STUDY ON THE IMPLEMENTATION OF PARABOLIC DISH BASED ON CONCENTRATED SOLAR POWER UNDER MALAYSIA ENVIRONMENT – (DIRECT NORMAL IRRADIANCE)

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A report submitted in partial fulfillment of the requirements for the degree of Bachelor of Electrical Engineering (Control, Instrumentation and Automation)

Faculty of Electrical Engineering

UNIVERSITI TEKNIKAL MALAYSIA MELAKA

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SUPERVISOR’S DECLARATION

“I hereby declare that I have read through this report entitle “Study On The Implementation of Parabolic Dish Based On Concentrated Solar Power Under Malaysia Environment – (Direct Normal Irradiance)” and found out that it has complied the partial fulfilment for awarding the degree of Bachelor of Electrical Engineering (Control, Instrumentation and Automation)”

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STUDENT'S DECLARATION

I declare that this report entitles "Study On The Implementation of Parabolic Dish Based On Concentrated Solar Power Under Malaysia Environment – (Direct Normal Irradiance)" is the result of my own research except as cited in the references. The report has not been accepted for any degree and is not concurrently submitted in candidature of any other degree.

Signature : ____________________________

Name : AMIRUL AZALY BIN RAMLI

Date :

"Dedicated to my beloved family, especially my father & mother

"Ramli Hanapiah and Julia Hussain"

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Firstly, I would like to praise ALLAH SWT for his blessing and gave me in good health and condition to carry on this Final Year Project (FYP) until it done well. For my parent who always support me and gave morale boost in any kind of condition I am for becoming an engineer and have a bachelor degree holder in future. I also would like to take opportunity to express my big gratefulness and thanks for my supervisor, Datuk Prof Dr. Ruddin Ab Ghani and Mdm. Syarifah as PhD student who assisted me, and gave support, guidance, advice, and encouragement along the period to completing this project report. Theirs guidance are helpful and really appreciated and without them this project will not even exist.

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ABSTRACT

Parabolic Dish (PD) is one of Concentrating Solar Power (CSP) technologies that change over sunlight to electricity. PD has demonstrated the most outstanding efficiency by changing over almost 31.25% of solar radiation into electricity and PD has developed as one of dependable and productive Renewable Energy (RE) technology. In any case, the assessment for the PD system performance by utilizing test approach are expensive and takes time. This project is to study on the effect of the Direct Normal Irradiance (DNI) based on the site selection generated from weather station in Malaysia and factor affecting DNI performance in PD system. This review is utilizing a recreation approach and MATLAB was utilized as the reference model of PD and analysis. The solar irradiation information data were downloaded from the Meteonorm7 Software and five locations will be selected in Penang, Kota Bharu, Kota Kinabalu, Kuching, and KL Airport, in Malaysia region has been chosen as the area for analysis. From the analysis of five selected locations, Penang is the best location for planting a CSP technologies using PD system and not preferable locations is at Kuching. This is because of Penang highest DNI intensity, low precipitation area with low relative humidity environment condition compare the others and for Kuching have lowest DNI intensity, high precipitation area with high relative humidity environment condition. As a conclusion, the installation of PD in Malaysia need to consider on DNI of area and the performance of PD. Based on the analysis, it could be possible for being implemented in Malaysia because of its DNI are near reaching minimum requirement of CSP technologies and also there is no technical reason that cannot build CSP technologies with low DNI value. Modification of PD system are needed for enhancing the performance for possibilities of installation.

ABSTRAK

Dish parabola (PD) adalah salah satu teknologi kuasa solar tertumpu (CSP) yang berubah dari cahaya matahari kepada tenaga elektrik. PD telah menunjukkan kecekapan yang tertinggi dengan menukar lebih hampir 31.25% daripada sinaran suria kepada elektrik dan PD telah dibangunkan sebagai salah satu teknologi tenaga yang produktif dan boleh diperbaharui (RE). Dalam kes ini, penilaian bagi pelaksanaan sistem PD dengan menggunakan sistem ujian sebenar adalah mahal dan mengambil masa. Projek ini adalah untuk mengkaji tentang kesan Sinaran Solar Langsung (DNI) berdasarkan pemilihan tapak yang diambil dari stesen kaji cuaca di Malaysia dan faktor prestasi DNI terhadap sistem PD. Kajian ini adalah menggunakan pendekatan membuat semula dan software MATLAB telah digunakan sebagai analisa. Maklumat data penyinaran solar diambil dari Software Meteonorm7 dan lima lokasi dipilih di malaysia antaranya di Penang, Kota Bharu, Kota Kinabalu, Kuching, dan KL Airport, sebagai kawasan untuk dianalisis. Daripada analisis daripada lima lokasi terpilih, Pulau Pinang adalah lokasi terbaik untuk membangunkan teknologi CSP menggunakan sistem PD dan kuching adalah bukan lokasi yang baik. Hal ini kerana Pulau Pinang mempunyai intensiti DNI yang tertinggi, kawasan hujan rendah dengan keadaan persekitaran kelembapan relatif rendah dengan dibandingkan dengan yang lain dan untuk di Kuching pula mempunyai intensiti paling rendah DNI, kawasan hujan tinggi dengan keadaan persekitaran kelembapan relatif yang tinggi. Kesimpulannya, pemasangan PD di Malaysia perlu mengambil kira di kawasan DNI dan prestasi PD. Berdasarkan analisis ringkas, boleh dikatakan ia mungkin boleh dilaksanakan di Malaysia kerana DNI di malaysia menghampiri keperluan minimum DNI untuk perlaksanaan teknologi CSP dan jugak tiada alasan menyatakan tidak boleh membina teknologi ini dengan nilai DNI yang rendah. Pengubahsuaian PD sistem diperlukan untuk menambah lagi kecekapan haruslah dilakukan.

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LIST OF SYMBOLS

CSP	: Concentrated Solar Power
PD	: Parabolic Dish
DNI	: Direct Normal Irradiance
RE	: Renewable Energy
PV	: Photovoltaic
FYP	: Final Year Project
NREL	: National Renewable Energy Laboratory
NASA	: National Aeronautics and Space Administration

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CHAPTER 1

INTRODUCTION

1.0 Project Background

Nowadays, our world need to overcome the negative impacts on the environment and the problems associated with fossil fuels. They need to forced many countries to inquire and change to environmental friendly as alternatives using renewable energy to sustain the increasing energy demand. So, solar energy is one of the best renewable energy source with least negative impacts on the environment and different countries already have formulated solar energy. Solar energy is the cleanest and most abundant renewable energy source available. Modern technology can harness this energy for a variety of uses, including generating electricity, providing light or a comfortable interior environment, and heating water for domestic, commercial, or industrial use. Various of technologies are used nowadays to harness the energy from the sun as solar thermal energy, ocean thermal energy conversion, solar ponds, solar tower and photovoltaic system. Now we realize that the solar power also knows as concentrated solar power (CSP) and photovoltaic (PV) are the most commonly used in further technologies and in process of development. CSP is using renewable source of energy of sun by absorbing the concentrated of heat on sunlight and transfer to electrical energy while PV devices generate electricity by absorbing the light via solar panel containing solar cell.

PV devices produce electricity directly from sunlight via electronic process that happens actually in specific types of material, called semiconductors. Electrons in these materials are free by solar energy and can be actuated to go through an electrical circuit, powering electrical devices or sending electricity to the grid. PV advances works like when the Photons begin strike and ionize semiconductor material on the solar board, creating external electrons to break free of their nuclear bonds. Because of the semiconductor structure, the electrons are constrained in one direction making a flow of electrical current. While the solar cells are not 100% productive to a limited extent since a portion of the light range is reflected, some is too weak to create electricity (infrared) and a few (ultraviolet) makes heat energy rather than electricity.

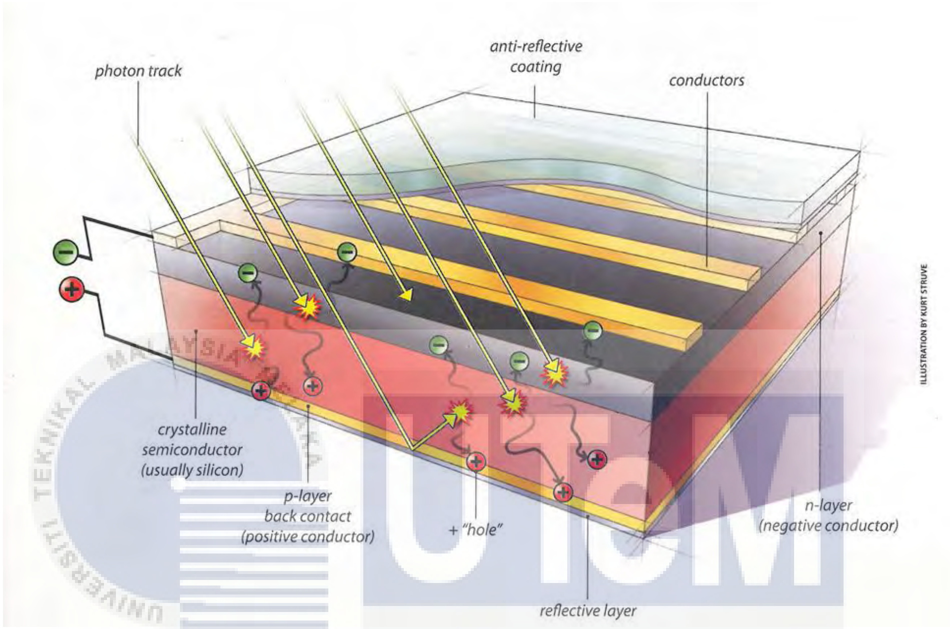


Figure 1.1 : Diagram of Typical Crystalline Silicon Solar Cell

For the Concentrated Solar Power (CSP) is the most likely candidate for providing the majority of this renewable energy, because it is amongst the most cost-effective renewable electricity technologies and because its supply is not restricted if the energy generated is transported from the world's solar belt to the population centres. Three main technologies have been identifying during the past decades for generating electricity in the 10 kW to several 1000 MW range:

i. Dish/engine technology, which can directly generate electricity in isolated locations.
ii. Parabolic and Fresnel trough technology, which produces high pressure superheated steam.
iii. Solar tower technology, which produces air above 1000°C or synthesis gas for gas turbine operation.

While these technologies have reached a certain maturity, as has been demonstrated in pilot projects in Israel, Spain and the USA, significant improvements in the thermo-hydraulic performance are still required if such installations are to achieve the reliability and effectiveness of conventional power plants.

CSP are very depending on the intensity of the sun radiation called DNI (Direct Normal Irradiance). Direct Normal Irradiance (DNI) is the amount of solar radiation received per unit area by a surface that is always held perpendicular (or normal) to the rays that come in a straight line from the direction of the sun at its current position in the sky. During clear sky condition, solar energy reaching more than 80% of DNI of the earth surface and some of it was absorb and scattered by ozone layer, water vapour and oxygen. The primary factor that changed solar radiation like weather condition such cloud and storm also will affect the DNI in which cloudy beam radiation become almost zero DNI.

1.1 Motivation of Research

Nowadays solar technology has been widely used in some country as backup power to the consumer but not in our country yet in Malaysia. Photovoltaic and Concentrated Solar Power both are type of solar technology and mature technologies. In this research, CSP can produce higher power output compare to PV but this CSP technologies not yet implemented in Malaysia and need to study the implementation of PD using CSP. CSP technologies seem using a PD looks quite possible to being implemented because of most of CSP technologies need large space of land but not PD seem not took more space than others CSP technologies.

Installation of PD in Malaysia has several things need to being consider such as DNI data. DNI main factor of installation PD using CSP technologies and without achieved the minimum required DNI, it possibly effect the performance of PD. DNI data need to be calculated and analysis based on the site location that need to be implemented and every location has difference intensity value of DNI.

1.2 Problem Statement

Many countries are working forward on innovation of renewable energy (RE), even though the support incentives from government and non-government to reduce the capital cost consumption for every single day we had through. Hence, there is a need to investigate the reliability of the RE to promote implementation solar renewable energy. This project focused on investigating of installation of PD using CSP based on DNI analysis data in Malaysia. PD is among the best CSP solar technologies based on high efficiency compare to others and need to be implemented. Meanwhile, the sun intensity DNI need to be consider as a major factor of installation of PD in Malaysia environmental. For CSP system technologies and PD performances it will be covered in Chapter 2 where the literature review in this report.

But for this project, the required method to solve the problem are collecting the DNI data of Malaysia using software. It slightly challenges because need to be familiar with the software before we could use it.

1.3 Objective

The objective for this project is:

i. To investigate the feasibility installation of Parabolic Dish (PD) technology system based on Concentrated Solar Power (CSP).
ii. To provide and collect data of Direct Normal Irradiance (DNI) in Malaysia environment using Meteonorm7 software.
iii. To analyse Direct Normal Irradiance (DNI) and the effecting factor of Precipitation/Rainfall and Relative Humidity on DNI intensity of Parabolic Dish (PD) using MATLAB Software.

1.4 Scope of Research

The scope for this project is to study the feasibility installation of parabolic dish (PD) based on concentrated solar power (CSP) and their DNI potential in Malaysia environmental. From the study, we could analyst and clarify the implementation of the parabolic dish in Malaysia based on the performance of parabolic dish (PD). This project also will focus on 4 major scope that are:

i. This research is only undergoing in Malaysia environment.
ii. This research will be on 25kW of parabolic dish using CSP technologies.
iii. This research is about analysing the potential of CSP technologies using PD based on DNI data used for analysis based on five type weather station selected in Malaysia. (Penang, Kuching, Kuala Lumpur Airport, Kota Kinabalu, and Kota Bharu)

1.5 Project Outline

In this report we will go through into five chapters:

Chapter 1:

In this chapter, we will discuss about the project background which is explain about the project. The problem statement of this project and the scope of the research also

Chapter 2:

In this chapter, reviews of the previous researcher about the project that are related with this project will be discussed. The information will be become additional source for the project in to be able more successful. To have a brief understanding of the researches related to the project, a few literature reviews had been done. This chapter will describe the related to the literature review.

Chapter 3:

For the chapter 3, the explanations about the flow chart of the project from the beginning to the end of the project. It will explain the principles of the method and techniques that are using by the previous researchers. The selected technique must be chosen to approach the objective of this project. The data will record from the experiment setup. The Gantt chart also will be discussed in this chapter.

Chapter 4:

For this part, the result of the project will be discussed. This will include the data collection, analysis of data plotting and explanation regarding the data gathered.

Chapter 5:

For the last chapter, it will discuss about the conclusion of the project for the implementation of parabolic dish (PD) using concentrated solar power (CSP) technologies based on analysis of direct normal irradiance (DNI) data to determine worth it or not for being implemented in Malaysia. Recommendation for this research are also being discusses in this chapter.

