UNIVERSITI MALAYSIA PAHANG

DECLARATION OF THESIS AND COPYRIGHT

Author's Full Name	:	AFYQ RUKAINI BIN MOHD RUZAINI
Date of Birth	:	
Title	:	Internet of Things Solar Irrigation System
Academic Session	:	2021/2022

I declare that this thesis is classified as:

☐ CONFIDENTIAL		(Contains confidential information under the Official Secret Act 1997)*
☐ RESTRICTED		(Contains restricted information as specified by the organization where research was done)*
☐ OPEN ACCESS		I agree that my thesis to be published as online open access (Full Text)

I acknowledge that Universiti Malaysia Pahang reserves the following rights:

1. The Thesis is the Property of Universiti Malaysia Pahang
2. The Library of Universiti Malaysia Pahang has the right to make copies of the thesis for the purpose of research only.
3. The Library has the right to make copies of the thesis for academic exchange.

Certified by:

____
(Student's Signature)

____
New IC/Passport Number
Date:

____
(Supervisor's Signature)

Ts. Dr. ROSHAHLIZA M RAMLI
Name of Supervisor
Date: 18 FEBRUARY 2022

NOTE : * If the thesis is CONFIDENTIAL or RESTRICTED, please attach a thesis declaration letter.

THESIS DECLARATION LETTER (OPTIONAL)

Librarian,
Perpustakaan Universiti Malaysia Pahang,
Universiti Malaysia Pahang,
Lebuhraya Tun Razak,
26300, Gambang, Kuantan.

Dear Sir,

CLASSIFICATION OF THESIS AS RESTRICTED

Please be informed that the following thesis is classified as RESTRICTED for a period of three (3) years from the date of this letter. The reasons for this classification are as listed below.

Author's Name	AFYQ RUKAINI BIN MOHD RUZAINI
Thesis Title	Internet of Things Solar Irrigation System
Reasons	(i)
	(ii)
	(iii)

Thank you.

Yours faithfully,

____
(Supervisor's Signature)

Date: 18 FEBRUARY 2022

Stamp: TS. DR. ROSHAHLIZA BINTI M RAMLI
PENSYARAH KANAN
FAKULTI TEKNOLOGI KEJURUTERAAN ELEKTRIK DAN ELEKTRONIK
UNIVERSITI MALAYSIA PAHANG
26600 PEKAN, PAHANG

Note: This letter should be written by the supervisor, addressed to the Librarian, *Perpustakaan Universiti Malaysia Pahang* with its copy attached to the thesis.

SUPERVISOR'S DECLARATION

We hereby declare that We have checked this thesis and in our opinion, this thesis is adequate in terms of scope and quality for the award of the degree of Bachelor of Engineering Technology (Electrical) With Hons...............................

____

(Supervisor's Signature)

Full Name : DR. ROSHAHLIZA BT M RAMLI

Position : LECTURER, FACULTY OF ENGINEERING TECHNOLOGY, UNIVERSITI MALAYSIA PAHANG

Date : 18 FEBRUARY 2022

____

(Co-supervisor's Signature)

Full Name :

Position :

Date :

STUDENT'S DECLARATION

I hereby declare that the work in this thesis is based on my original work except for quotations and citations which have been duly acknowledged. I also declare that it has not been previously or concurrently submitted for any other degree at Universiti Malaysia Pahang or any other institutions.

____

(Student's Signature)

Full Name : AFYQ RUKAINI BIN MOHD RUZAINI

ID Number : TB18050

Date :

INTERNET OF THINGS SOLAR IRRIGATION SYSTEM

AFYQ RUKAINI BIN MOHD RUZAINI

Thesis submitted in fulfillment of the requirements
for the award of the Bachelor of Engineering Technology

Faculty of Electrical & Electronics Engineering Technology
UNIVERSITI MALAYSIA PAHANG

DECEMBER 2021

ACKNOWLEDGEMENTS

I am deeply grateful to ALLAH "SWT" for providing me with the insight, strength, patience, and aid I needed to accomplish my project job. This study would not have been completed if it had not been for His will and favors.

This dissertation would not have been possible without the guidance and assistance of a number of people who contributed and extended their valuable assistance in the preparation and completion of this study. I am grateful to my supervisor, Dr Roshahliza binti M Ramli, for his patience, advice, comments, stimulating suggestions, and encouragement throughout the research, writing of this thesis, and project work.

I would also like to thank the laboratory staff for providing materials and technical assistance to help me finish the project. I am grateful for all of the direction, commitment, and collaboration for my senior design project, as well as their unwavering efforts in performing experiments and testing for the project.

Furthermore, I am grateful for the excellent collaboration with my groupmates, Muhammad Hadi Bin Zainal, Masturah Binti Hassan, Ahmad Nazmi Bin Zakaria and Manirah Binti Mohammad Masom, during this project. I'd also want to thank them for their excellent effort in completing this job as a whole.

Last but not least, I would like to express my heartfelt gratitude to my family members, particularly my dear parents, Mr Mohd Ruzaini Bin Mohd Sani and Mrs Azliza Binti Abdul Aziz, for their unending prayers, unwavering support, love, counsel, and trust during my studies. Their support gave me the strength to persevere despite all of the obstacles in completing my research and thesis. Not to mention all of my friends who are working with me to complete the project and thesis in order to acquire a degree.

ABSTRAK

Tesis ini membincangkan kemajuan sistem pengairan solar mudah alih Internet of Things (IoT) yang didayakan. Matlamat utama projek ini adalah untuk dapat memantau dan menguruskan air melalui wifi sambil menerima kuasa dari panel solar. Tambahan pula, pam air boleh meningkatkan kadar aliran dan tekanan air. Banyak Penjanaan Kuasa atau Loji Kuasa, sebagai contoh, menggunakan gas asli untuk mencipta tenaga. Akibatnya, untuk mengurangkan kebergantungan kita kepada gas asli, kita boleh beralih kepada sumber tenaga lain seperti tenaga suria. Tambahan pula, tenaga alternatif ini tidak mempunyai kesan alam sekitar yang negatif. Buruh manusia sering digunakan dalam sistem pengairan. Akibatnya, upah buruh dan pekerja sangat tinggi. Air adalah keutamaan penting bagi pengguna. Air digunakan untuk banyak hal, termasuk minuman, mandi, dan mencuci. Selain itu, air adalah penting untuk menyiram tumbuhan kerana ia boleh menyuburkannya. Walau bagaimanapun, peralatan pengairan ramai orang tidak cekap. Ini kerana pengairan kini bergantung kepada usaha manusia. Pam air boleh menapis air takungan ke dalam air bersih yang boleh diminum oleh manusia secara tetap.

ABSTRACT

This thesis discusses the advancement of Internet of Things (IoT)-enabled portable solar irrigation systems. The major goal of this project is to be able to monitor and manage the waterpump through wifi while also receiving power from the solar panel. Furthermore, the water pump may increase the flow rate and pressure of the water. Many Power Generation or Power Plants, for example, use natural gas to create energy. As a result, in order to lessen our dependency on natural gas, we may turn to other energy sources such as solar energy. Furthermore, this alternative energy has no negative environmental consequences. Human labour is often used in the irrigation system. As a result, labour and employee wages are exorbitantly high. Water is a significant priority for users. Water is utilised for many things, including drinks, bathing, and washing. Aside from that, water is essential for watering plants because it may nourish them. However, many people's irrigation equipment is inefficient. This is because irrigation now relies on human effort. The water pump may filter the reservoir's water into clean water that humans can drink on a regular basis.

TABLE OF CONTENT

LIST OF FIGURES

LIST OF SYMBOLS

kW	Kilowatts
CO2	Carbon Dioxide
W	Watt
V	Volt
NiCd	Nickel Cadmium
NiMH	Nickel Metal Hydride
MHz	Megahertz
cm	Centimetre
aH	Ampere Hour
A	Ampere

LIST OF ABBREVIATIONS

SBPWM	Simple Boost Pulse Width Modulation
ZSI	Z source inverter
AC	Alternate Current
DC	Direct Current
PV	Photovoltaic
PCB	Printed Circuit Board
LCD	Liquid Crystal Display
IDE	Integrated Development Environment
PWM	Pulse Width Modulation
MPPT	Maximum Power Point Tracking
RAM	Random Access Memory
IoT	Internet of Things

LIST OF APPENDICES

CHAPTER 1

INTRODUCTION

1.1 Background of study

Nowadays, the incessant outage of electricity in the cities can lead to non-availability of electrical power in the rural area as preferential treatment with regular supply is given to the cities. Although this phenomenon mostly occurs in developing or underdeveloped countries, it can be as a result of rationing of generated power to consumers. This clearly shows the geometrical increasing need for electrical power by all populace, with increasing demand comes the burden of an enormous generation of power which has a direct effect on the sources of generation. These sources are dwindling as effort is being placed on the reduction of over-reliance on fossil fuel based and other sources of power generation that create adverse effects on the earth through pollution. In the rural settings which are predominantly habited by farmers there exists little to no electrical power supply from the national grid as these rural areas are largely situated off-grid, therefore many works that need the use of power are done with human power or other means that can be sourced locally.

The unavailability of electrical power leaves the rural farmers to the mercy of other sources of water generation to irrigate their farmland and the use of human power to carry the water sourced to the field. To obtain optimum yield on such land efficient, sustainable water supply and management exerts a crucial role in supplemental irrigation of farmland.

Irrigation agriculture being practiced in most rural dwellings depends on human and animal power for the supply of water but this method is not efficient on a medium to large scale agricultural land, therefore, the use of the electrically powered pump for the generation of water resources on the land but the epileptic nature of supply cannot be relied on, therefore the need to source for an alternative which should befrom renewable resources to generate electrical power(Odugbose et al., 2021).

