**Faculty of Electrical Technology and Engineering**

**PROJECT TITLE**

**DESIGN AND DEVELOPMENT OF AN EFFICIENT WATER SPRINKLER SYSTEM FOR PHOTOVOLTAIC PANELS**



**YOUR NAME**

**MUHAMMAD SHAZWAN BIN SHAHRANI**

**Bachelor of Electronics Engineering Technology with Honours**

**2024**

**PROJECT TITLE**

# DESIGN AND DEVELOPMENT OF AN EFFICIENT WATER SPRINKLER SYSTEM FOR PHOTOVOLTAIC PANELS

**YOUR NAME**

**MUHAMMAD SHAZWAN BIN SHAHRANI**

**A project report submitted
in partial fulfillment of the requirements for the degree of
Bachelor of Electrical Engineering Technology with Honours**

**Faculty of Electrical Technology and Engineering**

**UNIVERSITI TEKNIKAL MALAYSIA MELAKA**

**2024**

**UNIVERSITI TEKNIKAL MALAYSIA MELAKA**
FAKULTI TEKNOLOGI KEJUTERAAN ELEKTRIK DAN ELEKTRONIK

**BORANG PENGESAHAN STATUS LAPORAN**
**PROJEK SARJANA MUDA II**

Tajuk Projek : DESIGN AND DEVELOPMENT OF AN EFFICIENT WATER SPRINKLER SYSTEM FOR PHOTOVOLTAIC PANELS

Sesi Pengajian : 2020-2024

Saya Muhammad Shazwan Bin Shahrani mengaku membenarkan laporan Projek Sarjana Muda ini disimpan di Perpustakaan dengan syarat-syarat kegunaan seperti berikut:

1. Laporan adalah hakmilik Universiti Teknikal Malaysia Melaka.
2. Perpustakaan dibenarkan membuat salinan untuk tujuan pengajian sahaja.
3. Perpustakaan dibenarkan membuat salinan laporan ini sebagai bahan pertukaran antara institusi pengajian tinggi.
4. Sila tandakan (✓):

| | | |
|---|---|---|
| ☐ | **SULIT*** | (Mengandungi maklumat yang berdarjah keselamatan atau kepentingan Malaysia seperti yang termaktub di dalam AKTA RAHSIA RASMI 1972) |
| ☐ | **TERHAD*** | (Mengandungi maklumat terhad yang telah ditentukan oleh organisasi/badan di mana penyelidikan dijalankan) |
| ☐ | **TIDAK TERHAD** | |

Disahkan oleh:

DR. EMY ZAIRAH BINTI AHMAD
PENSYARAH
Fakulti Teknologi dan Kejuruteraan Elektrik
Universiti Teknikal Malaysia Melaka

(TANDATANGAN PENULIS) (COP DAN TANDATANGAN PENYELIA)

Tarikh: 17/1/2024 Tarikh: 17/1/2024

*CATATAN: Jika laporan ini SULIT atau TERHAD, sila lampirkan surat daripada pihak berkuasa/organisasi berkenaan dengan menyatakan sekali tempoh laporan ini perlu dikelaskan sebagai SULIT atau TERHAD.

**DECLARATION**

I declare that this project report entitled Design And Development Of An Efficient Water Sprinkler System For Photovoltaic Panels is the result of my own research except as cited in the references. The project report has not been accepted for any degree and is not concurrently submitted in candidature of any other degree.

| | | |
|---|---|---|
| Signature | : | |
| Student Name | : | MUHAMMAD SHAZWAN BIN SHAHRANI |
| Date | : | 17/1/2024 |

# APPROVAL

I hereby declare that I have checked this project report and in my opinion, this project report is adequate in terms of scope and quality for the award of the degree of Bachelor of Electrical Engineering Technology with Honours.

Signature :

DR. EMY ZAIRAH BINTI AHMAD
PENSYARAH
Fakulti Teknologi dan Kejuruteraan Elektrik
Universiti Teknikal Malaysia Melaka

Supervisor Name : DR.EMY ZAIRAH BINTI AHMAD

Date : 17/1/2024

**DEDICATION**

*I am dedicating this thesis to my father, Shahrani Bin Muhammad who gave their full support through my ups and down and to my family that always there to help me builds my motivation and cheer me up when I feel lost. Also, a big thank you to my project supervisor Dr. Emy Zairah Binti Ahmad for the guidance throughout completing this thesis and to all other UTeM lecturers. Without their dedication in teaching, I wouldn’t reach until this far. Lastly, to my all-good friends, classmates, and teammates through bittersweet four years’ journey.*

*Thank you I appreciate all the support and good vibe through the process.*

# ABSTRACT

Floating photovoltaic (PV) systems have emerged as an innovative approach to harness solar energy by deploying solar panels on bodies of water. This technology offers unique advantages, including space efficiency, reduced evaporation, enhanced performance, reduced land use conflicts, and environmental benefits. Photovoltaic (PV) systems are widely used for solar energy generation, but they are susceptible to efficiency losses due to increased operating temperatures. Elevated temperatures can reduce the performance and lifespan of PV panels, leading to lower electricity output and decreased overall system efficiency. So, the aim of this project to design and develop a floating PV with water sprinkler. Cooling PV panels helps to lower their operating temperature, which directly improves their efficiency. By reducing the temperature, the panels can convert more solar energy into electricity, leading to increased power output and improved system performance. Then, methodology of this project when Arduino UNO connect with supply, temperature sensor as an input will function. If the condition temperature of solar panel is above 35°C, automatically water sprinkler system will turn on to reduce the temperature back to normal. By implementing a cooling system, the panels can be maintained at lower temperatures, reducing the risk of thermal stress and prolonging their operational life.

# *ABSTRAK*

Sistem fotovoltaik terapung (PV) telah muncul sebagai pendekatan inovatif untuk mengeksploitasi tenaga suria dengan memasang panel suria di atas badan air. Teknologi ini menawarkan kelebihan unik, termasuk kecekapan ruang, pengurangan penyejatan, prestasi yang lebih baik, pengurangan konflik penggunaan tanah, dan faedah alam sekitar. Sistem fotovoltaik (PV) secara meluas digunakan untuk penjanaan tenaga suria, tetapi ia rentan terhadap kehilangan kecekapan disebabkan oleh peningkatan suhu operasi. Suhu yang tinggi boleh mengurangkan prestasi dan jangka hayat panel PV, menyebabkan pengurangan output elektrik dan kecekapan keseluruhan sistem. Oleh itu, tujuan projek ini adalah untuk mereka bentuk dan membangunkan PV terapung dengan penyiram air. Pemjagaan penyejatan membantu menurunkan suhu operasi mereka, yang secara langsung meningkatkan kecekapan mereka. Dengan mengurangkan suhu, panel-panel ini dapat menukar lebih banyak tenaga suria menjadi elektrik, menghasilkan output tenaga yang lebih tinggi dan prestasi sistem yang lebih baik. Kemudian, metodologi projek ini adalah apabila Arduino UNO disambungkan dengan bekalan, sensor suhu sebagai input akan berfungsi. Jika keadaan suhu panel suria melebihi 35^°C, sistem penyiram air secara automatik akan dihidupkan untuk menurunkan suhu kembali ke tahap normal. Dengan melaksanakan sistem penyejatan, panel-panel ini dapat dikekalkan pada suhu yang lebih rendah, mengurangkan risiko tekanan terma dan memanjangkan jangka hayat operasi mereka.

## ACKNOWLEDGEMENTS

First and foremost, I would like to express my gratitude to my supervisor, Dr. Emy Zairah Binti Ahmad for the precious guidance, words of wisdom and patience throughout this project.

I am also indebted to Universiti Teknikal Malaysia Melaka (UTeM) and my family for the financial support through this degree which enables me to accomplish the project. Not forgetting my fellow colleague, for the willingness to share his thoughts and ideas regarding the project.

My highest appreciation goes to my parents, my supervisor and family members for their love and prayer during the period of my study.

## TABLE OF CONTENTS

# LIST OF TABLES

# LIST OF FIGURES

## LIST OF SYMBOLS

| | | |
|---|---|---|
| PV | - | Photovoltaic |
| V | - | Voltage |
| FPV | - | Floating Photovoltaic |
| OPVS | - | Overland Photovoltaic System |
| SPP | - | Solar Power Plant |
| | - | |
| | - | |
| | - | |

## LIST OF APPENDICES

# CHAPTER 1

# INTRODUCTION

## 1.1 Background

Floating PV systems typically use a variety of floating platforms, including rafts, pontoons, and barges, to support the solar panels. The platforms are anchored to the bottom of the water body and are designed to withstand the effects of waves, currents, and wind. The solar panels used in floating PV systems are like those used in ground-mounted PV systems but are designed to be more durable and resistant to corrosion from exposure to water. Then, the floating solar panel structure shades the body of water and reduces evaporation from these ponds, reservoirs, and lakes.

## 1.2 Overcome the overheat PV

Global warming and climate changes are the new challenges for mankind and this crisis is strongly connected to the burning of fossil fuels. For this reason, the search for Renewable Energy Sources has strongly increased in the last decade with an overwhelming importance in the electricity sector. Floating Photovoltaic also seems to participate in this growth with a development. The expected outcome of this project is an efficient water sprinkler system that can effectively cool photovoltaic panels.

## 1.3 Problem Statement

However, floating PV systems are vulnerable to harsh weather conditions such as strong winds, storms, and typhoons which can cause damage to the panels, mooring systems, and anchoring systems. In fact, the motion of the water can impact the stability of floating PV systems, leading to issues such as excessive panel tilting, shifting of mooring systems, and loss of electrical connections. Furthermore, the cooling of photovoltaic (PV) panels is a critical aspect of their performance and efficiency. Excessive heat can reduce the efficiency of PV cells, leading to lower energy output and decreased overall system performance. The problem lies in finding effective and sustainable methods to cool PV panels, particularly in regions with high ambient temperatures or limited access to natural cooling resources.