CHAPTER 2

LITERATURE REVIEW

2.0 Overview

This chapter is to provide the review from previous research based on the journal them wrote and had been done by a several researchers for the parabolic dish (PD) using Concentrated Solar Power (CSP). As we know, CSP technologies is the alternative for solar energy besides photovoltaic (PV) common people know that used semiconductor plate based on the sun light to generate energy, but for CSP is used heat source from the direct sunlight to generate the energy.

The concept is to find viability for installation of PD in Malaysia environment based on Direct Normal Irradiance (DNI) analysis. Gathering of DNI data from the journals, books, and software will help for the analysis to determine the possibility of installation of PD in Malaysia environment.

2.1 Solar Technologies

There are a few sorts of solar systems that are at present accessible. Nonetheless, each of them depends on very extraordinary ideas and science and each has its novel points of interest. Examination and correlation between various advancements will help us to embrace the most proficient and valuable innovation given a particular arrangement of conditions. Generally, photovoltaic solar boards (PV) and concentrated solar power (CSP) are the two most develop innovations. They have been marketed and anticipated that would encounter quick development later on, subsequently our accentuation will be on these two innovations.

PV innovation is moderately developed and right now has accomplished a specific level. Be that as it may, their yield is not exceptionally stable in the consistently changing climate and relies on upon the sun spectrum. Like photovoltaic board system, CSP system have been broadly popularized and under quick improvement, with 1.17GW (40GW limit was accomplished by photovoltaic segments in 2010). Analysts anticipate that it will achieve same level as photovoltaic frameworks in 2050. Both surpass 4000TWh/year and every will possess more than 10 percent of worldwide power era[1]. Solar radiances have offers favourable circumstances in lower set up and energy stockpiling system cost. Late advancement of thermoelectric innovation may likewise push the solar thermal power innovation into another stage.

Table 2.1: Characteristic of PV and CSP

Characteristic	PV	CSP
Use	Direct & Diffused Sunlight	Direct Sunlight
Size	From Watt to MW	10Mw to few hundred MW
Installation	Everywhere (roof etc.)	Flat Unused Land
Capacity	700 – 2000 Full Load Hours	2000 – 7000 Full Load Hours
Reserve Capacity	External	Internal (Fossil Operation)
Proofed Life Time	More than 20 Years	More Than 20 Years
Annual Production (2004)	More Than 25000 GWh	More Than 2500 GWh
Levelized Energy Cost (LEC)	0.20 – 0.35 €/kWh	0.15 – 0.25 €/kWh

(Source: Robert Pitz-Paal, Concentrated Solar Power Answer to key question, DLR)

2.2 Concentrated Solar Power (CSP)

Concentrated Solar Power (CSP) involves a progression of advances conceived for the change of the immediate part of solar radiation into high temperature thermal energy by method for concentrators in view of mirrors or focal points. CSP plants is that the energy can be effortlessly put away a lot of thermal energy with negligible calamities, accordingly they can give energy on request during day and night. CSP plants add to settle the power frame by repaying variances of renewable energy sources on the off chance that they are a piece of a similar system [2].

CSP technologies utilize mirrors or focal points to focus the solar radiation for warming fluid inside receiver and delivering steam; the steam then drives a turbine generator to produce electricity similarly as the ordinary power plants. Curiously, CSP can be outfitted with thermal storing system to produce electricity though during cloudy or after sunset. CSP has unique structure; in this way it will create diverse outcomes on the temperatures, concentrating proportion and the efficiencies. There are four sorts of CSP technologies as appeared in current technologies that is Parabolic Troughs system, Linear Fresnel system, Parabolic Dish System and Power Tower system.

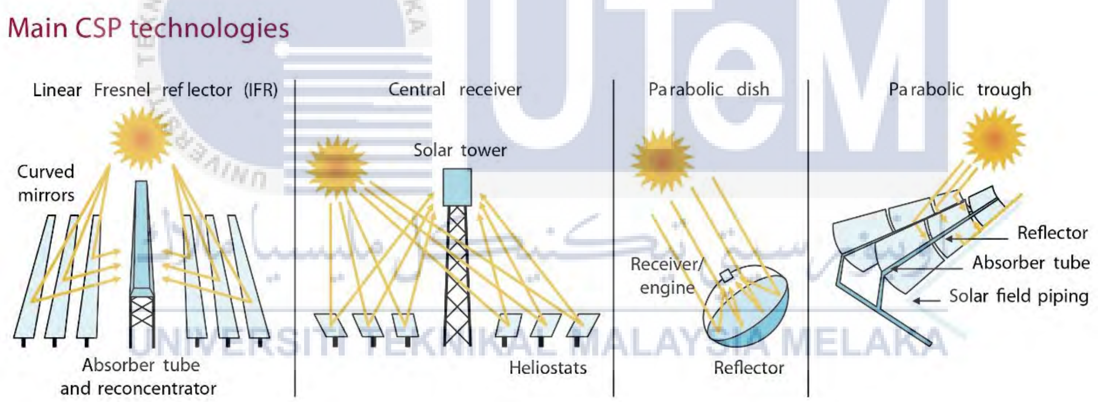


Figure 2.1: Four Types of CSP Technologies

CSP systems can be separated into line focusing and point focusing systems. Two remarkable sorts of line focusing systems are Parabolic Trough and Linear Fresnel, while the Parabolic Dish and Power Tower are point focusing systems. Line focusing system is furnished with single axis following system. It can focus sun beams around 100 circumstances and achieve working temperature up to 150°C[3]. For point focusing systems, for example, Parabolic Dish system and Power Tower system, they can concentrate sunlight to the extent 1,000 times and achieve working temperature more than 1000°C [3]. Point focusing systems are prepared with double axis tracking system to guarantee that daylight is constantly concentrated on the receiver. For the line focusing System, there utilize a trough-like mirror and an exceptionally covered steel absorber tube to change over sunlight into useful heat.

The troughs are typically intended to track the Sun along one axis, commonly north to south. To create electricity, the liquid coursing through the absorber tube normally engineered oil or water/steam exchanges the heat to a customary steam turbine power cycle. For focusing point system, particularly parabolic dish concentrators are moderately little units that have a motor generator mounted at the point of convergence of the reflector. The motor-generator unit can be founded on a Stirling engine or a small gas turbine.

Table 2.2: Performance data for various concentrating solar power (CSP) technologies

	Capacity unit MW	Concen-tration	Peak solar efficiency	Annual solar efficiency	Thermal cycle efficiency	Capacity factor (solar)	Land use m² MWh⁻¹ y⁻¹
Trough	10–200	70–80	21% (d)	10–15% (d) 17–18% (p)	30–40% ST	24% (d) 25–70% (p)	6–8
Fresnel	10–200	25–100	20% (p)	9–11% (p)	30–40% ST	25–70% (p)	4–6
Power tower	10–150	300–1000	20% (d) 35% (p)	8–10% (d) 15–25% (p)	30–40% ST 45–55% CC	25–70% (p)	8–12
Dish-Stirling	0.01–0.4	1000–3000	29% (d)	16–18% (d) 18–23% (p)	30–40% Stirl. 20–30% GT	25% (p)	8–12

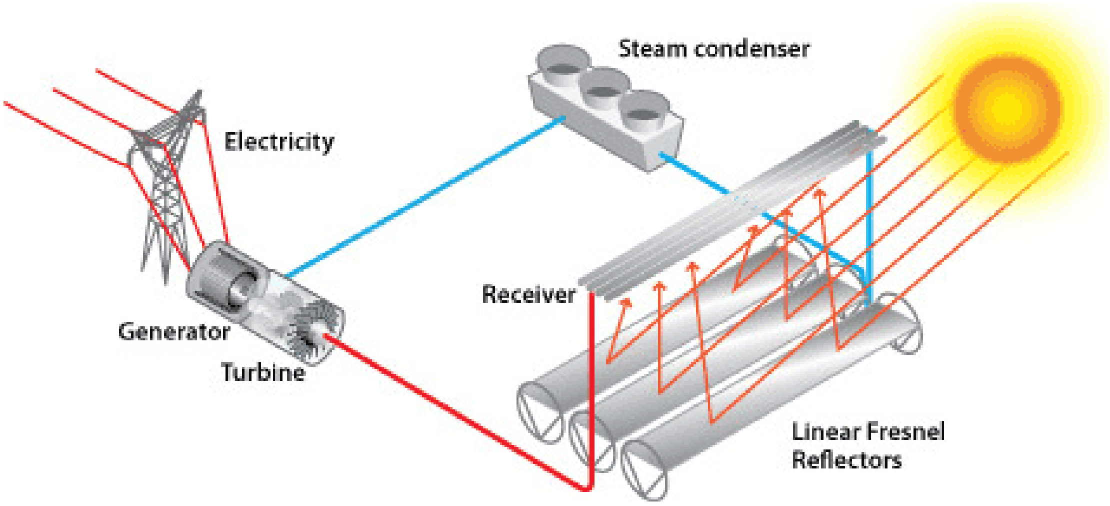
Table 2.2 gives an outline of a bit of the particular parameters of the differing concentrating solar power judgments. Parabolic troughs, linear Fresnel systems and power towers can be coupled to steam cycles of 10 to 200 MW of electric capacity, with thermal cycle efficiencies of 30–40%. The qualities for parabolic troughs, by a wide edge the most create advancement, have been appeared in the field. Today, these systems achieve yearly solar-to-electricity efficiencies of around 10–15%, with the point that they should to stretch around 18% in the medium term[4]. The qualities for various systems are, overall, projections in perspective of fragment and model system test data, and the assumption of create progression of current advancement. General solar-electric efficiencies are lower than the conversion efficiencies of typical steam or combined cycles, as they combine the conversion of solar energy to heat inside the power and the conversion of the heat to electricity in the power square. The conversion efficiency of the power square remains essentially the same as in fuel ended power plants.

2.2.1 Linear Concentrator

Linear concentrator act as collectors that capture the sun's energy with large mirrors that reflect and focus the sunlight onto a linear receiver tube. The receiver contains a fluid that is heated by the sunlight and then used to heat a traditional power cycle that spins a turbine that drives a generator to produce electricity. Alternatively, steam can be generated directly in the solar field, which eliminates the need for costly heat exchangers. Linear concentrator fields consist of a large number of collectors in parallel rows that are typically aligned in a north-south orientation to maximize annual and summer energy collection. For linear concentrator technologies, it has two types which is Linear Fresnel and Parabolic Through.

2.2.1.1 Linear Fresnel

Linear Fresnel technology is a propelled variation of parabolic trough. It has the favourable position that level mirrors can be utilized which are much less expensive than parabolic mirrors, and that more reflectors can be set in a similar measure of space, permitting a greater amount of the accessible sunlight to be used. Concentrating Linear Fresnel reflector can come in large plants or more compact plants. Linear Fresnel technology depends on a variety of linear mirror strips that focus light on to a fixed receiver mounted on a linear tower. The Linear Fresnel field can be envisioned as a split up parabolic trough reflector. The primary preferred perspective of this sort of system is that it utilizes level or flexibly bended reflectors which are less expensive contrasted with parabolic glass reflectors. Also, these are mounted near the ground, in this manner minimizing structural requirements.



(a)

(b)

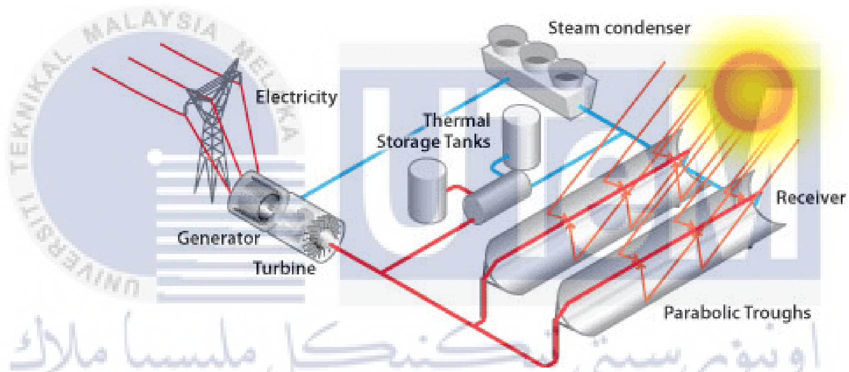
Figure2.2: (a) Linear Fresnel Concept System

(b) Implemented Linear Fresnel

Be that as it may, Linear Fresnel are less proficient than troughs in changing over solar energy to electricity and it is more difficult to storing capacity into their design.

2.2.1.2 **Parabolic Through**

In parabolic trough power plants are long trough shaped parabolic mirrors, generally coated silver or cleaned aluminium, concentrate Direct Normal Irradiation (DNI) to heat a medium in a pipe with thermal liquid running in the line of centre where the absorber is found. The trough is generally adjusted on a north-south axis, and pivoted to track the sun as it moves over the sky every day. The heat transfer liquid is then used to heat steam in a standard turbine generator. The procedure is temperate and, for heating the pipe, thermal efficiency ranges from 60-80%. The general efficiency from authority to grid, i.e. Electrical Output Power/Total Impinging Solar Power is around 15%, like Photovoltaic (PV) Cells but less than Stirling dish concentrators[2].



(a)

(b)

Figure 2.3: (a) Parabolic Through Concept System

(b) Implemented of Parabolic Through

Thusly, the decision of introduction relies on upon the application and whether more energy is required amid summer or amid winter. Parabolic Through can effectively deliver heat at temperatures somewhere around 50 and 400° C and they are the most develop solar technology to create heat at temperatures up to 400° C for solar thermal electricity era or process heat applications. However, utilization of oil-based heat transfer media limits working temperatures today to 400°C, bringing about just moderate steam qualities [1].

Table 2.3: Comparison of Linear Concentrator

Renewable Energy	Parabolic Trough	Linear Fresnel
Concentration	70-80	25-100
Temperature	~500°C	~500°C
Unit size	1-250 MW	1-250 MW
Efficiency	10-15%	9-15%

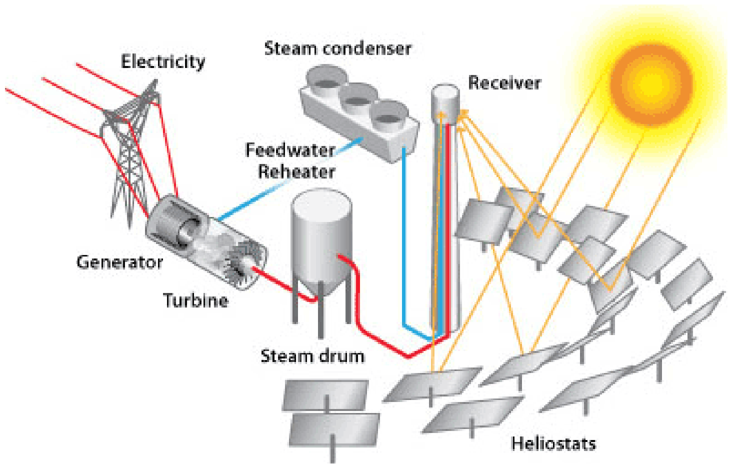
Table 2.3 illustrates how a Parabolic Through and Lineal Fresnel collector focuses sunlight onto its focal point.

