SOLAR ENERGY/SOLAR INVERTER RESOURCE ASSESSMENT FOR THE DEPARTMENT OF PHYSICS

BY

OVHARHE OREN BLESSING

(B.Sc Physics)

PSC2010441

DEPARTMENT OF PHYSICS,

FACULTY OF PHYSICAL SCIENCES,

UNIVERSITY OF BENIN,

BENIN-CITY,

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A PROJECT SUBMITTED TO THE DEPARTMENT OF PHYSICS, FACULTY OF PHYSICAL SCIENCES, UNIVERSITY OF BENIN, BENIN, EDO STATE, NIGERIA.

IN PARTIAL FULFILMENT OF THE REQUIREMENTS OF THE AWARD OF THE BACHELOR OF SCIENCE (B.Sc HONOURS) DEGREE IN PHYSICS

February, 2025.

CERTIFICATION

This is to certify that this research work was carried out by in the Department of Physics **OVHARHE OREN BLESSING**, Faculty of Physical Science, University of Benin, Nigeria under my supervision .

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DR. OSARODION EBOMWONYI   **DATE**

(Project Supervisor)

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PROF. C.O. AIGBOGUN   **DATE**

(Head of Department)

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EXTERNAL EXAMINER   **DATE**

DEDICATION

This Project Work is dedicated to God Almighty for His protection and guidance throughout my entire four years of studies at the University of Benin. To my parents, who have always supported me in all my activities and also for their love and support. This work is dedicated to all of you with Love and words of appreciation.

CERTIFICATION OF DISSERTATION ON PLAGIARISM

We the undersigned, attest to and declare that the dissertation of **OVHARHE OREN BLESSING** , titled SOLAR RESOURCE ASSESSMENT FOR THE UNIVERSITY OF BENIN has successfully passed the anti-plagiarism test, and does not violate any copyright regulations.

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DR. OSARODION EBOMWONYI	**DATE**
(Project Supervisor)	

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PROF. C.O. AIGBOGUN	**DATE**
(Head of Department)	

ACKNOWLEDGEMENTS

My Profound gratitude goes to the Almighty God for His unending love, mercy, guidance, and His grace that has sustained me throughout my stay at the University of Benin.

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I also want to thank my parents Mr Ogenero and Mrs Loveth Ovharhe for their financial, and moral support in the pursuit of this degree.

I thank all my team members for their contributions, ideas, and dedication in seeing that our project was successful.

I also appreciate my coworkers and friends, Sir T, Mr Timothy & Mr Josiah, for their coaching and support during this demanding but rewarding process, your support and motivation kept me going when times were rough.

Thank you all for your contributions to this project, I could not have done it without you.

ABSTRACT

Solar energy is a renewable and abundant resource that holds immense potential for meeting the world's growing energy demand while mitigating climate change. Accurate assessment of solar radiation patterns and availability is crucial for the efficient deployment of solar energy technologies and the optimization of renewable energy systems.This research project aims to conduct a comprehensive solar panel/ solar inverter resource assessment in the University Of Benin Ugbowo, Nigeria, to evaluate the solar energy potential around it. The study employs an approach which involved integrating satellite data analysis, gotten from the National Aeronautics and Space Administration (NASA) to quantify solar irradiance levels and characterize solar radiation . The findings of this research project will provide valuable insights into the periods of best insolation and also environmental factors influencing solar resource availability in the University Of Benin.Most domestic appliances such as personal computers, television sets and lighting systems among others, operation has largely been controlled by hydro-electric power supply [National Grid]. This is not much a reliable source of energy due to the persistent power failure from our only reliable Nation Grid in the country, which has been the result of low water level in the dam(s) during harmattan season, faulty underground cables and transformer failures.

Nigeria's energy sector is characterized by a dominance of fossil fuels, which contributes to climate change, air pollution, and environmental degradation. The country's renewable energy resources, particularly solar energy, remain largely untapped. This project seeks to contribute to the development of Nigeria's solar energy sector by designing, installing, and testing a solar powered energy system with an inverter.

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CHAPTER ONE

INTRODUCTION

The extraction, transportation, and conversion of fossil fuels for energy generation pose significant challenges. Consequently, researchers have explored alternative, renewable, and more efficient energy solutions. This presentation focuses on the viability and practicality of utilizing solar-powered inverters to efficiently regulate and distribute energy in various settings, including homes, offices, and workplaces. This Solar Radiation Resource Assessment Project provides planners and users of solar technologies with information on the best times and locations to use the sun's energy resource. The U.S. Department of Energy (DOE) established this assessment project to facilitate the deployment of solar technologies .The project team accomplishes this by producing and disseminating relevant and reliable information about solar radiation. The project is the major activity of DOE's Resource Assessment Program, which is funded and monitored by the Photovoltaics Division of the Office of Solar Energy Conversion.

1.1 Solar Energy

Energy from the sun has been used to provide electricity for many years. This form of renewable energy occupies less space compared to the space occupied by hydro-power projects (Martin, 2015). Developing countries can cover all their demands for energy by solar systems with 0.1% of the land area. Solar energy is available in abundance in most parts of the world. The amount of solar energy incident on the earth's surface is approximately1.5 x 1018 kWh/year, which is about 10,000 times the current annual energy consumption of the entire world. The density of power radiated from the sun (referred to as solar energy constant) is 1.373 kW/m2 .

what is solar energy:

The Sun is the fundamental driving force for energy in the Earth's climate system. Solar energy refers to the radiant energy emitted by the Sun, which can be harnessed and converted into various forms of usable energy, such as heat and electricity, using solar technologies (Frank and Kreith , 2013). Sun is a nuclear reactor that radiates off a massive amount of energy to the earth's surface through light and heat, such an energy source can be converted to electrical energy through the use of the photo electric effect or conduction of heat, to be used in various applications. Through the observation of plant and how they synthesize solar energy to produce food we come up with the process of photoelectric effect in production of electricity, we take account the different stages in photosynthesis which are the light-dependent reactions and the light – independent reactions and with this in mind we use photo-voltaic cells that create electrical charges that move in the direction of the electrical field which causes the charges to flow in a circuit. However For this project we would be discussing extensively on the solar resource assessment for a Photovoltaic system for the location at the University of Benin Ugbowo, Nigeria, located at Longitude 6.3990^{o}N and Latitude 5.6099^{o}E.

1.2 Solar Resource Assessment

The taking into consideration of environmental factors, electrical load and radiation from the sun . It refers to the evaluation and analysis of materials needed to fabricate a solar powered inverter and data on solar radiation to assess the solar energy potential of a given site or region. It encompasses the measurement, validation, and interpretation of solar irradiance parameters, including Direct Normal Irradiance (DNI), Global Horizontal Irradiance (GHI), and Diffuse Horizontal Irradiance (DHI), to support decision-making in renewable energy planning and project development (Carnohan, 2019) . Its a critical process used to evaluate the availability and characteristics of solar energy at a specific location. It involves the measurement, analysis, and modeling of solar radiation to determine the solar energy potential of a site. It also involves determining how much solar radiation is available to specific energy-producing or energy saving technologies, such as photovoltaic panels or smart windows.

1.2.1 Roles of Solar Resource Assessment

Solar resource assessment plays a pivotal role in optimizing the design, sizing, and performance of solar photovoltaic (PV) systems, ensuring their efficiency and effectiveness. Here's how:

1. **Design Optimization**: In solar resource analysis this refers to the process of systematically improving the efficiency, performance, and cost-effectiveness of solar energy systems through iterative design iterations and modeling techniques (Kalogioru, 2013). It involves maximizing the

utilization of available solar radiation resources, optimizing system components and configurations, and minimizing energy losses and environmental impacts to achieve the desired energy output and economic viability of solar projects. Solar resource assessment provides crucial data on solar irradiance levels, shading patterns, and environmental conditions at a specific location (IRENA, 2016). This information enables engineers and designers to optimize the layout and orientation of PV arrays, maximizing solar exposure throughout the day and across seasons. By strategically positioning solar panels and minimizing shading from surrounding objects, such as buildings or vegetation, design optimization ensures that each panel receives the maximum amount of sunlight, enhancing overall energy production potential.

2. **Sizing Accuracy**: Sizing accuracy in solar energy refers to the precision and reliability of calculations and methodologies used to determine the appropriate size and capacity of solar energy systems, such as photovoltaic (PV) arrays or solar thermal collectors (Myers, 2016). It involves accurately estimating the energy demand, solar resource availability, system performance factors, and other relevant parameters to ensure optimal system sizing and efficient utilization of available resources (Myers, 2016). Accurate estimation of solar resource

availability is essential for appropriately sizing PV systems to meet energy demand. Solar resource assessment helps determine the optimal capacity of the PV array based on the available solar irradiance and expected energy yield, by matching system size to energy requirements and solar resource potential. Additionally, precise sizing minimizes the risk of under-performance or overproduction, ensuring optimal utilization of resources and maximizing return on investment (IEA, 2016).

3. **Performance Enhancement**: Performance enhancement refers to the process of improving the efficiency, reliability, and output of solar energy systems through various techniques and strategies (Kalogioru, 2013).This may include optimizing system design and layout to maximize solar irradiance capture, enhancing component efficiency through technological advancements and material innovations, implementing tracking systems to optimize solar panel orientation and tilt angles for increased sunlight exposure, and integrating energy storage solutions to mitigate intermittency and enhance system reliability (Kalogioru, 2013). Continuous monitoring of solar resource data allows for real-time assessment of PV system performance. By comparing actual energy output with predicted values based on solar resource assessments, operators can identify deviations and diagnose potential issues affecting system efficiency, such as shading, bearing, or equipment malfunctions.

The global shift towards renewable energy sources, particularly solar energy, has gained momentum as a response to climate change and environmental concerns some of which are highlighted below.

- Solar energy has helped reduce greenhouse gas emissions from fossil fuels to a cleaner alternative (Dunlap, 2013). Solar energy, being abundant and emission-free, has emerged as a key solution to decarbonize the energy sector and limit the adverse impacts of climate change.
- Solar energy, being abundant and widely distributed, offers countries the opportunity to reduce reliance on imported fuels and achieve greater energy independence (World Energy Outlook, 2021).
- The rapid growth of the solar energy industry has created significant economic opportunities, driving job creation, innovation, and investment in clean energy technologies. As solar energy becomes increasingly cost-competitive with conventional energy sources, it offers the potential for sustainable economic growth and development, particularly in emerging markets (Renewable Energy and Jobs Annual Review, 2022).

1.2.2 Importance of an accurate Solar Resource Assessment

Accurate solar resource assessment is very necessary for decision-making in solar project development such as;

1. **Optimal Site Selection**: Optimal site selection involves identifying locations with favorable solar resource characteristics, such as high solar irradiance levels, minimal shading, and suitable land availability (Perez 2004). It is recorded that a panel inclined at a 45^0 due south would result in the maximum intake through earth's rotation. This process ensures that solar energy systems can maximize energy capture and output, leading to improved economic viability and performance. These observations enables developers to identify locations with high solar energy potential, optimizing site selection to maximize energy yield and economic returns. By choosing the most suitable sites for solar installations, stakeholders can enhance project viability and performance from the outset.
2. **Precise Energy Yield Estimation**: This involves accurately predicting the amount of energy that a solar energy system will produce over its lifetime. This estimation considers factors such as solar irradiance levels, system efficiency, tilt angle, shading, and weather conditions to provide realistic expectations of energy generation (Kreider, 2013). Accurate assessment of solar resource availability is crucial for estimating the energy production potential of solar installations with confidence. Reliable energy yield estimates are essential for project planning, financing, and risk assessment, guiding investment decisions and ensuring financial viability over the project's life-cycle.