## 1.4 Project Objective

The primary goal of the project is to increase the efficiency of photovoltaic panels, by maintaining an optimal operating temperature. To attain this propose, the work will be divided into several stages and will be carried out concerning to the following objectives:

a) To design and develop a cooling PV with water sprinkler.

b) To analyse the proposed system performance under real operating conditions.

## 1.5 Scope of Project

The scope of this project are as follows:

a) Monochrystalline Solar PV used in this project.

b) Develop water sprinkler system that suit with the project

# CHAPTER 2

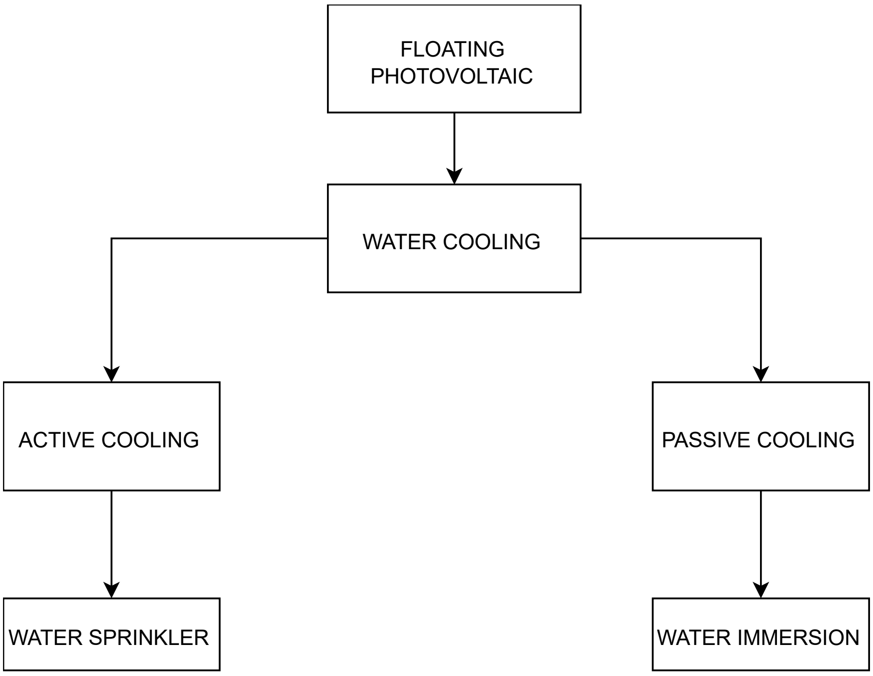
# LITERATURE REVIEW

## 2.1 Introduction

Our goal in this project is to develop and put into use a cooling system that uses water to control the temperature of floating solar panels. This system attempts to maximise the total energy generation capacity and increase the lifespan of the panels by maintaining ideal working temperatures, thereby enhancing their effectiveness and commercial feasibility.

## 2.2 Overview of water-cooling methods

Water cooling systems that are passive or active both have benefits and things to think about. Water is an effective coolant for dissipating heat due to its high thermal conductivity and heat capacity. When compared to air cooling, water cooling has better cooling capabilities since it can withstand large heat loads. When establishing water cooling systems, however, factors including system complexity, upkeep needs, and possible dangers of water leakage or component corrosion should be taken into mind.




### 2.2.1 Active cooling

In order to keep or regulate a system's temperature within a desired operating range, active cooling refers to a technique or process that actively removes or distributes heat from a system or component.Various methods are used in active cooling systems to promote heat transfer and maintain ideal temperatures. Common techniques for improving airflow or circulation of a cooling medium, such as air, water, or liquid coolant. These parts actively remove heat from the system or transfer it elsewhere, preventing overheating and guaranteeing proper performance.

#### 2.2.1.1 Water sprinkler

By actively removing extra heat from the PV panels, active cooling systems surpass passive methods. By properly sprinkling water across the panels surface, the suggested water sprinkler system cools the panels through evaporation and direct contact. This procedure distributes heat so that the panels may function at their ideal temperature range, thus increasing their output of energy.

### 2.2.2 Passive cooling

A group of design techniques and procedures known as passive cooling are used to control temperatures and dissipate heat without the need of active mechanical systems or outside energy sources. It reduces the need for artificial cooling techniques by utilizing natural processes and principles to maintain comfortable temperatures in a place or for certain purposes.



#### 2.2.2.1 Water immersion

Utilising the cooling qualities of water to remove heat from a system or component without the use of active mechanical devices is known as passive cooling by water immersion. It is based on the evaporative cooling theory, according to which heat is absorbed by water during evaporation, causing the temperature to drop. The target system or component is submerged in or surrounded by water in water immersion passive cooling to improve heat transfer. The mechanism produces heat, which the water absorbs and then dissipates as it evaporates, successfully cooling the system.

## 2.3 Overview of existing project

In this part, some of the earlier project designs and executions that have been carried out in relation with this project system will be reviewed. Years have been spent by a number of great academics figuring out how to best optimize the system for cooling floating photovoltaic panels.

### 2.3.1 Floating photovoltaic module temperature estimation: Modeling and comparison

Thermal, empirical, and computational fluid dynamics (CFD) models are used in this work to estimate and compare the temperature of the floating PV module. A three-level energy-balance equation for the FPV module is considered by the dynamic thermal model. As a result, a streamlined thermal model that requires fewer factors and makes it simpler to predict module temperature has been created. Second, the empirical model was created using least squares regression, which produced the minimum feasible root mean square error when comparing the observed and projected values. Finally, using the same heat transfer technique, the FPV system has been created in the COMSOL environment for CFD analysis. The projected outcomes from the models were contrasted with the actual data obtained at a Brazilian location and the pre-existing temperature and FPV models. The RMSE performance of the FPV models was substantially better than that of other comparable FPV models and their ground-based equivalents, and it was comparable to the data acquired from an installed FPV system [1].

### 2.3.2 Wave-induced structural response analysis of the supporting frames for multiconnected offshore floating photovoltaic units installed in the inner harbor

On the basis of the analysis findings, logical mooring types for FPVs put in the inner harbor were first researched. After that, in-depth parametric analyses were carried out to decide on a logical design approach for dynamic response mitigation. The initial configuration, axial stiffness and floater size. This study looked at both the dynamic and static responses of supporting frames to erratic waves in the inner harbor. Among other things, in the multiconnected system's corner module, there were important reactions that needed to be looked at for safety assessment. Additionally, it was demonstrated that the system's entire stiffness was regulated by the mooring stiffness which correlated with the reduction of the dynamic responses. Finally, it was discovered that the unjustifiable length of the frame was defined by the floater size, was a key factor in reducing structural responses. [2].



### 2.3.3 Floating Photovoltaic Plants as an Effective Option to Reduce Water Evaporation in Water-Stressed Regions and Produce Electricity

Firstly, The author effort intends to maintain such water resources while solving two important water and energy-related challenges. This research suggested using floating photovoltaic (FPV) panels with partial coverage technology on Lake Nasser to accomplish this purpose. The study's findings demonstrated how effective it would be to partially cover Lake Nasser with FPV panels in order to protect Egypt's water supplies, which are under risk because to water scarcity. When 50% of Lake Nasser's area was covered by FPV panels, water evaporation in the lake was reduced by 61.71% (9,074,081,000 m3/year), and 467.99 TWh/year of power were produced [3].

### 2.3.4 Enhancing the performance of floating photovoltaic system by using thermosiphon cooling

The objective of this study is to develop a passive cooling method using thermosiphon technology for floating photovoltaic (PV) systems. The thermosiphon utilizes free convection phenomena as a passive heat exchanger. Through experimental research, the study estimated the increase in electrical power production achieved by implementing a thermosiphon-based cooling system for floating PV systems compared to traditional floating PV setups. The experimental findings revealed that floating PV systems generated approximately 4.52% more power than terrestrial PV installations. Furthermore, when thermosiphon cooling was incorporated into the floating PV systems, the power output increased by about 7.86% compared to ground-based PV generation or by about 3.34% compared to standard floating PV systems. To investigate the fluid flow and temperature distribution within the system, a comprehensive numerical analysis was conducted. The simulations assumed laminar conditions for transient computations and considered temperature-dependent fluid characteristics using piecewise-linear functions. The numerical data indicated that the thermosiphon cooling system effectively dissipated heat from the PV panels to the environment. The suggested thermosiphon cooling technique demonstrated successful enhancement of the electrical energy production of floating PV units without requiring external energy for cooling [4].

### 2.3.5 Comparative assessment of offshore floating photovoltaic systems using thin film modules

This research paper focuses on evaluating the electrical efficiency of offshore floating solar systems in the Maldives Islands. The study specifically considers thin-film module-based offshore floating solar systems with a 5 MW installed capacity, proposed for installation at four offshore locations. Numerical simulations were conducted to assess the electrical performance of these systems and compare them with ground-mounted solar systems and floating photovoltaic systems on lakes. The findings indicate that the thin film-based offshore floating solar systems outperform pontoon-mounted and ground-mounted systems in terms of yearly energy generation, achieving a 13% and 14% increase, respectively. On average, the offshore systems exhibit superior performance, producing an annual energy output of 8.74 GWh with a maximum value of 87.10%. Cost analysis reveals that ground-mounted systems are 72% more expensive than floating systems. Additionally, when considering carbon footprints, the examination suggests that offshore systems have the potential to reduce carbon emissions by 14% more compared to other systems. This highlights the environmental benefits associated with offshore floating solar systems [5].

