it’s a source water tank for water supply.

5.3 Evaluate the Solution to Meet Desired Need

A solar charge controller is an essential component of any solar power system since it controls the quantity of power that is transferred from the sun panels to the batteries. To ensure that our demands would be met, we took into consideration the following factors**:**

Efficiency: We observe a solar charge controller with a high efficiency rating. As a result, less energy will be lost because our solar panels will be able to provide the batteries with the maximum amount of electricity they can produce.
Charge rate: A solar charge controller's charge rate determines how rapidly the controller can charge our batteries. To significantly reduce the time required to charge your device, search for a controller with a high charge rate battery.

Battery compatibility: We are able to verify that the capacity of our batteries are compatible with the solar charge controller selected. By doing this, we may be able to extend the life of our batteries and prevent damage from occurring.

Targeted Area: Solar water purifiers are devices that use solar energy to treat and purify water, making it safe for consumption. These systems are particularly beneficial in targeted areas where access to clean and safe drinking water is limited or nonexistent.

A number of particular suggestions for solar water purifiers for safe and affordable water supply include the following:

Solar Power Source: To capture solar radiation and turn it into electrical power, the system uses photovoltaic panels.

Reverse Osmosis Technology: This fundamental purification technique ensures high-quality water production by pushing water through a semipermeable membrane to eliminate impurities.

Desired Satisfaction of Needs: Cost-effectiveness is the crucial requirement that solar water purifiers meet by which the consumers are satisfied . Conventional water filtration techniques may need either costly equipment, chemicals, or continuous operating expenses. Solar water purifiers, on the other hand, use sunshine, a free and endless energy source. Solar water purifiers don't require fuel or energy after they are installed, therefore their ongoing expenses are quite low. They are therefore a cost-effective option for neighborhoods or homes without access to dependable electrical infrastructure or with limited resources.

Access to Clean Water: The system successfully satisfies the demand for a sustainable and dependable source of clean drinking water, particularly in places without consistent or dependable power.

Impact on the Environment: Using solar energy helps reduce carbon emissions and save the environment, which is consistent with the increased focus on environmentally friendly technologies.

Community Empowerment: By offering a decentralized method of water filtration, the installation of such systems in marginalized areas improves self-sufficiency.

Energy Efficiency: Solar power promotes sustainability, but how much sunshine a system receives determines how successful it is. Systems with adequate energy storage may be required for dependable operation during seasons with little sun.

Concerning Expenses: Long-term benefits could outweigh the initial setup expense, especially in distant areas where there may be benefits over time. When compared to conventional energy-dependent systems, operating costs can be significantly reduced.

Table 5.1: Evaluating the results with the desired needs

Objective	Result	Fulfill our desired need (YES/NO)
Design an efficient solar powered water purifier at a low cost	Designed a solar powered water purifier	YES
To make sure pure water is delivered in rural areas	Targeted area	YES
Prevent Overcharging	Charging Auto Cut Off at 12V of battery charge.	YES
Extending battery lifespan	By preventing overcharging and Auto load cut off when battery voltage will be less than 10V.	YES
Reducing the charging time	Fast Charge Up-to 12V in 3.6 hour	YES

NB: We can change the range of the voltage, which is mentioned above, by using our microcontroller command.

Table 5.2: Purifying levels of different types of water

Water types	pH		TDS		Iron		BOD	
Observation	Initial	After Purified	Initial	After Purified	Initial	After Purified	Initial	After Purified
Tubewell	6.4	7.4	500 mg/l	200 mg/l	<10 mg/l	<0.5 mg/l	5 mg/l	0.8 mg/l
Pond Water	6.5	7.5	600 mg/l	300 mg/l	500 mg / dl	310 mg / dl	50 mg/l	30 mg/l
Tap water	6.8	7.3	250 mg/l	340 mg/l	<10 mg/l	<0.5 mg/l	7 ppm	3 ppm

The data has been collected through our experimentation. Here, by collecting water from different places, we measured it through manual testing by different sensors.
We are pleased to declare that, following a significant amount of work and dedication, we have successfully accomplished the project objectives that were initially specified for this endeavor. We are happy to announce that our team's tireless efforts to ensure the project was properly planned and executed have paid off. We worked extremely hard to make sure that every choice we made, took us one step closer to realizing our goals and that we never lost sight of the wider vision. Because we worked together and took advantage of everyone's expertise and experience, we were able to overcome the difficulties that came up.

5.4 Conclusion

Finally, we have designed a water purification system using a reverse osmosis system that can be powered by solar devices. Based on the comprehensive design process and rigorous validation testing, it can be concluded that the solar water purifier utilizing reverse osmosis technology has successfully met the specified requirements and demonstrated its capability to provide clean and safe drinking water. The final design incorporates optimized components and system configurations, ensuring efficient operation and maximum purification efficiency. The validation process has confirmed the purifier's ability to effectively remove contaminants, including bacteria, viruses, and dissolved solids, from various water sources. Moreover, the solar water purifier has exhibited durability and reliability during both laboratory testing and field trials. This ensures its long-term functionality even in challenging environmental conditions. The completion of the final design and validation of the solar water purifier in reverse osmosis marks a significant milestone in addressing the global water crisis. This technology offers a sustainable and cost-effective solution for communities lacking access to clean water, particularly in remote or off-grid area

Chapter 6: Impact Analysis and Project Sustainability. [CO3, CO4]

6.1 Introduction

Each project, when presented for the first time, has its own set of impacts that make it powerful and vulnerable at the same time. When we analyzed our project's impact, we categorized it into a number of categories, such as societal, health and safety, cultural, etc. These impact categories are discussed in more detail below. We have also conducted a SWOT analysis to further analyze the impact of the project. Our project's innovative qualities, accurate measurement, and low power consumption are its strengths. The technology is cost-effective, dependable, and portable all at once.

6.2 Assess the impact of solution

The impact of the solar powered water purifier regarding societal, health, safety, legal and cultural concerns is reviewed below:

Societal:

The solar powered water purifier has a significant societal impact, particularly in areas where clean and safe drinking water is scarce. The solar powered water purifier provides communities with a sustainable and reliable source of clean and safe drinking water. This helps to prevent waterborne diseases, which leads to improved health outcomes, reduced mortality rates, and improved quality of life. Many communities in developing countries rely on traditional methods of water purification. These methods can be time-consuming, expensive, and often not very effective. Solar-powered water purifiers offer a more efficient, cost-effective, and environmentally friendly alternative, reducing the community's reliance on traditional methods. This system does not require fuel or electricity, other than sunlight, to operate, reducing greenhouse gas emissions and dependence on fossil fuels. Additionally, they do not produce any harmful by-products during the purification process, reducing water pollution and protecting ecosystems. It has the potential to create economic opportunities in communities where access to clean water is limited. With a reliable and sustainable source of clean water, individuals can save time and energy and engage in other productive activities. This can contribute to poverty reduction and economic development. By providing a reliable and sustainable source of clean water, these systems can support the growth of local businesses, improve agricultural productivity, and enhance overall community well-being. The solar-powered water purifier has a positive societal impact by improving access to clean and safe drinking water, reducing reliance on traditional methods, providing environmental benefits, empowering individuals economically, promoting education and gender equality, and contributing to community development.