Environmental friendly and renewable source of energy is the solar energy with little to no adverse effect on the environment when compared to fossil fuel-based source of fuel for energy generation and the energy can be utilized in the rural areas. Although solar energy is free, its availability depends on time, season, and geographical location.

This Renewable energy (RE) is fast growing the dominant space in certain country's power sector, with innovative drifts and tasks are challenging for the related manufacturers and, policy architects. There is sudden swell and drip in generation of the wind and solar producers, and users replacing the fossil or coal power generators. On grid transmission technology to long distance transmission has been down scaled.(Rana et al., 2020).

With the pace of innovation, agricultural systems have shifted from old methods to contemporary machinery or automation systems. There has been advancement in plant operation in the agricultural sector, which demands high accuracy in operations in order to optimize output as well as the quality of the product or crops. It is also necessary to lower the plantation's operating costs. We need an automated process to accomplish what is required. Water is a necessary and critical component for survival. Water makes up over 70% of the human body, whereas plants comprise nearly 90% of their weight in water. As a result, water is a vital ingredient for both humans and plants. To meet our body's water requirements, we must rely on outside sources. The same is true for crops, which require water for growth and development.

A water pump system using solar power is crucial to meet these watering needs that are versatile, cost- efficient, and both financially and environmentally sustainable. It is a socially and environmentally attractive technology to supply water. Especially if the need for water is in remote locations which are beyond the reach of power lines, solar power is often the economically preferred technology. A solar water pump system is essentially an electrical pump system in which the electricity is provided by one or several PhotoVoltaic (PV) panels. PV or solar panel is used because the solar energy produced is a truly renewable energy source. It can be harnessed in all areas of the world and is relied on, therefore the need to source for an alternative which should befrom renewable resources to generate electrical power(Odugbose et al., 2021).

Environmental friendly and renewable source of energy is the solar energy with little to no adverse effect on the environment when compared to fossil fuel-based source of fuel for energy generation and the energy can be utilized in the rural areas. Although solar energy is free, its availability depends on time, season, and geographical location.

This Renewable energy (RE) is fast growing the dominant space in certain country's power sector, with innovative drifts and tasks are challenging for the related manufacturers and, policy architects. There is sudden swell and drip in generation of the wind and solar producers, and users replacing the fossil or coal power generators. On grid transmission technology to long distance transmission has been down scaled.(Rana et al., 2020).

With the pace of innovation, agricultural systems have shifted from old methods to contemporary machinery or automation systems. There has been advancement in plant operation in the agricultural sector, which demands high accuracy in operations in order to optimize output as well as the quality of the product or crops. It is also necessary to lower the plantation's operating costs. We need an automated process to accomplish what is required. Water is a necessary and critical component for survival. Water makes up over 70% of the human body, whereas plants comprise nearly 90% of their weight in water. As a result, water is a vital ingredient for both humans and plants. To meet our body's water requirements, we must rely on outside sources. The same is true for crops, which require water for growth and development.

A water pump system using solar power is crucial to meet these watering needs that are versatile, cost- efficient, and both financially and environmentally sustainable. It is a socially and environmentally attractive technology to supply water. Especially if the need for water is in remote locations which are beyond the reach of power lines, solar power is often the economically preferred technology. A solar water pump system is essentially an electrical pump system in which the electricity is provided by one or several PhotoVoltaic (PV) panels. PV or solar panel is used because the solar energy produced is a truly renewable energy source. It can be harnessed in all areas of the world and is available every day. People cannot run out of solar energy, unlike some of the other sources of energy. Solar energy will be accessible as long as we have the sun. A typical solar powered pumping system consists of a solar panel array that powers an electric motor, which in turn powers a bore or surface pump as illustrated in **Error! Reference source not found.**.

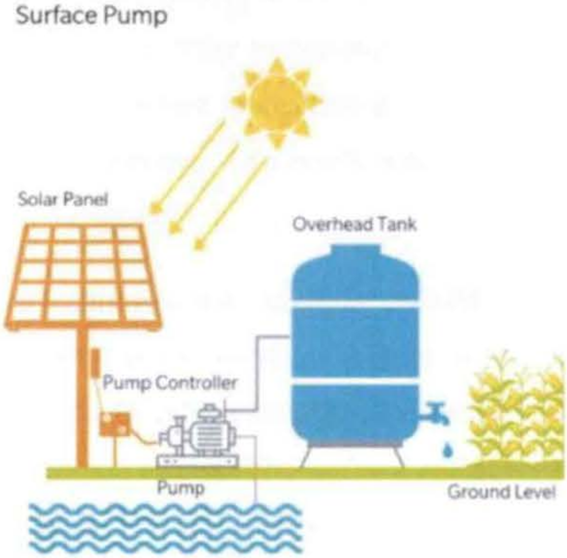

Figure 1-1 Basic Component Solar water pump
(*Solar Water Pumps: Things To Know and Tips For Use [2020]*, n.d.)

1.2 Problem Statement

Agriculture, such as rubber and palm oil, is a major economic sector in Malaysia. As a result, it is critical that the products be more quality. Farmers must focus on some critical issues, such as the appropriate amount of water supply for crop irrigation and the use of electricity for water pumps, in order to accomplish this. Farmers also work to minimize labour costs in order to reduce production costs. This method of irrigation necessitates a high level of water pressure. As a result, a diesel fuel water pump will be required to generate high water pressure.

In addition, due to the continuous and increasing use of fossil fuel and dieselbased of water pumps, the climate change and air pollution problem is exist and become worse. Fossil fuel and diesel contribute to 45 million ton of CO2 emission to the atmosphere and 8% – 12% of greenhouse gas emissions. The carbon dioxide that released to the atmosphere will cause acid rain produce. These acid rain can cause to the corrosion of the soil and the vegetation and crops.

Furthermore, the energy and electricity demand for the world is growing rapidly with the increasing of human population, urbanization and modernization. About 70% of the population is employed in agriculture sector, hence the demand for the energy and electricity is rising since the last few years. Agriculture sector consumed 18% of the total power generated compare to other sectors. This will cause the government need to produce huge amount of energy and electricity in order to support the requirement. The government spend a lot of money and sources in order to make sure that energy and electricity demand is enough(Rathore et al., 2018).

1.3 Objectives

Main objectives for these projects are to improve an existing Portable Solar Irrigation System within system, capacity solar battery storage. This can be achieved through the following objectives:

1. To develop portable solar water pump that operates using solar energy.
2. To develop a solar water pump that can be controlled and monitored through a mobile application.
3. To create a portable solar water pump at a low and reasonable cost.

1.4 Project Scope

The scope of this project is to design and develop a portable water pump that is powered by solar energy. This solar water pump's general appearance is inspired by wheeled travel luggage. This design makes it easier for the user to transport to any area. This solar water pump will be used in locations that are not connected to the power grid, and the usage of solar power will save energy costs such as fuel and electricity. The major parts of a portable solar powered water pump are a solar panel, a microcontroller, a solar rechargeable battery, a water pump, and a water filter. The rechargeable battery we use within 12V 7.2AH Seal Lead Acid. For the water pump, we use a DC water pump that is 12V, 100W has a maximum pressure around 160psi and the maximum flow rate is 8L/min. Also, this portable solar water pump may be operated and monitored through the use of a mobile app. The addition of a microcontroller, such as Arduino, improves the system by allowing the user to control it remotely. This system provides components such as a temperature sensor and a humidity sensor. These sensors assist the user in monitoring the surrounding situation so that the user may effectively care for their plants and livestock.

CHAPTER 2

LITERATURE REVIEW

2.1 Solar Energy

The recent increase in energy costs has prompted many individuals to explore for alternate solutions and sources to this problem. One of the most abundant forms of energy, solar energy, is becoming more widely available in a variety of applications. Take a look at where solar energy comes from.

Climate change is one of the most significant issues that humans are dealing with in this decade. Our society is mostly reliant on fossil fuels, with fossil fuels accounting for 80 percent of our primary energy. The burning of fossil fuels contributes significantly to a rise in the average temperature of our planet. The continuing extraction of fossil fuels poses a risk to humans. One answer to this problem is to replace fossil fuels with renewable energy. Instead of relying on non-renewable energy, our civilization should concentrate on harnessing renewable energy. The phrase "renewable energy" is used in English-language scientific and technical publications to contrast the depletion of fossil fuel sources.

Based on preliminary research, a comparison of renewable and limitless resources has been created. Renewable energy sources include animal power and wood, whereas limitless energy sources include solar radiation, wind, tidal, and hydropower. Until recently, the International Energy Agency (IEA) defined renewable energy as energy generated from natural processes that is supplied at a quicker rate than it is used(Rathore et al., 2018)

Because renewable energies such as wind and sun are abundant on our planet, they are commonly employed for power generation. Solar photovoltaic power generating systems are ideal for persons who live in isolated or rural places. There are two types of water pumps: wind-powered and solar-powered. Because wind power water pumps are dependent on wind speed, they are not ideal for all areas. It is not ideal for areas with low average wind speed. The wind system, on the other hand, causes noise pollution, which is negative for the neighbouring residents. While a solar-powered water pump runs quietly and without creating any noise pollution. Furthermore, a research concluded that solar energy is the greatest alternative for future energy compared to other renewable energies due to its abundance, cost effectiveness, and efficiency. Solar photovoltaic systems are regarded as one of the greatest options for meeting future energy demands. The cost of installing a solar photovoltaic system has recently dropped to an affordable level.

William Grylls Adams and his students, Richard Day, pioneered photovoltaic energy in 1876. They discovered at the time that when exposed to sunlight, selenium produces energy electricity. Calvin Fuller, Gerald Pearson, and Daryl Chapin discovered silicon solar cells in 1953. They discovered that this cell generated electricity, and that the electricity was efficient and sufficient to power small electrical devices. The New York Times said at the time that this finding was "the beginning of a new age, eventually leading to the reality of harnessing the practically infinite energy of the sun for the sake of civilization." After a few years, solar cells are becoming commercially available. However, the cost is too high, and most people will be unable to afford these solar cells. From the 1970s until the 1990s, solar cells were used to power homes and telecommunications on train crossings and rural locations. Nowadays, we can observe that solar energy is widely utilised in a number of settings. For example, consider the solar-powered automobile(Patay & Montvajszki, 2015).