### 2.3.6 Design and construction of a test bench to investigate the potential of floating PV systems

This report presents the results of an experimental analysis conducted on a small-scale Floating Photovoltaic System (FPVS) in the specific operational conditions of Morocco. The FPVS was designed and constructed for research and demonstration purposes, serving as an initial exploration of this concept. To assess and compare the electrical and thermal capabilities of the FPVS, it was compared to an equivalent capacity Overland Photovoltaic System (OPVS). To facilitate the analysis, a comprehensive test bench was proposed and established, consisting of the FPVS, OPVS, and a measuring station. The report provides detailed information on the design and construction process of the FPVS, as well as the setup of the complete test bench. The test findings reveal that, throughout the testing period, the average temperature of the FPV modules remained consistently lower than that of the OPV modules, with a temperature difference of up to 2.74°C. This indicates that the FPVS operates more efficiently than the OPVS, benefiting from the natural cooling effect of water. Additionally, the FPVS was found to generate up to 2.33% more energy per day compared to the OPVS. Furthermore, the report includes an experimental test conducted to compare the energy generation of the FPVS at different tilt angles. The test results demonstrate that the FPVS achieves the highest energy production when mounted at the optimal tilt angle for the specific location and time of year [6].

### 2.3.7 Renewable energy production based on solar power and magnetic field prototype

Due to a lack of fossil fuel dissipation, Bangladesh is currently experiencing a perilous consequence. In this study article, a brand-new form of power generation is suggested as a means of resolving the power need. To produce the most power, solar radiation and magnetic flux must be coupled. When solar radiation is at its strongest, the PV panel produces the most electricity. At night, the energy stream is cut off. However, depending on the direction of the water wave, the floating generator can deliver its maximum output day or night. This is why an integrated renewable energy system based on a PV-floating Generator is examined in this project. In comparison to traditional approaches, the experimental result demonstrates its real-world validity (maximum 14.5 Watt output) [7].



### 2.3.8 Performance enhancement of solar powered floating photovoltaic system using arduino

This study demonstrates how to improve the performance of a solar-powered floating photovoltaic system via an Arduino approach. The project's primary system controller is an Arduino nano. This project's goal is to evaluate how well the voltage, current, and power output are performing. Additionally, the research's prototype is being tested in two environments: on the surface of water and on land. According to the findings, the solar power on the water surface is more than on the land area. The project conclusion is that floating photovoltaic panels can generate power while simultaneously monitoring the system's performance [8].

### 2.3.9 Using remote sensing to calculate floating photovoltaic technical potential of a dam's surface

This research proposes the installation of a Floating Photovoltaic (FPV) solar power plant (SPP) in an abandoned dam region, aiming to generate electrical energy while mitigating water loss through evaporation. Determining the suitable coverage area for FPV panels proves challenging due to the constantly changing coastline of a dam utilized for agricultural irrigation. To address this, the study utilizes the supervised categorization feature of the Google Earth Engine to monitor shoreline changes over a 20-year period in the Demirköprü Dam region in Manisa, Turkey. Through analysis, the minimum surface area of the dam is determined to be 1,562.45 hectares. This area can accommodate a horizontally installed 2.03 GWp FPV SPP, capable of generating 3,328.33 GWh of electricity annually. Additionally, the FPV panels offer the added benefit of preventing the evaporation of approximately 28,231,026.90 cubic meters of water. Implementing this SPP could potentially recover around 7.82% of the water utilized for power production in 2019. Overall, this research highlights the potential of utilizing FPV technology in an abandoned dam area, enabling both sustainable energy generation and the conservation of water resources through evaporation reduction [9].

### 2.3.10 Spraying cooling system for PV modules

Since operating modules have conversion efficiencies between 10 and 15%, it is critical to regulate their temperature in order to increase energy production. To do this, the authors created a PV spraying cooling system that can significantly lower the operational temperature of modules. The authors of this study investigate various factors related to a cooling system for photovoltaic (PV) modules, including the number, geometry, and positioning of nozzles, temperature distribution of water and modules, formation of limestone, degradation of front glass properties, water consumption, and power output. They conduct experimental measurements using a specialized test rig to gather data. The experimental campaign demonstrates that implementing a cooling system with three 90° spraying nozzles, water pressure at 1.5 bar, and ON/OFF control (30 seconds on, 180 seconds off) can significantly enhance module efficiency. The cooling system reduces the module temperature by up to 24 °C and increases the efficiency from 11.18% to 13.27%. Consequently, the power output per single module also increases from 178.88 W to 212.31 W. However, despite the performance improvements, the study indicates that, as of the time of writing, the investment required for implementing such a cooling system is not financially viable. This is particularly true when considering a 1 MW floating PV facility, due to the equipment and installation costs, as well as the complexity involved in designing the plant. Therefore, further advancements in cost-effectiveness and simpler plant designs are necessary to make the cooling system financially feasible for widespread adoption [10].

### 2.3.11 Analysis of water environment on the performances of floating photovoltaic plants

This study's goal is to create and test mathematical models that can predict how well monofacial and bifacial PV modules mounted on water surfaces would perform. Different situations, including mono and bifacial rooftop installations, mono and bifacial FPV systems with passive and active cooling, and more are modelled starting with the energy balances of the PV modules. The models are tested against experimental data collected using FPV systems that Enel Green Power, Catania (Italy), placed at the Enel Innovation Lab. The data obtained indicate a 5.24% increase in energy owing to bifaciality. The energy collected by the FPV is increased by passive cooling by 3% (to a maximum of 6.4%), and by 2.6% for bifacial and monofacial technologies. Active cooling in FPVs increases the energy gathered for the bifacial and monofacial by 9.7% (up to a maximum of 13.5%) and 9.5%, respectively. [11].

### 2.3.12 Water spray cooling technique

This study presents an alternate method of cooling photovoltaic (PV) panels by sprinkling water on both sides of the panel surface simultaneously. The goal was to assess the cooling effect on PV panel performance under high solar irradiation conditions. A dedicated testing setup was carefully constructed in a Mediterranean environment to evaluate the devised cooling solution. The experimental results demonstrate that implementing the suggested cooling technique during peak solar irradiation can lead to a significant increase in electric power output and PV panel efficiency. The maximum total increase observed was 16.3% (effective 7.7%) in power output and 14.1% (effective 5.9%) in PV panel efficiency. Additionally, the cooling method effectively reduced the panel temperature when both sides of the panel were cooled simultaneously, lowering it from an average of 54 °C (in non-cooled panels) to 24 °C. The economic viability of the proposed water spray cooling technique was also evaluated. One notable advantage of this cooling approach is the self-cleaning effect it provides to the PV panel's surface, which further contributes to the overall power generation. In summary, the study demonstrates that the suggested water spray cooling method can enhance the electrical performance of PV panels under high solar irradiation conditions. Additionally, the cooling technique offers potential economic benefits while providing self-cleaning properties to the panel surface [12].

.

### 2.3.13 Floating photovoltaic with fins-assisted

The study focuses on different FPV configurations, such as a partially submerged floating (PSPV- AF) system with attached fins (AF) that was compared to a partially submerged floating (PSPV) system without fins and a bare conventional floating system (FPV-R), for which a thorough performance analysis and optimisation were carried out. The proposed improved system with connected fins was subsequently tested in a floating arrangement under actual outside conditions. The outcomes confirmed the superiority of the PSPV-AF system over more traditional techniques in the literature. When the submerged area ratio (AR), also known as the percentage value of the undersea area to module area, reaches 20%, it outperforms the FPV-R in terms of operating temperature reduction by about 19.07%. [13].

## 2.4 Comparison Of Literature Review



Table 2.1 shows comparison of existing project between the components that have been used. Based on the research that we have done, there are many methods that we can highlight.

**Table 1 Comparison of Literature Review**

| Component / Existing Project | Arduino UNO | Temperature sensor | Fins assisted | Thermosiphon | Charger controller | Spray cooling | Battery |
|---|---|---|---|---|---|---|---|
| floating photovoltaic system by using thermosiphon cooling | | | | | | | |
| floating photovoltaic system using arduino | | | | | | | |
| Spraying cooling system for PV modules | | | | | | | |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| Water spray for cooling techniques | | | | | | | |
| Floating photovoltaic with fins-assisted | | | | | | | |

## 2.5 Background of Solar Power System

Solar energy systems, which turn sunlight into electricity, are renewable energy sources. It uses solar panels made of photovoltaic cells to capture solar energy. Still under development, solar power systems are crucial to the global transition to renewable energy sources.



### 2.5.1 Types Of Solar Photovoltaic

Each type of solar PV technology has its own advantages, efficiency levels, and manufacturing processes. The choice of technology depends on factors such as cost, available space, installation requirements, and specific project goals.

#### 2.5.1.1 Monochrystalline Solar Panels

**Figure 1 Monochrystalline Solar Panels**

Monocrystalline solar panels are made from a single crystal structure of silicon. They have a high efficiency rate and a uniform black appearance. Mono-Si panels are known for their higher power output and good performance in low-light conditions. However, they are generally more expensive to produce.

#### 2.5.1.2 Polycrystalline solar panels



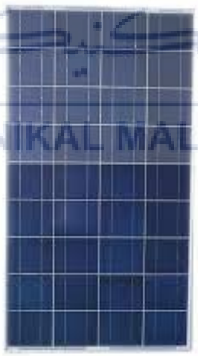


**Figure 2 Polychrystalline Solar Panel**

Polycrystalline solar panels are made from multiple crystal fragments of silicon. They have a blueish appearance due to their less uniform crystal structure. Poly-Si panels are cost-effective to manufacture and offer good efficiency levels. While they may have a slightly lower efficiency compared to monochrystalline panels, they are still widely used in residential and commercial installations,

#### 2.5.1.3 Thin-film solar panels

**Figure 3 Thin-film solar panels**

Thin-film solar panels use a thin layer of semiconductor material deposited on a substrate, such as glass, plastic, or metal. The most common thin-film materials include amorphous silicon (a-Si), cadmium telluride (CdTe), and copper indium gallium selenide (CIGS). Thin-film panels are flexible and lightweight, making them suitable for specific applications, such as building-integrated photovoltaics (BIPV) or portable solar devices. They typically have lower efficiency compared to crystalline silicon panels.