Health:

There are several health impacts of using a solar-powered water purifier:
Solar-powered water purifiers use solar energy to treat water, removing harmful bacteria, which reduces the risk of waterborne diseases. According to the World Health Organization, over 780 million people worldwide lack access to clean water, resulting in approximately 1.6 million deaths annually from diarrheal diseases alone. Solar-powered water purifiers can help reduce these numbers by providing a safe drinking water source. It is also used for treating water for hygiene purposes, including handwashing, cleaning utensils, and bathing. Solar-powered water purifiers eliminate the need for traditional fuel sources, such as coal, wood, or kerosene, which can emit harmful pollutants. Solar-powered water purifiers can have a significant impact on maternal and child health. Access to clean water improves the health and wellbeing of pregnant women, reducing the risk of complications during pregnancy and childbirth. to safe drinking water, promoting healthy growth and development and reducing the risk of waterborne diseases. This not only contributes to improving air quality but also has a long-term positive impact on public health, as reducing pollution can reduce respiratory issues and conditions. Overall, solar-powered water purifiers play a vital role in ensuring access to safe drinking water, reducing waterborne diseases, improving sanitation practices, and ultimately improving the overall health and well-being of communities.

Safety:

The safety impact of a solar-powered water purifier can have several positive effects:
Solar-powered water purifiers use sunlight as a renewable energy source to power the purification process. This means that no additional fuel or electricity is required, resulting in clean drinking water without the need for harmful chemicals or pollutants. It ensures that the water is safe for consumption, minimizing the risk of waterborne diseases. This promotes sustainable development and helps mitigate climate change. Besides, it also reduces the carbon footprint and helps combat global warming. Solar-powered water purifiers can be particularly useful in emergency situations or areas affected by natural disasters where infrastructure and power supply are disrupted. These purifiers can quickly and efficiently provide clean drinking water. Overall, the safety impact of solar-powered water purifiers is significant, as they provide clean drinking water in an environmentally friendly and sustainable manner, promoting public health and reducing the risk of waterborne illnesses.

Legal:

The legal impact of a solar-powered water purifier can vary depending on the jurisdiction and specific regulations in place. In many jurisdictions, there are specific regulations regarding the quality of drinking water. Solar-powered water purifiers must comply with these standards to ensure that the treated water is safe for consumption. Solar-powered water purifiers may require certification and compliance with electrical safety standards to ensure that they do not pose a risk of electrical hazards or fires. It may incorporate patented technology or designs. Manufacturers and users need to ensure that they do not infringe on any intellectual property rights. Violations of patents or trademarks can result in legal action, including injunctions and monetary damages. The production, use, and disposal of solar-powered water purifiers may be subject to environmental regulations. IIt is also sold to consumers and may be subject to consumer protection regulations. These regulations typically require accurate and truthful advertising, adequate product labeling, warranties, and protections against false or misleading claims. Solar-powered water purifiers that are produced or sold internationally may be subject to customs duties, licensing requirements, and restrictions on certain countries or entities. It must comply with applicable health and safety regulations to ensure a safe working environment for their employees. It is important for manufacturers, distributors, and users of solar-powered water purifiers to understand and comply with the relevant legal requirements to ensure the safe and lawful operation of these devices. Consulting with legal professionals or regulatory experts can help navigate the specific legal landscape in a given jurisdiction.

Cultural:

The cultural impact of solar-powered water purifiers can be significant in several ways. Solar-powered water purifiers can empower communities by providing a sustainable and independent source of clean water. This reduces the reliance on external aid or water sources, leading to self-sufficiency and a sense of ownership over their own resources. This empowerment can foster a culture of community resilience and problem-solving. The use of clean energy aligns with the growing global movement towards environmental sustainability and can influence cultural norms and behaviors towards more eco-friendly practices. This can lead to a shift in attitudes towards renewable energy adoption and environmental stewardship. The presence of solar-powered water purifiers can serve as a platform for educational outreach programs and awareness campaigns on water conservation and hygiene practices. Solar-powered water purifiers can have economic benefits for communities by reducing healthcare costs associated with waterborne diseases. Improved health and productivity resulting from access to clean water can lead to economic growth and poverty reduction. Additionally, the implementation and maintenance of solar-powered water purifiers can create employment opportunities, driving local economic development and contributing to the growth of the renewable energy industry. Overall, the cultural impact of solar-powered water purifiers can be transformative, promoting health, self-sufficiency, environmental consciousness, knowledge, and economic well-being within communities.

Table 6.1: SWOT analysis table

Strengths:	Weakness:
▪ The project will be used worldwide ▪ Empowering job in solar sector ▪ The power will have unparalleled access	▪ No individual owner ▪ Web based prototype ▪ Inability to operate due to bad weather
Opportunities:	**Threats:**
▪ Protect people from waterborne illness ▪ Urban growth ▪ Provide clean water	▪ Maintenance cost ▪ Insufficient data management ▪ Discontinuity of energy

Potential Strength:

The project can support sustainable development and promote a cleaner environment by making solar power the main source of energy for the water purifier. Utilizing solar energy lessens reliance on fossil fuels, which degrade the environment and are limited resources.In places with a lack of clean water, the initiative can offer access to safe and reasonably priced drinking water. This can aid in lowering the prevalence of water-borne illnesses, which pose a serious threat to global public health in many regions. The project may present chances for the expansion and development of the solar energy industry, resulting in the creation of jobs in a number of sectors, including production, installation, maintenance, and repair.

Tentative Weakness:

The presence of sunlight is necessary for the solar-powered water purifier to function. Poor weather, such as persistent rain, overcast skies, or even nighttime, might make the system ineffective. This restriction may lead to erratic access to a safe and economical water supply, particularly in the wetter months or where there is little natural light. There may be a lack of accountability in terms of system maintenance, repair, and replacement because the project lacks a specific owner. Additionally, especially in a communal environment, it could be challenging to manage and guarantee that the system is being used successfully. Because the prototype is web-based, it could need internet connectivity to function, which could restrict access in remote places.

Possible Opportunities:

A fundamental human right, access to safe drinking water is nevertheless denied to millions of people worldwide. Waterborne illnesses like cholera, typhoid, and dysentery are to blame for a large number of fatalities each year. Urban water resources are already under a lot of stress as a result of rapid urbanization, and this situation is only expected to get worse. The need for clean water rises as more people migrate into cities, placing stress on already-existing water treatment systems. The development of a solar-powered water purifier can offer a feasible and long-lasting solution to this issue, especially in places with poor access to electricity.

Tentative Threats:

Regular maintenance for solar-powered water purifiers includes cleaning the panels, monitoring the batteries, and making sure the filtration mechanism is working properly. System failure or decreased efficiency might occur if maintenance is neglected. The price of maintenance might be high, especially if specialist tools or knowledge are needed. If maintenance costs are not taken into account during the purifier's design and operation, it could put a strain on finances and force the project to be abandoned. A solar-powered water purifier needs to be operated and monitored with effective data management. This includes information on the production of energy, the quality of the water, and system performance. Inaccurate or inadequate information can result from improper data management, making it challenging to make decisions.

6.3 Evaluate the Sustainability

The designed system should be sustainable in terms of economics, social and the environment. And we can expect the system to have a long life of approximately 3–5 years if proper guidelines and methods are followed. We also need to develop the system so that it can provide pure water to consumers

1. Environmental Sustainability:

Our proposed solar water purifiers are totally environment friendly as they rely on renewable energy from the sun. This proposed design is also able to reduce the carbon footprint from the water filtration system by making use of solar energy in place of fossil fuels. On the other hand by efficiently filtering water using a solar powered filter the proposed project can reduce water waste. Also, filters can prevent contaminants and chemicals that may harm aquatic life from being released into the environment. This gives a brief idea on how environmental sustainability works in this project.