2.2.2 Point Concentrators

One criterion of a specific concentrator is the degree of concentration and hence temperature that is to be achieved. As a rule, concentrating energy onto a point produces high to very high temperature.

2.2.2.1 Central Receiver/ Solar Tower

Heliostat field collector can be utilized for amazingly high inputs of brilliant energy to mirror their incident energy solar radiation onto a typical focus as appeared in Figure 2.4.



(a)

(b)

Figure 2.4: (a) Solar Tower/ Central Receiver Concept System

(b) Implemented Solar tower/Central Receiver

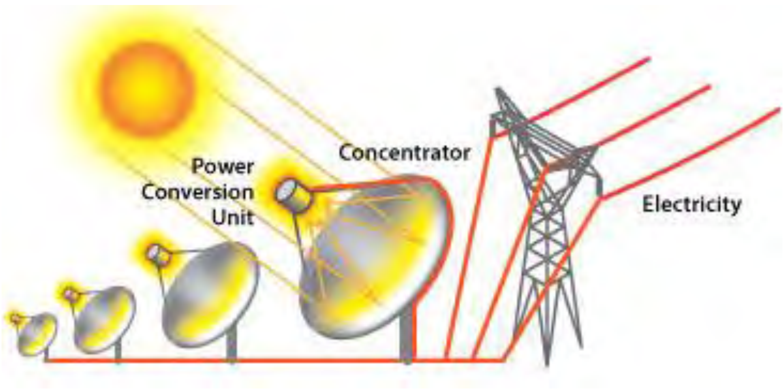
This is known as the heliostat field or central receiver gatherer. By utilizing slightly concave mirror sections on the heliostats, large measures of thermal energy can be coordinated into the hole of a steam generator to create steam at high temperature and pressure. The concentrated heat energy consumed by the receiver is transferred to a circulating liquid that can be stored and later used to deliver power. Central receivers have a few points of interest:

i. They gather solar energy optically and transfer it to a solitary receiver, minimizing thermal-energy transport prerequisites.
ii. They ordinarily accomplish fixation proportions of 300 –1500 and are highly productive, both in gathering energy and in changing over it to electricity.
iii. They can helpfully store thermal energy.
iv. They are very large (for the most part more than 10 MW) and along these lines advantage from economies of scale.

The normal solar flux impinging on the receiver has values somewhere around 200 and 1000kW/m2. This high flux permits working at moderately high temperatures of more than 1500°C and coordinates thermal energy into more effective cycles. Central receiver systems can integrate without much of a stretch incorporate in fossil fuelled plants for hybrid operation in a wide assortment of choices and can possibly work the greater part the hours of every year at superficial power utilizing thermal energy storing.

2.2.2.2 Parabolic Dish Stirling

The Dish Stirling comprises of a solitary parabolic reflector which concentrates light at the point of convergence of the reflector, which tracks the sun along two axes. Most of all the CSP innovations, parabolic dish systems are the most productive. The Stirling solar dish merges a parabolic concentrating dish with a Stirling heat engine which drives an electric generator. The expression "Stirling" alludes to the way that the gadget works on a basic heat-engine standard. Stirling solar energy generation is more effective than photovoltaic cells and the technology has a more extended lifetime [2]. This technology is perfect for rural places and can be delivered and easily troubleshoot.



(a)

(b)

Figure 2.5: (a) Parabolic Dish Concept System

(b) Implemented Parabolic Dish

The receiver ingests the brilliant solar energy, changing over it into thermal energy in a flowing liquid. The thermal energy can then either be changed over into electricity utilizing an engine-generator coupled straightforwardly to the receiver, or it can be transported through channels to a central power-conversion system. Parabolic dish systems can accomplish temperatures in abundance of 1500°C [1]. Parabolic dishes have a few imperative points of interest:

- Since they are continually pointing at the sun, they are the most proficient authority systems.
- Ordinarily, they have a fixation proportion ratio in the scope of 600–2000 and are highly productive at thermal-energy ingestion and power conversion systems.
- They have flexible collector and receiver units that can either work freely or as a feature of a larger system of dishes.

Parabolic-dish systems that produce electricity from a central power converter gather the retained sunlight from individual receivers and convey it by means of a heat-transfer liquid to the power-conversion systems. The need to flow heat transfer liquid all through the field raises configuration issues, for example, piping format, pumping prerequisites, and thermal misfortunes. The Stirling engine is the most widely recognized kind of heat engine utilized as a part of dish-engine systems[2]. For this system, certain level of dependability and large scale manufacturing still should be accomplished.

Table 2.4: Comparison of Point Concentrators

Renewable Energy	**Central Receiver / Solar Tower**	**Dish Stirling**
Temperature	~1.200°C	~1.200°C
Unit Size	1 – 200 MW	0,01-0,04 MW
Efficiency	14 – 17%	18-25%

2.3 Parabolic Dish System (PD)

Dish/engine systems change over the thermal energy in solar radiation to mechanical energy and next to electrical energy similarly that regular power plants change over thermal energy from burning of a fossil fuel to electricity. As showed in Figure 2.5, dish/engine systems utilize a mirror exhibit to reflect and concentrate approaching direct normal irradiance to a receiver, with a specific end goal to accomplish the temperatures required and effectively change over heat to work. This requires the dish track the sun in two axes. The concentrated solar radiation is consumed by the receiver and transfer to an engine [5]. Dish/engine systems are described by high efficiency, modularity, self-governing operation, and natural hybrid capability (the capability to work on either solar energy or a fossil fuel, or both). Of all solar technologies, dish/engine systems have shown the most elevated solar-to-electric conversion efficiency (29.4%) [6], and in this way can possibly get to be distinctly one of the slightest costly sources of renewable energy.

The modularity of dish/engine systems permits them to be conveyed individually for remote applications, or gathered together for small grid or end-of-line utility applications. Dish/engine systems can likewise be hybridized with a fossil fuel to give dispatched power. This technology is in the engineering advancement stage and technical difficulties remain concerning the solar components and the business accessibility of a solarizable engine.

However, PD has the potential to become one of the least expensive sources of RE. The advantage of this system is it has the higher of solar to electric efficiencies, modular and suitable for small scale area with each unit typically generating output of 3 to 25 kW [7].

2.3.1 **Concentrator**

Dish/engine systems use concentrating solar authorities that track the sun in two axes. A reflective surface, metalized glass or plastic, reflects episode solar radiation to a small area called the focus. The size of the solar concentrator for dish/engine systems is dictated by the engine. At an ostensible most extreme direct ordinary solar insolation of 1000 W/m2, a 25-kW dish/Stirling system's concentrator has a diameter of around 10 meters [5].

Concentrators utilize a reflective surface of aluminium or silver, kept on glass or plastic. The toughest reflective surfaces have been silver/glass mirrors, like beautifying mirrors used as a part of the home decoration. Accomplishments to grow minimal effort reflective polymer films have had limited success. Since dish concentrators have short focal lengths, generally thin glass mirrors (thickness of roughly 1 mm) are required to force the required shapes. Furthermore, glass with low-press substance is improve to enhance reflectance. Contingent upon the thickness and iron substance, silvered solar mirrors have solar reflectance values in the scope of 90 to 94% [5].

The perfect concentrator shape is a parabolic of transformation. Some solar concentrators estimated this shape with numerous, roundly formed mirrors upheld with a truss structure. A development in solar concentrator configuration is the utilization of extended layers in which a thin reflective film is extended over an edge or hoop. A moment film is utilized to stop the space behind. A part of vacuum is attracted this space, bringing the reflective film into an around circular shape. Figure 2.6 is a schematic of a dish/Stirling system that uses this idea. The concentrator's optical design and precision decide the focus proportion. Focus proportion, characterized as the normal solar flux through the receiver aperture by the ambient direct normal solar insolation, is commonly more than 2000. Fraction of the reflected solar flux that goes through the receiver gap, are as a rule more than 95%.

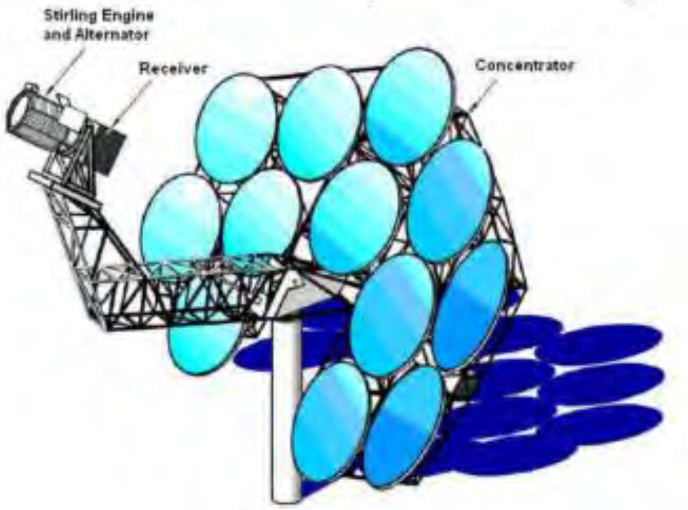


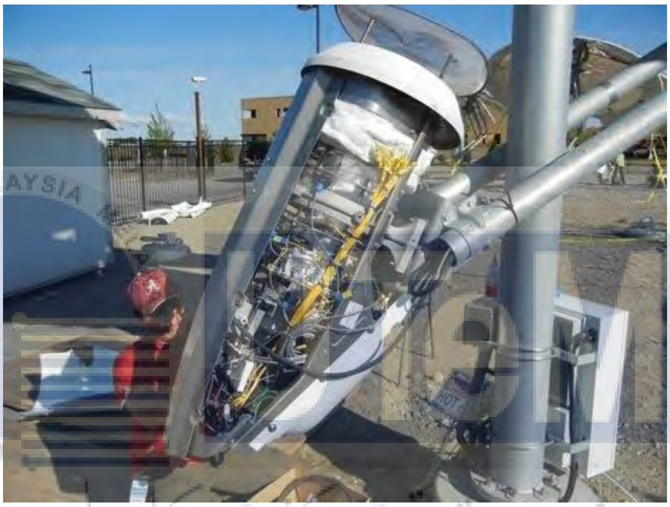
Figure 2.6: Schematics of a dish/engine System Concentrator with Stretches/Membrane Mirrors.

Tracking in two axes is refined in one of two ways, (1) azimuth-height tracking and (2) polar tracking. In azimuth-rise tracking, the dish turns in a plane parallel to the earth (azimuth) and in another plane opposite to it (elevation). This gives the gatherer left/right and up/down pivots. Rotational rates shift for the duration of the day yet can be effectively determined. The greater part of the larger dish/engine systems utilize this technique for tracking. In the polar tracking technique, the gatherer turns around an axis parallel to the earth's axis of rotation. The authority turns at a consistent rate of 15º/h to coordinate the rotational speed of the earth. Alternate axis of turn, the declination axis, is perpendicular to the polar axis. Drive about this axis happens gradually and changes by +/ - 23½º over a year. A large portion of the smaller dish/engine systems have utilized this technique for tracking [5].

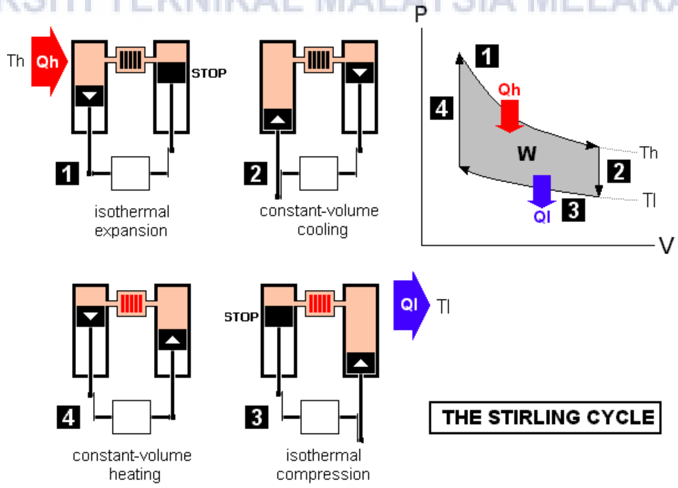
2.3.2 Receiver / Stirling Engine

The receiver retains energy reflected by the concentrator and transfers it to the engine's working liquid. The retaining surface is normally set behind the focus of the concentrator to lessen the flux force on it. An aperture is set at the focus to lessen radiation and convection heat misfortunes. Every engine has its own particular interface issues. Stirling engine receivers should effectively transfer concentrated solar energy with high pressure of oscillating gas, generally helium or hydrogen. In Brayton receivers the flow is unfaltering, yet at moderately low pressures. There are two general sorts of Stirling receivers, direct-illumination receivers (DIR) and indirect receivers which utilize a moderate heat-transfer liquid. Straightforwardly, lit up Stirling receivers adjust the heater tube of the Stirling engine to assimilate the concentrated solar flux. On account of the high heat transfer capacity of high-speed, high pressure helium or hydrogen, direct-illumination receivers are capable for retaining high amounts of solar flux (around 75 W/cm2). Nonetheless, adjusting the temperatures and heat addition between the cylinders of a numerous cylinder Stirling engine is a integration issue [5].

Fluid metal, heat-pipe solar receivers tackle this issue. In a heat-pipe receiver, fluid sodium metal is vaporized on the absorber surface of the receiver and consolidated on the Stirling engine's heater tubes. This outcome in a uniform temperature on the heater tubes, in this manner empowering a higher engine working temperature for a given material, and along these makes higher engine efficiency. Longer-life receivers and engine heater heads are additionally hypothetically practicable by the utilization of a heat-pipe. The heat-pipe receiver isothermally transfers heat by dissipation of sodium on the receiver/absorber and condenses it on the heater tubes of the engine. The sodium is latently come back to the absorber by gravity and conveyed over the absorber by vessel forces in a wick [5]. Stirling receivers are ordinarily around 90% effective in transferring energy deliver by the concentrator to the engine. Solar receivers for dish/Brayton systems are less created.



(a)



(b)

Figure 2.7: (a)The Receiver of Parabolic Dish

(b) Stirling Cycle with Pressure-Volume Chart

Furthermore, the heat transfer coefficients of generally low pressure air alongside the need to minimize pressure drops in the receiver make receiver plan a test. This approach gives essentially more prominent heat transfer zone than ordinary heat exchangers that use conduction through a wall.