### 2.5.2 Arduino UNO


**Figure 4 Arduino UNO**

The Arduino UNO is a widely used microcontroller board based on the ATmega328P chip. It features 14 digital input/output pins, six analog input pins, and various power pins. With a built-in USB interface, it can be easily programmed and connected to a computer. The board is powered by either a USB connection or an external power source, and it supports expansion shields for additional functionalities. Being open-source, the Arduino UNO has a large and active community, making it a popular choice for electronics projects and prototyping due to its versatility, simplicity, and extensive resources available.

### 2.5.3 Temperature Sensor

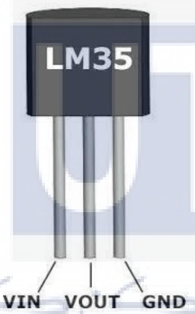



**Figure 5 Temperature Sensor**



A temperature sensor is an electronic device designed to measure and monitor temperature variations in its environment. It detects changes in temperature and converts them into electrical signals or digital readings. There are various types of temperature sensors, such as thermocouples, resistance temperature detectors (RTDs), thermistors, and digital temperature sensors. These sensors can be used in a wide range of applications, including climate control systems, industrial processes, weather monitoring, food storage, and medical devices. Temperature sensors play a crucial role in ensuring accurate temperature regulation, safety, and efficiency in numerous industries and everyday life.

### 2.5.4 Water sprinkler


**Figure 6: Water Sprinkler**

Water sprinkler cooling systems for solar panels are designed to mitigate the negative effects of high temperatures on solar panel efficiency and performance. These systems typically involve the use of water sprinklers or misters that spray water onto the surface of the solar panels

## 2.6 Summary

This chapter review about the important of component for water sprinkler system for cooling photovoltaic panels. All the information that has been researched is important to create a high quality system for the project.

# CHAPTER 3

# METHODOLOGY

## 3.1 Introduction

Water sprinkler cooling systems for photovoltaic (PV) panels are designed to address the issue of excessive heat and temperature-related performance losses in solar energy systems. These systems involve the use of water sprinklers or misters that spray water onto the surface of PV panels, helping to dissipate heat and maintain optimal operating temperatures. By cooling the panels, water sprinkler systems enhance their efficiency, improve power output, and prolong their lifespan. This introduction briefly highlights the purpose and benefits of water sprinkler cooling for PV systems, emphasizing their role in maximizing energy generation and mitigating the impact of heat on solar panel performance.



## 3.2 Methodology

This methodology shown that graphical representation of a process or system that uses different shapes and arrows to illustrate the flow of steps or activities. It provides a clear and structured visual depiction of how a process works, allowing to understand, analyze, and communicate complex workflows in a simplified manner. Figure 3.1 shown the flow of project in flowchart.

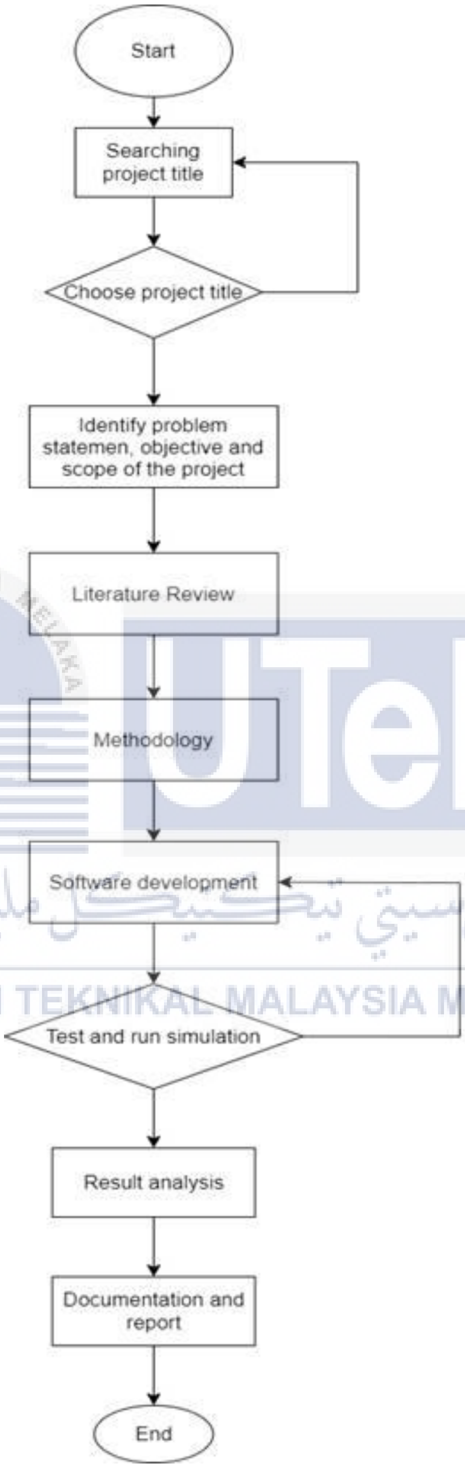



**Figure 7: Flowchart**

## 3.3 Project System Flowchart

Figure 3.1 shows the system flowchart for this project. Firstly, when the temperature sensor detects, if the condition of solar panel temperature above 35°C so water sprinkler system will turn on.

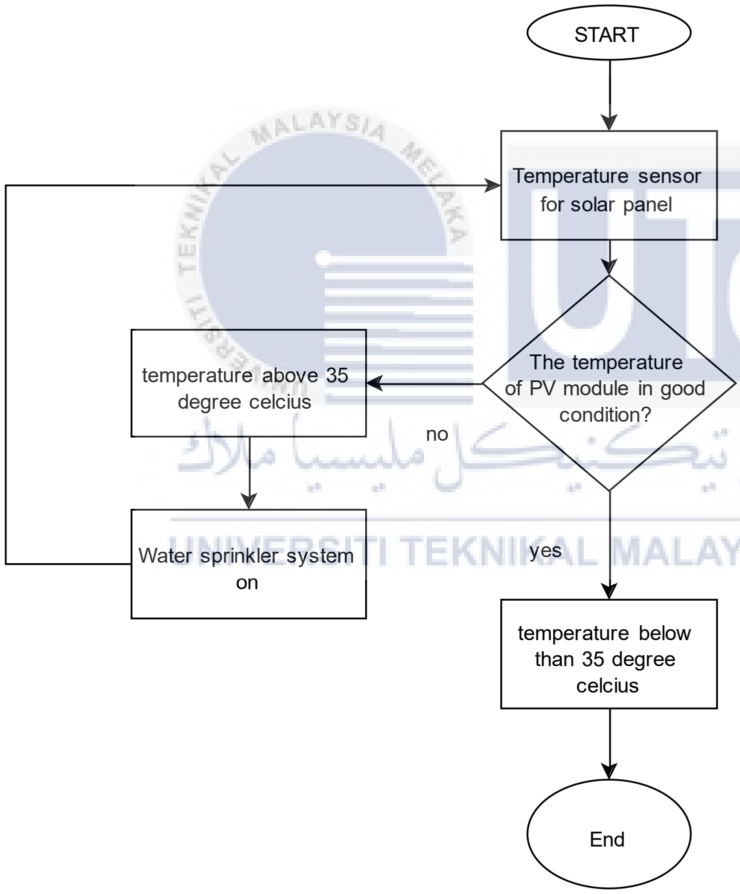



**Figure 8 : Project flowchart**

## 3.4 Block Diagram

Figure 3.3 shows that when Arduino UNO connect with supply, temperature sensor as an input will function. If the condition temperature of solar panel is above 35$^{\circ}$C, automatically water sprinkler system will turn on to reduce the temperature back to normal.

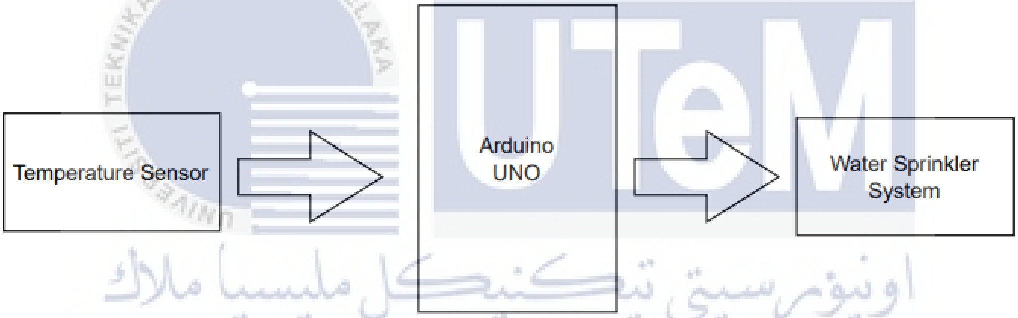





**Figure 9: Block Diagram**

## 3.5 Software Development

Software development is the process of designing, creating, testing, and maintaining computer programs or applications. It involves a systematic approach to building software solutions that meet specific requirements and deliver desired functionalities.

### 3.5.1 Proteus 8 Professional


**Figure 10: Proteus 8 Professional**

Proteus 8 Professional is a comprehensive software suite designed for electronic circuit design, simulation, and PCB (Printed Circuit Board) layout. It offers a wide range of tools and features to aid the development and testing of electronic systems. With Proteus 8 Professional, enable to design and simulate complex circuits using a user-friendly graphical interface. The software offers advanced simulation capabilities, allowing users to verify circuit functionality, test different scenarios, and analyze circuit performance.