Solar energy has been suggested as a viable solution for reducing pollution and combating climate change. Actually, solar energy is a significant energy source for humans since it is renewable. Solar energy systems are broadly classified as either passive solar or active solar, depending on how these technologies absorb and transform solar radiation into electricity. To harvest energy, active solar used photovoltaic systems, solar water heating, and concentrated solar power. Passive solar energy includes selecting light dispersion qualities that are good for thermal mass and constructing spaces that naturally circulate air. In reality, our sun is a natural nuclear reactor. The Sun emits minuscule amounts of energy known as photons, which travel a great distance and eventually reach Earth.

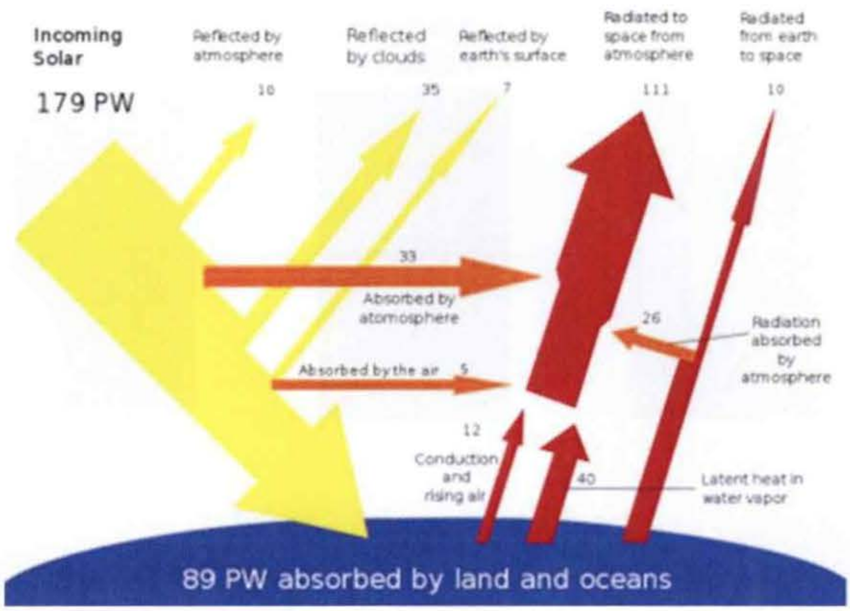

Figure 2-1 The Solar Energy Reaches Earth

When the sun's rays strike the solar panels, the solar panels catch the rays. The energy is subsequently converted to direct current by the solar panels (DC). The inverter will convert direct current to alternating current, which is what we use in our homes. Solar panels continue to generate electricity during the night. The power comes from the sun during the day, which the solar panels gather and store. An electrical circuit is produced in a conductor if the conductor is linked in positive attached to negative side. When an electron passes across a circuit, electricity is created. When an electron passes across a circuit, electricity is created. Solar panels are made up of multiple solar cells, and the material used to make these solar cells is silicon, which performs similarly to semiconductors. Direct current power may be generated using photovoltaic solar panels. Electrons in solar panels only flow in one way around the circuit. However, in the case of alternating current, the electrons within acted like they were being pushed and pulled and reversed direction. The alternating current is created when a wire coil is spun adjacent to a magnet.

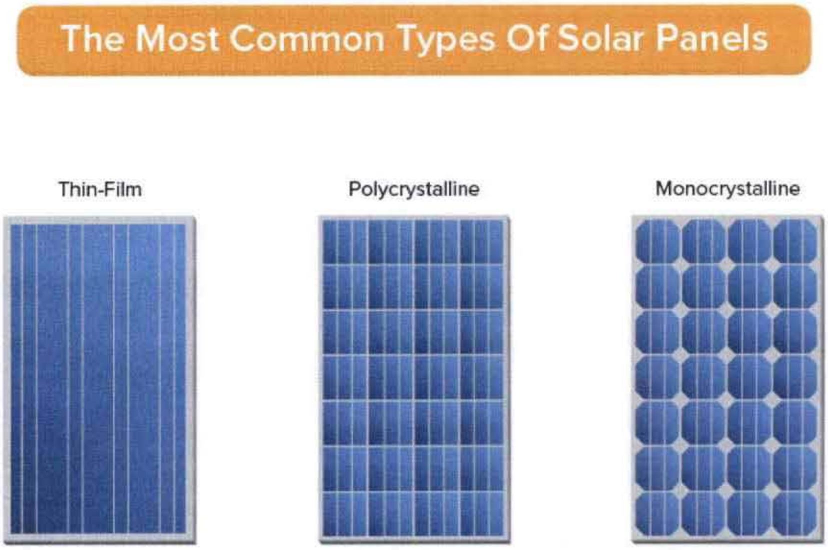

Figure 2-2 Type of Solar Panel

Solar photovoltaic water pumping systems are an excellent replacement for electricity, fossil fuel, and diesel-powered water pumps. In the 1970s, a research was conducted to investigate the economic feasibility and practicality of solar water pumps. A solar water pump is a hybrid of a photovoltaic and a pumping device. People from several fields such as electrical, mechanical, electronics, civil, and computer engineering are involved in the solar water pump. Over the last few decades, the globe has continued to rely on finite and non-renewable energy sources that require millions of years to replenish. As a result of increased energy consumption as a result of industrialization, the globe is confronted with a slew of environmental issues such as acid rain, global warming, and the greenhouse effect. The worldwide surface temperature is 0.6°C higher than the average temperature between 1900 and 2010(Li et al., 2017).

A solar photovoltaic system directly turns sunlight into electric energy using the photovoltaic effect. This solar photovoltaic system is a beneficial and long-term solution to the present environmental dilemma and catastrophe. This type of green energy can secure the security of energy, water, and the environment. As solar water pumps are widely used in agricultural production, the combination of solar energy and water pump plays an important role. Solar photovoltaic systems do not emit any hazardous by products that pollute the environment. Because solar energy is not collected from the earth's strata, it does not emit any hazardous pollutants into the environment. The photovoltaic cell transforms solar energy from sunlight to electrical energy, and this energy powers the motor via the controller, which keeps the pumping running smoothly. It may be used to hold a battery for electric charge storage as well as a reservoir for water storage(Li et al., 2017).

The photovoltaic system, power control system, and dynamic system are the three primary components of the solar photovoltaic water pumping system. For the photovoltaic system, the photovoltaic array consists of one or more photovoltaic modules that are prewired together, whereas the photovoltaic module combines solar cells in either parallel or series to achieve higher power levels. The series or parallel connection is determined by the voltage required by the pump. The photovoltaic array is intended to provide the appropriate power supply to the pump while minimising energy losses. A tracking system can be used in conjunction with a solar array to maximise system performance. The power control system is made up of three components: a controller, an inverter, and energy storage. The controller's job is to charge batteries, avoid overcharging, and terminate the charging process if the battery is full. In this section, maximum power point tracking is also utilised to track the maximum power from the solar array. The inverter's job is to convert direct current to alternating current and enable the alternating current to operate. The dynamic system is made up of a motor and a pump. The dynamic system generates flow by pumping water. The motor takes in electrical energy and converts it into kinetic energy. The pump's job is to transform kinetic energy into hydraulic energy or water. Varied types of pumps have different capabilities and are determined by the amount of water required(Li et al., 2017).

2.2 Monocrystalline and Polycrystalline

Energy is currently one of the most important necessities of both developed and developing countries. Even though there are many methods of producing and using energy, all countries demand inexpensive, big, and clean energy sources. Because fossil fuels will be depleted after a certain length of time, and because their production is quite expensive, it is necessary to identify alternative energy sources and to profit from these sources as efficiently as possible. Furthermore, the usage of energy sources that cannot be replenished to a major extent has considerably exacerbated environmental concerns. As a result, the trend toward renewable energy sources with little environmental impact is beneficial in every way. Renewable energy sources are described as energy flows that are replenished at the same rate as they are consumed. All renewable energy sources on Earth derive from the action of solar radiation, which may be turned to energy directly or indirectly using various methods.

Even though it is the most expensive renewable energy technology, "photovoltaic" technology is the easiest to develop and implement. However, its greatest advantage is that it is an environmentally friendly technology with low maintenance costs. Aside from this, photovoltaic systems are modular. In other words, they may be assembled wherever they are needed. In the event of a surge in demand, more photovoltaic models may be simply added to the system in a short period of time. Other energy generation technologies are not affected by this. Photovoltaic systems built near to end customers, in particular, reduce the need for transmission and distribution gear while increasing the dependability of local electric supply.

When compared to amorphous silicon, crystalline silicon is more efficient while still employing a minimal quantity of material. Silicon offers various benefits, including its abundance on Earth, low contamination rate, great durability, and the microelectronics industry's extensive knowledge. Although many different methods have been developed, monocrystalline and polycrystalline silicon cells are the most often employed in production.

The power performance of monocrystalline and polycrystalline panels was tested under outdoor conditions in this research. There are monocrystalline (80 x 98 cm) and polycrystalline (67 x 100 cm) solar panels with a total power of 100 W in the testing equipment. It is not feasible to activate both panels at the same time due to the system's architecture. The system has ten load levels that display the resistance characteristic. Each produces a 10 W resistance. An 11-graded switch can be used to control the amount of produced load (resistance). As a result, the system may be given a load ranging from 10

W to 100 W. The 11th grade of switches was intended to be a short circuit(Taşçioğlu et al., 2016).