3. **Effective System Sizing and Design**: This involve selecting the appropriate size and configuration of solar energy systems based on energy demand, available space, budget constraints, and other site-specific factors. This ensures that solar systems are optimized for performance, reliability, and cost-effectiveness (Myers, 2013).Solar resource assessment informs the sizing and design of solar energy systems, ensuring they are appropriately scaled to meet energy demand while maximizing efficiency and sustainability. From understanding the available solar resource, developers can optimize the configuration of photovoltaic arrays, tilt angles, and tracking systems to capture the maximum amount of sunlight. Proper system sizing and design not only enhance energy production but also minimize costs and resource utilization, improving overall project.
4. **Long-Term Performance Monitoring**: This involves continuously monitoring the operation and output of solar energy systems over their operational lifespan this can be aided with a charge controller that monitors the temperature of the system, total amount of input and output voltage/current of each component . This allows for the detection of any performance issues, degradation, or malfunctions, enabling timely maintenance and optimization to ensure optimal energy production and system reliability. (Kalogirou, 2013). Solar resource assessment supports ongoing performance monitoring and optimization of solar installations throughout their operational lifespan. (IEA, 2020). From comparing actual

energy production with predicted values based on solar resource assessments, operators can assess system performance, diagnose issues, and implement corrective measures as needed. Continuous monitoring ensures that solar projects operate at peak efficiency, maximizing energy generation and revenue generation over time.

1.2.3 Challenges in Solar Resource Assessment

- **Climate conditions**: conditions such as cloud cover, atmospheric moisture, Aerosols and particulate matter pose great threat to solar assessment. Cloudiness affects amount of direct solar radiation reaching the earths surface, with overcast conditions reducing solar irradiance level. Water vapor in the atmosphere can attenuate solar radiation through absorption, thereby affecting solar resource availability. Airborne particles like dust and pollution can also scatter and absorb sunlight causing low solar irradiance levels.
- **Terrain or Topography**: A Terrain characteristic affects the angle at which solar radiation strikes the earths surface. Mountains, Hills and other artificial structures like buildings and trees cast shadows that reduce solar irradiance leading to localized shading effects.
- **shading effect**: Seasons as well as time of day and year also affects solar resource availability. Due to the earths orbital motion and axial tilt solar

resource availability varies through out the day and across seasons. Reflections from nearby structures or water bodies can alter solar radiation distribution and impact the efficiency of the energy capture.

1.3 Aim and Objectives

The aim of this project is to evaluate solar resource potential

The objectives of this project are to:

1. determine the solar resource assessment for solar panel.
2. identify the periods of high and low insolation.
3. identify periods where Photovoltaic panels are able to harness solar radiations.
4. Winding of primary, secondary and feedback wiring.
5. Calculations on the expected output of each component.

CHAPTER TWO

LITERATURE REVIEW

2.1 History of solar resource assessment

Solar resource assessment has evolved significantly over time, with early civilizations observing and harnessing the power of the sun for various purposes (Jaeger-Waldau, 2016). The concept of solar radiation measurement began to take shape in the 19th century with the invention of instruments like the pyranometer, which enabled the quantification of solar irradiance levels. Throughout the 20th century, advancements in technology, such as the deployment of satellite-based sensors and the development of numerical models, revolutionized solar resource assessment, allowing for more accurate and comprehensive evaluations of solar energy potential (Jaeger-Waldau, 2016).

Solar resource assessment is the evaluation of solar radiation data, including direct, diffuse, and global solar irradiance, to determine the solar energy potential of a given location. It involves the measurement, analysis, and modeling of solar radiation patterns, variability, and characteristics, with the aim of informing renewable energy planning, project development, and policy decision-making (Jaeger- Waldau, 2016).

2.2 Terminologies in Resource Assessment

1. **Solar Irradiance:** This is a radiometric term for the power of electromagnetic radiation at a surface, per unit area. It is used when the electromagnetic radiation is incident on the surface. Irradiance fluctuates according to the weather and the sun's location in the sky. This location constantly changes through the day due to changes in both the sun's altitude (or elevation) angle and its azimuth (or compass) angle (Jayakumar, 2009).
2. **The solar constant:** This is the amount of incoming solar electromagnetic radiation per unit area, measured on the outer surface of Earth's atmosphere on a plane perpendicular to the rays. The solar constant includes all types of solar radiation, not just the visible light. It is estimated to be roughly 1,366 watts per square meter (W/m^2) according to satellite measurements. The solar constant does not remain constant over long periods of time (Jayakumar, 2009).

3. **The solar window:** This represents the effective area through which useful levels of sunlight pass throughout the year for a specific location. It is used to determine potential shading problems when designing a photovoltaic system (Jayakumar, 2009).

2.3 Solar PV Technology

Solar cell is a device which converts photons in Solar rays to direct-current (DC) and voltage (Jayakumar 2009). The associated technology is called Solar Photovoltaic (SPV). The amount of current generated by a PV cell depends on its efficiency, its size (surface area) and the intensity of sunlight striking the surface. The amount of solar power available per unit area is known as irradiance (Jayakumar, 2009).

2.3.1 Solar Photovoltaic setup for Home lighting application

Home light systems are powered by solar energy using solar modules. The generated electricity is stored in batteries and used for the purpose of lighting

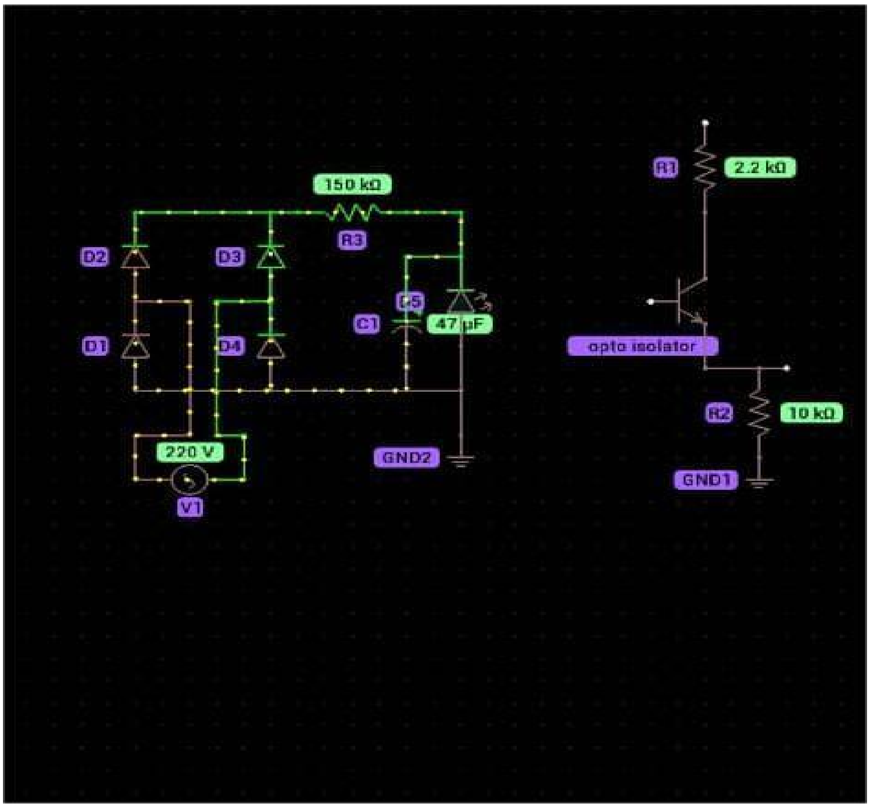
whenever required. The Solar Home Lighting system is a fixed installation designed for domestic application. The system comprises of Solar PV Module (Solar Cells), charge controller, battery inverter and lighting system.

Figure 2 1 : Schematic of Solar Home Lighting System (source: SRNE Blog)

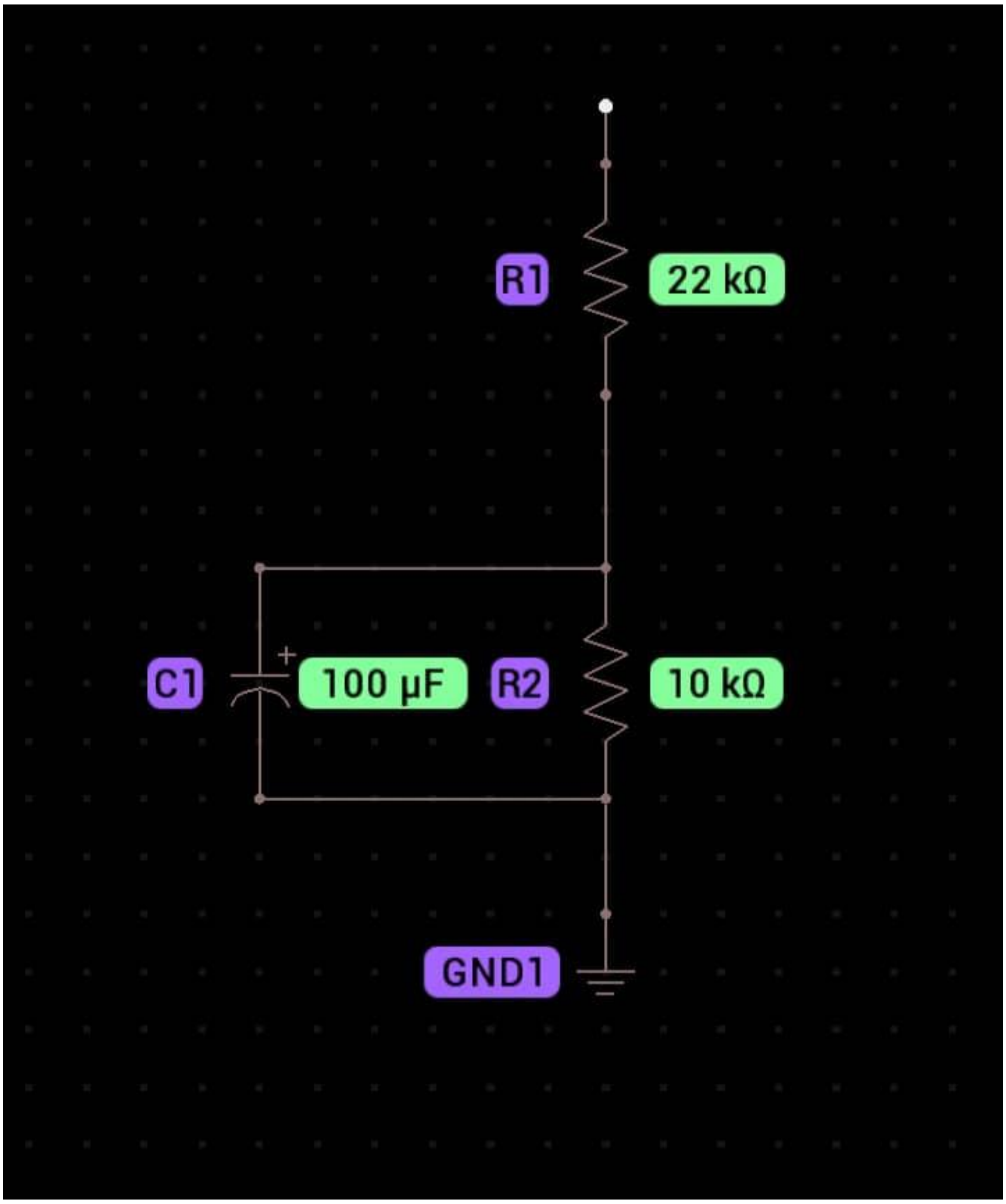
2.4 Components Of the Inverter;

For an inverter system certain circuits are to be connected to the transformer and the micro-controller.