2. Economical Sustainability:

The main target audience of our project is the rural community and they will get hugely economic benefits through the solar water purifier as there is a lack of pure water in urban areas. Considering the low percentage of people able to afford pure water,we are trying to make it cost effective. As the filters do not require electricity or fuel there is a low maintenance. At the initial step the installation cost might be high but it will be beneficial for rural communities in the long run. On the other hand, the solar powered water filter is able to filter large amounts of water in a short time which will help in reducing time and resources to carry out water filtration and distribution.

3. Social Sustainability:

We believe that our project will benefit society. The waste water after filtering can be used for fish farming. Because high TDS is available from this water which is beneficial for fish farming. The proposed project is also able to increase access to safe drinking water in communities that lack access to clean water which can improve health outcomes, reduce the incidence of water-borne illnesses, and improve the quality of life for the people in those communities. Moreover it can create employment opportunities for individuals involved in the installation, maintenance, and distribution of the solar-powered water filter. This can help stimulate economic growth and development in communities.

6.4 Conclusion

The sustainability of a project is a critical factor in determining its effectiveness. It is not worth the time, energy, and resources to invest in something that will not endure. Similarly, we conducted a thorough analysis of our project to determine its level of sustainability. Fortunately, our project is highly sustainable in all three dimensions: social, economic, and ecological. This is because it would not have any negative environmental impacts. If the project goes as planned, this will be acknowledged and the general public will be able to ensure a pure and clean drinking water which will help to lead a healthy life with confidence.

Chapter 7: Engineering Project Management. [CO11, CO14]

7.1 Introduction

No individual can do the work required to turn a concept into a proposal and turn it into an actual product. It always takes the joint efforts of many brains to achieve what initially seemed unattainable. A team was needed to complete this technical mission. However, when working in groups, it is important to plan and lead the team. Without a good strategy, good management, and team direction, execution inconsistencies are bound to occur and ultimately lead to project failure. So we organized the assigned tasks, presented them on a Gantt chart, and sent them to all group members. This schedule was strictly adhered to throughout the project. However, our real life still has some ups and downs, so we may not have followed the project schedule correctly, but at least we tried to complete all tasks within the allotted time.

7.2 Define, plan and manage engineering project

Table 7.1: Tentative project plan of the final year design project

Tentative Project Plan			
EEE 400P			
Task	Start Date	End Date	Duration (Days)
Problem identification	26/01/23	13/02/23	18
Topic review and finalization	13/02/23	20/02/23	07
Concept note preparation	20/02/23	02/03/23	10
Project proposal report	03/03/23	14/04/23	41
EEE400D			
Task	Start Date	End Date	Duration (Days)
Analyzing different softwares	01/06/23	08/06/23	07
Started simulation using software (Proteus)	10/06/23	20/06/23	10
Preparation of draft report and progress presentation	24/06/23	04/07/23	14
Final report preparation	11/07/23	24/08/23	43

EEE 400C			
Task	Start Date	End Date	Duration (Days)
Selecting and testing components	08/10/23	18/10/23	10
Testing the system to match with outcome	18/10/23	11/11/23	24
Designing prototype	12/11/23	26/11/23	14
Project showcase preparation	30/11/23	14/12/23	14
Project final report	16/12/23	28/12/23	12

Gantt Chart:

Table 7.2: Gantt chart for EEE400P

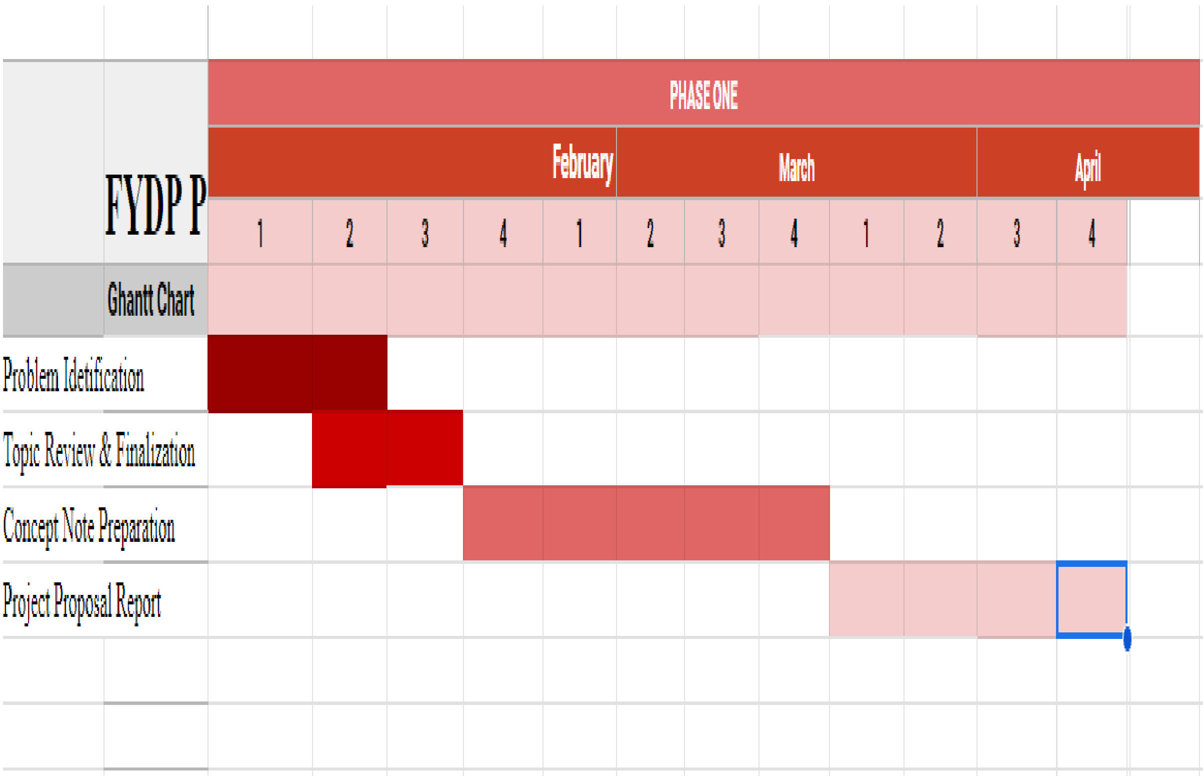


Table 7.3: Gantt chart for EEE400D

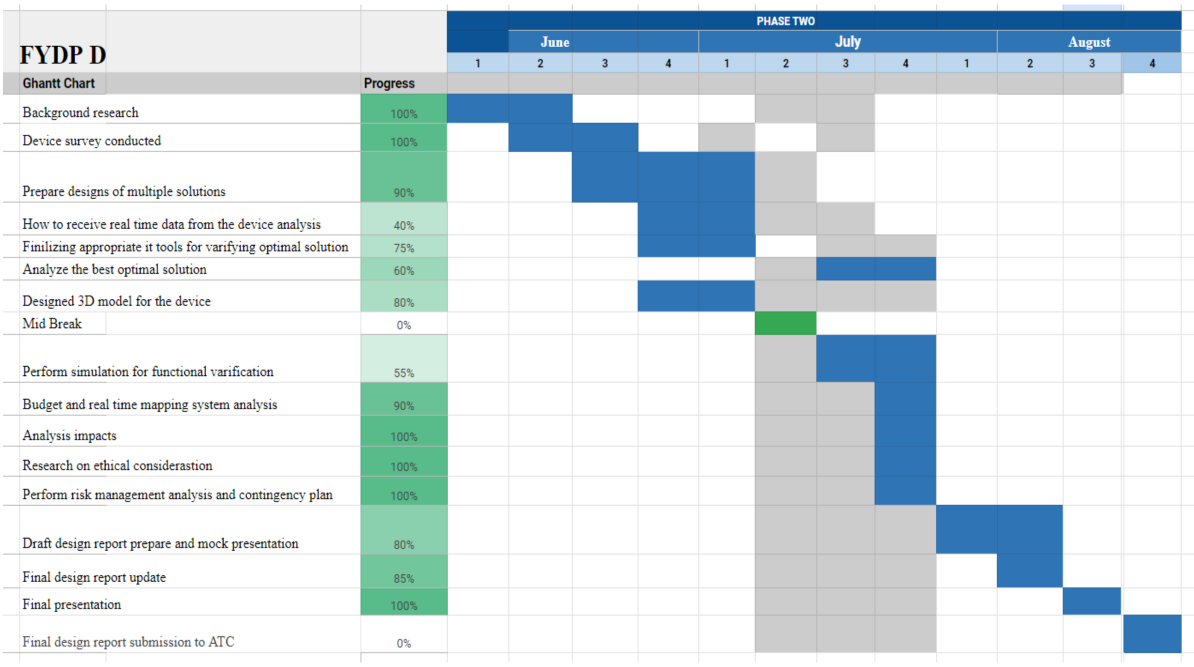
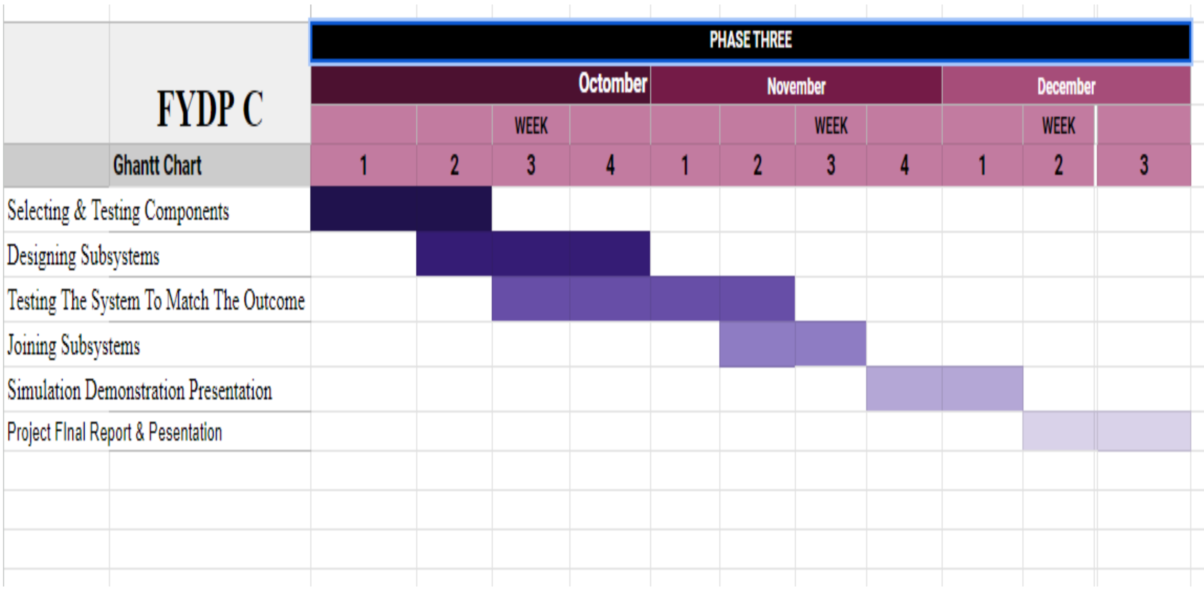


Table 7.4: Gantt chart for EEE400C



7.3 Evaluate project progress

Below is the progress status which has been followed throughout the semester, keeping in mind the timeframe of the final showcase

Table 7.5: Evaluation of the project progress

Date/Time/Place	Attendee	Summary of Meeting Minutes	Responsible	Comment by ATC
08.10.2023	1.Jeny 2. Anan 3. Rabby 4.Tanvir	Discussing optimal designs and preparation of workflow	Jeny, Tanvir	N/A
11.10.2023	1.Jeny 2. Anan 3. Rabby 4.Tanvir	Selection of components according to the requirements of our designs	Anan, Rabby	N/A
16.10.2023	1.Jeny 2. Anan 3. Rabby 4.Tanvir	Analyzing the components and preparing to assemble the whole design.	Jeny, Anan, Tanvir, Rabby	N/A
20.10.2023	1.Jeny 2. Anan 3. Rabby 4.Tanvir	Started designing the system	Jeny, Anan, Tanvir, Rabby	N/A
25.10.2023	1.Jeny 2. Anan 3. Rabby 4.Tanvir	Done proper testing to observe the required outcomes.	Jeny, Anan, Tanvir, Rabby	N/A
27.10.2023 - 1.11.2023	1.Jeny 2. Anan 3. Rabby 4.Tanvir	Preparation for the progress presentation.	Jeny, Anan, Tanvir, Rabby	N/A
3.11.2023 - 15.11.2023	1.Jeny 2. Anan 3. Rabby 4.Tanvir	Designing the prototype, discussing how to improve the project prototype and testing its viability	Jeny, Anan, Tanvir, Rabby	N/A
25.11.2023	1.Jeny 2. Anan 3. Rabby 4.Tanvir	Final testing of the designed prototype	Jeny, Anan, Rabby	N/A
5.12.2023	1.Jeny 2. Anan 3. Rabby 4.Tanvir	Poster preparation	Jeny, Rabby	N/A
10.12.2023	1.Jeny 2. Anan 3. Rabby 4.Tanvir	Discussion for the project showcase	Jeny, Anan, Tanvir, Rabby	N/A
14.12.2023	1.Jeny 2. Anan 3. Rabby 4.Tanvir	Final Project Showcase	Jeny, Anan, Tanvir, Rabby	N/A

7.4 Conclusion

The first step was to create a timeline chart, which included the tasks and the names of the individuals assigned to them. This was then discussed, agreed upon by each member, and distributed. The tasks outlined in EEE400P were easily completed in accordance with the timeline chart. The same was done in EEE400D, and the Gantt chart was distributed among all members. As long as the timeline chart was followed, everything proceeded in a systematic and orderly manner, as planned. The same scenario is being repeated in EEE400C in order to achieve similar satisfactory outcomes.

Chapter 8: Economical Analysis. [CO12]

8.1 Introduction

A project is only recognized by stakeholders, customers, investors, and everyone else when it turns out to be economically feasible. Since it is highly uncertain that anyone would want to waste time and resources on a project that would fail. Therefore, in order to ensure that a project concept is widely adopted, it must be profitable. When a project proposal is proposed, the implementation costs, necessary finance, and time period for realizing a return on investment must all be considered. It will need further investigation to prove the project's long-term sustainability. In our project of a water purification system through solar energy, the main idea is to promote the system through different sources to attract stakeholders and show how economically feasible the device is for consumers. After having the tentative cost of the project, it will attract a good number of investors, which will be needed in the coming times.