The engine in a dish/engine system changes over heat to mechanical power in a way like conservative engines that is by compacting a working liquid when it is cool, heating the packed working liquid, and afterward extending it through a turbine or with a cylinder to deliver work. The mechanical power is changed over to electrical power by an electric generator or alternator. Various thermodynamic cycles and working liquids have been considered for dish/engine systems. These contain Rankine cycles, utilizing water or a natural working liquid Stirling cycles. Therefore, more fascinating thermodynamic cycles and minor departure from the above cycles have likewise been considered. The heat engines that are for the most part supported utilize the Stirling and open Brayton (gas turbine) cycles. Heat can likewise be provided by a supplemental gas burner to permit operation amid shady climate and around evening time. Electrical yield in the present dish/engine models is around 25 kW for dish/Stirling systems and around 30 kW for the Brayton systems under thought.

2.4 Direct Normal Irradiance (DNI)

CSP is relying upon the power of the sun's radiation intensity as the DNI. DNI is solar irradiance that arrives in an immediate line from the sunlight. On clear sky conditions, the DNI speaks to more than 80% of the solar energy achieving our world's surface [3]. Besides that, a lot of the solar radiation achieving on our world's surface is consumed and scattered as described in figure 2.8. The solar radiation is consumed by ozone, oxygen and water vapour. Climate conditions, for example, cloud & storm become a major factor affects the changes of solar radiation towards the surface. At the moment, when the shady day the normal beam radiation is become around zero [7].

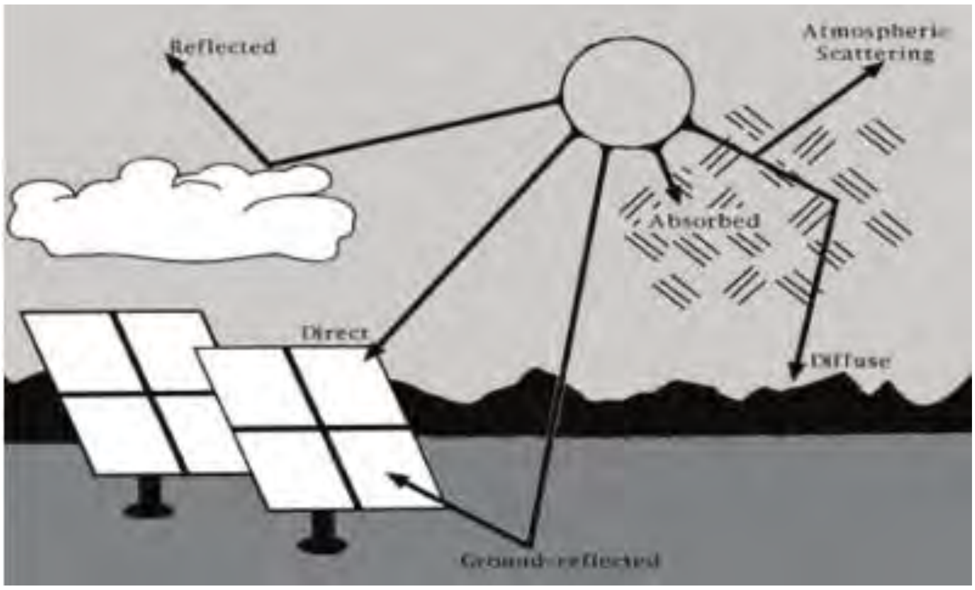


Figure 2.8: Illustration of Radiation from the Sun

In the meantime, a great solar source is a top main concern for CSP technology. In this way with a specific end goal to be economically possible, CSP technology requires DNI of no less than 1900-2000kWh/m2/year or daily solar radiation estimation of no less than 5kWh/m2/day. Malaysian DNI is around 1,401-1,600 kWh/m2/year [3]. The CSP plant is built up for the most part in a nation with DNI higher than 1800kWh/m2/year. In any case, there is no specialized motivation behind why CSP plants can't keep running at DNI levels lower than 1800kWh/m2/year.

In this way, to get an exact investigation, particularly on the execution of CSP system; it is fundamental to think about the quality and the future dependability of the sunlight[8]. In the interim, to expand the measure of rate of heat transfer to the receiver, it is significant to have as high and as long time workable for the information irradiance. Henceforth, a great solar efficiency is a top needs for CSP technology and just tough solar irradiance can be concentrated for delivering high temperatures for creating vapour and after that produce the electricity [7].

2.4.1 Site Selection for DNI Collecting Data

Sunlight is act as the fuel for all solar energy era innovations. Like any era, source information of the quality and future dependability of the fuel is basic to exact analysis of system performance and economically related feasibility of the project. With solar energy systems, the inconstancy of the supply of sunlight most likely speaks to the single most remarkable instability in a solar power plant's performance to being predicted.

Parabolic dish has some favourable circumstances, for example, it is modular, suitable for small scale plant and most advanced for small CSP plant. Despite that, selecting a suitable site is a standout amongst the most essential parts for building up a reasonable solar CSP plant, for example, the parabolic dish technology. The points in selecting a site or the area are to amplify creation and minimize cost. Key to the siting of CSP technologies, the parabolic dish facilities require direct plentiful solar radiation with a specific end goal to generate electricity as strong direct solar irradiation can be engaged to generate the highest temperatures required for electricity era. Then again, indirect sunlight can't be concentrated and areas with significant cloud cover are inappropriate for parabolic dish plant [9]. Thus, the electricity era of any of the plant is for the most part affected by the solar irradiance. Besides, more than 5 kWh/m2/day of Direct Normal Irradiance (DNI) is required with a specific end goal to work and economic [3].

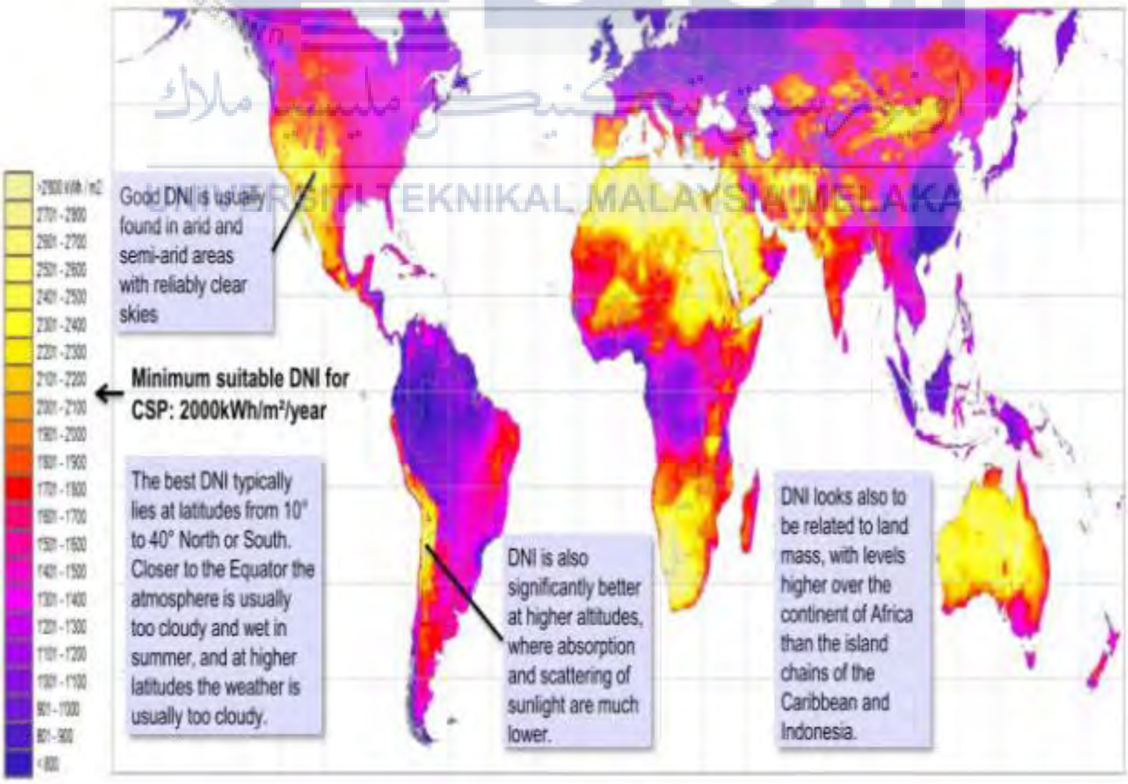


Figure 2.9: World Direct Normal Irradiance Maps

Be that as it may, narrowing down the information to a particular few square kilometres of land requires considering nearby effects, while satellite information is extremely helpful in mapping large areas, singular sites ought to be checked by utilizing ground-monitoring stations. Local measurement can be contrasted with same-day satellite information to test for partiality in the satellite model outcomes. Precise resource information will stay basic to a power plant's proficient operation all through its service life. Examination of plant output as a component of solar radiation resource is one worldwide pointer of power plant execution. Overall efficiency indicates a degradation of at least one power plant parts component and maintenance required.

2.4.2 **Malaysia Meteorological Data**

The capability of a CSP plant is largely controlled by DNI. In any case, the DNI will be determined by meteorological factors. In this way, it is basic to know the meteorological information, for example, solar radiation, rainfall, cloud cover and the humidity to consider before building up any CSP plant.

2.4.2.1 **Solar Radiation**

Malaysia is situated at Southeast Asia, somewhere around 1° and 7° in North latitude and 100° and 120° in East longitude. The aggregate of Malaysia's landmass is around 329,845 km2 and very nearly 60% of Malaysia landmass is comprised of East Malaysia and the rest is Peninsular Malaysia as appeared in Figure 2.10[3].

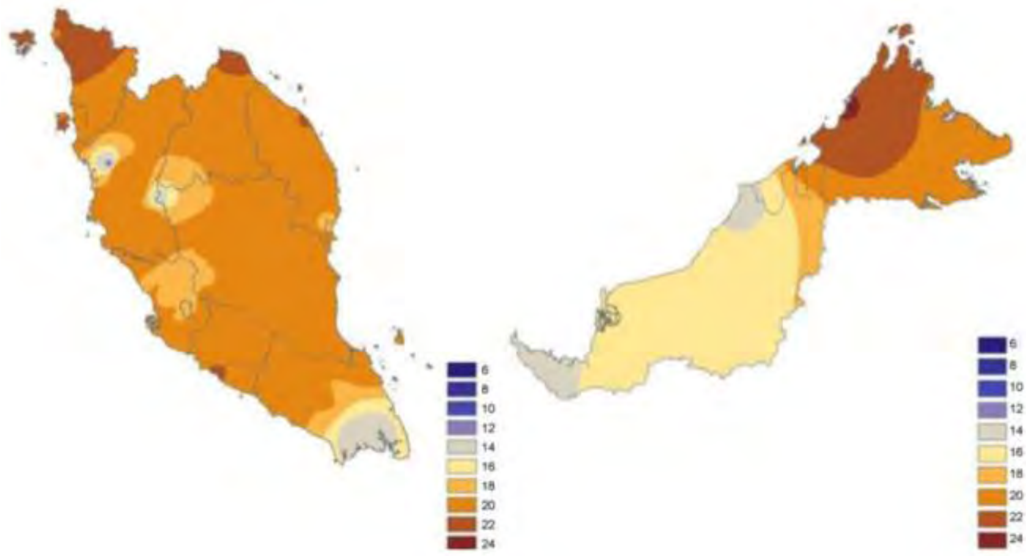


Figure 2.10: Annual average solar radiation (MJ/m2/day)

The day by day solar irradiation in Malaysia is around 4.7 to 5.8 kWh/m2 (is said to be accomplished 6.8kWh/m2 in August and November), month to month is 133.0 kWh/m2 and yearly esteem around 1596.5 to 1643 kWh/m2/year. The daylight span is over 2,200 hours for each year and yearly temperature fluctuates from 26 to 28◦C. [3]The northern states and a few places in the East Malaysia get high solar radiation during the time. Solar radiation is diminished from the northern states toward the southern states. Northern states, for example, Perlis, Kedah, Penang, Kelantan, Malacca and some places in East Malaysia (particularly Sabah) get the most measure of solar radiation, while Johor at the southern Peninsular Malaysia and most parts in Sarawak get the least solar radiation. All things considered, by assessing the solar radiation information in Malaysia, northern states and a few places in east Malaysia are feasible place for CSP contrasted with different places in Malaysia.

2.4.2.2 **Rainfall/Precipitation**

Malaysia is situated in the tropical wet climate zone where yearly precipitation is around 2250 mm/year. For the most part, Sabah and Sarawak get a larger measure of rainfall contrasted with different states in Peninsula Malaysia. Kuching and Bintulu in Sarawak, encounter substantial rainfall with the estimation of 11.68 mm and 11.02 mm, while lower rainfall are Sitiawan, Tawau and Malacca with the estimation of 4.86 mm, 5.33 mm and 5.42 mm [3]. Zones that experience heavier rainfall, for example, Kuching and Bintulu have low potential for CSP installation compared to Sitiawan, Tawau and Malacca with large measure of rainfall will influence the efficiency of the concentrator and generally for CSP system.

2.4.2.3 Cloud Cover

Cloud cover is moderately high consistently and it is exceptionally uncommon to have clear skies for an entire day even in the dry time frame. Numerous regions in Malaysia have the most remarkable estimations of cloud cover in October until February and least estimation of the cloud cover from Mac to September. As indicated by Engel-Cox et.al (2012), Tawau has an essentially bring down cloud cover contrasted with different areas in Malaysia; while Kota Bharu, Kota Kinabalu, Kuantan and Labuan are the ones with the most elevated cloud cover[3]. In the interim, Malacca and Bayan Lepas have been distinguished as areas with low cloud cover in Peninsular Malaysia. Cloud with particular weather examples is among the most imperative component that cut-off, limit and dispense with a large measure of sunlight from achieving the environment and hence influencing the measure of radiation got at the world's surface.

2.4.2.4 Relative Humidity

Humidity in Malaysia varies from 80% to 90%. The low relative humidity area was Subang and Bayan Lepas; 78.6% and 79.4%[3]. The higher relative humidity areas are a few cities in Sarawak such as Kuching, Bintulu, Miri and Sibu. Others are Kuantan, Sitiawan and Tawau, while areas with a slightly lower humidity are Kota Bharu, Kota Kinabalu, Malacca, and Labuan. Overall, heavy rainfall, constant high temperature, high levels of cloud cover and relative humidity are the characteristics of Malaysian tropical climate. However, northern states and several places in Sabah receive high solar radiation, lower rainfall, lower cloud cover and lower humidity. These places can be considered as viable for CSP development compared to other places in Malaysia.