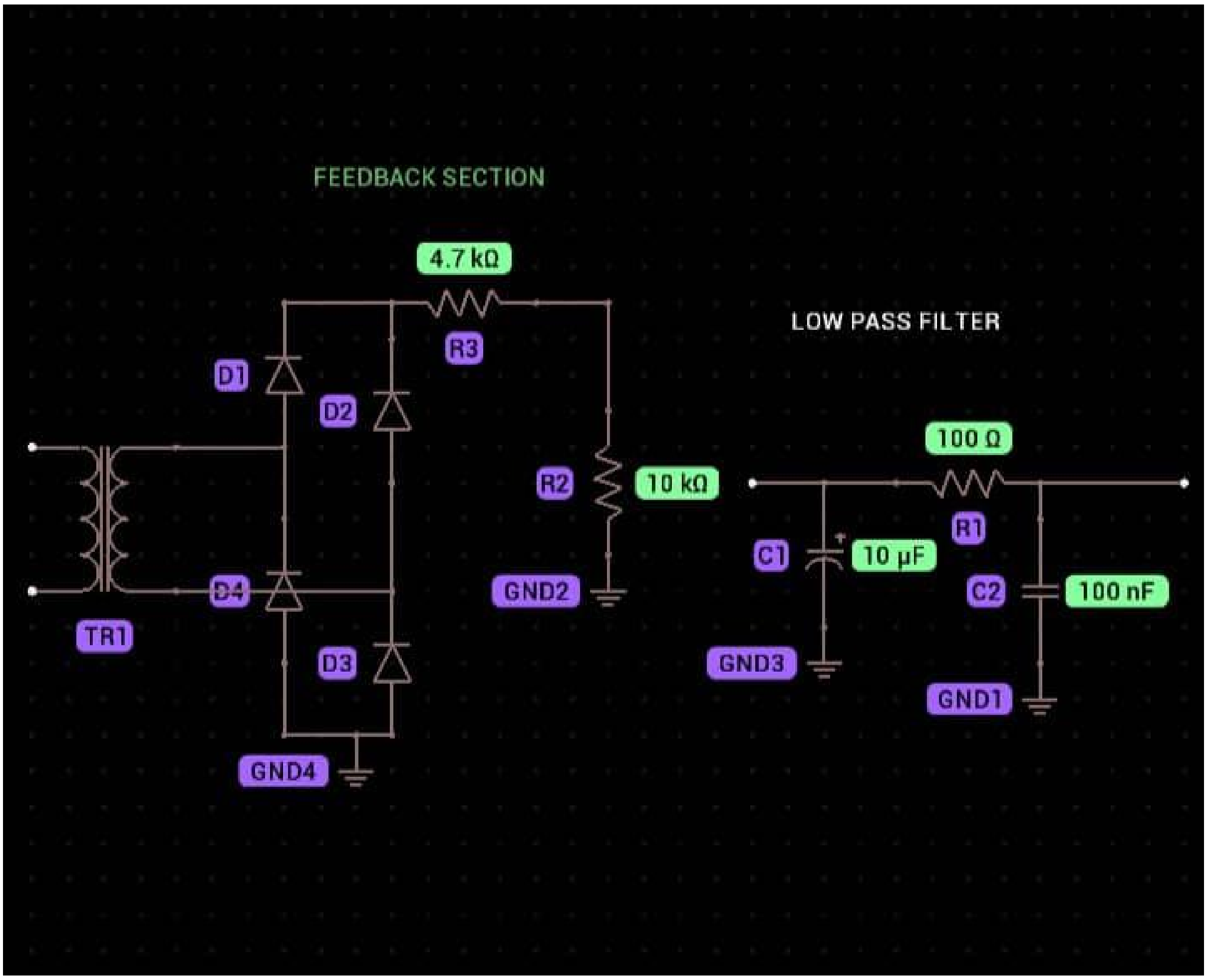
1) The Mains sensor



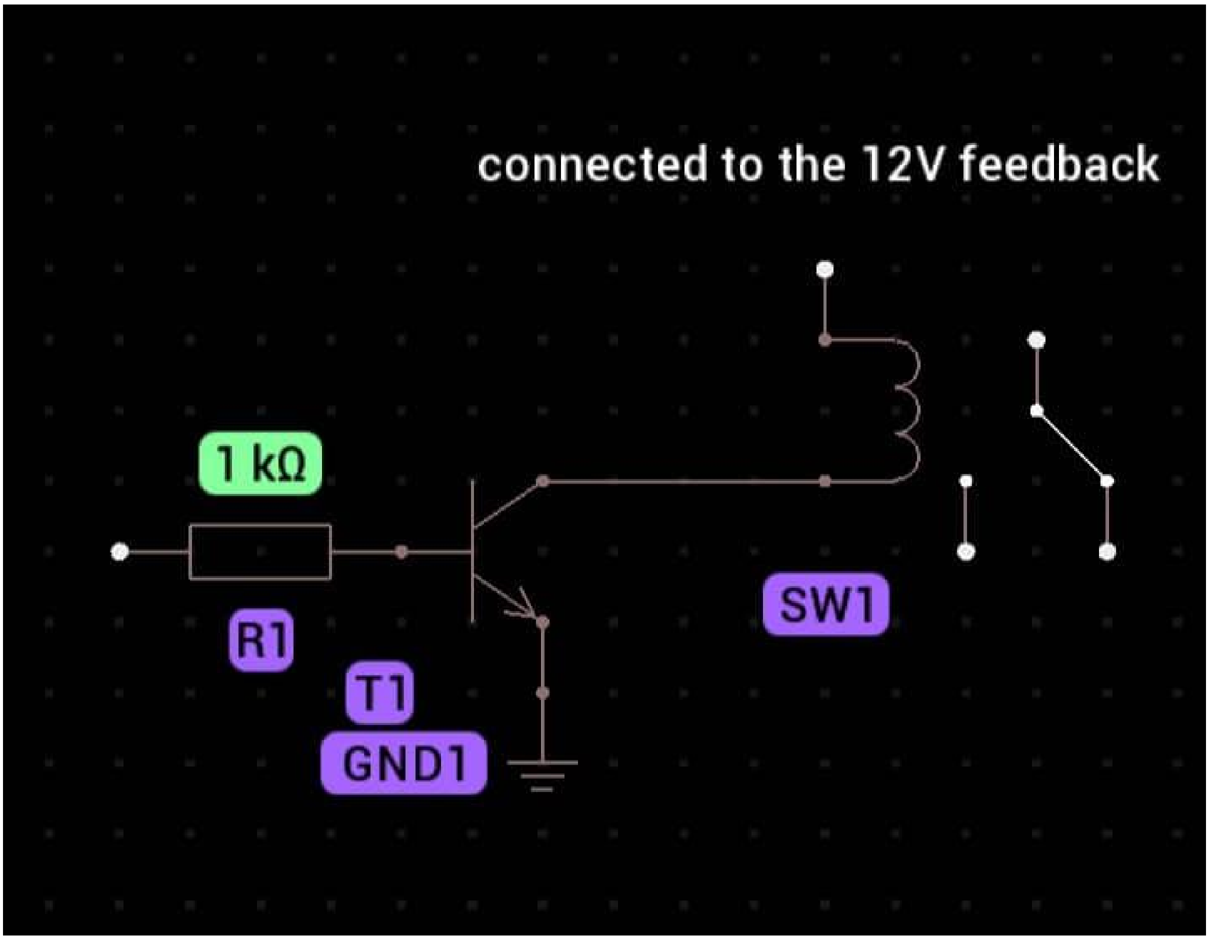
2) The battery sensor



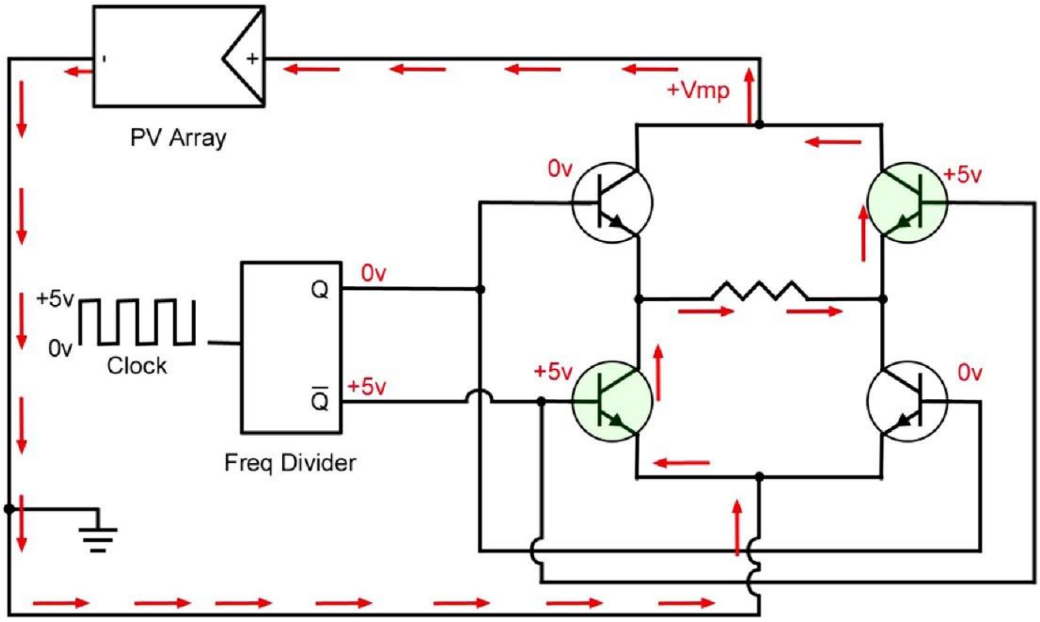
3) The feedback section(control section)



4) The relay



H bridge configuration: This setup enables the direct current(DC) coming from the solar panels to pulsate and become a suitable alternating current(AC). This process works by passing current periodically through diagonally positioned metal-oxide semi-conductor field-effect transistors (MOSFETs) .



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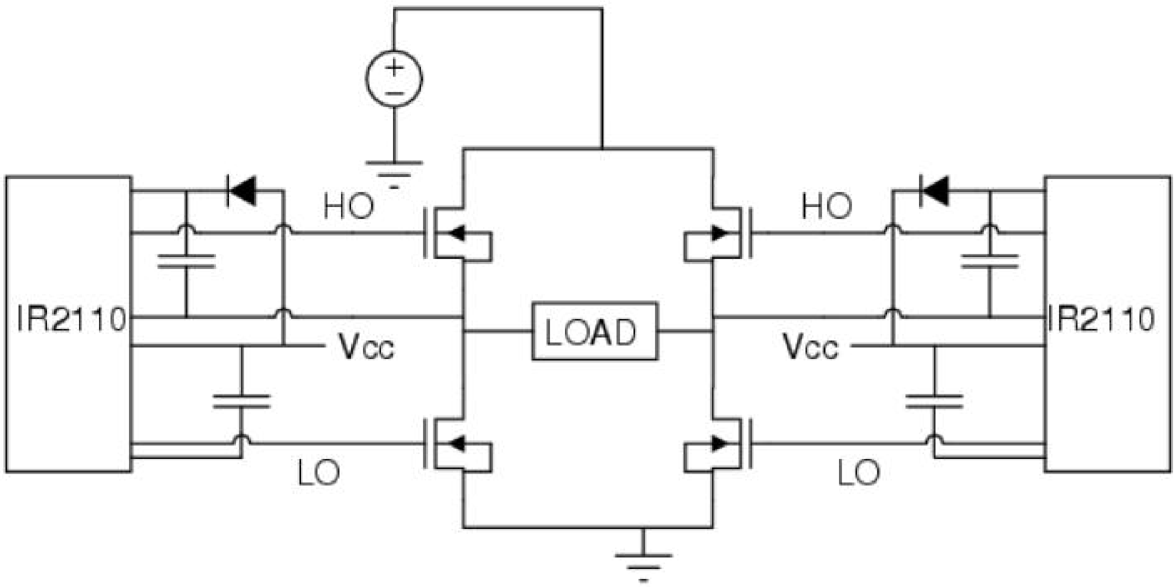
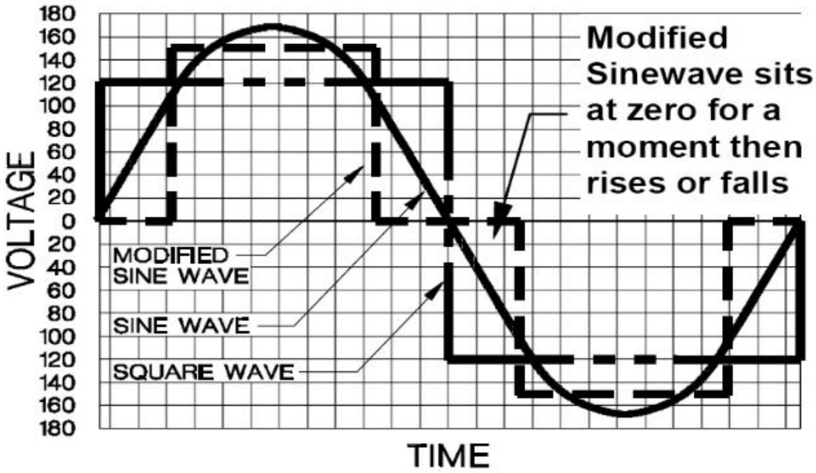


Operating principles of the inverter: The inverter requires a direct current (DC)source to be able to convert to alternating current(AC) . The will produce a modified or pure sine wave when viewed through an oscilloscope. The steadiness/consistency of the wave is dependent on the amount of transistors used and the filtration's done throughout the system



Modified Sine wave and Sine wave Waveforms.
http://www.wholesalesolar.com/pdf.folder/Download%20folder/sine_modsine.pdf

CHAPTER THREE

C METHODOLOGY

In achieving the solar resource assessment for the University of Benin, lots of data collection and analysis with validation were involved, all of which would be highlighted in this chapter.