8.2 Economic analysis

One of the biggest challenges with a shift to renewable energy is the additional financial burden it creates compared to its current non-renewable counterpart. This is why motives should be created, such as promotion and other government support, which will be needed to encourage the move. Additionally, in order to be economically operational, our water purification system powered by solar energy needs to be very large. The larger the solar generation system, the more profitable it will be, including a quicker payback period. However, building a system of this scale presents challenges, even with a large number of participants, and the initial investment is a warning sign for new entrants. In an effort to reduce this initial investment, the profit margin will become negligible with a significantly longer payback period. As mentioned above, the government must promote solar water purification systems and create application processes to get this product to consumers by making the process simple and transparent. The government must ensure proper funding for this product, as initially the cost might be expensive as it's a new product. Therefore, we must keep in mind the demands of consumers and their right to purchase this product by reducing the budget.

8.3 Cost benefit analysis

The cost benefit analysis has been conducted in terms of designing the system before making the prototype of the water purification system through solar energy as well as the hardware prototype that has been developed. Cost benefit analysis mainly focuses on how much the system will cost and whether it will be beneficial to consumers as the price of the device is fixed. So the analysis gives a brief understanding of the cost and whether it will be beneficial or not. The cost analysis from economic aspects is elaborated in the following:

The tentative budget of the optimum design before making it as a prototype. In these few components, price tags were estimated as they were taken from different sources. The price even varies if it is mass produced in factories because the raw materials will be in large numbers.

Table 8.1: Initial budget for the project

Components	Price
• Mini Solar Cell 4 piece	280*4 = 1120 Taka
• Arduino Nano	590 Taka
• Reverse Osmosis Membrane	3000 Taka
• Battery 12V Rechargeable	830 Taka
• Charger for Battery	600 Taka
• Turbidity Sensor	1400 Taka
• pH Sensor (Analog)	2499 Taka
• Tank (20 Liter)	600 Taka
	Total= 12939 Taka

In the initial budget, it is mentioned that all the necessary components play a significant role in solar powered reverse osmosis filtration systems. Also, there are some high quality batteries and solar panels, which are mostly costly and aren't available in Bangladesh and, as a result, need to be imported, making the product costly. We've thoroughly considered various factors, such as solar panel and battery availability, in crafting the ultimate prototype design.

Table 8.2: Cost of the prototype

SOLAR-POWERED REVERSE OSMOSIS WATER PURIFIER - BILL OF MATERIALS							
Segment	**Product/ Component Name**	**Specifications / Details**	**Material**	**Quantity/ Set**	**Unit Price**	**Total Price**	**Grand Total Cost**
Water Filtration System	RO Water Purifier	75 GPD		1	9500	9500	**22620**
	Solenoid Valve	24V		1	500	500	
						10000	
Water Reservoir, Pump, Accessories	DC Water Pump	12V - 2A		1	800	800	
	Flex Pipe	Black-6 feet		6	20	120	
	25 Liter Water Drum	Source Tank		1	400	400	
	10 Liter Water Container	Waste Water Tank		1	350	350	
	Ballast weight	24mm SS 316 Nut	SS 316	1	100	100	
	12-6mm reducer			1	40	40	

	Pipe Clamp			2	25	50	
						1860	
Structure and Fasteners	Structural Frame	40ft	3/4" MS Box Channel	1	1500	1500	
	Frame Fabrication Charge	Cutting, welding, powder coating		1	2000	2000	
	Fastener Set	Screws, Nuts, Washers and wheels		1	400	400	
	Cable Tie	Black		30	1	30	
						3930	
Solar Power System	Solar Panel	12V - 50 Watt		50	37	1850	
	Solar Battery	12V - 9AH		2	700	1400	
	Solar Charge Controller	10A		1	500	500	
	Solar Panel Cable	70/76 Gauge (03 yards)		3	120	360	

						4110	
Electronics and Wiring	150W Boost Converter	12-32V to 12-35V		1	420	420	
	Electrical Wire	White, 10ft		1	300	300	
	Cable Lugs	Lugs and battery jacks		1	100	100	
	LCD Display			1	150	150	
	Circuit Board and components	Arduino Nano, LM-2596, Connectors		1	600	600	
	Ultrasonic Sensor	Sensor, holder, 3D printed mount		1	300	300	
	Float Switch	Sealed with sealant		1	500	500	
	Relay Module	Single Channel, Dual Channel		1	350	350	
						2720	

8.4 Evaluate Economic and Financial Aspects

According to the given budget and project specifications, there is a clear opportunity to expand the market for solar powered water purifiers in Bangladesh at a low cost. To determine the demand for reasonably priced, safe water in the chosen area,we need to do a market analysis. Also determine rivals and prospective partners. Take into account the locals' willingness and capacity to pay for clean water.

By determining the cost of carrying on with the operations, accounting for component replacement, maintenance, and oversight. We must Consider the energy expenditures related to solar panel maintenance and water filtration. When evaluating the project's societal impact, we take into account improved health outcomes, reduced rates of waterborne illnesses, and increased access to safe drinking water.

We looked into any potential cultural or sociological barriers that would prevent the technology from being adopted. Bangladesh's main energy source is natural gas, which makes up 46.5% of the country's energy mix, whereas solar power barely makes up 1.84%. Because natural gas could be obtained from Bangladesh's reserves, it was initially the most affordable alternative. We also determined the project's anticipated return on investment, which will make the solar-powered water purifier's financial viability more understandable to stakeholders and investors. We also evaluated the project's long-term viability, which must be able to take into account the technology's scalability, societal acceptability, and environmental impact. Moreover, the inclusion of an extra backup system significantly enhances its performance and helps to achieve the primary objectives of this project.

8.5 Conclusion

Creating a solar-powered water purifier for a cost-effective and safe water source might be a worthwhile and profitable endeavor. Together with the project's possible risks and uncertainties, the economic and financial analysis should take into account the project's expenses and benefits. The project's up-front costs will pay for the costs of materials and production, marketing and distribution, and R&D. The ongoing costs will include maintenance, repairs, filter replacements, and other component replacements. Apart from reducing the quantity of illnesses caused by water, the project will help people who don't currently have access to pure and safe drinking water. The initiative might create jobs and strengthen the local economy. Implementing the solar-powered water purification project can boost local economies by generating employment possibilities for the system's manufacture, installation, and maintenance. This beneficial economic effect may go beyond the project's immediate boundaries.
A few particular elements to take into account in the economic analysis are

- The price of solar panels and additional parts.
- The price of supplies and labor.
- The price of marketing and distribution.
- The product's prospective market.

Chapter 9: Ethics and Professional Responsibilities CO13, CO2

9.1 Introduction

Ethics in project management is based on the principles of integrity, transparency, and accountability throughout the project lifecycle. Ethical decision-making during the project development process ensures that the choices made are in the best interest of all stakeholders rather than just the individual. Using ethical standards in project management promotes trust, maintains reputation, and assists in achieving project goals. By working ethically, sharing responsibilities, and fulfilling those responsibilities as professionals, it will significantly reduce the risk of conflict of interest among individuals by prioritizing the interests of stakeholders. With all of these lessons learned, we did our share of ethical and shared responsibilities as professionals throughout the project development process. Most importantly, we never missed an opportunity to give credibility to the sources we used to achieve an honorable result for our project.