2.5 Meteonorm7 Software

The software Meteonorm7 from the Swiss company Meteotest (www.meteonorm.com) offers the possibility to create climate data for any location worldwide. Meteonorm7 is comprehensive meteorological reference, joining an index of meteorological data and computing technique for solar application and system design at any desired area in the world. Meteonorm7 is for mainly a climate combine with a weather generator. It conveys typical meteorological years for any site and meteornorm7 is more than 30 years of experiences in development of meteorological databases for energy application. Meteonorm7 conveys precise weather data for wherever on Earth: radiation, temperature, humidity, wind, precipitation and other climate parameters.

Figure 2.11: Meteonorm software logo

Based on data from 8,325 weather stations, five geostationary satellites and 30 years of experience, Meteonorm7 offers best in class introduction models, conveying worldwide weather data with most extreme precision. Recover weather data in more than 35 data positions. Utilize Excel arrange for manual investigation or browsed the greater part of the standard organizations utilized as a part of photovoltaic, solar warm or building/energy simulation programming. Some feature from the Meteonorm7 software is:

- The database is fed by 8,325 weather stations worldwide as well as by five geostationary satellites with global coverage.
- Built-in state-of-the-art interpolation models deliver data for any location worldwide with a precision comparable to measurements.
- The standard is 1991–2010 for radiation and 2000–2009 for other parameters; other periods can be selected.
- Current data can be accessed online directly from the software. Meteonorm7 also allows users to import custom data.
- Meteonorm7 contains several climate change scenarios, also can plan for the future.
- Over 30 parameters including global radiation, direct radiation, temperature, precipitation, humidity, wind, and more.
- Meteonorm7 delivers monthly, hourly and even minute values. Meteonorm7 data is used by most of the energy simulation software applications in the market.
- More than 35 output formats are available: CSV, TMY2, TMY3, and more.

CHAPTER 3

PROJECT METHODOLOGY

3.0 Overview

For this chapter, it will describe the methodology on how proceeding the project to achieve the objective and scope that mention before in Chapter 1. In other ways of understanding, it kinds of a step in sequential way to produce a specific target or output. This chapter will contain flowchart process, project Gantt chart and key milestone for project development.

3.1 Project Flowchart

Before build the flow chart, objective and scope must be clear and deeply understand. Flowchart need to being drafted and brainstorm because it was a root of the project and need advises from the supervisor before permanently stated the flowchart process. It started with problem statement of the project which is stated the problem faced on society and act as motivation for develop the project.

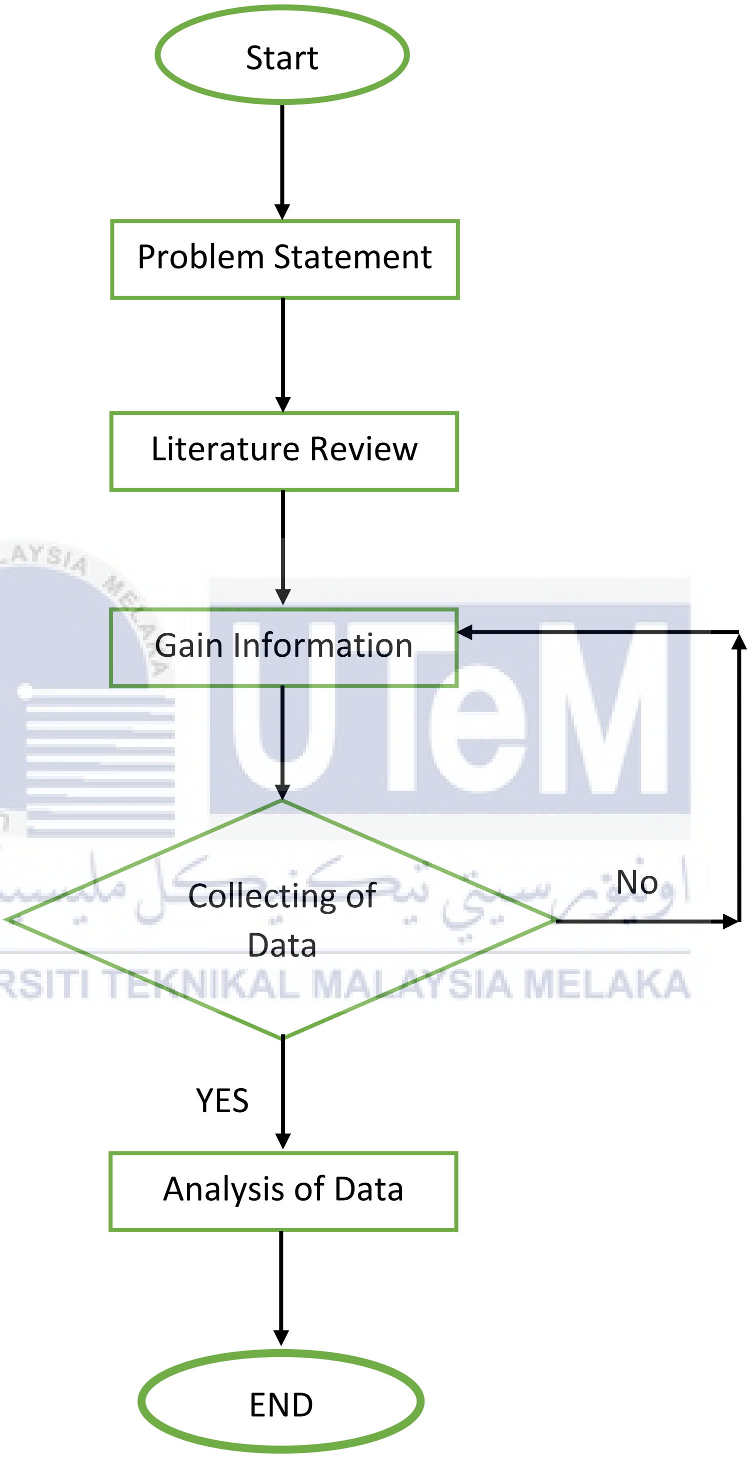


Figure 3.1: Flow chart of research project

Regarding to the flowchart above, the project starts with the theory and the literature review on various kind of experiments that already done related to the process of installation of PD in Malaysia. Before analyse, climate data must be exported to Microsoft Office Excel for data sorting and imported by MATLAB to stimulate the result in graph and data plotting.

3.2 Literature Review

In Literature review section, it discusses about the previous researchers works on the project topics issue in form of journal, books, article, paper and others. For this project, most of them discusses about the technology of CSP, PD system, and the DNI environment that affect the installation of PD. From that, it gives general information to be discussed for analysis about the project.

3.3 Collecting Data from the previous journal and Meteonorm7 software

In this section, all the data being collected in two way using review of previous journal and using a software Meteonorm7 runs on demo mode to gather the climate data. For demo mode on Meteonorm7 software, the data table provided could not automatically being save to disk or drive. So, manual step need to be done like to copy the data table and save it by our self into Microsoft Office Excel as medium of storage data. Climate data from Meteonorm7 software provided are taking from them their own database from Swiss Company that plant their own sensors to gathered data in Malaysia weather station. The data gathered since year of 1991 until 2010 for period radiation and since year 2000 until 2009 for period temperature. Some of the data are limited and need to buy their database provided by NREL & NASA to do an analysis but it is out of our scope of research for buying database for analysis. For this project, climate data collected based on demo mode of meteonorn7 software and previous researcher that provide data for analysis based on selected location that suitable for installation.

3.4 Steps Using Meteornorm7 Software

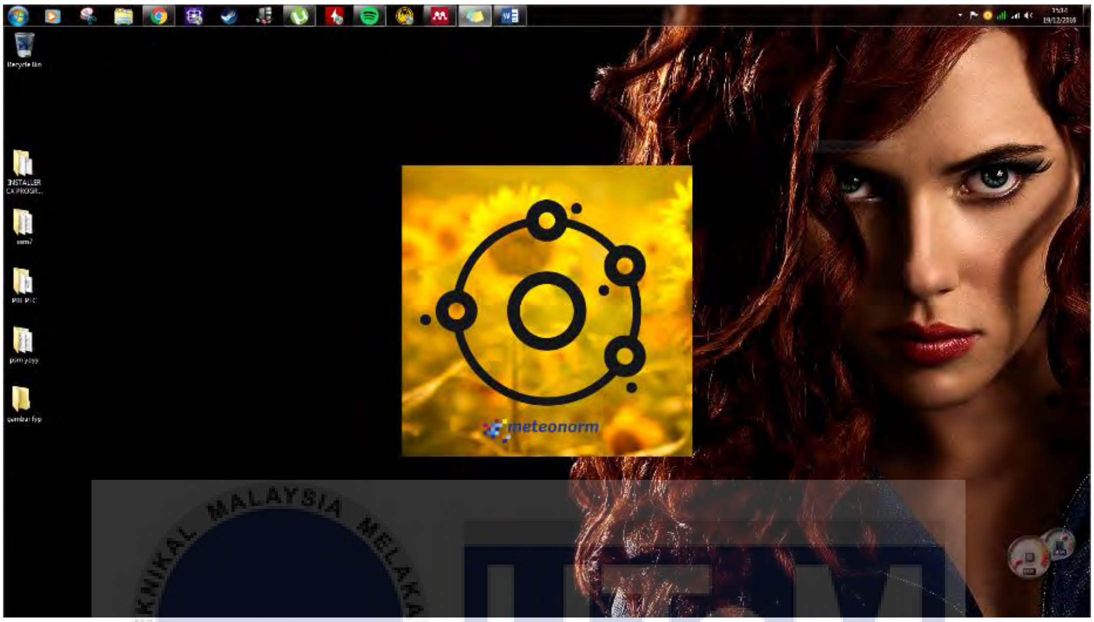


Figure 3.2: Meteonorm7 Software User Interface

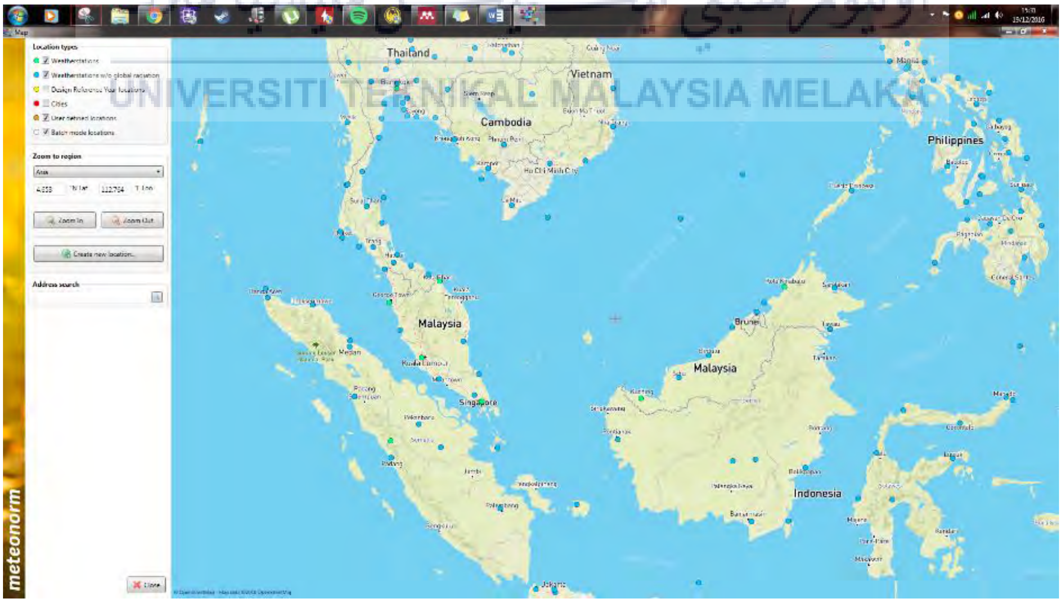


Figure 3.3: Selection of Weather Station Located in Malaysia

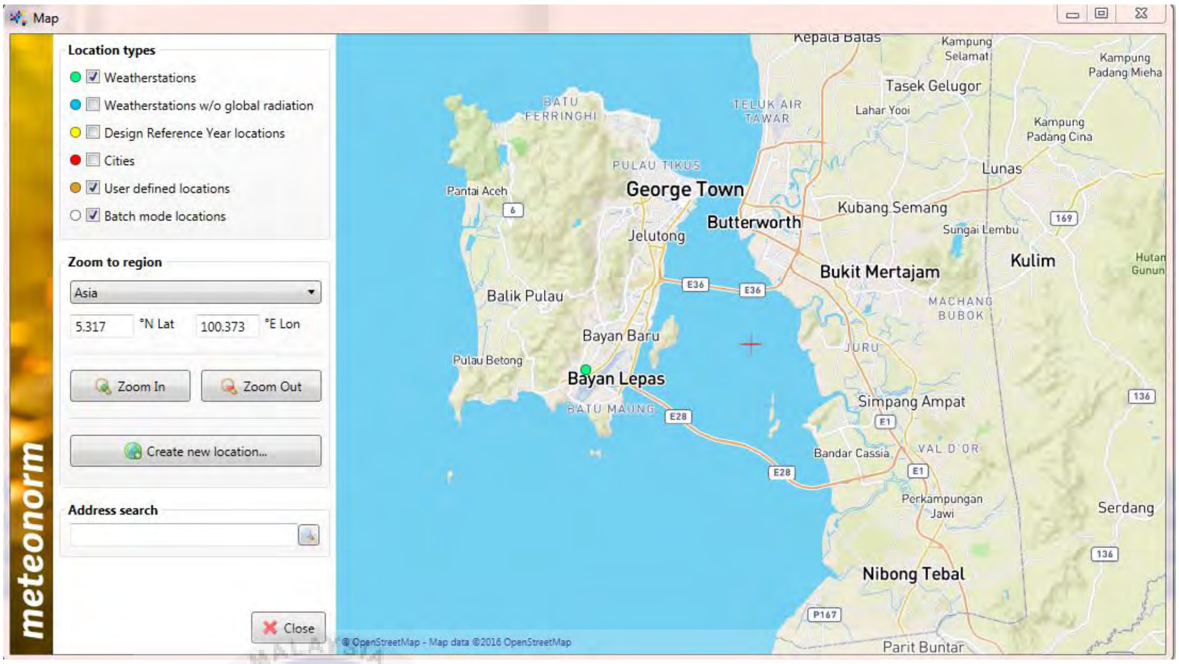


Figure 3.4: One of the Weather Station selection in Malaysia to gather the data

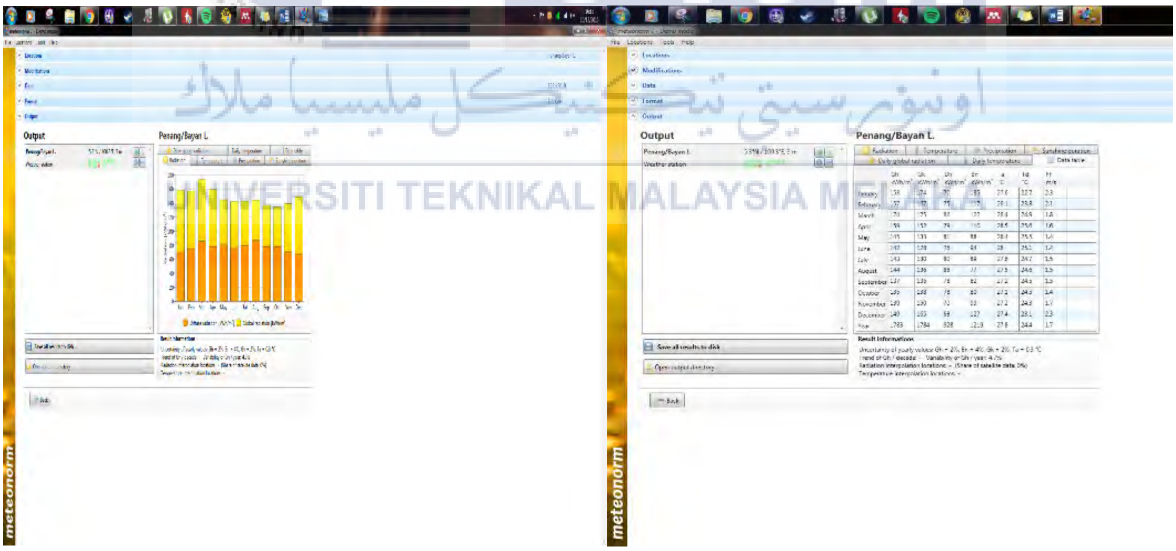


Figure 3.5: Example from data from the weather station

Data from this software are will be presented in Chapter 4 as the result of gathering data in Malaysia. Several site locations in Malaysia based on location of weather stations in Malaysia environment.