3.1 Solar Data Collection

Here, satellite data from the National Aeronautics and Space Administration (NASA) plays a vital in achieving the solar data for the course of this project. This data were collected for the duration of 10 years ranging from   January 2015 to January 2025 for the University of Benin

3.1.1 Statistics of Data Acquired

The data set from NASA also includes climatic meteorological averages for

- Daily maximum and minimum temperatures
- Record maximum and minimum temperatures
- Heating and cooling degree days
- Relative humidity
- Wind speed

For the purpose of this project we are dealing with the daily temperatures for both maximum and minimum temperatures. The average monthly insolation was calculated using Microsoft excel and a histogram was plotted which gave an understanding to the months with best insolation levels**.** The data used to make the bar chart which was gotten from NASA is available in Appendix 1

Also with the aid of Mat-Lab, a cumulative distribution frequency curve of the average monthly insolation for low and high insolation months was plotted with the data in table of Appendix 2. The following steps were taken in the array of figures below figures below.

PLATE 3.1 ; Run the matlab

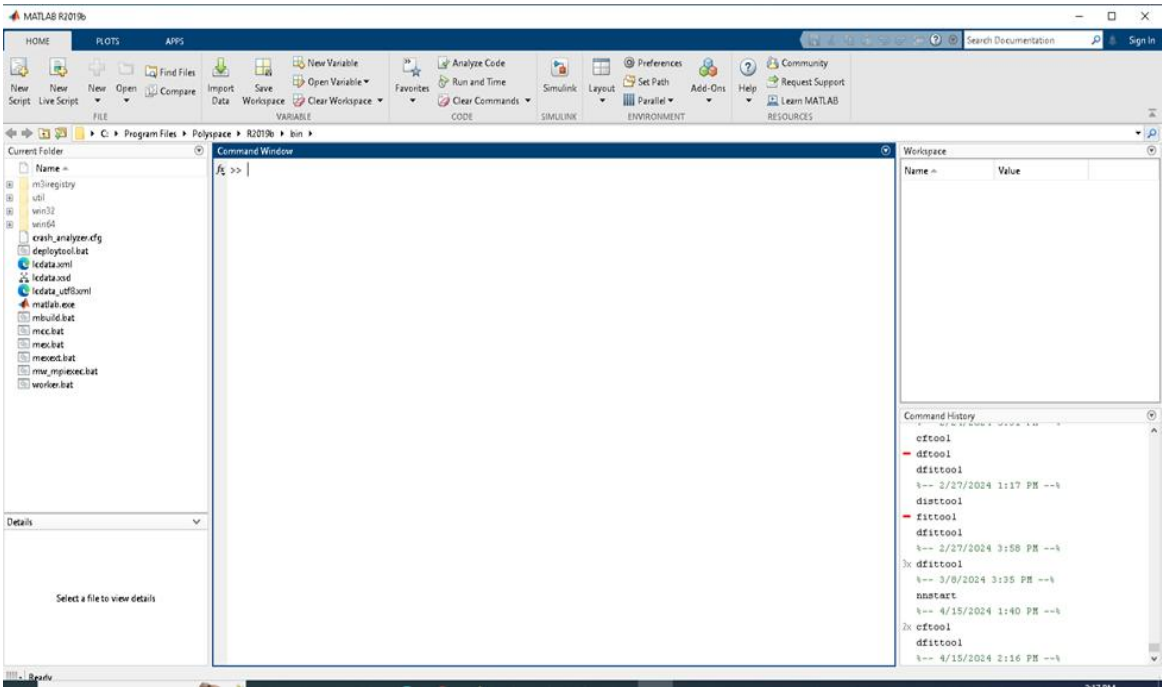
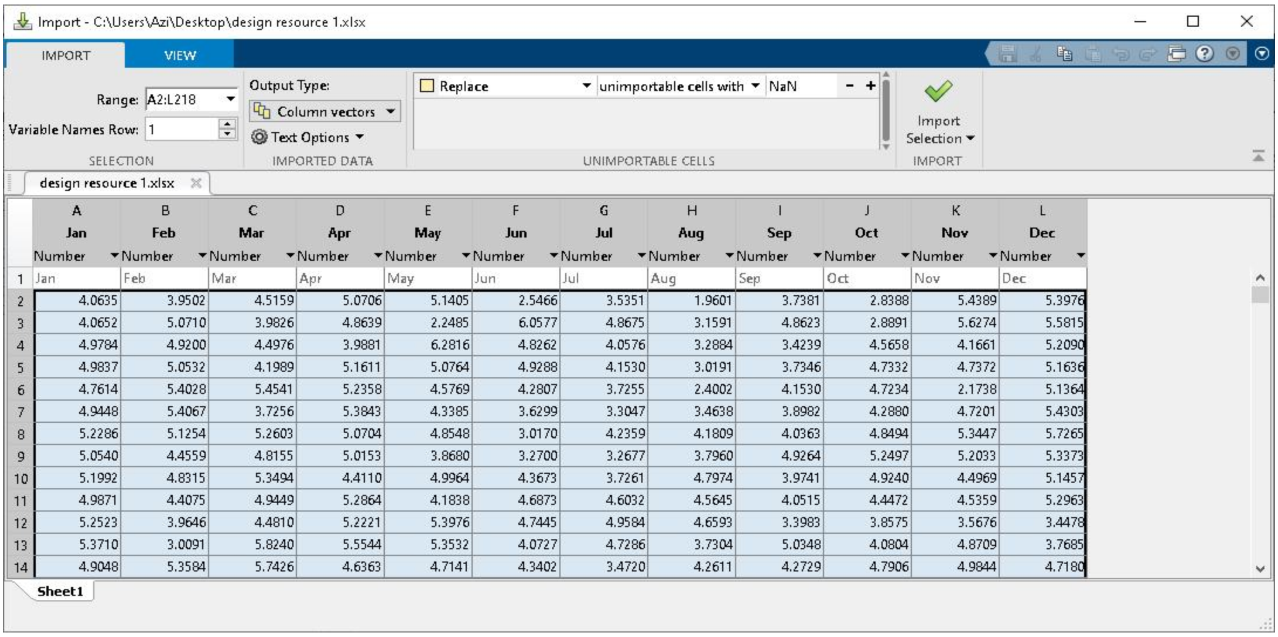


PLATE 3.2: choose column vectors output type, and import the data sets from Appendix 2



	A Jan Number	B Feb Number	C Mar Number	D Apr Number	E May Number	F Jun Number	G Jul Number	H Aug Number	I Sep Number	J Oct Number	K Nov Number	L Dec Number
1	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
2	4.0635	3.9502	4.5159	5.0706	5.1405	2.5466	3.5351	1.9601	3.7381	2.8388	5.4389	5.3976
3	4.0652	5.0710	3.9826	4.8639	2.2485	6.0577	4.8675	3.1591	4.8623	2.8891	5.6274	5.5815
4	4.9784	4.9200	4.4976	3.9881	6.2816	4.8262	4.0576	3.2884	3.4239	4.5658	4.1661	5.2090
5	4.9837	5.0532	4.1989	5.1611	5.0764	4.9288	4.1530	3.0191	3.7346	4.7332	4.7372	5.1636
6	4.7614	5.4028	5.4541	5.2358	4.5769	4.2807	3.7255	2.4002	4.1530	4.7234	2.1738	5.1364
7	4.9448	5.4067	3.7256	5.3843	4.3385	3.6299	3.3047	3.4638	3.8982	4.2880	4.7201	5.4303
8	5.2286	5.1254	5.2603	5.0704	4.8548	3.0170	4.2359	4.1809	4.0363	4.8494	5.3447	5.7265
9	5.0540	4.4559	4.8155	5.0153	3.8680	3.2700	3.2677	3.7960	4.9264	5.2497	5.2033	5.3373
10	5.1992	4.8315	5.3494	4.4110	4.9964	4.3673	3.7261	4.7974	3.9741	4.9240	4.4969	5.1457
11	4.9871	4.4075	4.9449	5.2864	4.1838	4.6873	4.6032	4.5645	4.0515	4.4472	4.5359	5.2963
12	5.2523	3.9646	4.4810	5.2221	5.3976	4.7445	4.9584	4.6593	3.3983	3.8575	3.5676	3.4478
13	5.3710	3.0091	5.8240	5.5544	5.3532	4.0727	4.7286	3.7304	5.0348	4.0804	4.8709	3.7685
14	4.9048	5.3584	5.7426	4.6363	4.7141	4.3402	3.4720	4.2611	4.2729	4.7906	4.9844	4.7180

PLATE 3.3: A work space column of the input data appears at the corner having all the months present.

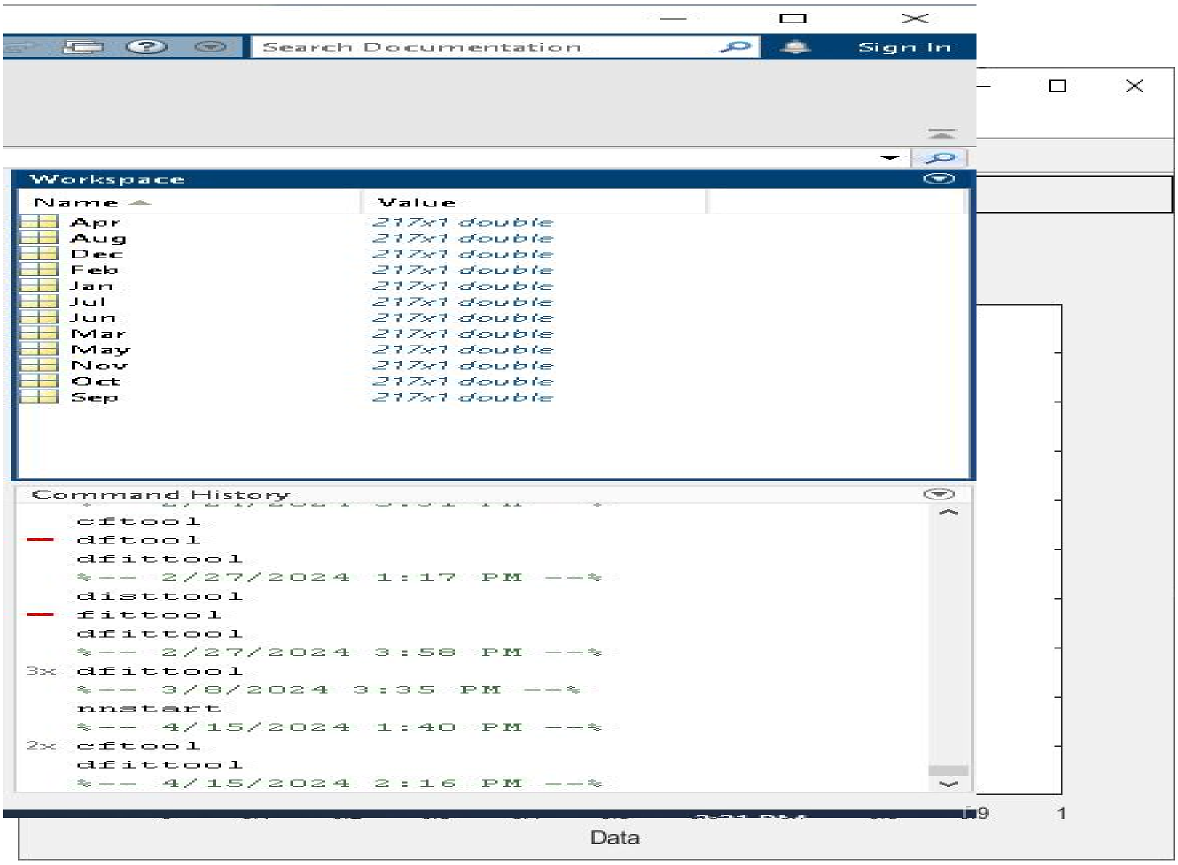


PLATE 3.4: click the command "dfittool" and a distribution filter come up

PLATE 3.5: click "data', input the months with highest insolation and months with lowest insolation and click "create data set"