9.2 Identify ethical issues and professional responsibility

When the project is carried out, the idea that the solar panel is the primary component will turn out to be the component that costs the most. Consequently, searching for ways to decrease the expense of execution is a typical plan. As indicated by the possibility of the task, the ideal interest group being the middle to lower income individuals, they don't have the idea of purifying water through a reverse osmosis system with the help of solar energy. Therefore, it will unquestionably be unethical to deceive them using inexpensive panels, elements, and devices. First of all, they should be properly trained to utilize this product, and we must take steps to prepare tutorial sessions in order to gain a better understanding of the product. To avoid misunderstandings during the delivery of the final product, the responsibilities must be divided professionally. For instance, the budget plan distribution can be somebody's liability, and the tutorial session to adapt the clients could be the duty of another person. It must be guaranteed that each task must be divided equally and informed of each other so as to avoid miscommunication and carelessness of any sort. A little misinterpretation can result in ruining the project. Besides, for the establishment of solar panels and their execution, a high spending plan is required. So alongside government appropriations, there will be enormous and limited scope ventures by the inhabitants. It is essential to guarantee not to isolate the scale and huge scope of financial backers and to give them equivalent significance no matter what their likely impact, as this will be the ethical thing to do. Finding enough land is essential for installing the solar panel. After effectively finding it, we need to ensure that we get the land proprietor's permission prior to beginning the work. Finally, the motive of getting pure water must be ensured, as this is our agenda. We have to make sure that the proper installation of batteries, solar panels, a reverse osmosis system, and sensors is done. If installments of machines aren’t properly done, this will make the goal of our project indistinct and will be equivalent to cheating.

9.3 Apply ethical issues and professional responsibility

Creating a solar-powered water purifier to provide a cheap and safe source of water is a great idea that meets a pressing need. But, for the whole project lifecycle, it is crucial to keep professional obligations and ethical concerns in mind. These are some important things to remember:

Effect on the Environment:

Ethical Consideration**:** Make sure the solar-powered water purifier's materials are sustainable and kind to the environment.

Professional Responsibilities: Carry out a comprehensive environmental impact evaluation and select materials and production techniques that reduce environmental impact.

Equity and Access:

Ethical Consideration**:** Make sure that the water purifier's advantages are shared fairly and take disadvantaged or marginalized communities' needs into account.

Professional Responsibilities: Build the system with inclusivity in mind, taking into account things like pricing and accessibility for every community member.

Openness and Responsibility:

Ethical Consideration: Give accurate and frank information about the solar-powered water purifier's features, limits, and potential hazards.

Professional Responsibility: Provide systems for continuing observation and assessment, and take responsibility for the effectiveness and effects of the water purifier.

Extended Durability:

Ethical Consideration: Make sure the community has the resources necessary to maintain and repair the solar-powered water purifier and that it is built with long-term sustainability in mind.

Professional Responsibility: Take into account the end-of-life disposal of the purifier's component parts and train and assist the nearby communities with maintenance.
It is essential to use wires and cables that are the right size to avoid overheating. Fuse and circuit breakers are essentially used to keep the PV system wiring from overheating and catching fire. Appliances are also protected from energy by them. Furthermore, in this case,

lightning arresters should be installed to protect the generation panel because solar panels are known to be more susceptible to lightning damage.

9.4 Conclusion

The creation of a solar-powered water purifier requires a strong dedication to moral standards and professional obligations in order to provide a reliable and reasonably priced water supply. This project offers a chance to demonstrate careful and responsible procedures throughout its whole lifecycle, in addition to providing a technological answer to an urgent global issue. The ethical issues cover a wide range of topics, including equity, cultural sensitivity, community involvement, and environmental effects. The project can meet ethical norms and improve community well-being by using eco-friendly materials, including the local community in decision-making, providing equal access, taking cultural nuances into consideration, and placing a high priority on data protection. Professionalism has an equally important role in guaranteeing the longevity and prosperity of the solar-powered water purifier. This calls for open communication, taking responsibility for the system's operation, and putting in place systems for continuing observation and assessment. Fostering long-term sustainability also necessitates building a robust system and giving local communities the assistance and training they need to maintain and repair the technology. The project becomes a model for responsible and sustainable technology development by incorporating these ethical considerations and professional duties into every stage of the project. In the end, the solar-powered water purifier's success will be determined by its positive effects on the community as well as its technological effectiveness, all while adhering to professional duty and ethical standards. This strategy makes sure that the technology's advantages are achieved without sacrificing the dignity, autonomy, or well-being of the people it is meant to help.

Chapter 10: Conclusion and Future Work.

10.1 Project Summary/Conclusion

The project is a solar power water purifier for safe and affordable water supplies. The first initiative of this project is to supply clean drinking water, and the second concern is to remove the dependency on electricity for which the solar connection is given to the system. And finally, the device is portable so that it can serve in different places according to demand. The water purifier employs reverse osmosis as the primary purification method. This process involves the use of a semi-permeable membrane to selectively remove contaminants, bacteria, and other impurities from the water, ensuring a high level of water quality. An essential goal of the project is to develop a water purifier that is economically accessible to a broad range of communities. The project emphasizes the delivery of safe and clean drinking water to address public health concerns. The use of reverse osmosis ensures the removal of harmful substances, providing a reliable source of potable water that positively impacts community health. By utilizing solar energy and optimizing the design, the team aims to reduce operational costs and make the technology more affordable for various socio-economic groups. In our project, we focus on some specific areas and places to use this device where the sun gets enough sunlight. Solar water purifiers are particularly useful in regions with high solar radiation, such as arid and semi-arid areas. However, they may not be as effective in areas with low solar radiation or cloudy weather. It can be a ship, a yard, a picnic spot, or any open yard. It can also help reduce the dependency on electricity and lower its cost for long term uses. As it is a portable device, we can move it and place it according to its needs. Throughout the project, community engagement is a key focus. Moreover, the team collaborates with local communities to understand their specific water needs, incorporate feedback, and tailor the technology to suit local conditions, ensuring the project's relevance and sustainability. Besides, we also use some sensors to automate the system for some purposes. Basically, it's a prototype of a solar power water purification system. That's why there are some issues as well, but we will work on these issues further to overcome them and build them into a commercial device. Additionally, the initial cost of installing a solar water purifier can be high, which may limit its accessibility for some communities.

10.2 Future Work

The purpose of this project is to provide safe water without relying on electricity. The project was designed in that way. It does not require power plant electricity supply. The sunlight is the source of power for this project, as we used a solar panel. In this project, we add different types of sensors and pumps for running and functioning the device properly, but in the future, we have some different plans for the project. In this project, the solar panel is not automated, but in the future, we plan to make it automated with respect to the sunlight. As the sunlight is not always fixed to a certain place, we need to move it manually, but if we can automate it, then we don't need any manual help. Another plan is to connect the device to our mobile or laptop to send notifications of its maintenance. We are planning to develop an app for this purpose. The app will notify us about the water level, quality, validity of the parts, and other relevant information. Means that without seeing the device, we can get all its information easily through this app. And finally, we planned to add a ph sensor to the reserve tank to measure the water ph balance. Normally, ph sensors are not waterproof, so we cannot place them in the water, but we planned to connect them in a different way so that they can fully fill the target and remain safe from damage. Till now, we have planned this fact for the future, but if we get any new ideas to implement with this device, we will definitely work on it further. Basically, our target is to make it as professional as possible for commercial use.