### 3.5.2 Arduino IDE

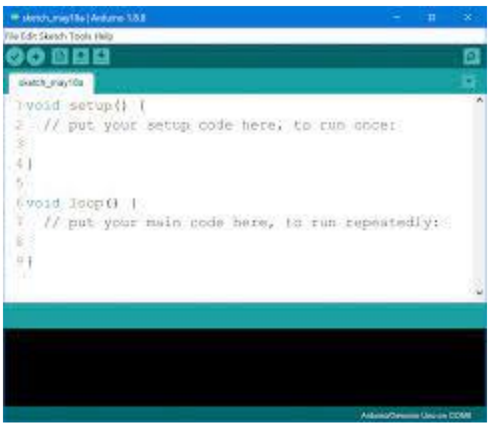



**Figure 11: Arduino IDE**

The Arduino IDE (Integrated Development Environment) is a software platform specifically designed for programming and developing applications for Arduino microcontroller boards. It provides a user-friendly interface that simplifies the process of writing, compiling, and uploading code to Arduino boards. With the Arduino IDE, users can write code using the Arduino programming language, which is based on C/C++, and utilize the extensive library of pre-written functions for various tasks. The IDE includes features like syntax highlighting, code suggestions, and a built-in serial monitor for debugging and testing. It also supports a wide range of Arduino boards, allowing users to easily switch between different models.

## 3.6 Component Of Project

Components are essential elements that make up a project, and their selection depends on the specific requirements and goals of the project.



### 3.6.1 Monochrystalline Solar Panel

**Figure 12: Monochrystalline Solar Panel**

These panels are made from a single crystal structure of silicon, resulting in a uniform black appearance. Monocrystalline panels are known for their high efficiency rates and excellent performance, particularly in low-light conditions. They offer a higher power output per square foot compared to other solar panel types, making them space-efficient and suitable for installations where space is limited. Monocrystalline panels are also durable, long-lasting, and aesthetically pleasing, blending well with various architectural styles. While they may be slightly more expensive to produce, their superior efficiency and reliability make them a popular choice for residential and commercial solar installations, enabling users to maximize energy generation and reduce their carbon footprint.

### 3.6.2 SP8266

**Figure 13: SP8266**



The ESP8266 is a versatile and cost-effective Wi-Fi module with a built-in microcontroller, commonly employed for IoT and embedded applications. Featuring support for IEEE 802.11 b/g/n standards, GPIO pins, and ample flash memory for program storage, it allows devices to connect to Wi-Fi networks and interface with various sensors. Widely embraced by a vibrant community, it can be programmed using the Arduino IDE, making it accessible for both hobbyists and professionals seeking an affordable solution for projects such as home automation, sensor networks, and other IoT applications.

### 3.6.3 LM35


**Figure 14: LM35**

The LM35 is a precision analog temperature sensor integrated circuit widely used for measuring temperature in electronic circuits and systems. Manufactured by Texas Instruments and other semiconductor companies, the LM35 provides an accurate and linear voltage output directly proportional to the Celsius temperature. It has a temperature range typically from -55°C to 150°C and operates on a single power supply. With a low self-heating capability and low output impedance, the LM35 is favored in applications such as temperature-controlled systems, environmental monitoring, and various electronic projects where precise temperature sensing is essential. Its straightforward interfacing and reliability make it a popular choice for temperature measurement in a diverse range of applications.

### 3.6.4 Water spinkler system

A water sprinkler system is a device or set of devices designed to distribute water in a controlled manner over a specific area such as like we use in this project for cooling PV solar panel.

#### 3.6.4.1 Water Pump



**Figure 15: Water Pump**

A water pump is a mechanical device used to move water from one location to another. It creates flow and pressure to push water through pipes or channels to a desired destination. So, the specification water pump that used in this project 800L/H 12V DC 5M Submersible Water Pump.

#### 3.6.4.2 Pipes and tubing

A network of pipes and tubing is used to transport water from the water source to the sprinkler heads.

#### 3.6.4.3 Sprinkler Heads

**Figure 16: Sprinkler Heads**

Sprinkler heads are the devices responsible for distributing water over the desired area. They are mounted on risers or pop-up bodies and release water in a pattern, either through rotating nozzles or fixed spray patterns. Sprinkler heads can be adjusted to control the spray distance, angle, and pattern. So, the specification that used in this project for sprinkler heads is 120-520L / H flow and spray radius range 4-6 meters

#### 3.6.4.4 Battery Seal Lead Acid




**Figure 17: Battery Seal Lead Acid**

A 12V 5Ah battery refers to a battery with a voltage of 12 volts and a capacity of 5 ampere-hours (Ah). The voltage rating indicates the electrical potential difference provided by the battery. In this case, the battery has a nominal voltage of 12 volts, which is a common voltage for many applications.

#### 3.6.4.5 Relay

**Figure 18: Relay**

A relay is an electromechanical switch that is controlled by an electric current. It consists of a coil and one or more sets of contacts. When an electrical current flows through the coil, it generates a magnetic field that causes the contacts to open or close, allowing or interrupting the flow of current in another circuit. Relays are commonly used to control high-voltage or high-current circuits with a low-voltage and low-current control signal, providing electrical isolation between the control and load circuits. They find applications in various fields, including automation, industrial control systems, automotive electronics, and home appliances. Relays are essential components for tasks such as switching on/off electrical devices, controlling motors, and managing complex electronic systems.



### 3.7 Summary

In conclusion, the methodology report provides a comprehensive overview of the research process and procedures undertaken to achieve the study objectives. The report has acknowledged the limitations and constraints encountered during the research process. Factors such as sample size, time constraints, access to resources, or potential biases have been discussed, providing a realistic assessment of the study's scope and generalizability.

# CHAPTER 4

# RESULTS AND DISCUSSION

## 4.1 Introduction

The utilization of water sprinkler cooling systems in photovoltaic (PV) installations represents a crucial aspect in enhancing the overall efficiency and performance of solar energy systems. As the demand for sustainable energy sources continues to rise, the effective management of temperature within PV panels becomes paramount to optimize their output. In this context, the integration of water sprinkler cooling systems has emerged as a promising solution to mitigate the impact of elevated temperatures on solar cell efficiency. This section of the study delves into the results obtained from the investigation of the water sprinkler cooling system's impact on photovoltaic performance. By examining various parameters, such as temperature reduction, energy yield, and overall system efficiency, we aim to assess the effectiveness and potential benefits of employing this cooling technique. Additionally, the discussion will explore the underlying mechanisms and interactions between the water sprinkler system and PV panels, providing insights into the thermal management strategies that contribute to improved overall performance. The subsequent analysis and interpretation of the results will be presented, offering a comprehensive discussion on the implications of water sprinkler cooling in the context of photovoltaic technology. This exploration is essential for advancing our understanding of how innovative cooling solutions can play a pivotal role in optimizing solar energy systems, contributing to the broader goal of sustainable and efficient renewable energy production.

## 4.2 Results And Analysis

Water sprinkler system for cooling photovoltaic panels has been designed and simulated by using Proteus 8 Professional while Arduino IDE software has been used to develop coding in this project. Firstly, as shown in figure 18 using Proteus 8 Professional display that Simulino UNO as a microcontroller. Next, Fan-DC depicted as an output for water sprinkler system. Input for this simulation is DHT 11 act as a temperature sensor.

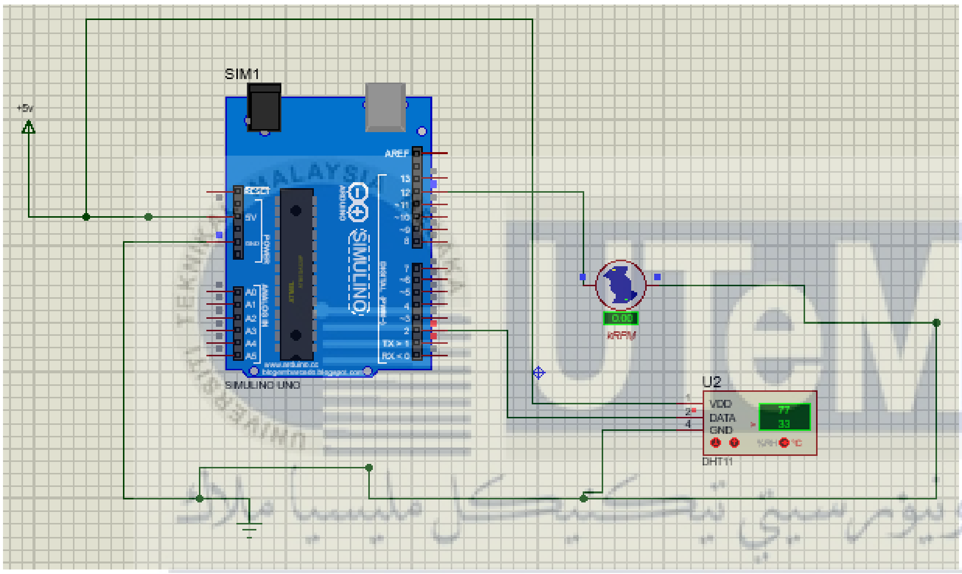





**Figure 19: Proteus 8 Professional Simulation at** 33°C

Start with the flow of the project where the condition of temperature solar panel is below than 35°C as shown in figure 18. This means that temperature of solar panel is in good condition. As a proof, Fan-DC still maintain as 0kRPM.