3.5 Site Selection

Site selection also a crucial part in this project for develop CSP plant using PD technology system. Most of the CSP plant must be placed in area of high DNI. Site will be select in this research including peninsular Malaysia, Sabah and Sarawak. In this study five location/site will being analyse. In the meantime, to demonstrate the impact of solar irradiance DNI, the rainfall/precipitation and humidity factor must be considered before develop of PD because it could affect the DNI performance in certain site locations as a part of this review.

Information data from individual years and a delegate yearly solar resources are required to make correlations with option sites and gauge power plant yield. Since site selection is constantly in historical, more years of information are better for deciding on yearly data set of information to analyse.

Figure 3.6: Weather station located in Malaysia with green dot

3.6 Compute and Analysis of Data

In this section, analysis from the data collected that contain several stage of analysis. The climate data collected will be stimulate from Meteonorm7 software and presented to the MATLAB software as data plotting and analysis. Microsoft Office Excel also being use for medium for data storage and sorting before plotting graph in MATLAB software. From the result of data plotting, we could analysis the data and result and discuss about the performance of DNI in Malaysia environment. The analysis is based on the five site locations are being selected. The good DNI results are depends on the rainfall/precipitation and relative humidity in the surrounding area. The data are refer based on the average data of years and being sorted by their month that from January until December. From that, performance of DNI will be analyse from the data plotting. For climate data of precipitation/rainfall and Relative humidity, Meteonorm7 software not provide the data table unless could use the licenced software of Meteonorm7. So, from the graph simulation of precipitation, the data need to gathers manually by list it out in table form on Microsoft Office Excel. For relative humidity, some mathematical calculation need to be done to gather the data. Some data from Meteonorm7 are needed for the calculation such as the air temperature and dewpoint temperature in degree Celsius to provide the answer of relative humidity in the location. Relative humidity used August-Roche-Magnus approximation to calculate relative humidity percentage.

3.6.1 Parameters from Meteonorm7 Software

Meteonorm7 software revolves around irradiation and temperature parameter and over than 30 parameters in this software. But for this research, 8 parameters are used on collecting data and analysis.

Table 3.1: Parameters used in data collection and analysis

Parameters	Units	Parameters	Units
GH - Global Horizontal Radiation	kWh/m^2	Ta - Air Temperature	°C
DH - Diffuse Radiation	kWh/m^2	Td - Dewpoint Temperature	°C
Bn - Direct Normal Irradiance (Beam)	kWh/m^2	RR - Precipitation	mm

FF - Wind speed	m/s	RH – Relative Humidity	%

3.7 Project Gantt Chart

Table 3.2: Project Gantt Chart FYP 1

item	WEEKS										
	1	2	3	4	5	6	7	8	9	10	11
FYP 1											
Find Supervisor	■										
Title Confirmation		■									
Familiar With Topic		■	■								
Log Book Preparation			■	■	■						
Objective & Scope				■	■						
Problem Statement				■	■						
Report Outline			■	■	■						
Theory & Basic Principle					■	■					
Find Sources						■	■				
Literature Review						■	■				
Methodology							■	■			
Preliminary Result								■	■		
Conclusion									■		
Panel Feedback Form									■	■	
FYP Report Submission									■	■	
FYP Presentation											■

Table 3.3: Project Gantt Chart FYP 2

item	**WEEKS**													
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**	**14**
FYP 2														
Finalize title for FYP														
Meet supervisor														
Sources confirmation														
Deeply study on DNI														
Data collection														
Data sorting on Microsoft excel														
MATLAB graph plotting														
Result Analysis														
Prepare final progress report														
Final draft report Submission														
FYP Presentation														

3.8 Key Milestone

Table 3.4: Key Milestone

No.	**Milestone**	**Date**
1	Literature Review Study on CSP technology, PD system, and DNI that affect system Investigate of the Data gathered of DNI in Malaysia Environment	**September – November 2016**
2	Report Writing for Presentation FYP 1	**December 2016**
3	Study on Meteonorm7 software for gathering data. Study on importing data from Meteonorm7 to Microsoft excel and export to MATLAB software for graph plotting	**March – April 2017**
4	Analysis of data Report Writing Presentation for FYP 2	**May - June 2017**

CHAPTER 4

RESULTS AND DISCUSSION

4.0 Overview

This section will be discussed about all the result and achievement. The basic theory had learnt about the CSP technologies, PD system, and DNI on literature review section, data could we get from several software listed such a Meteonorm7, Microsoft Office Excel, and MATLAB software. This chapter also will describe about the discussion and analysis of all data gathered.

4.1 Site Selection

As mentioned in chapter 3, data will be collected from the books, journal and software that related to the project. Data from software that generate from a software such as Meteonorm7 are needed for analysing. Those data will come in form of raw data table and need to study before analyse. MATLAB software used to develop a graph of DNI performance based on five locations that being selected and stimulating the data. Precipitation and Relative Humidity graph also will be developed for analyse. For now, skills are needed to be familiar with the software to get the output for working analysis.

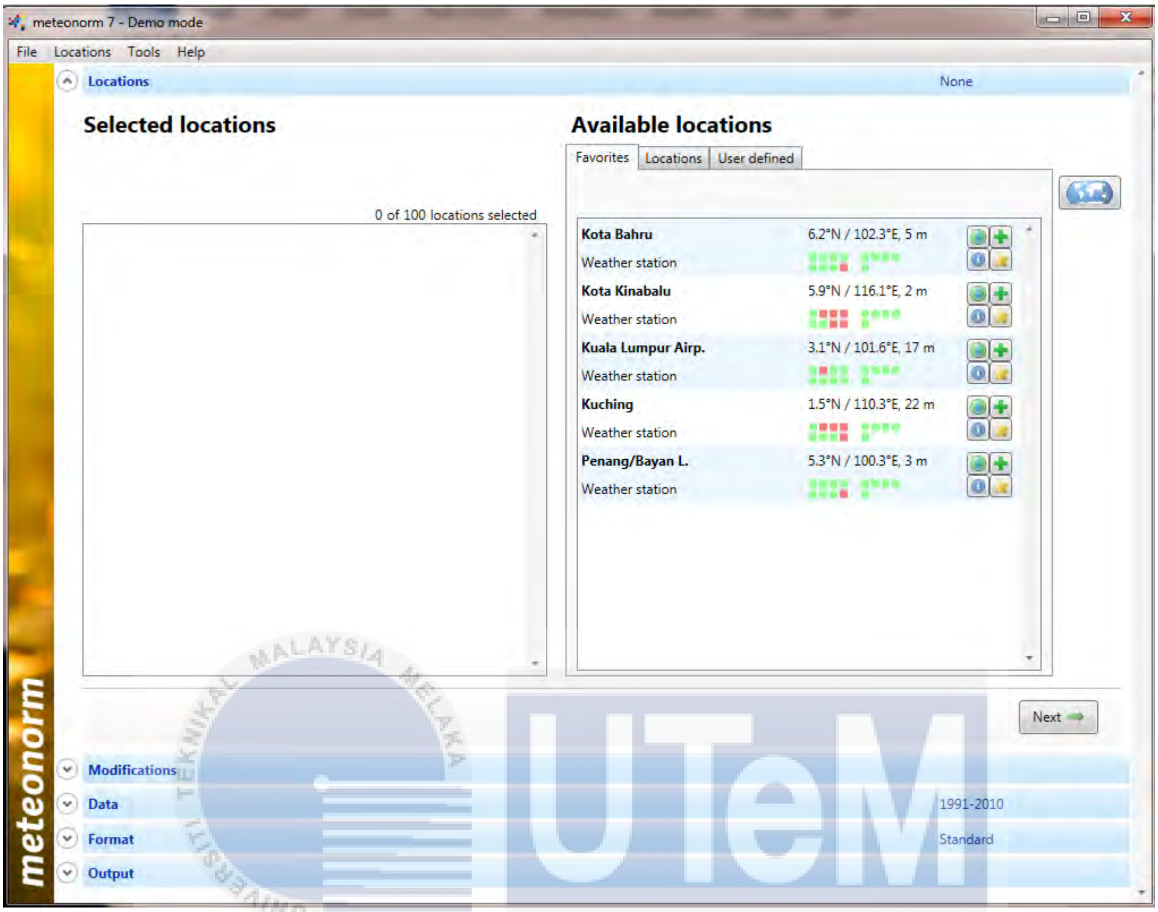


Figure 4.1: Meteonorm7 software main page

Now, Malaysia has eight meteorological and radiation station based on Meteonorm7 software but three of it could not generate global horizontal irradiance used for calculating the DNI value. For this study, five site locations were selected for be process and analysis based on data provided by Meteonorm7 software which is Kota Bharu, Kota Kinabalu, KL Airport, Kuching, and Penang. Those station are places over the states for meteorological data monitors and solar radiation. Five location has been chosen wisely based on location of weather station in Malaysia. Latitude and longitude also has been permanently stated based on data of previous researcher on the DNI radiation.

4.1.1 Site Selection and Coordinate of Weather Station

Table 4.1: The latitude and longitude data locations

Cities In Malaysia	Latitude & Longitude
Kota Bharu	6.167 ° N, 102.283 ° E
Kota Kinabalu	5.933 ° N 116.050 ° E
Subang Airport	3.117 ° N 101.550 ° E
Kuching	1.483 ° N 110.333 ° E
Penang/ Bayan Lepas	5.300 ° N 100.267 ° E

From the software, those DNI data generated from the software are based on location of whether station located in Malaysia. Period of data radiation are between years of 1991 until 2010. Weather Station will update their data with each decade and will update on years of 2021. The output format used for the software standard output format without any condition and specific selection. Those report data are collected via the software on 10th December 2016 and recollected on April 2017 for calibration of climate data from previous data.

4.2 Data Collection and Data Plotting of Direct Normal Irradiance

Result and Data Table data of DNI generated from the Meteonorm7 software. Result and Data Collection of Data Table DNI in five Selected site locations. All parameter are shows when use this software, but focus on parameter "Bn" that represent DNI value in certain place. From the result, software did not neglect the uncertainty of yearly values which is for Gh = 2%, Bn = 4%, Ta = 0.3°C**.** Results of generating data table from Meteonorm7 software in five selected locations in Malaysia

Penang/Bayan L.

Radiation | Temperature | Precipitation | Sunshine duration
Daily global radiation | Daily temperature | Data table

	Gh kWh/m²	Dh kWh/m²	Bn kWh/m²	Ta °C	Td °C	FF m/s
January	163	66	148	27.8	22.2	2.5
February	159	70	128	28.2	22.7	2.2
March	173	80	129	28.2	23.8	2
April	160	80	110	28.3	24.6	1.8
May	153	73	111	28.5	24.6	1.7
June	141	84	81	28.2	24.3	1.8
July	148	83	90	27.9	24.1	1.9
August	144	86	78	27.8	24	1.8
September	138	76	84	27.5	24	1.8
October	135	81	76	27.2	24	1.7
November	135	79	81	27.4	23.9	1.8
December	145	69	118	27.6	23.1	2.4
Year	1797	929	1235	27.9	23.8	1.9

Result informations

Uncertainty of yearly values: Gh = 2%, Bn = 4%, Ta = 0.3 °C
Trend of Gh / decade: - Variability of Gh / year: 4.7%
Radiation interpolation locations: - (Share of satellite data: 0%)
Temperature interpolation locations: -

Figure 4.2: Data table generated for Penang site.

Kuching

Radiation | Temperature | Precipitation | Sunshine duration
Daily global radiation | Daily temperature | Data table

	Gh kWh/m²	Dh kWh/m²	Bn kWh/m²	Ta °C	Td °C	FF m/s
January	109	67	64	25.7	23.4	1.6
February	105	71	48	25.9	23.3	1.6
March	130	89	57	26.3	23.4	1.4
April	131	86	64	26.6	23.8	1.4
May	136	82	78	27.2	24	1.5
June	131	74	83	26.9	23.5	1.5
July	138	75	91	26.8	23.2	1.7
August	140	85	77	27	23.2	1.7
September	131	82	67	26.4	23.4	1.6
October	128	75	74	26.3	23.4	1.6
November	124	70	80	26.1	23.6	1.5
December	117	83	50	26	23.5	1.6
Year	1520	938	832	26.4	23.5	1.6

Result informations

Uncertainty of yearly values: Gh = 2%, Bn = 4%, Ta = 0.3 °C
Trend of Gh / decade: - Variability of Gh / year: 6.5%
Radiation interpolation locations: - (Share of satellite data: 0%)
Temperature interpolation locations: -

Figure 4.3: Data table generated for Kuching site.

Kuala Lumpur Airp.