In the near future, we'll add RFID (Radio-Frequency identification) system for consumer benefit so that we can earn revenue.

Chapter 11: Identification of Complex Engineering Problems and Activities.

The planned project included a few complicated engineering activities and was affected by a variety of factors, including competing demands for resources and analyses, creativity, adherence to codes and laws, and more. A number of these factors have been identified and are described in detail below.

11.1: Identify the Attribute of Complex Engineering Problem (EP)

Attributes of Complex Engineering Problems (EP)

Table 11.1: Selection of attributes of complex engineering problem for our project

	Attributes	Put tick (√) as appropriate
P1	The depth of knowledge required	√
P2	Range of conflicting requirements	
P3	The depth of analysis required	√
P4	Familiarity of issues	√
P5	Extent of applicable codes	
P6	The extent of stakeholder involvement and needs	√
P7	Interdependence	

11.2: Provide Reasoning How the Project Addresses the Selected Attribute (EP)

P1. Depth of knowledge required: To execute the solution, we require considerable coding knowledge as well as an in-depth understanding of various electrical components. For example, operating a microcontroller to run the system requires detailed knowledge of embedded programming languages. The hardware prototype implementation also requires expertise in selecting which component will be suitable, which coding software needs to be used, etc.

P3. Depth of analysis required: Depth of analysis is required for optimal design solutions. We must be able to conduct enough analysis and be able to select the optimal solution among the alternate design approaches for the project.

P4. Familiarity of issues: This problem is a complex engineering problem and is not like the problems we solved for our course curriculum. In a country like Bangladesh, people are often deprived of pure drinking water, especially in urban areas, and as a result, they suffer from various diseases. Our project ensures that people of all ages and mediums can enjoy a healthy lifestyle and stay away from diseases.

P6. Extent of stakeholder involvement and needs: The needs of different stakeholders like users, students, and common individuals. As the project is mainly designed for the general public, we must make sure to inform a large number of consumers about the project.

11.3 Identify The Attribute of Complex Engineering Activities (EA)

Attributes of Complex Engineering Activities (EA)

Table 11.2: Selection of attributes of complex engineering activities for our project

	Attributes	Put tick (√) as appropriate
A1	Range of resource	√
A2	Level of interaction	√
A3	Innovation	
A4	Consequences for society and the environment	√
A5	Familiarity	√

11.4 Provide reasoning how the project addresses the selected attribute (EA)

A1. Range of resources: A wide range of resources are needed for the implementation of this project, such as budget, equipment, technology, and materials. And resource management skills. A project requires many resources to run properly. These resources will help us easily construct the prototype of the project and also provide new information about it.

A2. Level of interaction: Information and comments must be exchanged with many parties. Additionally, we must reconcile requirements that clash. As this device is intended for the general public, we need to make sure to interact with as many people as we can to know how we can improve and meet the demands. Moreover, by doing a survey, it will be beneficial for us to know their demands, what will be good for them, and how to overcome the improvements.

A3. Consequences for society and the environment: Effectively evaluate the impact of the project in societal, health, safety, legal, and cultural contexts. Before designing a project, we must remember that we must conduct an analysis of the project from a social and environmental perspective. For example, will the device be harmful to the environment or will it have a social impact? We need to ensure that.

A4. Familiarity: Some of the contents and technical details of this problem are unfamiliar to the students. While designing, simulating, or assembling devices, we discover that there are some areas with which we are not familiar. These things help us gain knowledge about them, and a review of the literature has been done on these topics.

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Appendix

Logbook

FYDP-P Logbook

Date/Time /Place	Attendee	Summary of Meeting Minutes	Responsible	Comment by ATC
09.02.2023	1.Jeny 2.Anan 3.Tanvir	1. Discussed ideas 2. Showed some topics	Anan, Jeny, Rabby, Tanvir	An Introductory Meeting with ATC
13.02.2023 Messenger call	1.Jeny 2. Anan 3. Rabby 4.Tanvir	1. Research topics which can be finished in a year 2. Go through some research papers	Anan, Jeny, Rabby, Tanvir	No meeting with ATC
15.02.2023 Atc Meeting	1.Jeny 2.Anan 3.Tanvir	1. One year time 2. Three alternative design Software simulation is possible or not.	Anan, Jeny, Rabby, Tanvir	1. New topic 2. Find some research paper related to this 3. You have to complete in one year
20.02.2023 Atc Meeting	1.Jeny 2.Anan 3.Tanvir	1. Approval of our topic	Anan, Jeny, Rabby, Tanvir	1. You have to complete it in one year 2. Find proper simulation software
21.02.2023 Messenger call	Anan, Jeny, Rabby, Tanvir	1. Search complex engineering problems. 2. Search research papers	Anan, Jeny, Rabby, Tanvir	No meeting
22.02.2023 Atc Meeting	Jeny,Tanvir	1. Draft concept note sample check 2. Ideas to fulfill the requirements 3..Must maintain CO outcomes 4.Reference according to IEEE format	Anan, Jeny, Rabby, Tanvir	1.You have to do according to the format 2. You have to follow all suggestions provided
24.02.2023 Messenger call	Anan, Jeny, Rabby,	1. Gathering information about draft concept note	Anan, Jeny, Rabby, Tanvir	N/A

	Tanvir	2. Multiple design approach 3. Objectives		
25.02.23 Messenger call	Anan, Jeny, Rabby, Tanvir	1. Specifications, requirements and constraints. 2. Conclusion	Anan, Jeny, Rabby, Tanvir	N/A
26.02.23 Messenger call	Anan, Jeny, Rabby, Tanvir	1. Started writing of draft concept note	Anan, Jeny, Rabby, Tanvir	N/A
28.02.23 Google Meet	Anan, Jeny, Rabby, Tanvir	1. Making of slides for concept note for progress presentation	Anan, Jeny, Rabby, Tanvir	N/A
1.03.2023 Google Meet	Anan, Jeny, Rabby, Tanvir	1. Rehearsal for presentation 2. Revising our concept note	Anan, Jeny, Rabby, Tanvir	N/A
20.03.2023	Anan	1. Discussion on how to write the project proposal paper	Anan, Jeny, Rabby, Tanvir	1.Follow the sample provided
24.03.2023 Google Meet	Anan, Jeny, Rabby, Tanvir	1. Started working on project proposal paper 2.Problem statement 3.Objectives 4. Requirements and constraints	Jeny, Rabby	N/A
25.03.2023 Google Meet	Anan, Jeny, Rabby, Tanvir	1. Continuation of project proposal paper 2. Multiple design approaches 3. Methodology 4. Impact 5. Budget	Anan, Tanvir	N/A
31.03.2023 Google Meet	Anan, Jeny, Rabby, Tanvir	1. Started working on slide for mock presentation 2.Taking ideas from our workings of project proposal 3. Inputting bullet points 4. Making gantt chart	Anan, Jeny, Rabby, Tanvir	N/A
6.04.2023 Atc Meeting	Anan, Jeny, Rabby, Tanvir	Mock presentation	Anan, Jeny, Rabby, Tanvir	1. Change the background of the slide 2. Change the font size 3. Work on design 4. Use bullet points