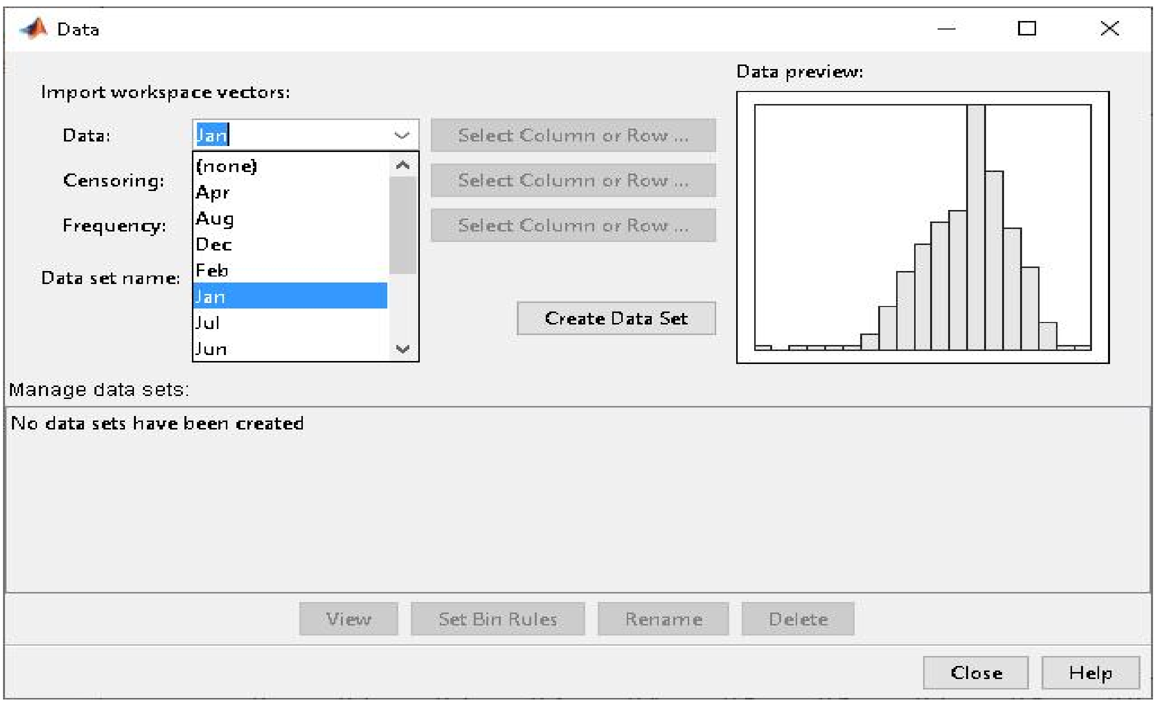
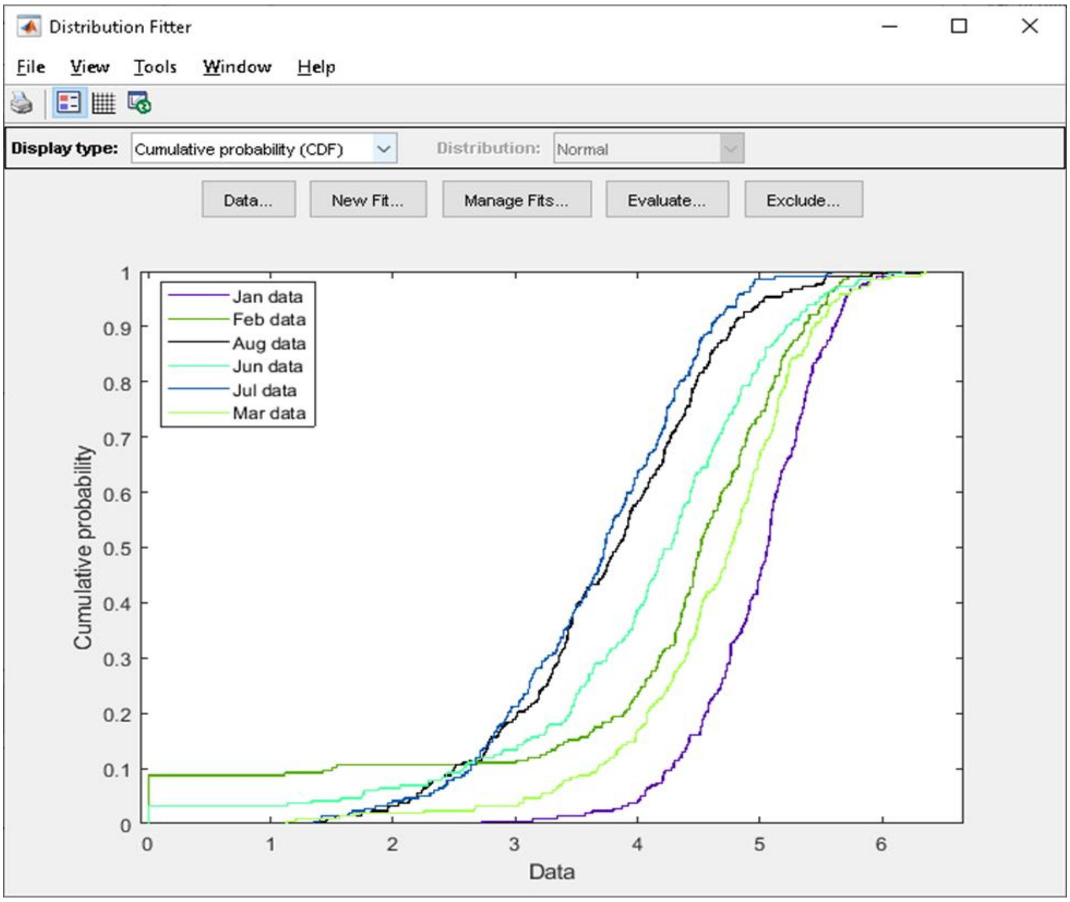


PLATE 3.6: After creating the data set, change the display type to Cumulative Distribution Function



CHAPTER FOUR

RESULT AND DISCUSION

4.1 RESULTS

The data from Appendix 1 with the aid of excel generated an average insolation chart as shown in the figure below

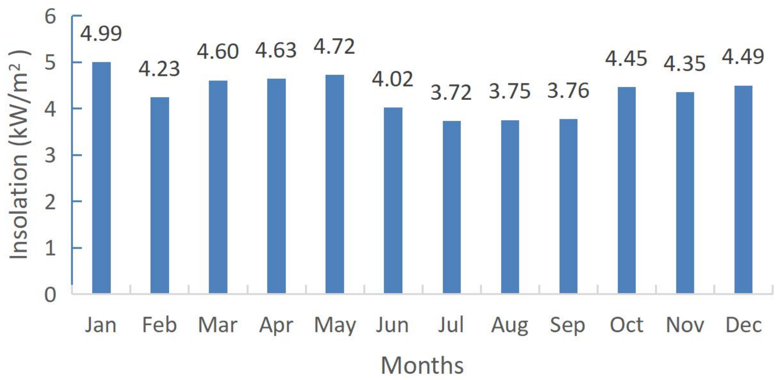


FIGURE 4.1.1 A bar chart showing ten years solar isolation average for the university of benin

The results from the Mat Lab cumulative distribution curve

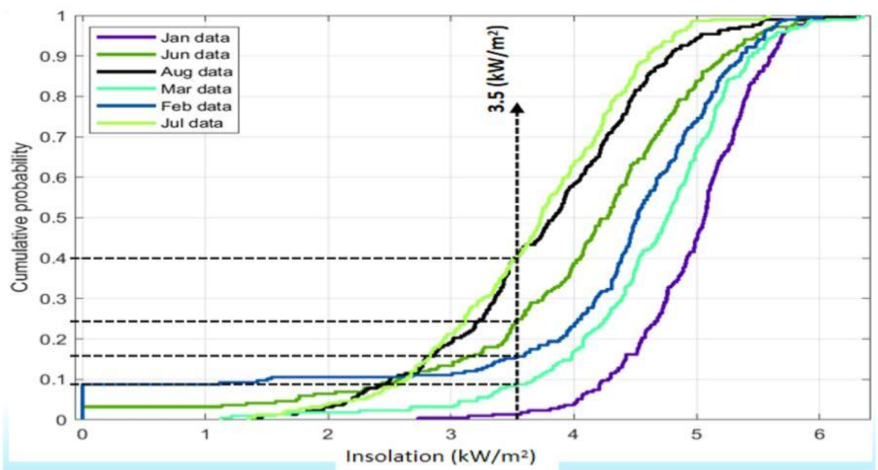


FIGURE 4.1.2: Cumulative frequency graph of average monthly solar insolation for low and high insolation month

4.2 DISCUSSION

From Figure 4.1.1 the bar chart shows the ten-year solar insolation average for the University of Benin providing a clear representation of the average amount of solar energy received over a decade. Each bar in the chart represents the average solar insolation of each month covering a decade, with the height of the bar indicating the magnitude of solar energy received.

By examining the bar chart, we can quickly identify patterns and trends in solar insolation over the ten-year period. For example, bars of similar height, suggests that solar insolation levels are relatively consistent moving from one month to another. On the other hand, the variations in bar heights, indicates fluctuations in solar insolation moving from one month to another.

It's safe to say, that the bar chart showing the ten-year solar insolation average provides valuable insights into the historical solar energy availability of UNIBEN. This information is essential for solar resource assessment, helping stakeholders make decisions about the feasibility and viability of solar energy projects in this area.

From Figure 4.1.2, the cumulative frequency graph, showing solar insolation for high and low insolation months provide a representation of how solar energy varies over time. In this graph, the x-axis represents the solar insolation levels in kW/m^2, while the y-axis represents the cumulative frequency of occurrence.

For high insolation months, the graph shows a steep increase in cumulative frequency as solar insolation levels rise. This indicates that high levels of solar energy are consistently available during these months, with little variation in insolation levels.

Conversely, for low insolation months, the graph shows a slower increase in cumulative frequency, indicating that solar insolation levels are generally lower and less consistent during these months. There may be fluctuations in insolation levels, leading to a less steep slope on the graph.

Comparing the cumulative frequency graphs for high and low insolation months, we can gain insights into the seasonal variability of solar energy available here in UNIBEN. This information is valuable for solar energy planning and system design, as it helps identify periods of peak and low solar energy generation, allowing for better optimization of solar energy systems and resource management.

CHAPTER FIVE

FINDINGS, CONCLUSION AND SUGESTIONS FOR FURTHER STUDIES

5.1 FINDINGS

From the study of the solar resource assessment for UNIBEN the following findings were achieved:

Comparing the average insolation levels across the ten-year period has allowed us to assess the long-term solar energy potential for the University of Benin. From Figure 4.1.1, we discover that UNIBEN over the decade has a great number of high average insolation values telling us that the UNIBEN receives more solar energy over time, making it potentially more suitable for solar energy applications to excel and serve more efficiently.

The resource assessment for UNIBEN was determined to have its highest solar insolation to be 4.99kWh/m^2 whiles the lowest insolation to be 3.72kWh/m^2/day.

From Figure 4.1.2 the months of January, March , April and also May has the highest insolation of 5.0kW/h/m^2/days, 4.6Kw/h/m^2/days, 4.6kW/h/m^2 /days, 4.7Kw/h/m^2days respectively, therefore the solar panels can charge batteries effectively , as the probability of sunshine intensity at these months are high.

5.2 CONCLUSION

Today, solar resource assessment plays a crucial role in renewable energy planning, project development, and policy formulation, contributing to the global transition to a sustainable energy future (Jaeger-Waldau, 2016).