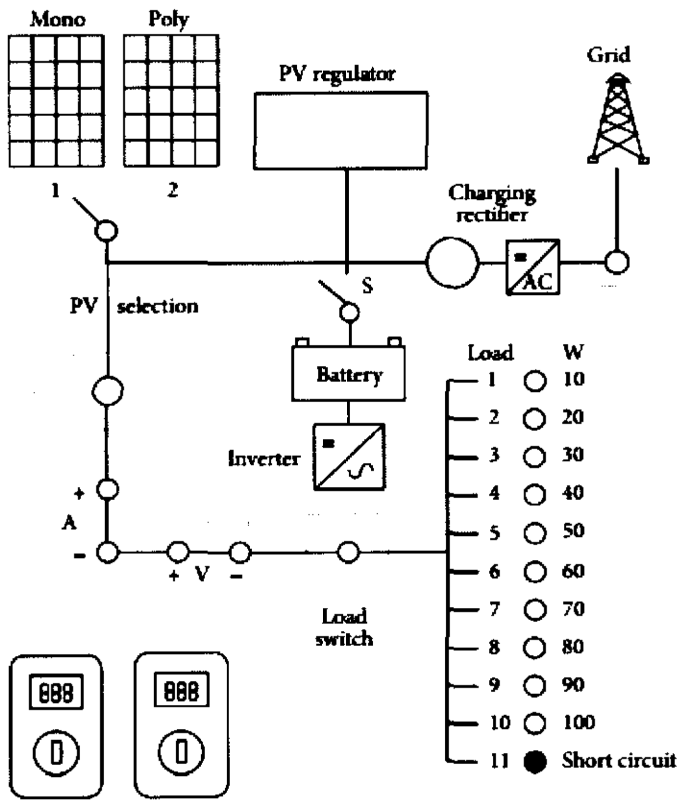

Figure 2-3 Circuit View

And the maximum power values that monocrystalline and polycrystalline solar panels can generate under various loads are as follows. During the testing period of a monocrystalline solar panel, 13.56 W power was obtained under a 10 W load, 26.97 W power was obtained under a 20 W load, 39.56 W power was obtained under a 30 W load, 53.39 W power was obtained under a 40 W load, 62.17 W power was obtained under a 50 W load, 74.6 W power was obtained under a 60 W load, 85.7 W power was obtained under a 70 W load, and 7.09 W power was obtained as highest under short circuit.

Figure 2-3 shows the energy production performance of panels on a daily basis. Differences in energy output are seen depending on the intensity of the radiation reaching the panel surface. Monocrystalline and polycrystalline have average energy performances of 546.82 Wh and 517.52 Wh, respectively. On the 19th and 24th of August, 2014, the maximum and minimum energy output from panels were realised. The measurement findings demonstrate that monocrystalline solar panels outperformed polycrystalline panels on every experiment day.

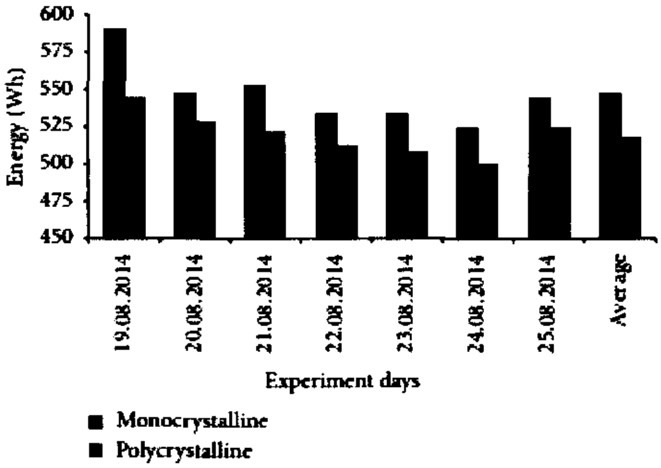

Figure 2-4 Power output performance

Figure 2-4 depicts the daily module efficiency bar graph for each kind of solar panel used in this experiment. More study is needed, based on prior studies, to establish whether exact conditions lead each type of panel to perform better. Based on the results of this experiment, it can be stated that monocrystalline solar panels are the best type of photovoltaic module to utilise.

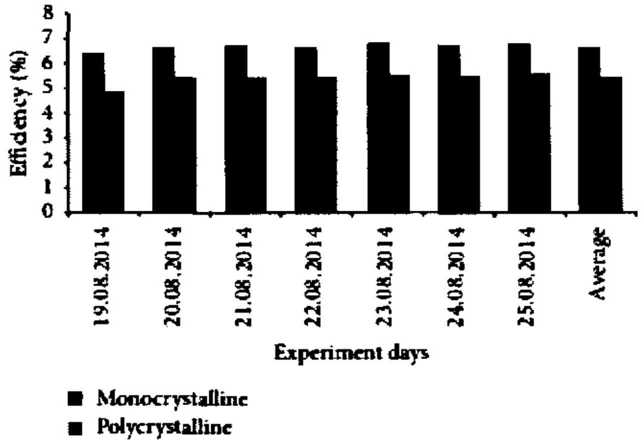

Figure 2-5 Solar panels efficiencies

2.3 Internet of things in smart agriculture

The Internet of Things (IoT) is an intelligent and promising technology that provides novel and practical solutions in a variety of fields, as seen in Fig. 2.4, including smart cities, smart homes, traffic control, healthcare, smart agriculture, and so on. In the agriculture industry, IoT technology has advanced significantly in agriculture management. This technology enables all agricultural devices and equipment to be linked together in order to make the best irrigation and fertiliser delivery decisions. The smart systems improve the accuracy and efficiency of gadgets that monitor plant development and even livestock rearing. Wireless sensor networks (WSNs) gather data from various sensing devices. Furthermore, cloud services must be coupled with IoT in order to evaluate and process distant data, which helps decision-making and the implementation of the best judgments. Smart farm management necessitates the use of information and communication technology (ICT), ground sensors, and control systems mounted on robots, autonomous vehicles, and other automated devices. The success of smart systems is dependent on the availability of high-speed internet, intelligent mobile devices, and satellites(Said Mohamed et al., 2021).

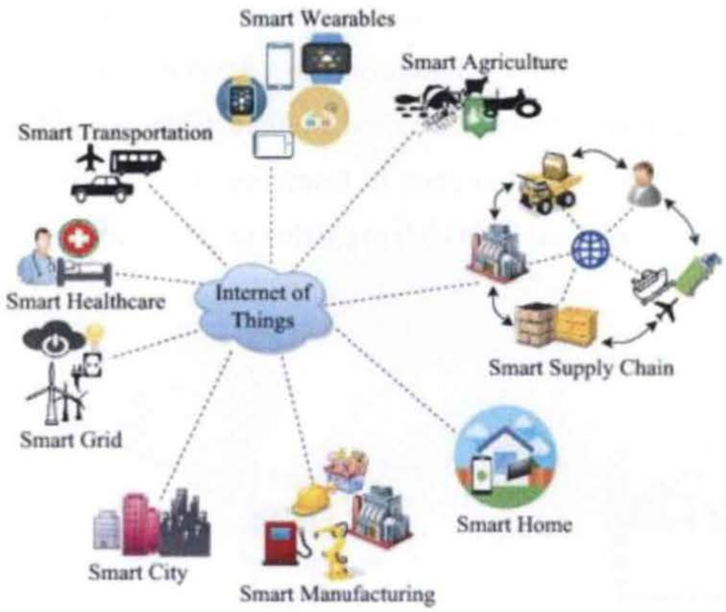

Figure 2-6 IoT applications in several fields.

2.4 Type of Solar Water Pump

As the name implies, a solar water pump runs on solar energy. As a result, it is incredibly cost-effective, long-lasting, simple to install, and requires little maintenance. The maintenance and operating costs are also relatively inexpensive as compared to a standard water pump because an installed pump can last up to 20 years. However, in order to function properly, the solar panels must be cleaned on a regular basis. However, in locations where there is no electricity or a steady source is unavailable, these systems are the greatest solution. Water for livestock, crop irrigation, drinking and cooking water supplies are just a few of the usual applications for this solar water pump system. As a result, during hot weather months and in hot places, the demand for water is significant. As a result, private residences and farmers require a steady and continuous supply of water. Aside from that, a solar water pump is a pumping system that is powered by photovoltaic panels (PV).

Solar pumping systems are classified into two types: direct coupled and indirect coupled. With no batteries, a direct coupled system is employed when water is only required during the day or when continuous water supply is not required. A storage tank, on the other hand, is required to assure uninterrupted water delivery. Meanwhile, in a battery-coupled system, batteries are used to store DC currents; direct current from solar panels during the day is stored in batteries before being sent to the pump at any time when water is required. Due to the requirement of pumping over a longer period, the use of batteries provides a stable working voltage to the DC motor of the pump.

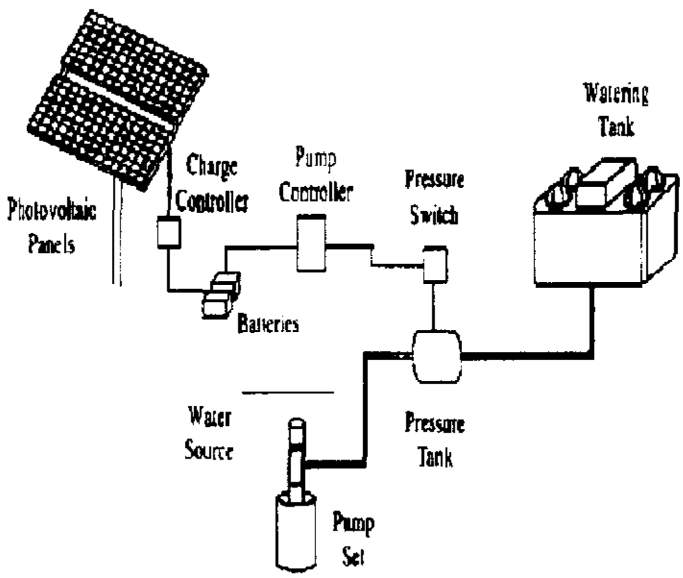

Figure 2-7 Battery-coupled solar water pumping system

However, there are several disadvantages to using batteries. Because it might lower overall system efficiency, the operating voltage is determined by the batteries rather than the PV panels. The voltage supplied by the batteries can be one to four volts lower than the voltage produced by the panels during maximum sunshine conditions, depending on their temperature and how thoroughly the batteries are charged. This decreased efficiency can be alleviated by using an appropriate pump controller that increases the battery voltage provided to the pump(Patay & Montvajszki, 2015).