FYDP-D Logbook

Date/Time/Place	Attendee	Summary of Meeting Minutes	Responsible	Comment by ATC
1.06.2023	1.Jeny 2.Anan 3.Tanvir	Ideas to implement software design	Jeny, Anan, Tanvir, Rabby	Implement software simulation and find out the optimum solution for our project.
4.06.2023	1.Jeny 2. Anan 3. Rabby 4.Tanvir	Discussed preliminary design of multiple engineering solutions.	Jeny, Anan, Tanvir, Rabby	N/A
10.06.2023	1.Jeny 2. Anan 3. Rabby 4.Tanvir	Selected tools to design and analyze solutions.	Anan, Rabby	N/A
2.07.2023 - 5.07.2023	1.Jeny 2. Anan 3. Rabby 4.Tanvir	1. Progress Presentation Slide Preparation 2. Making Slides and Fulfilling and PO	Jeny, Anan, Tanvir, Rabby	N/A
11.07.2023	1.Jeny 2. Anan 3. Rabby 4.Tanvir	Simulated first approach	Anan, Rabby	N/A
20.07.2023	1.Jeny 2. Anan 3. Rabby 4.Tanvir	Simulated second approach	Anan, Rabby	N/A
23.07.2023	1.Jeny 2. Anan 3. Rabby 4.Tanvir	Background Research and Survey Finalization for report writing	Jeny	N/A
25.07.2023	1.Jeny 2. Anan 3. Rabby 4.Tanvir	Identified ethical issues and professional responsibilities for report writing	Jeny	N/A
31.07.2023	1.Jeny 2. Anan 3. Rabby 4.Tanvir	1. Budget 2. Adjustment of Project Plan 3. Risk Management 4. Contingency Plan for report writing	Jeny, Rabby	N/A
17.08.2023-20.08.2023	1.Jeny 2. Anan	Preparing slides for final presentation	Jeny, Anan, Tanvir, Rabby	N/A

	3. Rabby 4.Tanvir			
21.08.2023	1.Jeny 2. Anan 3. Rabby 4.Tanvir	Showed the final presentation slides to ATC	Jeny, Anan, Tanvir, Rabby	Add videos to slide
23.08.2023	1.Jeny 2. Anan 3. Rabby 4.Tanvir	Showed the final presentation slides to ATC	Jeny, Anan, Tanvir, Rabby	N/A
28.08.2023	1.Jeny 2. Anan 3. Rabby 4.Tanvir	1. Analyze the Multiple Design Solutions to find the Optimal Solution 2. Proper Referencing for report writing	Anan Rabby	N/A
30.08.2023	1.Jeny 2. Anan 3. Rabby 4.Tanvir	1. Report Summary 2. Improving Design Report for report writing	Jeny, Tanvir	N/A
31.08.2023	1.Jeny 2. Anan 3. Rabby 4.Tanvir	Finalization of Design Report	Jeny, Anan, Tanvir, Rabby	N/A

FYDP-C Logbook

Date/Time/Place	Attendee	Summary of Meeting Minutes	Responsible	Comment by ATC
08.10.2023	1.Jeny 2. Anan 3. Rabby 4.Tanvir	Discussing optimal designs and preparation of workflow	Jeny, Tanvir	N/A
11.10.2023	1.Jeny 2. Anan 3. Rabby 4.Tanvir	Selection of components according to the requirements of our designs	Anan, Rabby	N/A
16.10.2023	1.Jeny 2. Anan 3. Rabby 4.Tanvir	Analyzing the components and preparing to assemble the whole design.	Jeny, Anan, Tanvir, Rabby	N/A
20.10.2023	1.Jeny 2. Anan 3. Rabby 4.Tanvir	Started designing the system	Jeny, Anan, Tanvir, Rabby	N/A
25.10.2023	1.Jeny 2. Anan 3. Rabby 4.Tanvir	Done proper testing to observe the required outcomes.	Jeny, Anan, Tanvir, Rabby	N/A
27.10.2023 -	1.Jeny	Preparation for	Jeny, Anan, Tanvir,	N/A

1.11.2023	2. Anan 3. Rabby 4.Tanvir	progress presentation.	Rabby	
3.11.2023 - 15.11.2023	1.Jeny 2. Anan 3. Rabby 4.Tanvir	Designing the prototype and discussing how to improve the project prototype and testing its viability	Jeny, Anan, Tanvir, Rabby	N/A
25.11.2023	1.Jeny 2. Anan 3. Rabby 4.Tanvir	Final testing of the designed prototype	Jeny	N/A
5.12.2023	1.Jeny 2. Anan 3. Rabby 4.Tanvir	Poster preparation	Jeny, Rabby	N/A
10.12.2023	1.Jeny 2. Anan 3. Rabby 4.Tanvir	Discussion for the project showcase	Jeny, Anan, Tanvir, Rabby	N/A
14.12.2023	1.Jeny 2. Anan 3. Rabby 4.Tanvir	Final Project Showcase	Jeny, Anan, Tanvir, Rabby	N/A
16.12.2023 - 26.12.2023	1.Jeny 2. Anan 3. Rabby 4.Tanvir	Discussion of final report writing according to given format	Jeny, Anan, Tanvir, Rabby	N/A

Related Code :

Code for the system :

```
int MotorRelay = A0;
int TapRelay = A2;
int FloatSwitch = 12;
float distance = 0;
#include <LCD_I2C.h>
LCD_I2C lcd(0x27, 16, 2); // Default address of most PCF8574 modules, change according
#include <HCSR04.h>
UltraSonicDistanceSensor distanceSensor(9, 10);
void setup()
{
  lcd.begin(); // If you are using more I2C devices using the Wire library use lcd.begin(false)
  lcd.backlight();
  pinMode(MotorRelay, OUTPUT);
  pinMode(TapRelay, OUTPUT);
      pinMode(FloatSwitch, INPUT_PULLUP);
  digitalWrite(MotorRelay, HIGH);
  digitalWrite(TapRelay, HIGH);
  lcd.setCursor(0, 0); // Or setting the cursor in the desired position.
  lcd.print(" Solar Powered");
  lcd.setCursor(0, 1); // Or setting the cursor in the desired position.
  lcd.print("   RO Filter");
  delay(4000);
  lcd.clear();
}
void loop()
{
distance = distanceSensor.measureDistanceCm();
```

```
 if(distance > -1 && distance <= 17)
{     digitalWrite(TapRelay, LOW);
      lcd.clear();
      lcd.setCursor(0, 0); // Or setting the cursor in the desired position.
lcd.print("Tap  is open.");
lcd.setCursor(0, 1); // Or setting the cursor in the desired position
lcd.print("Collect Water...");
}
else
{
 digitalWrite(TapRelay, HIGH);
if(digitalRead(FloatSwitch) == 0)
{
 lcd.clear();
lcd.setCursor(0, 0); // Or setting the cursor in the desired position.
lcd.print(" State: Normal");
lcd.setCursor(0, 1); // Or setting the cursor in the desired position.
lcd.print("BRAC University");
digitalWrite(MotorRelay, LOW);
}
else
{
lcd.clear();
lcd.setCursor(0, 0); // Or setting the cursor in the desired position.
lcd.print(" Warning! Inlet");
lcd.setCursor(0, 1); // Or setting the cursor in the desired position.
```

```
lcd.print("tank is empty!!!");
digitalWrite(MotorRelay, HIGH);
}
}
// lcd.setCursor(0, 0); // Or setting the cursor in the desired position.
// lcd.print(distance);
 delay(100);
}
```