Resource assessment tool in general is necessary for system design. For a PV System, the system designers should not design a system set up based on their own assumptions but try to ensure all contingencies have been considered. A proper resource assessment is necessary for the estimation sizing for a PV system such as:

To Determine the number of solar panels to be used in a designing a PV system after first considering and understanding the load to be applied.

Battery bank sizing will also be determined so as so serve more efficiently on days of low isolation

It should be noted that array sizing (in series, parallel or both), wiring and other safety components should be carefully considered in designing a PV System.

A well conducted solar resource assessment provides valuable insights for making appropriate decisions about solar energy projects so as to enable solar installations harness maximum energy available at a specific location, leading to more efficient and sustainable outcomes.

5.3 SUGGESTIONS FOR FURTHER STUDIES

The following are some suggestions for further studies:

Further studies should be made on ways to enhance the accuracy, efficiency and durability of solar cells

More innovative technologies should be explored to for solar resource studies in extreme regions such as Polar Regions and dessert areas

Research should be conducted to develop high resolution solar resource maps and data base using advanced technologies.

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APPENDIX 1

Data from NASA showing the ten-year solar insolation average for the University Of Benin

Days	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
1	5.1	5.1	4.5	4.3	4.8	4.3	4.1	3.4	3.2	4.1	4.7	4.6
2	5.3	4.8	4.7	4.7	4.8	4.5	4.2	3.7	4.0	4.3	4.1	4.3
3	5.1	4.8	5.0	4.5	5.1	4.7	3.8	4.0	3.9	4.4	4.3	4.3
4	5.2	4.9	4.9	4.8	4.2	4.5	3.6	4.0	3.9	4.3	4.5	4.4
5	5.0	5.1	4.9	5.0	4.9	4.2	3.6	3.8	3.3	4.5	4.1	4.6
6	5.0	4.9	3.9	4.6	4.6	4.0	4.4	3.6	3.6	4.5	4.4	4.6
7	5.0	4.9	4.9	4.9	5.2	4.3	3.8	3.9	4.0	4.1	4.3	4.6
8	5.0	4.7	4.8	5.0	5.0	4.4	3.6	3.8	3.8	4.4	4.6	4.4
9	5.2	4.7	4.5	3.6	4.7	4.3	3.4	3.7	3.5	4.2	4.4	4.2
10	5.1	4.8	4.7	5.1	4.5	4.7	3.6	4.1	3.9	4.2	4.1	4.4
11	5.0	4.8	4.2	4.8	5.1	4.1	4.0	3.7	3.7	4.3	4.3	4.3
12	5.1	4.8	4.7	4.8	4.8	4.1	4.1	4.0	4.0	4.2	4.7	4.3
13	4.9	5.0	4.4	4.6	4.6	4.3	3.9	3.8	3.5	4.9	4.9	4.5
14	5.0	5.0	4.7	4.9	4.6	4.0	4.0	3.4	4.0	4.3	4.6	4.5
15	5.0	4.8	5.0	5.0	4.9	4.2	4.0	4.2	4.0	5.0	4.6	4.3
16	5.0	4.6	4.6	5.1	4.5	4.1	3.2	3.8	3.7	4.4	4.7	4.6
17	4.9	4.7	4.5	5.3	4.7	4.2	3.8	4.0	4.4	4.7	4.4	4.5
18	4.9	4.4	4.3	4.9	5.0	4.0	4.1	3.8	4.1	4.3	4.6	4.4
19	4.9	4.8	4.6	5.0	5.0	4.8	3.9	3.5	4.2	4.2	4.2	4.6
20	5.0	4.7	5.0	4.4	4.4	3.4	3.6	3.8	4.1	5.1	4.3	4.6
21	5.0	4.6	4.5	5.1	4.5	4.2	3.7	3.5	3.9	4.7	4.6	4.7
22	4.7	4.5	4.1	5.0	4.5	3.9	3.8	3.5	4.1	4.6	4.5	4.4
23	4.9	4.5	4.7	5.0	4.5	4.0	3.4	3.6	4.1	4.3	4.4	4.7
24	5.0	4.1	4.3	4.6	5.0	3.6	3.6	3.5	4.1	4.5	4.6	4.7
25	5.2	4.4	4.5	4.6	4.5	4.3	3.4	3.9	4.0	4.5	4.7	4.8
26	5.0	3.6	5.0	4.5	4.8	4.1	3.4	3.9	3.6	4.5	4.7	4.4
27	5.0	4.2	4.3	4.8	4.6	4.0	3.4	3.4	4.3	4.5	4.5	4.4
28	4.7	4.4	5.0	4.6	4.9	3.7	3.3	4.0	3.7	4.3	4.6	4.5
29	4.7	0.9	4.8	5.3	3.9	3.9	3.5	4.0	4.3	4.5	4.7	4.5
30	4.9	0.0	4.4	5.0	4.8	4.0	3.7	3.5	4.0	4.8	4.7	4.6
31	5.1	0.0	4.5	0.0	5.0	0.0	3.7	3.5	0.0	4.7	0.0	4.7

Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
4.06	3.95	4.52	5.07	5.14	2.55	3.54	1.96	3.74	2.84	5.44	5.40
4.07	5.07	3.98	4.86	2.25	6.06	4.87	3.16	4.86	2.89	5.63	5.58
4.98	4.92	4.50	3.99	6.28	4.83	4.06	3.29	3.42	4.57	4.17	5.21
4.98	5.05	4.20	5.16	5.08	4.93	4.15	3.02	3.73	4.73	4.74	5.16
4.76	5.40	5.45	5.24	4.58	4.28	3.73	2.40	4.15	4.72	2.17	5.14
4.94	5.41	3.73	5.38	4.34	3.63	3.30	3.46	3.90	4.29	4.72	5.43
5.23	5.13	5.26	5.07	4.85	3.02	4.24	4.18	4.04	4.85	5.34	5.73
5.05	4.46	4.82	5.02	3.87	3.27	3.27	3.80	4.93	5.25	5.20	5.34
5.20	4.83	5.35	4.41	5.00	4.37	3.73	4.80	3.97	4.92	4.50	5.15
4.99	4.41	4.94	5.29	4.18	4.69	4.60	4.56	4.05	4.45	4.54	5.30
5.25	3.96	4.48	5.22	5.40	4.74	4.96	4.66	3.40	3.86	3.57	3.45
5.37	3.01	5.82	5.55	5.35	4.07	4.73	3.73	5.03	4.08	4.87	3.77
4.90	5.36	5.74	4.64	4.71	4.34	3.47	4.26	4.27	4.79	4.98	4.72
4.85	5.68	5.57	4.99	3.48	4.11	4.22	4.49	4.05	4.24	5.40	4.76
4.21	4.39	5.25	5.92	5.37	4.72	4.31	4.20	4.47	4.99	5.20	4.41
4.53	4.36	4.56	5.22	5.61	4.09	2.81	4.43	3.82	4.70	5.37	4.72
4.21	4.66	5.18	5.41	6.15	3.53	2.71	4.61	4.68	4.01	4.45	4.43
5.11	4.42	4.69	3.33	5.15	3.57	3.61	3.79	4.32	2.37	4.23	4.44
5.08	5.48	4.91	5.02	5.17	5.20	4.48	3.92	4.36	2.37	4.80	4.71
5.08	4.47	4.71	3.98	4.07	5.32	4.44	4.15	3.46	6.20	4.89	4.66
5.16	4.48	4.51	4.96	5.16	4.91	3.96	2.20	4.27	5.29	6.07	5.46
4.30	5.17	4.87	3.17	5.16	2.65	3.64	1.83	4.96	4.99	5.60	4.94
4.58	4.22	4.27	5.11	5.04	4.48	2.83	3.72	3.27	4.15	5.43	5.23
4.85	3.60	4.48	4.14	5.44	4.32	2.44	4.37	4.56	4.68	5.09	5.45
5.09	3.29	4.07	4.34	6.10	4.60	2.09	3.57	3.76	2.53	4.93	5.40
4.53	3.72	5.38	3.18	4.74	5.03	3.50	3.39	2.55	3.93	4.73	4.40

5.00	**4.55**	**3.61**	**5.72**	**5.27**	**4.57**	**4.72**	**4.40**	**3.30**	**4.55**	**4.81**	**4.74**
4.79	**4.06**	**4.85**	**3.44**	**4.64**	**3.13**	**3.58**	**4.79**	**2.23**	**3.63**	**4.71**	**5.00**
4.60	**4.01**	**4.40**	**5.01**	**4.10**	**4.82**	**3.88**	**2.20**	**4.65**	**4.88**	**6.10**	**5.28**
3.92	**4.31**	**5.14**	**4.75**	**5.90**	**4.61**	**2.71**	**3.00**	**3.51**	**2.59**	**5.64**	**4.82**
4.42	**4.57**	**6.06**	**4.11**	**5.72**	**4.28**	**2.49**	**2.88**	**2.16**	**4.85**	**4.02**	**5.07**
5.42	**4.54**	**4.02**	**4.86**	**5.42**	**3.60**	**4.82**	**3.90**	**3.89**	**4.52**	**3.53**	**5.12**
5.82	**4.35**	**5.13**	**4.08**	**4.81**	**4.46**	**1.96**	**3.94**	**4.43**	**3.99**	**4.27**	**3.07**
5.07	**4.52**	**4.75**	**4.39**	**5.01**	**4.71**	**3.43**	**4.24**	**3.52**	**4.84**	**5.76**	**3.49**
5.41	**3.89**	**4.57**	**4.41**	**4.50**	**2.44**	**2.97**	**4.09**	**2.38**	**4.77**	**4.87**	**4.33**
4.76	**4.06**	**4.80**	**5.00**	**1.92**	**4.57**	**3.17**	**4.60**	**3.38**	**4.60**	**5.20**	**4.94**
4.34	**3.94**	**4.53**	**4.71**	**5.72**	**3.19**	**4.92**	**4.44**	**3.15**	**4.83**	**4.88**	**5.02**
5.17	**4.52**	**4.30**	**4.60**	**5.56**	**3.58**	**3.11**	**3.75**	**4.02**	**4.66**	**5.09**	**5.62**
5.29	**4.18**	**4.39**	**5.00**	**5.54**	**5.21**	**4.30**	**2.48**	**2.77**	**4.66**	**5.09**	**5.71**
5.22	**4.68**	**4.36**	**5.14**	**5.56**	**5.14**	**4.61**	**3.38**	**4.58**	**4.60**	**4.08**	**5.33**
5.68	**4.57**	**5.14**	**4.07**	**4.77**	**4.34**	**1.42**	**4.48**	**3.25**	**5.80**	**5.51**	**5.26**
5.13	**4.39**	**4.27**	**3.60**	**5.18**	**3.26**	**3.35**	**3.47**	**4.51**	**3.27**	**5.85**	**5.49**
5.62	**5.09**	**4.99**	**3.66**	**4.74**	**4.02**	**4.80**	**3.31**	**4.04**	**5.58**	**5.86**	**5.48**
5.62	**4.52**	**4.30**	**4.23**	**4.88**	**3.93**	**4.57**	**3.41**	**2.68**	**4.84**	**5.03**	**5.35**
5.58	**4.49**	**4.49**	**4.65**	**1.96**	**4.37**	**4.30**	**3.42**	**4.26**	**2.75**	**4.97**	**5.56**
5.89	**1.42**	**4.09**	**4.71**	**5.66**	**3.60**	**4.51**	**4.21**	**3.59**	**5.39**	**5.38**	**5.65**
5.71	**4.84**	**3.40**	**5.00**	**3.67**	**3.97**	**2.96**	**3.86**	**4.02**	**5.18**	**5.46**	**5.83**
5.30	**4.65**	**3.03**	**5.44**	**4.16**	**4.42**	**4.42**	**4.15**	**4.16**	**4.80**	**6.07**	**5.82**
5.09	**4.48**	**4.00**	**5.46**	**4.30**	**4.33**	**4.24**	**3.27**	**3.54**	**4.78**	**5.09**	**5.04**
4.66	**4.02**	**5.05**	**5.39**	**5.66**	**3.42**	**3.03**	**3.34**	**3.91**	**4.43**	**5.06**	**5.34**
5.09	**4.59**	**5.10**	**5.54**	**4.49**	**2.29**	**3.58**	**3.32**	**4.40**	**4.33**	**5.23**	**5.60**
4.69	**4.50**	**3.06**	**5.48**	**5.55**	**4.46**	**4.64**	**2.74**	**3.78**	**4.40**	**4.98**	**5.56**
4.98	**4.45**	**3.81**	**5.01**	**5.25**	**4.46**	**4.49**	**4.43**	**5.00**	**4.52**	**5.23**	**5.64**
4.00	**2.69**	**5.55**	**5.01**	**1.40**	**4.57**	**4.26**	**2.73**	**2.89**	**4.51**	**4.90**	**5.64**