In direct-coupled pumping systems, power is transferred directly from the PV modules to the pump, which then pushes water through a conduit to where it is needed. This device is only intended to pump water during the day. The volume of water pumped is entirely determined by the amount of sunshine that strikes the PV panels and the type of pump used.

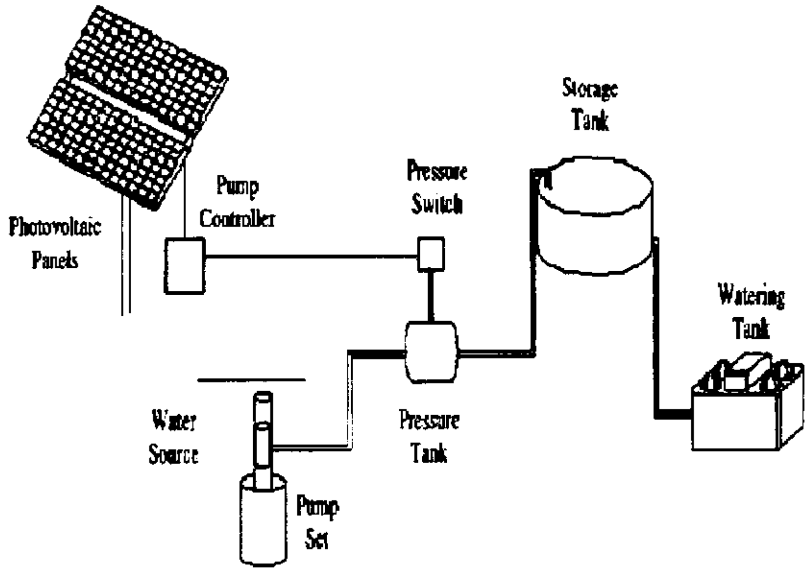

Figure 2-8 Direct-coupled solar water pumping system

The volume of water pumped varies throughout the day due to fluctuations in the strength of the light and the angle at which it strikes the PV panel. For example, during peak solar hours, the pump runs at about 100 percent efficiency with maximum water flow. Under low-light situations, however, pump efficiency might reduce by up to 25% or more. To compensate for these varying flow rates, the pump and PV modules should be matched for efficient system functioning.

2.5 Electrical Component

The solar water pump is made up of several distinct materials and components. The same is true for the electric and electronic components, which are the most critical and significant components in generating the operation of this solar water pump system. In this situation, a battery-coupled solar water pump system will be used. To design this system, numerous electrical components must be considered, including solar panels, a pump, a charge controller, and a battery. Electric components link all of the different parts of a machine and provide commands to each individual portion via a microprocessor, allowing the machine to function as a whole. We utilise Arduino as the microcontroller, which allows the user to configure and send commands to the machine.

2.5.1 Type of Pump

The solar water pump is made up of several distinct materials and components. The same is true for the electric and electronic components, which are the most critical and significant components in generating the operation of this solar water pump system. In this situation, a battery-coupled solar water pump system will be used. To design this system, numerous electrical components must be considered, including solar panels, a pump, a charge controller, and a battery. Electric components link all of the different parts of a machine and provide commands to each individual portion via a microprocessor, allowing the machine to function as a whole. We utilise Arduino as the microcontroller, which allows the user to configure and send commands to the machine.

The Submersible water pump is a hermetically sealed pump mechanism that pumps water by pushing it rather than drawing it. It can work in this condition because the pump is completely submerged in the liquid to be pushed. This enables the pump to be lowered into a deep pit for pumping purposes without encountering difficulties such as pump cavitation, which may harm moving parts by forming vapour bubbles.

Finally, Diaphragm Pumps are widely utilised and can handle a wide range of liquids. Diaphragm pumps are classified as "positive displacement" pumps because their flow rates do not fluctuate significantly with the discharge "head" / pressure against which the pump is working (for a given pump speed). Diaphragm pumps are capable of transporting liquids with low, medium, or high viscosities, as well as liquids with a high solids content. Because they may be built with a wide range of body materials and diaphragms, they can also withstand numerous strong substances such as acids.

In this solar water pump system, we then employ a DC water pump. In general, it consumes one-third to one-half the energy of a traditional AC pump. As a result, a pump controller protects the pump against high or low voltage circumstances while also maximising the volume of water pushed under less-than-ideal lighting settings. To run an AC pump, an inverter, an electrical component that transforms DC power from solar panels into AC electricity, is required(Patil & Zende, 2017).

2.5.2 Type of Battery

For rechargeable batteries, there are four primary chemistries. So the first one is, Nickel-Cadmium Batteries. The nickel–cadmium battery (NiCd battery or NiCad battery) is a rechargeable battery that uses nickel oxide hydroxide and metallic cadmium as electrodes. When not in use, Ni-Cd batteries excel at maintaining voltage and storing charge. However, NI-Cd batteries are susceptible to the dreaded "memory" effect when a partially charged battery is recharged, decreasing the battery's future capacity. In compared to other types of rechargeable cells, Ni-Cd batteries have a decent life cycle and performance at low temperatures, as well as a reasonable capacity, but their most important benefit is their ability to supply their entire rated capacity at high discharge rates. They come in a variety of sizes, including those used for alkaline batteries, ranging from AAA to D. Individual Ni-Cd cells are utilised, as are packs of two or more cells. Smaller packs are used in portable gadgets, electronics, and toys, whereas larger packs are used in aircraft starting batteries, electric cars, and backup power supplies.

The second type is Nickel-Metal Hydride Batteries, Another sort of chemical arrangement utilised for rechargeable batteries is nickel metal hydride (Ni-MH). The chemical process at the positive electrode of a battery is identical to that of a nickel–cadmium cell (NiCd), with both battery types employing the same nickel oxide hydroxide (NiOOH). However, instead of cadmium, which is used in NiCd batteries, the negative electrodes of Nickel-Metal Hydride batteries employ a hydrogen-absorbing alloy. Because of its high capacity and energy density, NiMH batteries are used in high drain devices. A NiMH battery has two to three times the capacity of a NiCd battery of the same size, and its energy density is comparable to a lithiumion battery. Unlike NiCd batteries, NiMH batteries are not prone to the "memory" effect that NiCad batteries have.

Other type of rechargeable battery is Lithium-ion Batteries, One of the most common forms of rechargeable batteries are lithium ion batteries. They may be found in a variety of portable appliances, including mobile phones, smart gadgets, and a variety of other home battery products. Because of their small weight, they are widely used in aeronautical and military applications. Lithium-ion batteries are a form of rechargeable battery in which lithium ions migrate from the negative electrode to the positive electrode during discharge and back to the negative electrode during charging. In contrast to the metallic lithium used in nonrechargeable lithium batteries, Li-ion batteries employ an intercalated lithium compound as one electrode material. In comparison to other battery types, lithium ion batteries have a high energy density, little or no memory effect, and minimal self-discharge. Their chemistry, as well as their performance and cost, change depending on the application. For example, lithium-ion batteries used in handheld electronic devices are typically based on lithium cobalt oxide ($LiCoO2$), which provides high energy density and low safety risks when damaged, whereas lithium iron phosphate batteries, which offer a lower energy density but are safer due to a lower likelihood of unfortunate events occurring, are widely used in powering electric tools and medical equipment. Lithium ion batteries have the highest performance-to-weight ratio, followed by lithium sulphur batteries.

And last but not least Lead-Acid Batteries, Lead acid batteries are a low-cost, dependable power source that is commonly utilised in heavy-duty applications. Because of their size and weight, they are always employed in non-portable applications such as solar-panel energy storage, vehicle ignition and lighting, backup power, and load levelling in power generation/distribution. Lead-acid batteries are the earliest form of rechargeable batteries, and they are still highly relevant and significant in today's society. Lead acid batteries have very low energy to volume and energy to weight ratios, but they have a very big power to weight ratio and can thus produce massive surge current when needed. These characteristics, together with their low cost, make these batteries21 appealing for use in a variety of high current applications, such as powering vehicle starting motors and storing backup power supplies.

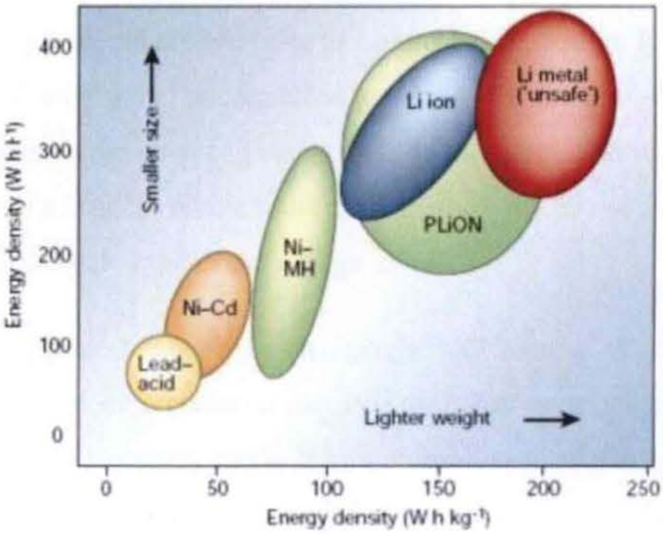

Figure 2-9 Types of battery comparison

2.5.3 Type of Solar Charge Controller

A solar charge controller regulates the power from the solar array that enters the battery bank. It guarantees that the deep cycle batteries are not overcharged throughout the day and that power is not reversed to the solar panels overnight, draining the batteries. Some charge controllers have extra features like as illumination and load management, although their primary function is to manage power.