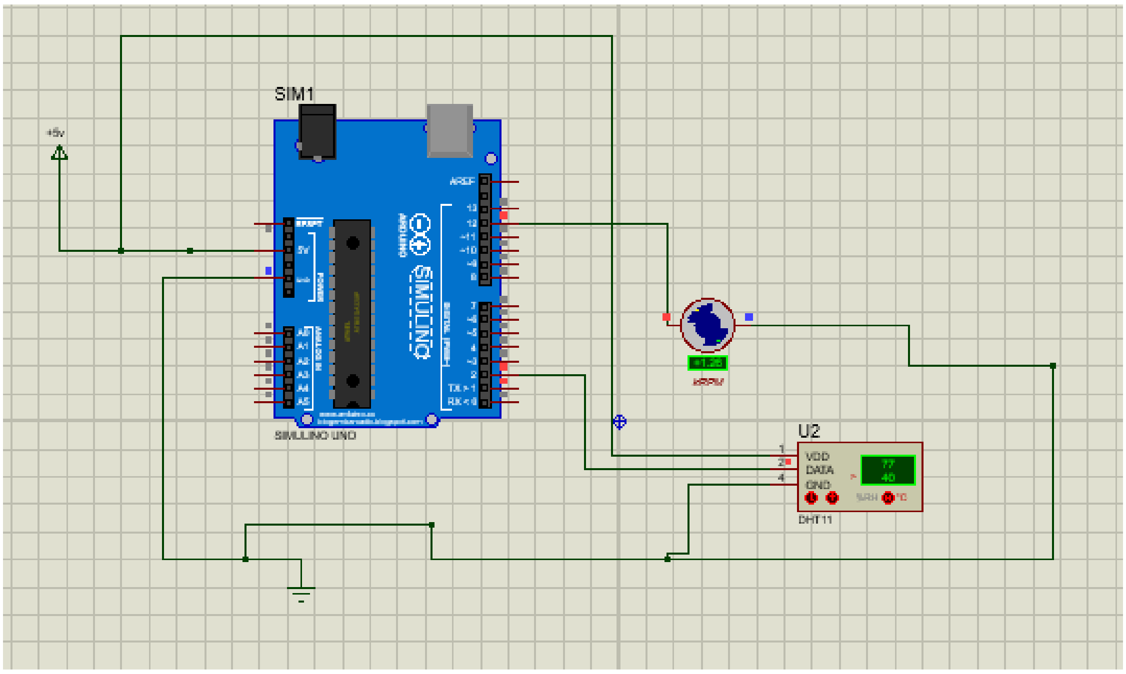



**Figure 20: Proteus 8 Professional Simulation at** 40℃

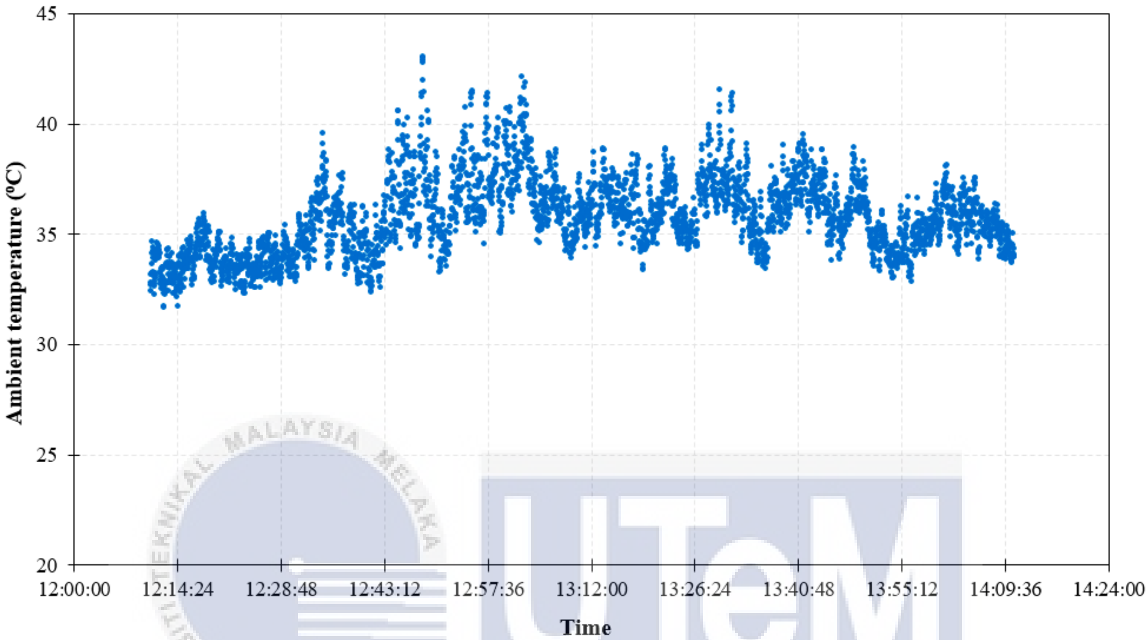
Next, the temperature has been increased to see the difference outcome. As shown in figure 19 the temperature has been set to 40℃ at DHT 11 so this mean when above 35℃, the temperature of solar panel is not in good condition. So, automatically Fan-DC that act as a water sprinkle system turned on. As a proof, the kRPM change from 0 to 1.26 at Fan-DC after we change the temperature

## 4.3 Solar PV Specifications

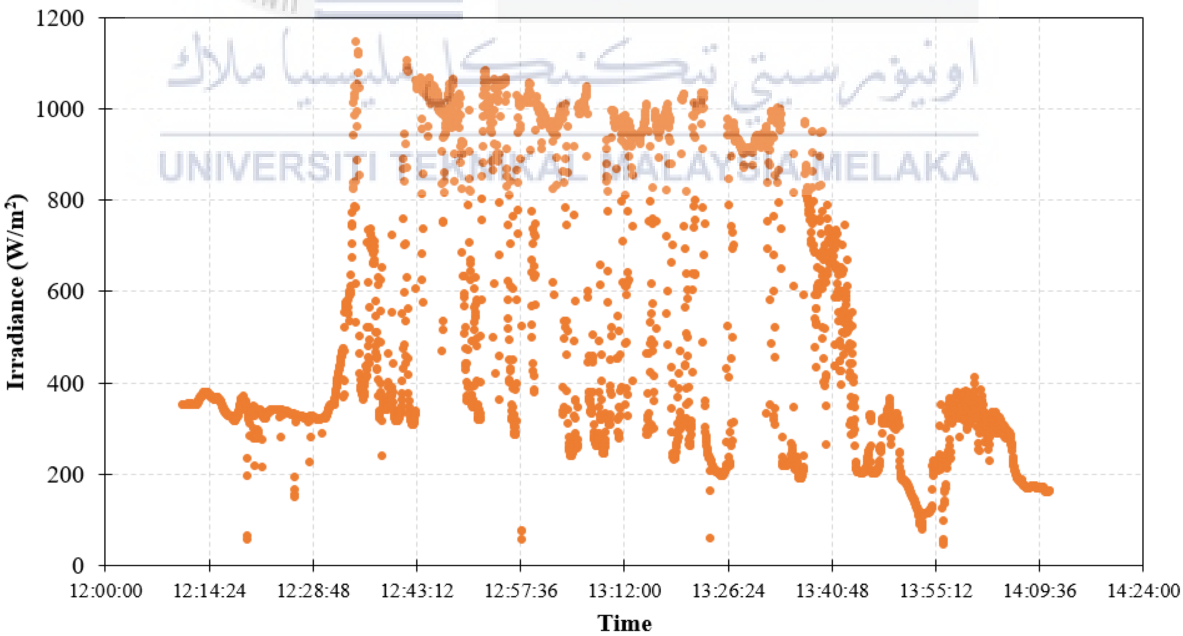
| Technical Specification | |
|---|---|
| Maximum Power (Pmax) | 150 |
| Voltage at Pmax (Vmp) | 18 |
| Current at Pmax (Imp) | 8.33 |
| Open-Circuit Voltage (Voc) | 21.6 |
| Short-Circuit Current (Isc) | 9.16 |

## 4.4 Solar Irradiance and Ambient Temperature Measurements

Measuring solar irradiance and ambient temperature is crucial for evaluating the performance of photovoltaic (PV) panels due to their direct impact on the efficiency and output of the solar energy conversion process.



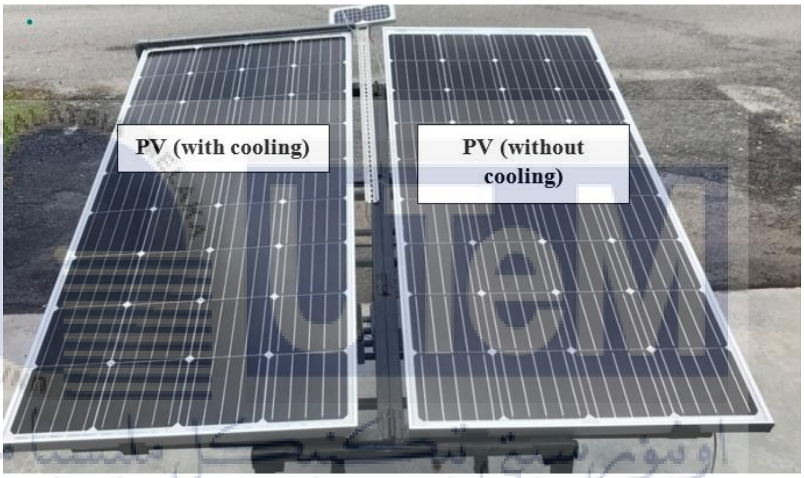

(a)




(b)