4.63	**3.35**	**5.50**	**5.10**	**4.79**	**3.52**	**2.81**	**3.02**	**3.55**	**4.14**	**5.27**	**5.34**
4.52	**5.55**	**3.35**	**2.94**	**5.88**	**3.46**	**3.37**	**3.18**	**4.81**	**4.49**	**5.39**	**4.84**
3.57	**4.84**	**5.14**	**6.22**	**4.68**	**3.50**	**4.42**	**4.05**	**4.85**	**4.45**	**5.50**	**4.66**
3.14	**5.13**	**3.38**	**6.08**	**4.65**	**3.71**	**1.40**	**4.27**	**4.67**	**2.53**	**5.71**	**5.03**
4.16	**4.91**	**5.42**	**5.80**	**5.05**	**3.45**	**3.11**	**2.30**	**3.33**	**3.91**	**5.12**	**5.16**
4.30	**5.06**	**4.75**	**6.40**	**4.89**	**3.84**	**3.70**	**3.61**	**4.64**	**2.72**	**5.34**	**5.50**
4.51	**5.22**	**4.42**	**3.33**	**4.84**	**5.52**	**3.70**	**3.50**	**3.15**	**5.32**	**3.73**	**5.84**
4.41	**5.61**	**3.34**	**3.68**	**4.65**	**3.26**	**4.20**	**2.63**	**4.74**	**4.66**	**4.95**	**5.36**
5.30	**4.98**	**3.31**	**4.60**	**5.22**	**5.49**	**5.12**	**4.76**	**4.63**	**4.34**	**5.07**	**5.05**
5.95	**4.56**	**4.79**	**4.84**	**5.48**	**5.58**	**4.27**	**3.45**	**4.04**	**4.36**	**5.35**	**5.32**
4.68	**4.47**	**5.21**	**4.83**	**4.89**	**4.18**	**3.79**	**4.36**	**3.34**	**4.65**	**5.52**	**4.48**
5.41	**5.32**	**4.91**	**3.76**	**4.27**	**4.73**	**4.95**	**4.49**	**3.77**	**3.45**	**5.23**	**4.43**
4.54	**5.66**	**1.13**	**4.95**	**5.63**	**2.06**	**2.59**	**3.43**	**4.83**	**5.52**	**5.33**	**4.86**
5.09	**5.16**	**3.68**	**5.69**	**4.98**	**5.55**	**4.13**	**2.75**	**4.38**	**4.82**	**4.81**	**5.26**
5.40	**4.77**	**5.15**	**4.00**	**5.09**	**3.53**	**4.52**	**4.59**	**3.74**	**3.23**	**5.78**	**5.19**
5.18	**4.48**	**3.75**	**5.78**	**4.70**	**4.78**	**4.67**	**5.00**	**2.37**	**3.61**	**5.96**	**4.82**
4.98	**3.91**	**5.10**	**5.48**	**5.55**	**5.16**	**2.37**	**4.00**	**4.19**	**4.53**	**5.40**	**5.04**
4.72	**4.46**	**4.98**	**3.44**	**4.05**	**3.48**	**2.90**	**4.63**	**3.25**	**3.64**	**4.42**	**4.42**
4.92	**4.85**	**4.63**	**5.43**	**5.45**	**2.82**	**3.80**	**2.77**	**2.74**	**4.37**	**5.58**	**4.84**
5.69	**4.61**	**4.51**	**4.76**	**3.90**	**4.81**	**4.92**	**4.32**	**2.80**	**2.63**	**5.88**	**5.23**
5.27	**4.35**	**2.25**	**4.81**	**5.64**	**1.76**	**4.01**	**3.74**	**4.00**	**4.96**	**5.35**	**5.00**
5.26	**4.96**	**4.67**	**5.52**	**5.03**	**3.89**	**3.48**	**2.04**	**4.79**	**3.23**	**5.53**	**5.24**
5.19	**4.62**	**6.31**	**5.68**	**3.48**	**5.04**	**3.80**	**2.77**	**4.69**	**4.47**	**4.61**	**4.52**
5.10	**4.83**	**4.82**	**5.74**	**6.04**	**6.05**	**3.75**	**2.25**	**4.35**	**4.45**	**4.64**	**4.78**
4.59	**4.31**	**4.45**	**5.43**	**4.16**	**4.63**	**3.47**	**3.47**	**4.13**	**5.05**	**4.28**	**4.77**
4.08	**3.79**	**2.67**	**5.42**	**5.53**	**2.29**	**4.07**	**4.04**	**4.21**	**4.64**	**4.75**	**5.16**
4.42	**3.64**	**5.40**	**5.65**	**5.02**	**4.71**	**2.42**	**2.89**	**3.43**	**5.48**	**4.69**	**5.49**
5.32	**3.33**	**4.98**	**5.75**	**4.87**	**5.05**	**3.74**	**3.75**	**4.31**	**4.94**	**4.31**	**5.42**

5.58	**3.94**	**4.96**	**5.53**	**3.33**	**4.22**	**3.34**	**3.26**	**3.63**	**3.85**	**4.82**	**5.36**
2.73	**4.56**	**4.67**	**5.14**	**2.91**	**2.43**	**3.68**	**4.31**	**3.26**	**4.75**	**4.57**	**4.59**
5.39	**4.17**	**4.72**	**4.62**	**3.53**	**3.76**	**3.37**	**3.26**	**4.12**	**4.43**	**5.11**	**5.13**
5.35	**4.81**	**4.52**	**4.24**	**5.28**	**4.30**	**3.72**	**4.34**	**1.97**	**5.06**	**5.18**	**4.53**
4.73	**4.70**	**5.20**	**4.93**	**3.19**	**3.01**	**3.21**	**3.94**	**5.14**	**5.29**	**5.35**	**5.38**
4.88	**3.98**	**3.78**	**1.15**	**4.61**	**3.82**	**3.33**	**3.88**	**4.64**	**5.16**	**4.68**	**3.82**
5.54	**4.60**	**3.21**	**5.92**	**5.29**	**4.58**	**3.14**	**1.46**	**4.68**	**5.58**	**4.88**	**3.66**
5.43	**4.88**	**5.24**	**5.26**	**4.86**	**3.98**	**3.35**	**2.28**	**3.47**	**4.84**	**5.25**	**4.41**
5.36	**4.83**	**4.91**	**5.19**	**4.89**	**5.81**	**4.25**	**4.45**	**3.48**	**5.48**	**3.18**	**4.48**
5.47	**4.77**	**3.45**	**5.38**	**3.60**	**3.92**	**4.30**	**3.23**	**3.91**	**5.09**	**4.15**	**4.83**
4.89	**4.31**	**4.23**	**4.67**	**5.49**	**5.19**	**4.20**	**3.83**	**3.83**	**5.60**	**5.07**	**5.08**
5.17	**4.90**	**4.63**	**4.57**	**2.28**	**4.17**	**2.91**	**2.32**	**4.12**	**5.14**	**5.20**	**5.41**
5.38	**4.67**	**4.85**	**4.35**	**4.91**	**5.63**	**4.49**	**4.17**	**4.14**	**3.48**	**4.79**	**5.12**
5.30	**4.79**	**5.11**	**4.82**	**5.02**	**4.38**	**3.74**	**3.13**	**3.91**	**4.87**	**5.06**	**5.59**
5.03	**4.43**	**5.41**	**5.43**	**5.51**	**5.78**	**4.08**	**2.24**	**1.83**	**3.91**	**5.26**	**5.45**
5.16	**5.04**	**4.93**	**4.98**	**5.45**	**5.04**	**3.07**	**3.76**	**3.08**	**3.58**	**5.63**	**5.52**
5.05	**5.21**	**4.42**	**1.39**	**5.17**	**5.49**	**4.00**	**4.07**	**4.60**	**5.37**	**5.28**	**5.44**
4.62	**5.17**	**5.37**	**5.90**	**4.66**	**4.09**	**4.23**	**3.35**	**4.44**	**2.49**	**5.68**	**4.77**
5.08	**5.07**	**5.62**	**4.28**	**5.10**	**4.69**	**3.05**	**3.89**	**3.67**	**4.59**	**5.38**	**4.26**
5.49	**5.01**	**3.86**	**5.09**	**4.54**	**4.10**	**3.45**	**3.37**	**3.99**	**4.98**	**4.97**	**1.47**
5.01	**4.93**	**3.51**	**3.73**	**5.46**	**3.38**	**4.95**	**3.44**	**4.16**	**3.16**	**5.72**	**3.20**
5.09	**5.19**	**3.06**	**6.21**	**4.73**	**4.84**	**5.59**	**4.21**	**5.01**	**4.82**	**4.32**	**3.89**
5.21	**5.07**	**4.49**	**4.44**	**5.50**	**4.52**	**4.23**	**3.95**	**4.31**	**2.56**	**5.02**	**4.26**
4.21	**5.41**	**4.87**	**5.57**	**4.87**	**4.30**	**3.67**	**3.94**	**2.79**	**4.81**	**4.74**	**4.62**
5.29	**5.50**	**3.98**	**5.38**	**5.14**	**2.90**	**3.55**	**3.59**	**4.54**	**4.72**	**4.57**	**4.75**
5.10	**5.25**	**5.22**	**4.57**	**4.67**	**4.43**	**4.38**	**2.91**	**4.45**	**5.27**	**4.84**	**4.67**
5.37	**5.23**	**5.91**	**5.05**	**1.52**	**4.67**	**2.74**	**2.79**	**4.12**	**4.82**	**3.33**	**4.92**
4.80	**5.17**	**5.91**	**2.70**	**5.90**	**3.49**	**2.21**	**3.21**	**4.30**	**5.03**	**4.90**	**4.59**