PWM and MPPT are the two technologies available for solar charge controllers. They are significantly different in terms of how they perform in a system. An MPPT charge controller costs more than a PWM charge controller, however it is frequently worthwhile to spend the extra money.

PWM is an abbreviation for "Pulse Width Modulation" and refers to a solar charge controller. These work by connecting the solar array directly to the battery bank. When there is a continuous connection from the array to the battery bank during bulk charging, the array output voltage is 'drawn down' to the battery voltage. As the battery charges, its voltage rises, and the voltage output of the solar panel climbs as well, consuming more solar power as it charges. As a result, you must ensure that the nominal voltage of the solar array is equal to the voltage of the battery bank. It is important to note that when we speak to a 12V solar panel, we are referring to a panel that is built to function with a 12V battery. When a 12V solar panel is connected to a load, the actual voltage is close to 18 Vmp (Volts at maximum power). This is due to the fact that charging a battery necessitates the use of a higher voltage source. The battery would not charge if the battery and solar panel both started at the same voltage.

A 12V solar panel is capable of charging a 12V battery. A 24V solar panel or array (two 12V panels linked in series) is required for a 24V battery bank, whereas a 48V array is required for a 48V battery bank. If you attempt to charge a 12V battery with a 24V solar panel, you will waste more than half of the panel's output. If you try to charge a 24V battery bank with a 12V solar panel, you will waste 100% of the panel's potential and may even empty the battery.

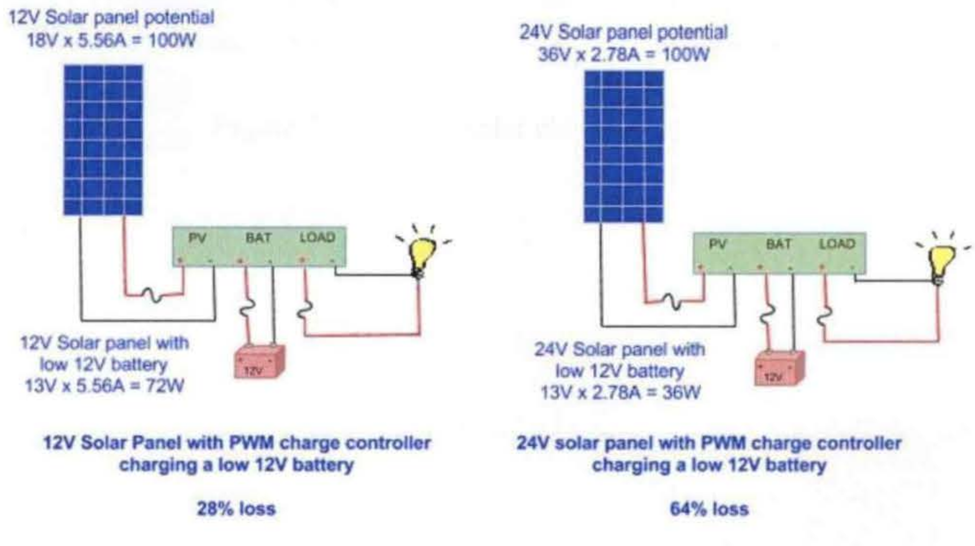

Figure 2-10 PWM solar charge controller

MPPT is an abbreviation for "Maximum Power Point Tracking," which is a type of solar charge controller. It measures the panel's Vmp voltage and converts the PV voltage to the battery voltage. Because power entering the charge controller equals power out of the charge controller, when the voltage is reduced to match the battery bank, the current is increased, allowing you to utilise more of the panel's available power. You can utilise a higher voltage solar array rather of a battery, such as the more widely available 60 cell nominal 20V grid-tie solar panels. You can charge a 12V battery bank with a 20V solar panel, or two in series can charge up to a 24V battery bank, and three in series can charge up to a 48V battery bank. This expands the number of solar panels that may now be employed for your off-grid solar setup.

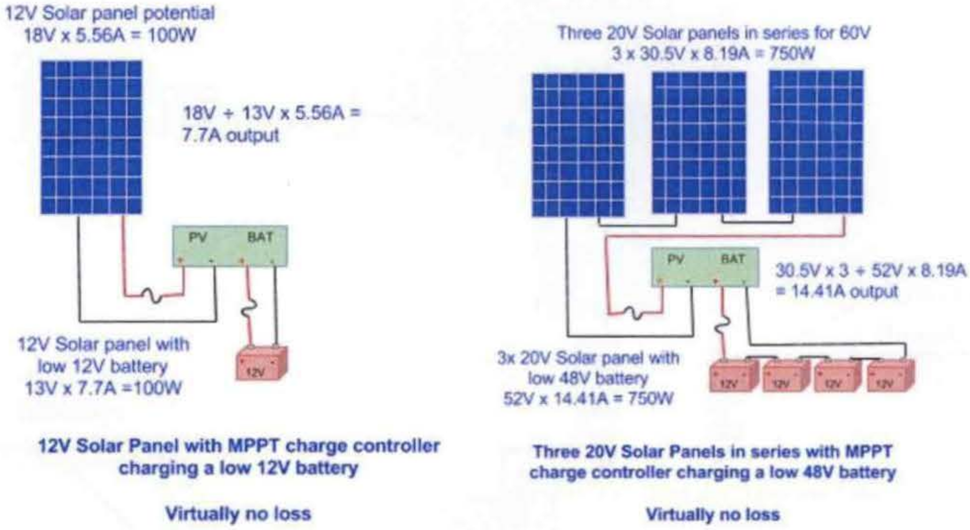

Figure 2-11 MPPT solar charge controller

CHAPTER 3

METHODOLOGY

3.1 Proposed Design

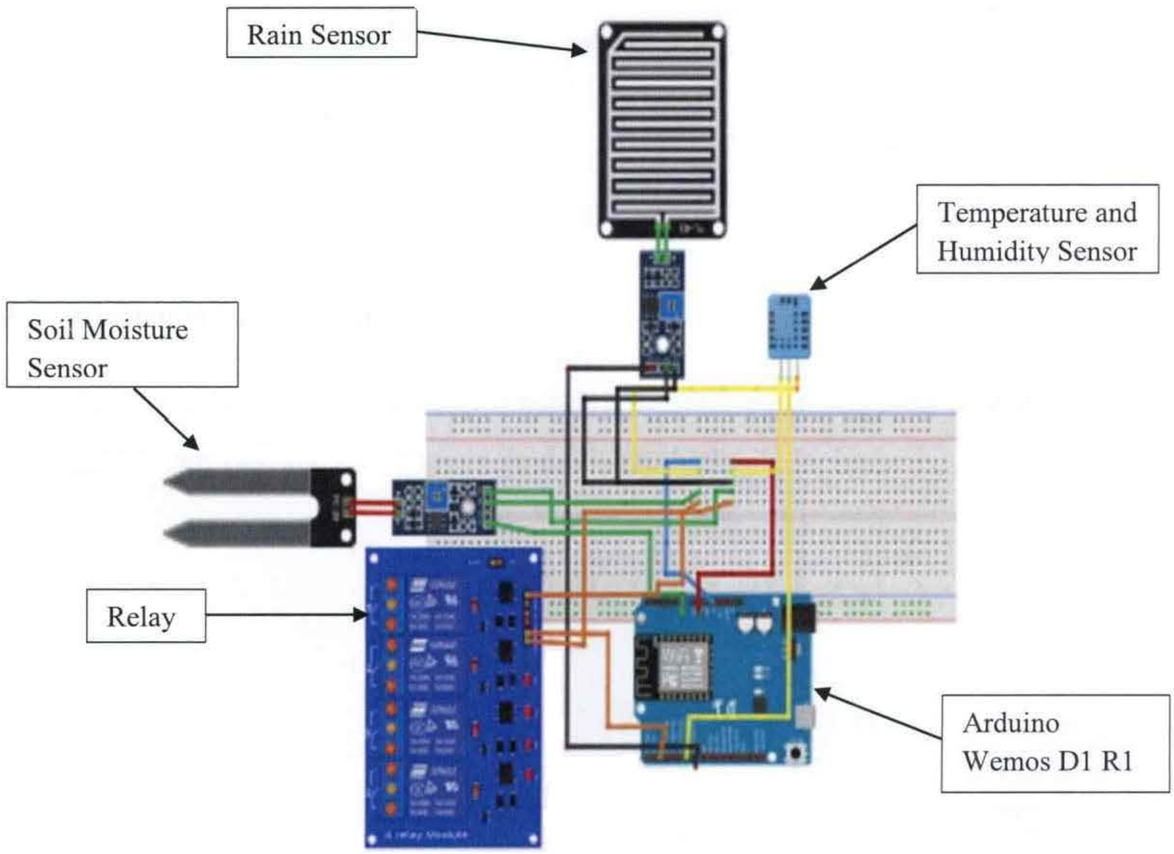

Figure 3-1 Microcontroller system

3.2 Electrical and control system

This solar water pump has a control system as well as electrical components. The control system consists of an Arduino, a Wemos D1 R1, and sensors, while the electrical components include a water pump, a solar panel, a solar charge controller, and a battery.

After conducting study, we chose to combine a sensor, a Wemos D1 R1, and an Arduino to create a system that can perceive its surroundings and be controlled remotely through mobile or tablet devices. Soil moisture sensor, humidity sensor, temperature sensor, and rain sensor are among the sensors utilised. The soil humidity sensor assists the farmer in sensing soil humidity and stopping the water pump once the soil humidity reaches an acceptable level. These sensors assist the user in monitoring the surrounding circumstances so that the user may better care for their plants and livestock.