Radiation | Temperature | Precipitation | Sunshine duration
Daily global radiation | Daily temperature | Data table

	Gh kWh/m²	Dh kWh/m²	Bn kWh/m²	Ta °C	Td °C	FF m/s
January	130	79	78	27.3	22.8	1.8
February	131	71	86	27.8	22.8	1.7
March	150	85	88	28.1	23.4	1.8
April	140	85	75	28	24.1	1.6
May	143	81	89	28.6	24.1	1.8
June	131	76	78	28.2	23.7	1.8
July	133	80	75	27.8	23.3	1.9
August	134	77	79	27.8	23.4	1.8
September	131	73	81	27.6	23.3	1.8
October	136	83	73	27.5	23.5	1.7
November	120	75	63	27.1	23.7	1.6
December	119	74	67	27.2	23.5	1.6
Year	1599	941	932	27.8	23.5	1.7

Result informations

Uncertainty of yearly values: Gh = 2%, Bn = 4%, Ta = 0.3 °C
Trend of Gh / decade: 1.9% Variability of Gh / year: 5.9%
Radiation interpolation locations: - (Share of satellite data: 0%)
Temperature interpolation locations: -

Figure 4.4: Data table generated for Kuala Lumpur Airport site.

Kota Kinabalu

Radiation | Temperature | Precipitation | Sunshine duration
Daily global radiation | Daily temperature | Data table

	Gh kWh/m²	Dh kWh/m²	Bn kWh/m²	Ta °C	Td °C	FF m/s
January	137	70	105	26.8	23.4	1.8
February	133	68	94	26.9	23.4	1.7
March	166	95	98	27.3	23.7	1.8
April	170	78	127	28	24.3	1.9
May	155	89	94	28	24.1	2
June	145	78	94	27.6	23.7	2.1
July	155	78	107	27.6	23.5	2.2
August	153	83	96	27.7	23.5	2.4
September	149	83	96	27.4	23.7	2.3
October	149	78	96	27.2	23.8	2.2
November	136	75	88	27.2	23.9	2
December	134	72	97	27.1	23.7	1.9
Year	1782	946	1192	27.4	23.7	2

Result informations

Uncertainty of yearly values: Gh = 5%, Bn = 9%, Ta = 0.3 °C
Trend of Gh / decade: 17.2% Variability of Gh / year: 9.5%
Radiation interpolation locations: - (Share of satellite data: 0%)
Temperature interpolation locations: -

Figure 4.5: Data table generated for Kota Kinabalu site.

Kota Bahru

Radiation | Temperature | Precipitation | Sunshine duration

Daily global radiation | Daily temperature | Data table

	Gh kWh/m²	Dh kWh/m²	Bn kWh/m²	Ta °C	Td °C	FF m/s
January	143	76	106	26.3	22.6	3.1
February	152	75	110	26.7	22.7	2.8
March	183	80	142	27.4	23.6	2.7
April	185	83	139	28.4	24.2	2.3
May	169	80	128	28.2	24.3	2.1
June	157	80	112	28.1	24	2
July	158	79	110	27.8	23.8	2
August	159	77	113	27.6	23.7	2
September	155	79	106	27.4	23.7	2
October	145	89	79	27	23.8	1.9
November	116	68	72	26.5	23.9	1.9
December	110	67	64	26.4	23.3	2.7
Year	1833	934	1281	27.3	23.7	2.3

Result informations

Uncertainty of yearly values: Gh = 2%, Bn = 4%, Ta = 0.3 °C
Trend of Gh / decade: 5.6% Variability of Gh / year: 4.6%
Radiation interpolation locations: - (Share of satellite data: 0%)
Temperature interpolation locations: -

Figure 4.6: Data table generated for Kota Bharu site.

From the Table 4.2, it shows that the DNI value in five site location with total amount of DNI value in a year. The data collected from the result generated by software.

Table 4.2: Total of DNI value in kWh/m² per year for five site locations

Site Location	*Radiation of DNI in kWh/m² per Year*
Penang	1235
Kuching	832
Subang Airport	932
Kota Kinabalu	1192
Kota Bharu	1281

Furthermore, the data table of five locations in Malaysia was plotted in graph using MATLAB software in Figure 4.7 using for analysis. Result of data plotting and will be act as reference of analysis in DNI value in Malaysia environment.

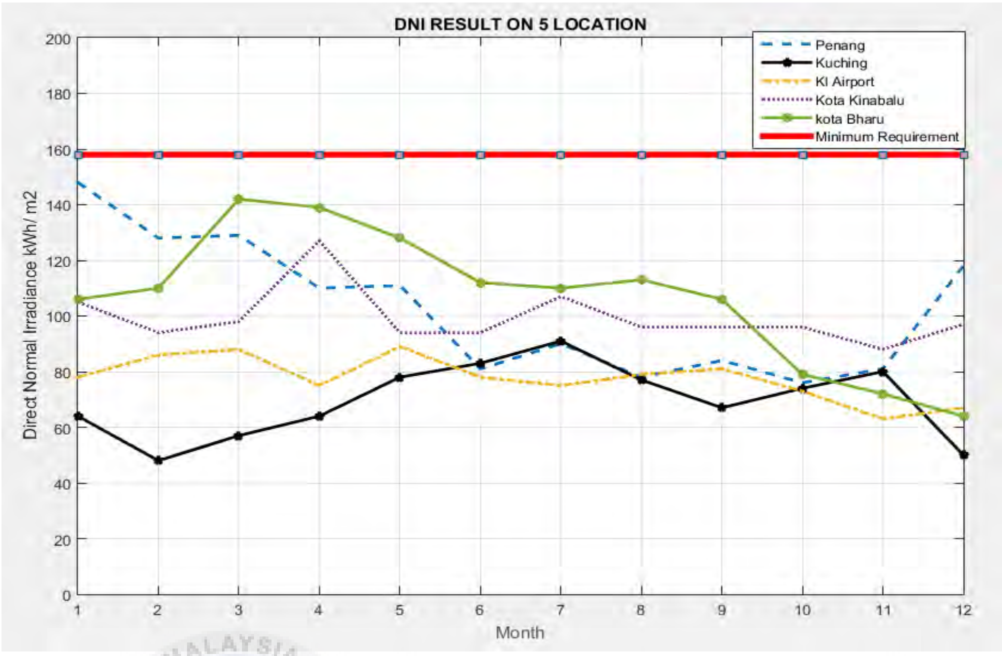


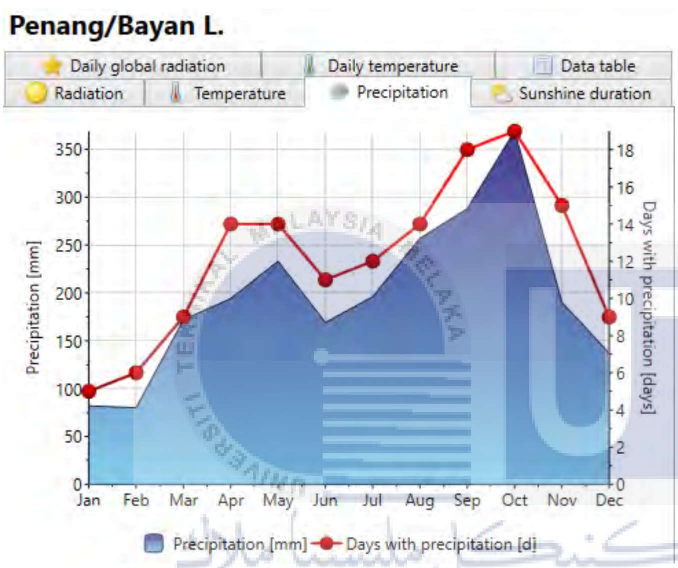
Figure 4.7: Data plotting of DNI results on 5 selected locations.

From the Figure 4.7, result of plotting graph states that the DNI result for five selected locations which is Penang, Kuching, Kl Airport, Kota Kinabalu, and Kota Bharu. From the graph above, the red straight line is indicated the minimum requirement of installation of CSP technologies which is 160kWh/m² for each average month. From the result generated, there are no one of selected locations were achieved the minimum requirement of DNI value. The highest DNI achieved by Penang area which is gain 148 kWh/m² follow by Kota Bharu 142 kWh/m², Kota Kinabalu 127 kWh/m², Kuching 91 kWh/m² and the least is by KL Airport which is 63 kWh/m². The monthly pattern of DNI from December until May, all five selected location gain their high DNI compare to the rest of the month which is from June until November. Then, it stated that only half of the year the higher radiation (but not reach minimum requirement) reached Malaysia environment. So, the highest DNI is in Penang and only gain 65% of DNI to achieve the CSP minimum requirement. They need to enhance more 35% of DNI to achieved to the minimum requirement to steadily performing CSP technologies. In recent study of readings journals and books about DNI, no researchers could prove that could not plant a CSP technologies in low DNI area. So the possibility for implemented the CSP technologies are low but need also to consider the others factor affecting the DNI or need another some modification to enhancing the performance.

4.3 Data Collection and Data Plotting of Precipitation/Rainfall

For precipitation/rainfall data result, Meteonorm7 did not provide any data table like DNI data to be measured, but graph illustration was given by Meteonorm7 software for analysis. In this case, the illustration graph data of precipitation need to collect manually to get raw data of precipitation.

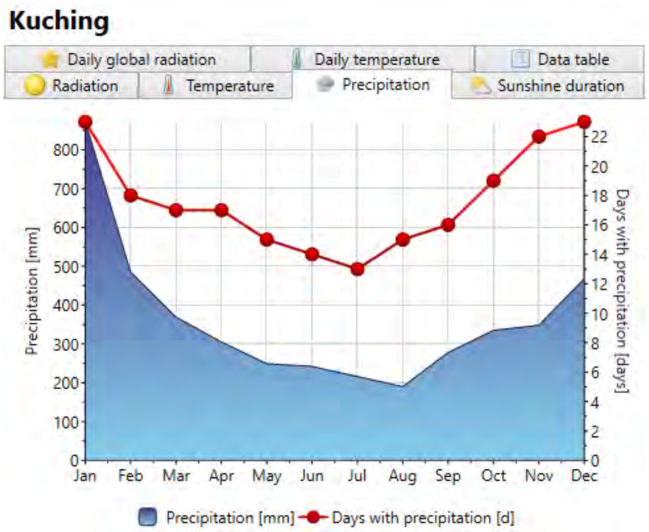
Table 4.3: Precipitation data at Penang in millimetre, mm per month and daily



	montly,mm	daily,mm
January	100	5
February	120	6
March	175	9
April	187	14
May	230	14
June	175	11
July	190	12
August	265	14
September	289	18
October	350	19
November	200	15
December	185	9
Year	2466	

Figure 4.8: Graph illustration by Meteonorm7 at Penang

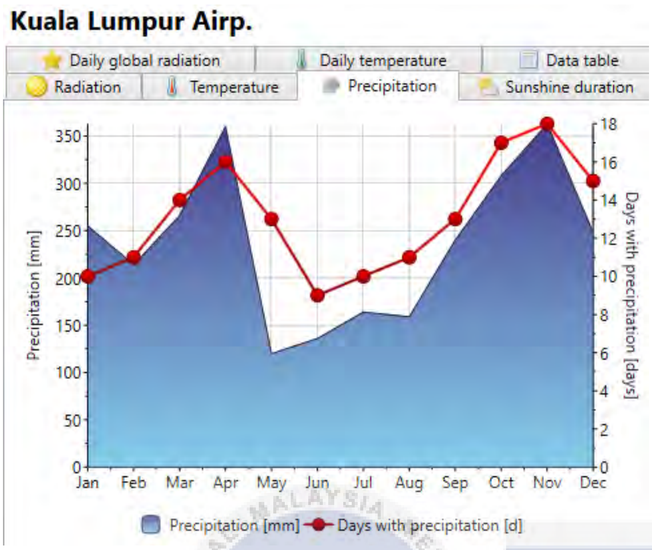
Table 4.4: Total of Precipitation value at Kuching in millimetre, mm per month and daily



	montly,mm	daily,mm
January	860	23
February	500	18
March	370	17
April	300	17
May	250	15
June	250	14
July	220	13
August	190	15
September	280	16
October	340	19
November	350	22
December	475	23
Year	4385	

Figure 4.9: Graph illustration by Meteonorm7 at Kuching

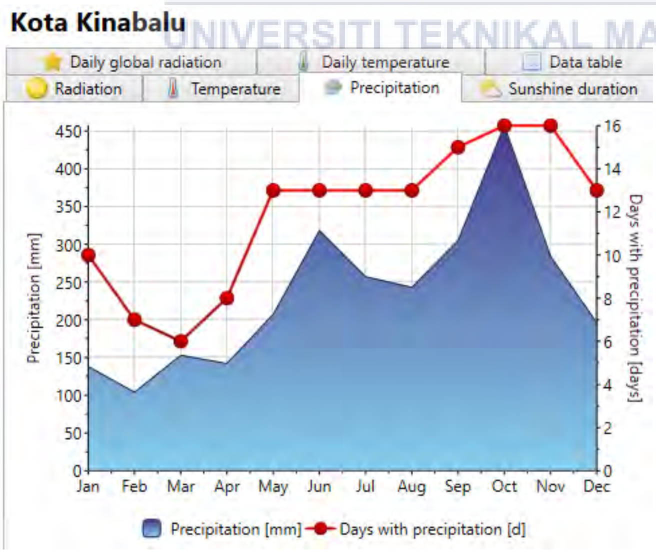
Table 4.5: Total of Precipitation value at Kuala Lumpur Airport in millimetre, mm per month and daily



	montly,mm	daily,mm
January	260	10
February	225	11
March	280	14
April	360	16
May	120	13
June	130	9
July	160	10
August	155	11
September	240	13
October	310	17
November	360	18
December	250	15
Yearly	2850	

Figure 4.10: Graph illustration by Meteonorm7 at KL Airport

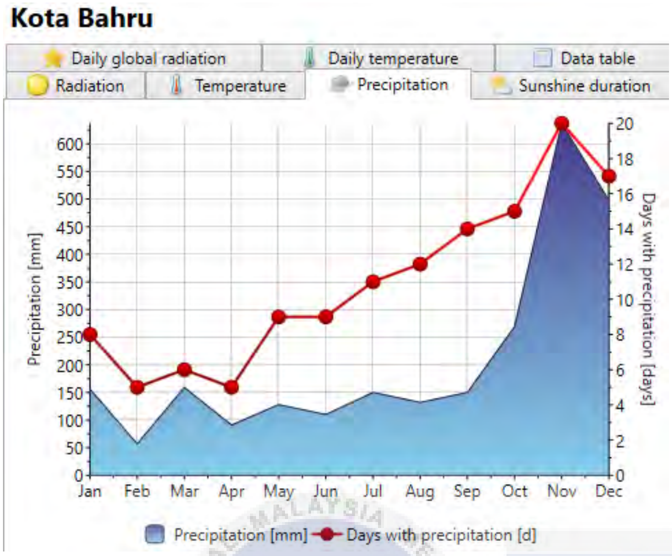
Table 4.6: Total of Precipitation value at Kota Kinabalu in millimetre, mm per month and daily



	montly,mm	daily,mm
January	140	10
February	100	7
March	150	6
April	145	8
May	200	13
June	325	13
July	250	13
August	240	13
September	300	15
October	450	16
November	280	16
December	200	13
Yearly	2780	

Figure 4.11: Graph illustration by Meteonorm7 at Kota Kinabalu

Table 4.7: Total of Precipitation value at Kota Bharu in millimetre, mm per month and daily



	montly,mm	daily,mm
January	155	8
February	60	5
March	155	6
April	75	5
May	125	9
June	100	9
July	150	11
August	135	12
September	145	14
October	270	15
November	660	20
December	500	17
Yearly	2530	

Figure 4.12: Graph illustration by Meteonorm7 at Kota Bharu

From the Table 4.8, it shows that the precipitation in five site locations with total amount of precipitation value per year. The data collected from the result generated by Microsoft Office Excel software with mathematical calculation.