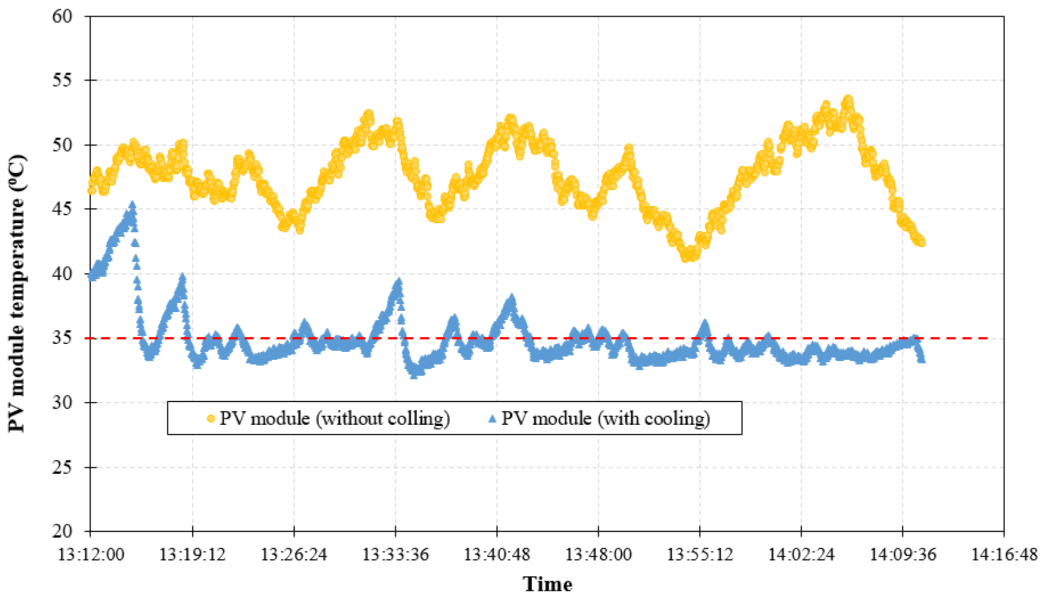
## 4.5 Temperature difference between PV modules (with and without cooling)

The efficiency of PV modules is highly sensitive to temperature. Generally, as the temperature of the panels increases, their efficiency decreases. Therefore, reducing the operating temperature of PV modules can have a positive impact on their overall performance. The experimental testing was conducted during clear and blue sky from 10 am to 4pm. Two similar PV modules were tested simultaneously and mounted 1.0m above the ground as illustrated in the following figure. Temperature profiles have been plotted to establish a behavioural pattern for PV both modules.




Tested PV modules (with and without cooling)






**Temperature profile for both PV modules**

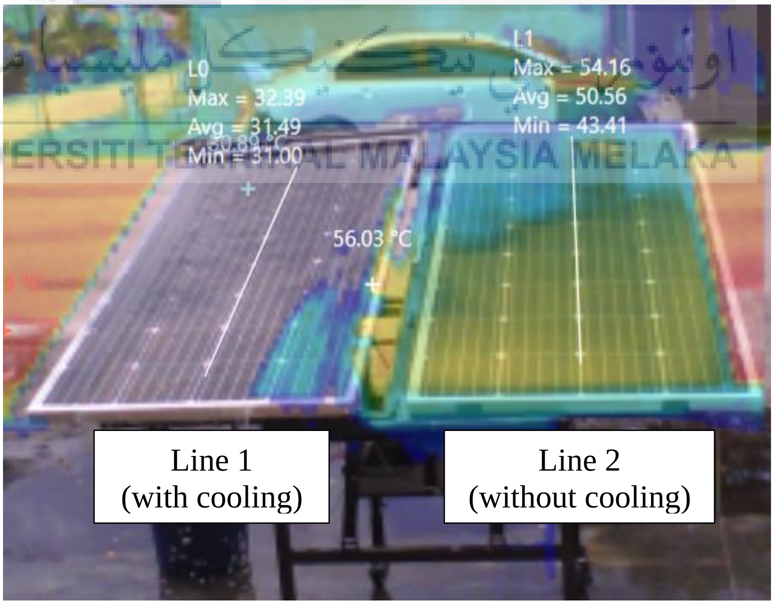
## 4.6 Temperature uniformity across PV module

The evaluation of temperature uniformity across a photovoltaic (PV) module is important for assessing the efficiency and overall performance of the module. Temperature variations across the module's surface can impact its electrical characteristics and long-term reliability. Further, the temperature uniformity for both modules was determined using the following expression:

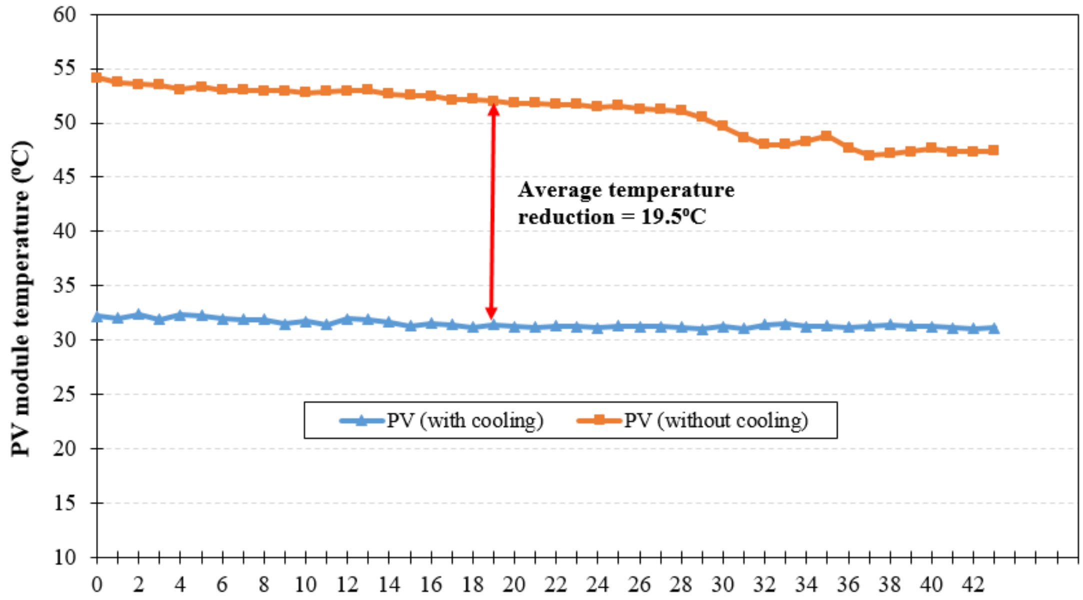
$$\%T_{unifomity} = \left[1 - \frac{T_{max} - T_{min}}{T_{average}}\right] \times 100\%$$

The temperature uniformity for both PV modules were evaluated by using infrared thermal imager. The recorded images were then further analysed with FlukeConnect Software. This software can be used to map the temperature profiles across PV modules. The recorded thermal images were illustrated in the following figure.



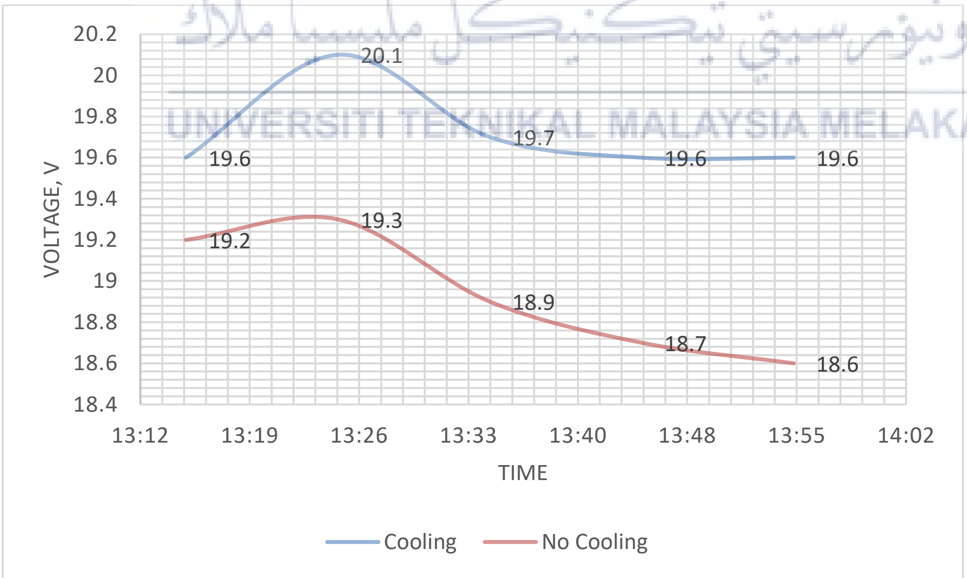



Thermal images for both PV modules were recorded using IR Thermal Imager

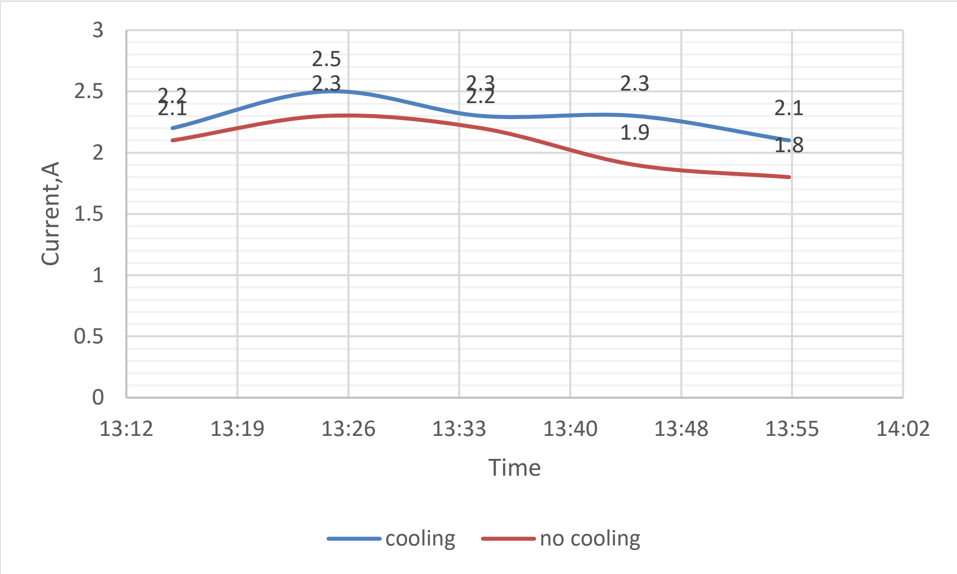



Based on the above figure, the average temperature reduction due to automated water cooling was 19.5 °C. This result indicates a significant impact on the operating temperature of the PV module.