3.2.1 Electrical Component

For the solar panel we used two panel. The solar panel we used is 50W with maximum voltage 18V and maximum current 2.78A

Figure 3-2 Solar Panel

A Panasonic lead acid 12v, 7.2aH battery is utilised to power the tiny diaphragm water pump. It measures 15.1 cm (L) x 9.4 cm (H) x 6.5 cm (W) and weighs around 2.85kg. When needed, the battery capacity can deliver energy to the motor for up to 1-2 hours.

Figure 3-3 Panasonic lead acid battery

The solar charge controller, also known as a 'charge regulator' or solar battery maintainer, is a device that governs the charging and discharging of a solar panel system's solar battery bank.

Figure 3-4 PWM Solar Charge Controller

Preventing overcharging of the battery is critical simply because the voltage generated by even a 12V solar panel is higher - between 16 and 20V. Such voltages are too high for 12 V batteries (which are completely charged at voltages about 14- 14.5V), since they might shorten the battery's lifespan and even destroy it. As a result, a solar charge controller is required in the event of a higher voltage solar array (by utilising a 24V panel or connecting two 12V solar panels in series).

The main functions of the charge controller in a solar panel system are as follows: ensuring that the battery bank is not overcharged during the day, preventing the electricity stored in the battery from returning to the solar array at night, managing how much power is drained from the battery by the appliances connected to it, and, if necessary, disconnecting these loads from the battery to prevent it from overcharging.

To recapitulate, the charge controller is the battery's power management. Other essential aspects of solar charge controllers include controlling the electricity supplied from the solar array to the battery based on the level of charge of the battery. This increases battery life. Low-voltage disconnect (LVD) — disconnecting the plugged load(s) in the event of a low battery charge status and reconnecting the loads when the battery is charged again. The LVD function is suited for the low-power demands seen in RV solar systems. Reverse current protection - prevents the solar panels from draining the battery at night when the panels are unable to charge the battery. Control display screen — displays the voltage and state of charge of the battery banks, as well as the current drawn by the solar array.

To save money, we would want to utilise PWM instead. Even with PWM, though, there are far too many options on the market.

Here is the list of requirements that we look for the charge controller:

i. We need a solar charger controller with an LCD display so we can check the battery, voltage level, and charging status without having to use a volt metre.
ii. Support for 12V and 24V, as if we chose to connect two 12V solar panels in series to create a higher voltage system.
iii. Handle maximum current from the solar panel, to avoid being damage by itself.

Its specifications are as follows:

- Voltage: DC 12V/24V
- Self-consuming: 10MA
- Rated Charge Current: 20A
- Rated Load Current: 20A
- Over charge Protection: 14.4V/28.8V
- Over charge Floating charge: 13.7V/27.4V
- Charge recover voltage: 12.6V/25.2V
- Over discharge Protection: 10.7V/21.4V
- Over discharge Recover: 12.6V/25.2V
- USB output: 5V/3A
- Operating temperature: -35°C-60°C

The figure below depicts several menu displays on its LCD. Because the default setup is already for a sealed lead acid battery, we don't change it much.

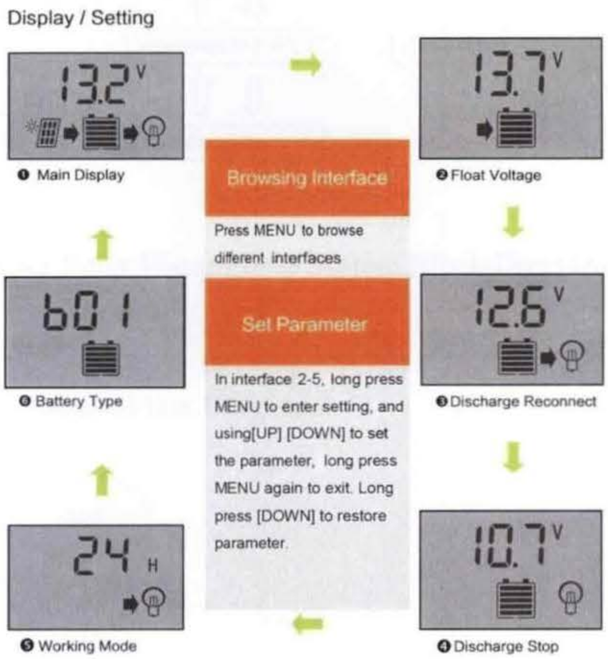

Figure 3-5 Allpowers Charge Controller Menu

Figure 3-6 Solar charge controller attached with prototype

3.3 Overall Block Diagram

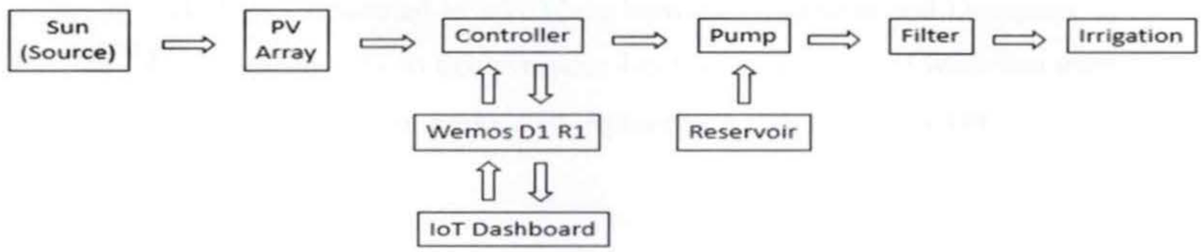

Figure 3-7 Solar Water Pump System Block Diagram

3.4 Microcontroller System Flow Diagram

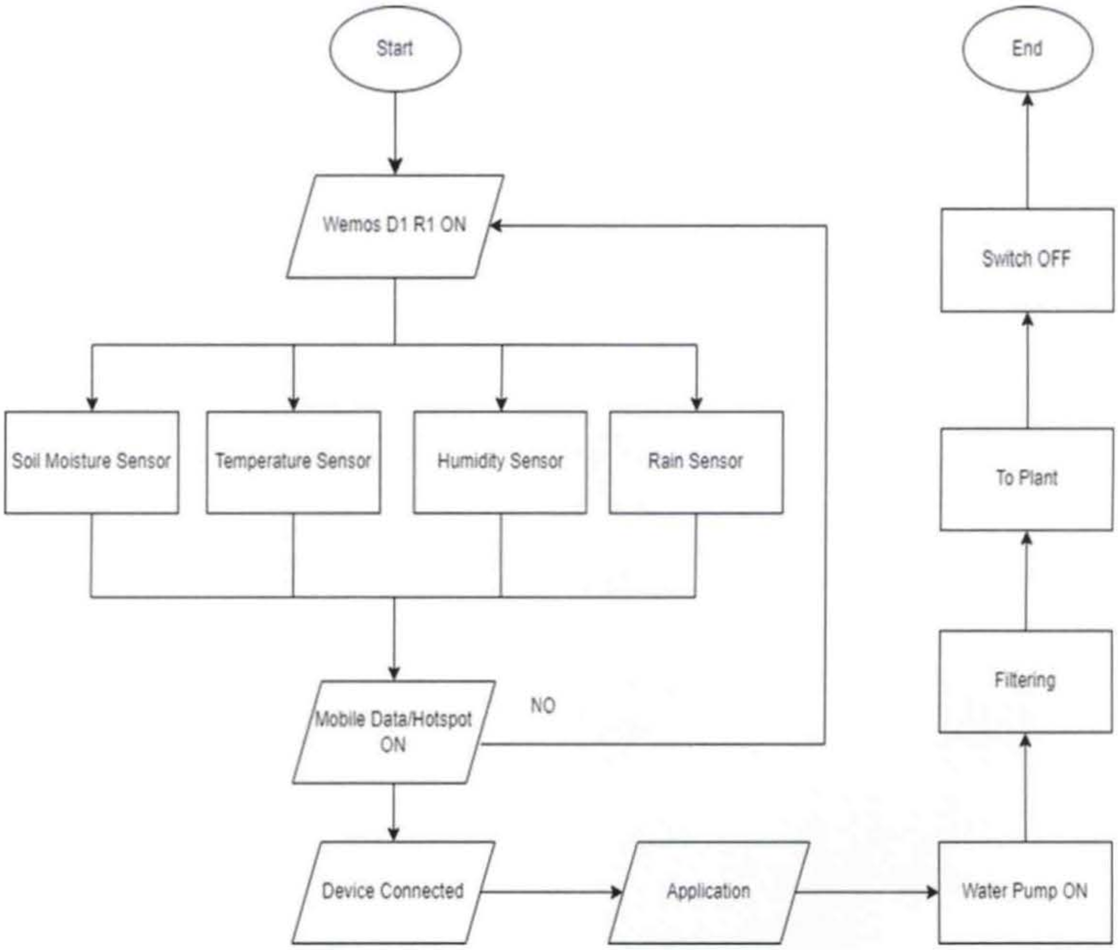

Figure 3-8 Microcontroller Flow Diagram

3.5 Timeline

The SDP 2 was scheduled to take place between September and December of 2021. The jobs are split evenly so that everyone has their own scope of work that must be completed within the time frame specified. Appendix A has the Gantt chart.

CHAPTER 4

RESULTS AND DIISCUSSION

4.1 Final Design

The microcontroller was installed in a microcontroller box, which also contained electrical components such as an Arduino Wemos D1 R1, a relay, a 9V battery to power the microcontroller, and a 12V battery to power the water pump. Inside the upper box was the microcontroller box. The water pump was housed in the prototype's lowest section. In addition, the prototype has a solar panel and a solar charge controller. The soil moisture sensor, rain sensor as well as the humidity and temperature sensors, are likewise affixed to the prototype's side.