Table 4.8: Total of Precipitation value in mm per year for five site locations

Site Location	*Precipitation in (mm) per year*
Penang	2466
Kuching	4385
Subang Airport	2850
Kota Kinabalu	2780
Kota Bharu	2530

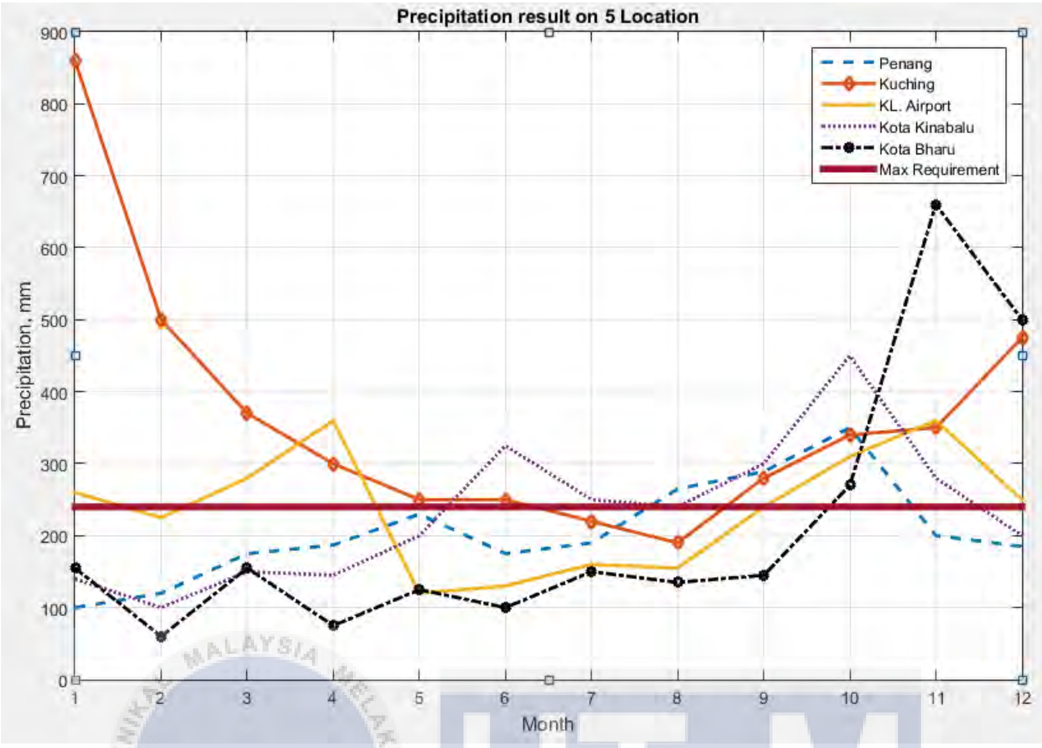


Figure 4.13: Data plotting of Precipitation results on five selected locations

After the data harvested manually, data plotting can be done using MATLAB software for the analysis of precipitation/rainfall in five different locations in Malaysia environment. What we had learnt before, precipitation or rainfall are one of most factor that could affect the performance of DNI in their surrounding area. From the data plotting in Figure 4.13, there are a straight line act as benchmark on high or low precipitation in the area indicate which is 250mm per month. If the value of exceed the red line in the graph, that mean there are high precipitation area and if the value below the red straight line, it means it is a low precipitation area. Based on five selected locations, Kuching is the extremely higher precipitation area compare to others which is 860mm per month in January and the average per year is 4385mm. The lowest precipitation is the best location for implementing the CSP technologies especially parabolic dish that very sensitive to the rain because the axis of the automatic rotor could be disturbed by the rain and it is keep changing direction to find the best sunlight radiation. So, for this study the best place for the lowest precipitation is Kota Bharu and Penang which is 60mm per month and for Penang have steady precipitation by their monthly result follow up by Kota Kinabalu 100mm, KL Airport 120mm, and Kuching 190mm. The precipitation also has a pattern of heavy rain which is from May until October they had most of lower precipitation in their location but for another rest month November until April had high precipitation in their area.

4.4 Data Collection and Data Plotting of Relative Humidity

From the relative humidity data result, Meteonorm7 also did not provided in their software. If the software is licenced, maybe the relative humidity will be provided together in data table. In a means time, the data of relative humidity can be collected by solving the mathematical calculation. Below is the mathematical formula used to solve the relative humidity data.

Relative Humidity:

$$RH = 100 \frac{e^{\left(\frac{a\,T_d}{b+\,T_d}\right)}}{e^{\left(\frac{aT_a}{b+T_a}\right)}} \tag{4.1}$$

where:

a = 17.625

b = 243.04

T_a = Air temperature in ºC
T_d = Dewpoint temperature in ºC
RH = Relative humidity in %

Based on the August-Roche-Magnus approximation, considered valid for:

0 ºC < T_a < 60 ºC
1% < RH < 100%
0 ºC < T_d < 50 ºC

The mathematical formula is based on the August-Roche-Magnus approximation and the relative humidity conversion. For solving the mathematical equation, some parameter need to collect together such as the air temperature and the dewpoint temperature. Below is the result of relative humidity after the calculation was conducted.

Penang

Table 4.9: Data Table of relative humidity calculated using formula for Penang

	Ta ° C	Td ° C	Rh (%)
January	27.8	22.2	71.61
February	28.2	22.7	72.12
March	28.2	23.8	77.07
April	28.3	24.6	80.39
May	28.5	24.6	79.46
June	28.2	24.3	79.42
July	27.9	24.1	79.86
August	27.8	24	79.85
September	27.5	24	81.26
October	27.2	24	82.7
November	27.4	23.9	81.25
December	27.6	23.1	76.52
Year	27.9	23.8	78.43

Kuching

Table 4.10: Data Table of relative humidity calculated using formula for Kuching

	Ta ° C	Td ° C	Rh (%)
January	25.7	23.4	87.15
February	25.9	23.3	85.6
March	26.3	23.4	84.11
April	26.6	23.8	84.65
May	27.2	24	82.7
June	26.9	23.5	81.68
July	26.8	23.2	80.68
August	27	23.2	79.74
September	26.4	23.4	83.61
October	26.3	23.4	84.11
November	26.1	23.6	86.14
December	26	23.5	86.13
Year	26.4	23.5	84.12

Kuala Lumpur Airport

Table 4.11: Data Table of relative humidity calculated using formula for Kuala Lumpur Airport

	Ta ° C	Td ° C	Rh (%)
January	27.3	22.8	76.47
February	27.8	22.8	74.27
March	28.1	23.4	75.68
April	28	24.1	79.4
May	28.6	24.1	76.67
June	28.2	23.7	76.61
July	27.8	23.3	76.55
August	27.8	23.4	77.01
September	27.6	23.3	77.45
October	27.5	23.5	78.85
November	27.1	23.7	81.7
December	27.2	23.5	80.25
Yearly	27.8	23.5	77.48

Kota Kinabalu

Table 4.12: Data Table of relative humidity calculated using formula for Kota Kinabalu

	Ta ° C	Td ° C	Rh (%)
January	26.8	23.4	81.66
February	26.9	23.4	81.18
March	27.3	23.7	80.75
April	28	24.3	80.35
May	28	24.1	79.4
June	27.6	23.7	79.34
July	27.6	23.5	78.39
August	27.7	23.5	77.93
September	27.4	23.7	80.28
October	27.2	23.8	81.71
November	27.2	23.9	82.2
December	27.1	23.7	81.7
Yearly	27.4	23.7	80.28

Kota Bharu

Table 4.13: Data Table of relative humidity calculated using formula for Kota Bharu

	Ta ° C	Td ° C	Rh (%)
January	26.3	22.6	80.13
February	26.7	22.7	78.74
March	27.4	23.6	79.79
April	28.4	24.2	78.03
May	28.2	24.3	79.42
June	28.1	24	78.46
July	27.8	23.8	78.89
August	27.6	23.7	79.34
September	27.4	23.7	80.28
October	27	23.8	82.68
November	26.5	23.9	85.66
December	26.4	23.3	83.11
Yearly	27.3	23.7	80.75

From the Table 4.14, it shows that the relative humidity in five site locations with total average of Relative Humidity percent per year. The data collected from the result generated by Microsoft Office Excel software with mathematical calculation of August-Roche-Magnus approximation formula.

Table 4.14: Total of Relative Humidity value in percentage per year for five site locations

Site Location	*Relative Humidity in Percent per Year (%)*
Penang	78.43
Kuching	84.12
KL Airport	77.48
Kota Kinabalu	80.28
Kota Bharu	80.75

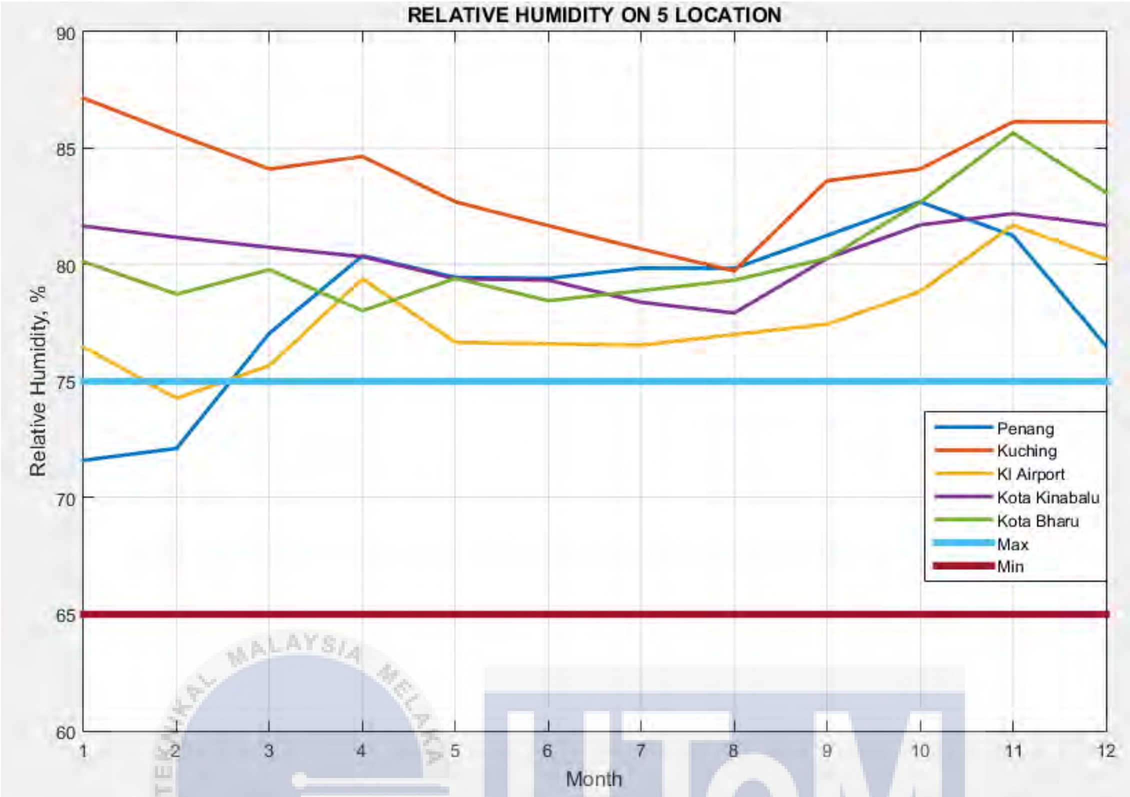


Figure 4.14: Data plotting of relative humidity results on five selected locations

From the tabulated result of relative humidity, data can be plot in a graph using MATLAB software. The data plotting of relative humidity, it shows that five selected locations made the almost same pattern of relative humidity. The lowest relative humidity is located at Penang which is has 71.6% follow up by KL Airport 75.6%, Kota Bharu 78%, Kota Kinabalu 79% and the highest is located in Kuching which is 87%. Besides that, the Red and Light Blue line is the indicator or benchmarking for suitable indicator for developing the CSP technologies. This indicator is referring on the Thai Solar Ltd Corp and be used as our benchmarking for relative humidity percentage. The benchmark of Thailand, is the relative humidity is for highest is 75% and the lowest is 65% in Thailand solar system. Therefore, relative humidity for Malaysia environment are slightly higher for implementation of CSP that could affecting on DNI intensity value.

CHAPTER 5

CONCLUSION & RECOMMMENDATION

Since last semester, FYP was conducted to study the technologies of CSP using PD system for being implemented in Malaysia environment. Besides study on the technologies, DNI data also being gathered and found out the DNI in Malaysia environment are not enough to support the CSP technologies. From that, the factor always affects the DNI value is precipitation, relative humidity and cloud cover. In this study, cloud cover could not be analyse because of lack of source and data within it has over the scope of research. Malaysia are located slightly upper on world equator which is still gain some more precipitation and the humidity because the tropical climate. Precipitation and relative humidity factors should need to be consider because of high precipitation and high relative humidity also effect the performance of DNI. This factor will may slightly effect the DNI value on the site locations for CSP implementation because of the precipitation and relative humidity could diffuse and scattered more sun radiation towards earth surface area. Based on the result, the pattern of climate changes on five selected locations can be concluded by determine the half of the year the performance of CSP could be utilized with the nearly reach of minimum requirement DNI intensity. So if decided to plant a CSP technologies in Malaysia, half of the outcome output per year will be reduced because of the Malaysia environment on climate condition.

For the recommendation, the research and analysis should be continuing to gain any new ideas until the implementation of CSP technologies using PD could get their maturity in some others day. This is because of every country have a RE from sunlight and need solar technologies to be harvest for our next future generation. So the CSP project could possible if the site location for build PD are suitable with DNI outcomes and also need more research on the modify the PD system to enhanced the DNI value, estimating precipitation and humidity in some other time.

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