## 4.7 Graph Voltage Against Time



## 4.8 Graph Current against Time




## 4.9 Summary

In conclusion, the investigation into the integration of a water sprinkler cooling system for photovoltaic installations has yielded valuable insights into its potential impact on system performance. The results demonstrate a significant reduction in panel temperatures, directly translating into enhanced energy yield and overall system efficiency. The cooling mechanism employed by the water sprinkler system proves effective in mitigating the adverse effects of elevated temperatures on solar cell performance. This temperature control not only prevents efficiency losses associated with overheating but also contributes to prolonged panel lifespan, thereby improving the long-term reliability of the photovoltaic system.

# CHAPTER 5

# CONCLUSION

## 5.1 Conclusion

The positive outcomes observed in our study underscore the critical role of effective thermal management in solar energy systems through the implementation of water sprinkler cooling systems in photovoltaic installations. The substantial reduction in panel temperatures directly contributes to a notable enhancement in energy conversion efficiency. By mitigating the losses associated with high temperatures, the cooling effect facilitates more consistent and efficient operation of solar cells. Looking ahead, future research can delve deeper into optimizing the design and operational parameters of water sprinkler cooling systems. This may involve exploring advanced control strategies, precision irrigation techniques, and the integration of smart technologies to further enhance the efficiency of the cooling system. Additionally, comprehensive economic analyses and life cycle assessments can provide a more detailed understanding of the overall benefits and drawbacks of this technology. In conclusion, findings illuminate the potential of water sprinkler cooling systems to significantly elevate the performance, efficiency, and reliability of photovoltaic installations. As we continue advancing renewable energy technologies, these insights contribute to ongoing efforts to make solar power an increasingly viable and sustainable source of electricity in our pursuit of a cleaner and greener energy future.

## 5.2 Project objectives

The objective of the project has been achieved. For instance, to design, develop, and evaluate an efficient water sprinkler system specifically tailored for cooling floating photovoltaic (PV) panels was successful. The aim is to mitigate the detrimental effects of excessive heat on the panels, thereby optimizing their performance and enhancing energy generation. By maintaining lower panel temperatures through an effective cooling mechanism, the project seeks to increase the overall efficiency and longevity of the PV system. The project investigated the impact of the water sprinkler system on power output, temperature reduction, and energy conversion efficiency, providing valuable insights into the feasibility and benefits of implementing such a system in floating PV installations.

## 5.3 Commercialization



The outlook for commercializing water sprinkler cooling systems in the realm of photovoltaic installations is optimistic, given the observed positive impacts on energy efficiency and the extended lifespan of solar panels. With documented enhancements in energy conversion efficiency and increased energy yield, these systems emerge as valuable assets for solar energy projects, potentially providing a competitive advantage in the growing renewable energy market. The relevance of water sprinkler cooling systems in the face of escalating demand for sustainable energy solutions is evident, emphasizing the need for their commercial viability. However, the successful introduction to the market depends on addressing practical considerations, including optimizing system design, minimizing water consumption, and adapting the technology to varying climate conditions. Collaborative efforts among researchers, industry players, and policymakers are crucial for navigating regulatory landscapes, developing cost-effective solutions, and fostering widespread adoption. In conclusion, the encouraging outcomes of this study indicate that water sprinkler cooling systems hold significant potential for contributing to the commercial success of photovoltaic installations, playing a pivotal role in the global shift towards cleaner and more efficient energy sources.

## 5.4 Future Works

Future research endeavors in the domain of water sprinkler cooling systems for photovoltaic installations should concentrate on refining and broadening our comprehension of this technology to ensure its sustained efficacy and widespread acceptance. Exploring advanced control strategies and integrating smart technologies to optimize the operational parameters of the cooling system holds promise for further efficiency improvements. Additionally, investigating precision irrigation techniques and alternative water sources can aid in minimizing water consumption, addressing sustainability concerns.

**Table 2 Gantt chart**

| PROGRESS | WEEK | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 |
| Application Mendeley | | | | | | Mid Sem | | | | | | | |
| Download Journal | | | | | | | | | | | | | |
| Chapter 1 - Problem Statement | | | | | | | | | | | | | |
| Objective | | | | | | | | | | | | | |
| Abstract | | | | | | | | | | | | | |
| Chapter 2 - Literature Review | | | | | | | | | | | | | |
| Component preparation | | | | | | | | | | | | | |
| Chapter 3 - Methodology | | | | | | | | | | | | | |
| Chapter 4 - Collect Data | | | | | | | | | | | | | |
| Chapter 5 - Conclusion | | | | | | | | | | | | | |
| Report Finalized | | | | | | | | | | | | | |
| Slide Presentation | | | | | | | | | | | | | |
| Final Presentation Preparation | | | | | | | | | | | | | |

# REFERENCES


[1] M. A. Rahaman, T. L. Chambers, A. Fekih, G. Wiecheteck, G. Carranza, and G. R. C. Possetti, “Floating photovoltaic module temperature estimation: Modeling and comparison,” *Renew Energy*, vol. 208, pp. 162–180, May 2023, doi: 10.1016/j.renene.2023.03.076.

[2] J. Song, J. Kim, W. C. Chung, D. Jung, Y. J. Kang, and S. Kim, “Wave-induced structural response analysis of the supporting frames for multiconnected offshore floating photovoltaic units installed in the inner harbor,” *Ocean Engineering*, vol. 271, Mar. 2023, doi: 10.1016/j.oceaneng.2023.113812.

[3] M. Abdelgaied, A. E. Kabeel, M. Zeleňáková, and H. F. Abd-Elhamid, “Floating Photovoltaic Plants as an Effective Option to Reduce Water Evaporation in Water-Stressed Regions and Produce Electricity: A Case Study of Lake Nasser, Egypt,” *Water (Switzerland)*, vol. 15, no. 4, Feb. 2023, doi: 10.3390/w15040635.

[4] B. Sutanto, Y. S. Indartono, A. T. Wijayanta, and H. Iacovides, “Enhancing the performance of floating photovoltaic system by using thermosiphon cooling method: Numerical and experimental analyses,” *International Journal of Thermal Sciences*, vol. 180, Oct. 2022, doi: 10.1016/j.ijthermalsci.2022.107727.

[5] N. Ravichandran, N. Ravichandran, and B. Panneerselvam, “Comparative assessment of offshore floating photovoltaic systems using thin film modules for Maldives islands,” *Sustainable Energy Technologies and Assessments*, vol. 53, Oct. 2022, doi: 10.1016/j.seta.2022.102490.

[6] A. El Hammoumi, A. Chalh, A. Allouhi, S. Motahhir, A. El Ghzizal, and A. Derouich, “Design and construction of a test bench to investigate the potential of floating PV systems,” *J Clean Prod*, vol. 278, Jan. 2021, doi: 10.1016/j.jclepro.2020.123917.

[7] O. Qays and F. Yasmin, “Renewable energy production based on solar power and magnetic field prototype in Bangladesh,” *International Journal of Applied Power Engineering (IJAPE)*, vol. 9, no. 1, p. 29, Apr. 2020, doi: 10.11591/ijape.v9.i1.pp29-35.

[8] N. A. A. Jamil, S. A. Jumaat, S. Salimin, M. N. Abdullah, and A. F. M. Nor, “Performance enhancement of solar powered floating photovoltaic system using arduino approach,” *International Journal of Power Electronics and Drive Systems*, vol. 11, no. 2, pp. 651–657, Jun. 2020, doi: 10.11591/ijpeds.v11.i2.pp651-657.

[9] A. M. Ates, O. S. Yilmaz, and F. Gulgen, “Using remote sensing to calculate floating photovoltaic technical potential of a dam’s surface,” *Sustainable Energy Technologies and Assessments*, vol. 41, Oct. 2020, doi: 10.1016/j.seta.2020.100799.

[10] A. Benato, A. Stoppato, F. De Vanna, and F. Schiro, “Spraying cooling system for pv modules: Experimental measurements for temperature trends assessment and system design feasibility,” *Designs (Basel)*, vol. 5, no. 2, Jun. 2021, doi: 10.3390/designs5020025.

[11] G. M. Tina, F. Bontempo Scavo, L. Merlo, and F. Bizzarri, “Analysis of water environment on the performances of floating photovoltaic plants,” *Renew Energy*, vol. 175, pp. 281–295, Sep. 2021, doi: 10.1016/j.renene.2021.04.082.

[12] S. Nižetić, D. Čoko, A. Yadav, and F. Grubišić-Čabo, “Water spray cooling technique applied on a photovoltaic panel: The performance response,” *Energy Convers Manag*, vol. 108, pp. 287–296, Jan. 2016, doi: 10.1016/j.enconman.2015.10.079.

[13] N. A. S. Elminshawy, D. G. El-Damhogi, I. A. Ibrahim, A. Elminshawy, and A. Osama, "Assessment of floating photovoltaic productivity with fins-assisted passive cooling," *Appl Energy*, vol. 325, Nov. 2022, doi: 10.1016/j.apenergy.2022.119810.