Figure 4-1 Solar panel and solar charge controller attached with prototype

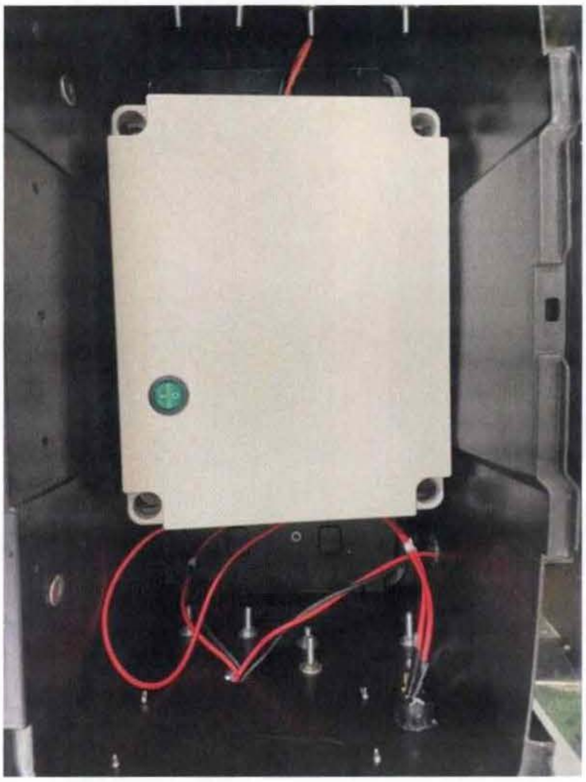

Figure 4-2 Microcontroller box

Figure 4-3 Water pump

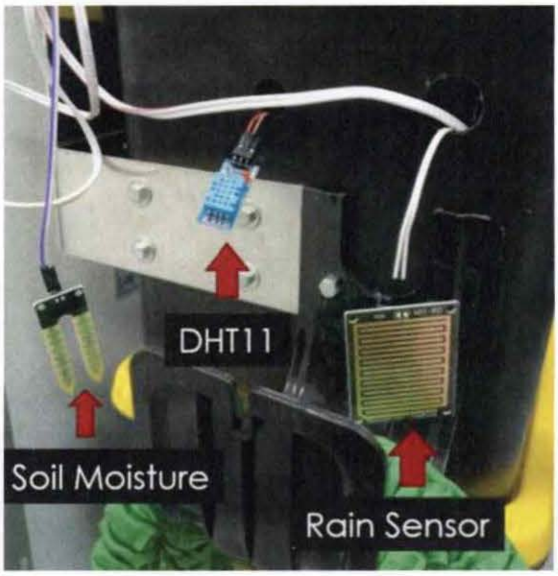

Figure 4-4 Sensor attached with prototype

Figure 4-5 Connection of electrical components

4.2 Onsite Demonstrating

On 9 December 2021, we participated in a Research Discussion with the Food Assurance & Sustainable Food Assurance Research Institute of Universiti Malaysia Kelantan at the Main Meeting Room of the Faculty of Electrical & Electronic Technology.

Figure 4-6 Brochure

Figure 4-7 Demonstration to Food Assurance & Sustainable Food Assurance Research Institute UMK

Figure 4-8 Participants involved in the Research Discussion

4.3 Results

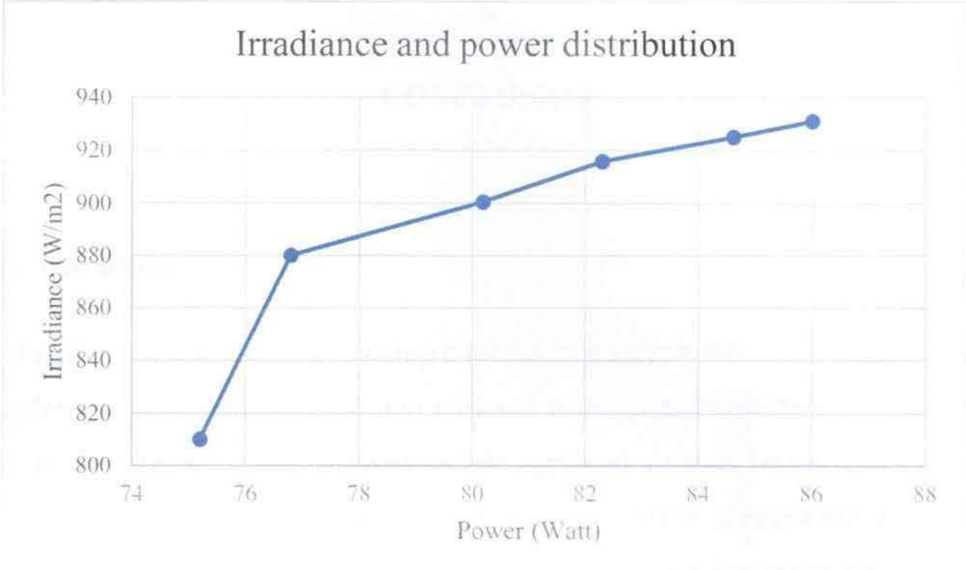

Figure 4-9 Graph irradiance between power

The graph above depicts a comparison between solar irradiation and the amount of power supplied to a water pump with various nozzles. The experiment takes place in the afternoon, from 11:00 to 15:00. According to the graph above, the nozzle with the cone obtained the highest sun irradiance measurement and received more electricity. Jet nozzle obtained the lowest sun irradiation value and received less power. According to the pattern of the irradiance reading growth data, when the solar irradiance grows, the power supplied by the solar panel increases, and more power is delivered to the water pump with varied nozzles.

CHAPTER 5

CONCLUSION

5.1 Conclusion

Finally, we were able to develop a model of a solar water pump irrigation system that employs a microcontroller arduino wifi and is combined with three sensors and one relay. Web monitoring (cayenne) and mobile applications may be used to monitor and operate the sensor and relay. Following that, we were able to connect the water pump to a filter, which can be turned on and off by the relay that has been set up at online monitoring (cayenne) and mobile applications. The water pump may be activated through a switch and an Arduino microcontroller.

5.2 Recommendation

There are various enhancements that may be made to improve the safety, usefulness, and efficiency of this solar-powered portable water pump. By upgrading and customising this solar-powered portable water pump, it can eventually become a marketable product.This created solar water pump has the potential to be enhanced into a superior design. In terms of specification and design, the height and weight of the solar water pump may be smaller and lighter, since smaller and lighter solar water pumps are simpler to transfer and carry to any location. Because of the solar panel, the weight of the created solar water pump is rather hefty. The addition of two solar panels raises the overall weight of the solar water pump. The size of the solar water pump may be enhanced and made to be smaller, but the output remains the same. Other suggestions for improving the use of this solar-powered portable water pump include constructing a folding frame for the solar panel. To make this water pump more portable, the frame of the solar panel may be rotated 180 degrees, reducing the total size of the water pump system.

REFERENCES

Gertler, M. S. (2003). Tacit knowledge and the economic geography of context, or the undefinable tacitness of being (there). *Journal of Economic Geography*, *3*(1), 75–99. https://doi.org/10.1093/jeg/3.1.75

Li, G., Jin, Y., Akram, M. W., & Chen, X. (2017). Research and current status of the solar photovoltaic water pumping system – A review. *Renewable and Sustainable Energy Reviews*, *79*(December 2016), 440–458. https://doi.org/10.1016/j.rser.2017.05.055

Odugbose, B., Adeyemi, H. O., Adetifa, B., & Babalola, A. A. (2021). Design of Solar Powered Water Pumping System for Irrigation in. *FUW Trends in Science & Technology Journal*, *5*(January), 956–962.

Patay, I., & Montvajszki, M. (2015). Solar PV for water pumping and irrigation. *Progress in Agricultural Engineering Sciences*, *11*(1), 9–28. https://doi.org/10.1556/446.11.2015.2

Patil, S. S., & Zende, R. M. (2017). Solar powered water pumping system. *Proceedings of 2017 3rd IEEE International Conference on Sensing, Signal Processing and Security, ICSSS 2017*, *January 2005*, 186–190. https://doi.org/10.1109/SSPS.2017.8071589

Rana, D., Mishra, S. P., & Pani, B. B. (2020). *Efficiency of Solar Powered Water Pumps for Rural Farmers in Odisha ; India Efficacy of Solar Powered Water Pumps for Rural Farmers in Odisha ; India. January 2021.*

Rathore, P. K. S., Das, S. S., & Chauhan, D. S. (2018). Perspectives of solar photovoltaic water pumping for irrigation in India. *Energy Strategy Reviews*, *22*(December 2017), 385–395. https://doi.org/10.1016/j.esr.2018.10.009

Said Mohamed, E., Belal, A. A., Kotb Abd-Elmabod, S., El-Shirbeny, M. A., Gad, A., & Zahran, M. B. (2021). Smart farming for improving agricultural management. *Egyptian Journal of Remote Sensing and Space Science*, *September*. https://doi.org/10.1016/j.ejrs.2021.08.007

Solar Water Pumps: Things To Know and Tips For Use [2020]. (n.d.). Retrieved December 8, 2021, from https://solarmagazine.com/solar-water-pumps/

Taşçioğlu, A., Taşkin, O., & Vardar, A. (2016). A Power Case Study for Monocrystalline and Polycrystalline Solar Panels in Bursa City, Turkey. *International Journal of Photoenergy*, *2016*. https://doi.org/10.1155/2016/7324138

APPENDICES

Appendix A: Gantt Chart SDP 2

	Week 1	Week 2	Week 3	Week 4	Week 5	Week 6	Week 7	Week 8	Week 9	Week 10	Week 11	Week 12	Week 13	Week 14
Project meeting														
SDP 2 Briefing														
Specify Detail Requirements														
Develop Prototype														
Apply Final Consucion														
Implementation (Roll-out Final Design)														

Appendix B: Activities Photo