4.75	**4.32**	**5.42**	**5.06**	**6.00**	**6.17**	**3.64**	**3.83**	**2.99**	**3.30**	**5.01**	**4.78**
4.58	**4.39**	**4.49**	**5.11**	**4.98**	**4.05**	**4.51**	**4.80**	**3.86**	**3.80**	**4.88**	**4.39**
4.11	**4.36**	**4.90**	**4.67**	**1.62**	**3.48**	**3.98**	**3.31**	**4.52**	**5.05**	**4.46**	**4.57**
4.82	**5.56**	**4.90**	**4.98**	**5.99**	**4.99**	**3.91**	**3.35**	**4.58**	**4.39**	**4.94**	**4.09**
4.03	**5.27**	**1.69**	**3.84**	**5.36**	**4.79**	**3.25**	**2.57**	**4.16**	**3.70**	**5.65**	**3.33**
4.39	**5.37**	**5.40**	**5.66**	**5.18**	**4.13**	**2.67**	**3.92**	**2.83**	**4.49**	**6.00**	**4.91**
4.86	**5.55**	**4.84**	**6.01**	**4.58**	**4.08**	**2.87**	**4.87**	**5.22**	**5.05**	**5.90**	**5.23**
5.63	**5.17**	**5.42**	**4.62**	**2.08**	**3.77**	**3.39**	**2.42**	**3.81**	**5.07**	**5.91**	**4.61**
4.53	**5.04**	**5.12**	**5.88**	**5.68**	**4.45**	**2.94**	**4.28**	**3.98**	**4.31**	**5.78**	**3.52**
4.98	**4.65**	**4.42**	**5.10**	**4.95**	**4.39**	**4.08**	**3.43**	**3.59**	**3.68**	**5.49**	**4.04**
4.40	**4.17**	**4.92**	**2.64**	**4.91**	**5.11**	**3.89**	**3.58**	**3.22**	**3.85**	**5.12**	**4.72**
4.36	**3.64**	**5.35**	**2.59**	**4.88**	**4.33**	**3.58**	**3.51**	**3.44**	**4.68**	**4.25**	**4.43**
4.21	**3.88**	**3.83**	**3.00**	**5.79**	**5.27**	**3.22**	**2.51**	**4.19**	**4.94**	**4.29**	**5.14**
3.88	**3.39**	**5.03**	**3.89**	**5.06**	**4.78**	**3.90**	**4.83**	**4.73**	**4.20**	**5.22**	**5.60**
5.12	**5.48**	**3.87**	**4.35**	**5.40**	**5.39**	**3.61**	**3.71**	**3.49**	**3.17**	**5.47**	**4.29**
4.89	**4.88**	**5.30**	**4.95**	**5.28**	**4.42**	**4.80**	**3.68**	**1.34**	**4.97**	**3.18**	**4.73**
5.07	**4.96**	**5.89**	**4.63**	**4.60**	**5.39**	**2.56**	**5.26**	**2.45**	**5.34**	**3.14**	**4.50**
5.66	**4.10**	**5.12**	**5.27**	**5.69**	**4.94**	**3.74**	**4.95**	**4.11**	**4.07**	**5.53**	**4.87**
5.90	**4.00**	**5.65**	**2.97**	**2.72**	**4.33**	**4.34**	**3.93**	**3.31**	**3.74**	**4.61**	**5.66**
5.15	**4.21**	**5.59**	**4.95**	**4.51**	**3.96**	**4.82**	**2.76**	**3.24**	**5.13**	**4.92**	**5.65**
5.05	**3.71**	**4.77**	**5.57**	**5.49**	**4.86**	**1.67**	**4.75**	**4.84**	**5.27**	**6.08**	**4.78**
5.11	**4.27**	**4.37**	**5.51**	**4.11**	**4.63**	**4.34**	**4.54**	**5.76**	**5.48**	**5.77**	**4.11**
5.12	**3.26**	**4.52**	**5.29**	**5.03**	**4.44**	**4.17**	**4.02**	**2.08**	**5.42**	**5.85**	**3.47**
4.92	**4.16**	**4.80**	**4.81**	**2.13**	**4.35**	**4.46**	**3.92**	**5.45**	**4.01**	**5.17**	**4.83**
4.76	**4.36**	**5.00**	**3.07**	**4.84**	**5.22**	**4.65**	**3.55**	**4.34**	**4.33**	**4.40**	**5.22**
5.09	**4.11**	**4.43**	**5.35**	**3.42**	**3.09**	**4.43**	**3.29**	**5.02**	**4.00**	**5.70**	**5.10**
5.06	**4.11**	**5.46**	**5.20**	**4.36**	**4.20**	**2.67**	**3.48**	**4.41**	**4.74**	**5.16**	**5.49**
5.01	**5.36**	**5.23**	**4.88**	**3.78**	**1.89**	**4.45**	**4.59**	**3.51**	**5.13**	**5.38**	**5.31**

5.36	1.50	5.11	4.96	4.93	4.44	3.75	4.87	4.95	6.02	4.47	5.28
5.14	4.68	5.08	3.21	4.35	1.74	2.44	3.78	5.02	1.92	4.65	5.34
5.13	4.15	3.91	5.19	3.98	3.90	2.93	3.11	3.74	6.30	5.62	5.45
5.04	5.12	4.99	5.36	2.12	4.18	3.42	2.50	5.03	4.67	4.86	5.78
5.29	3.53	4.60	4.90	5.94	2.59	3.82	3.08	2.86	5.60	4.68	4.77
4.84	4.77	4.94	4.64	4.96	4.02	2.72	3.19	5.20	5.68	5.74	4.59
4.92	4.89	4.31	3.01	5.09	4.85	2.68	2.13	3.96	4.87	5.61	5.39
5.36	4.31	4.25	5.86	3.50	4.92	4.45	1.53	4.49	3.93	5.29	5.34
5.55	3.79	4.68	3.10	5.59	4.20	4.18	3.99	4.61	4.76	3.61	5.09
5.02	4.38	6.35	5.46	4.57	4.16	2.85	1.35	2.58	4.39	5.25	5.13
4.68	4.89	4.07	5.74	3.19	3.50	2.00	4.13	5.18	5.42	5.46	5.34
5.40	5.10	4.46	5.50	4.80	2.89	1.64	5.03	4.82	5.15	5.03	5.07
5.32	5.34	4.08	5.93	5.46	4.62	3.07	4.45	2.83	4.51	5.38	5.17
5.26	5.26	4.29	5.05	4.83	4.15	3.86	4.98	3.81	5.66	4.06	5.33
5.31	4.67	4.08	5.44	2.19	4.84	1.35	3.20	4.56	3.02	4.77	5.09
5.33	4.70	4.79	4.70	4.10	4.29	4.30	2.87	4.25	5.90	5.73	4.24
5.65	4.73	2.67	4.99	5.07	3.98	3.97	2.86	2.22	5.62	5.16	5.14
5.15	4.34	4.08	5.29	5.16	1.76	3.97	4.31	3.74	3.41	5.02	5.05
5.38	4.50	4.15	2.62	4.56	4.30	4.22	3.43	4.94	4.39	5.10	4.75
5.43	4.33	5.75	5.08	5.28	5.13	4.15	3.49	2.42	2.52	5.33	4.76
5.35	4.89	4.72	4.72	4.27	3.41	3.13	4.23	3.63	3.33	4.80	4.79
5.43	4.83	4.93	4.78	5.67	4.15	2.94	3.78	3.77	3.67	1.39	5.06
5.70	4.39	1.21	3.32	5.55	4.52	3.91	2.98	1.42	4.75	4.00	5.21
4.75	4.36	5.56	6.08	4.38	3.06	3.69	4.22	4.53	3.68	4.84	5.44
4.55	3.11	5.56	3.20	6.09	3.74	3.68	2.94	3.83	1.37	5.33	5.19
4.76	4.07	4.84	2.78	2.80	2.61	3.40	1.96	3.51	3.27	4.23	5.64
4.73	1.54	3.83	6.42	6.13	3.64	2.61	4.22	3.93	4.62	4.72	5.32
4.58	4.03	5.19	5.24	5.03	4.43	2.64	4.75	4.25	3.57	5.05	4.68

4.30	**1.12**	**4.74**	**5.63**	**5.61**	**4.75**	**2.77**	**4.59**	**4.09**	**4.04**	**5.16**	**4.70**
4.89	**3.43**	**4.84**	**4.64**	**3.11**	**4.98**	**4.50**	**4.27**	**2.27**	**5.33**	**5.24**	**5.19**
4.02	**3.21**	**5.54**	**5.44**	**5.38**	**5.33**	**4.81**	**4.38**	**3.37**	**4.33**	**5.49**	**5.13**
4.28	**6.02**	**5.00**	**3.69**	**4.60**	**3.99**	**3.55**	**4.47**	**4.42**	**4.22**	**4.44**	**5.25**
4.23	**5.55**	**4.21**	**4.54**	**3.77**	**4.07**	**3.95**	**4.06**	**4.85**	**4.56**	**4.06**	**5.60**
4.69	**5.16**	**4.79**	**4.91**	**5.09**	**3.97**	**5.54**	**4.50**	**5.06**	**4.95**	**4.90**	**5.80**
4.76	**4.43**	**5.50**	**4.08**	**6.65**	**4.45**	**4.10**	**4.69**	**5.18**	**4.23**	**5.25**	**4.94**
4.94	**5.65**	**5.04**	**5.14**	**4.98**	**1.14**	**2.79**	**2.78**	**3.29**	**2.27**	**5.27**	**5.07**
4.42	**5.49**	**4.98**	**4.85**	**4.71**	**3.87**	**2.63**	**4.46**	**4.40**	**4.25**	**5.11**	**5.17**
4.40	**5.62**	**4.77**	**4.92**	**4.32**	**3.44**	**3.64**	**3.90**	**3.09**	**5.34**	**4.72**	**5.02**
4.66	**5.82**	**4.33**	**5.39**	**6.19**	**4.06**	**4.50**	**3.36**	**3.41**	**4.54**	**4.91**	**5.76**
4.72	**5.11**	**5.08**	**5.31**	**5.72**	**3.99**	**2.34**	**1.74**	**3.22**	**4.00**	**5.69**	**6.09**
3.34	**4.52**	**1.56**	**4.74**	**4.12**	**3.46**	**4.33**	**2.14**	**5.08**	**3.80**	**5.77**	**6.23**
5.59	**4.75**	**5.15**	**4.77**	**4.92**	**4.07**	**3.80**	**3.47**	**4.04**	**4.50**	**5.62**	**5.99**
5.49	**4.76**	**5.65**	**2.62**	**4.98**	**3.24**	**1.85**	**3.88**	**1.80**	**3.14**	**5.23**	**5.93**
4.92	**5.01**	**5.22**	**5.61**	**5.45**	**5.05**	**2.85**	**3.46**	**4.60**	**3.78**	**4.63**	**5.34**
3.81	**5.19**	**5.23**	**4.94**	**5.42**	**5.37**	**1.77**	**3.41**	**4.58**	**2.82**	**5.55**	**5.75**
3.63	**5.31**	**4.72**	**4.44**	**1.57**	**4.22**	**3.22**	**5.53**	**3.78**	**4.61**	**3.87**	**6.13**
4.51	**4.31**	**4.25**	**6.55**	**4.65**	**4.99**	**3.63**	**5.46**	**2.52**	**4.77**	**4.76**	**5.89**
5.30	**4.51**	**5.15**	**2.24**	**4.59**	**5.00**	**3.78**	**3.85**	**4.11**	**4.27**	**5.45**	**6.03**
5.66	**4.46**	**3.68**	**6.77**	**6.14**	**4.97**	**4.22**	**4.54**	**5.04**	**3.88**	**5.00**	**5.55**
5.74	**4.16**	**4.11**	**5.36**	**5.39**	**5.80**	**4.54**	**3.69**	**4.14**	**4.07**	**5.02**	**5.38**
5.83	**5.36**	**4.66**	**5.07**	**2.84**	**5.34**	**4.00**	**4.09**	**1.56**	**4.01**	**4.68**	**5.10**
5.51	**5.06**	**5.16**	**3.20**	**3.53**	**5.09**	**2.83**	**5.52**	**4.10**	**3.93**	**5.11**	**5.28**
5.08	**4.86**	**5.24**	**6.25**	**6.43**	**4.66**	**4.71**	**4.10**	**4.17**	**4.80**	**5.13**	**5.41**
5.33	**5.55**	**3.98**	**6.37**	**5.37**	**3.75**	**4.61**	**3.43**	**2.79**	**2.91**	**5.43**	**4.93**
4.72	**5.72**	**3.99**	**5.28**	**5.22**	**4.65**	**3.15**	**3.19**	**2.94**	**4.33**	**5.37**	**4.78**
5.00	**4.20**	**5.16**	**5.30**	**5.01**	**3.95**	**3.03**	**5.54**	**3.33**	**3.52**	**5.14**	**4.97**

5.38	**4.45**	**4.39**	**5.35**	**4.56**	**4.60**	**3.73**	**5.91**	**2.85**	**4.14**	**5.26**	**5.00**
4.37	**4.46**	**5.00**	**4.87**	**4.00**	**4.37**	**2.31**	**4.39**	**2.88**	**3.89**	**5.31**	**4.70**
4.56	**3.61**	**4.47**	**5.20**	**4.71**	**3.65**	**3.11**	**5.35**	**5.15**	**4.98**	**5.22**	**4.73**
4.73	**4.62**	**4.94**	**5.14**	**5.89**	**1.57**	**3.77**	**6.34**	**4.79**	**4.73**	**5.27**	**4.83**
4.91	**0.00**	**4.05**	**4.92**	**5.62**	**5.46**	**3.87**	**4.75**	**4.49**	**4.13**	**5.44**	**4.74**
5.47	**0.00**	**5.05**	**5.32**	**6.03**	**1.33**	**4.04**	**3.56**	**2.09**	**4.27**	**4.81**	**4.39**
5.59	**0.00**	**5.22**	**5.71**	**4.96**	**3.60**	**4.17**	**5.18**	**4.80**	**5.02**	**4.52**	**5.05**
5.50	**0.00**	**5.14**	**4.65**	**5.24**	**2.69**	**3.11**	**5.04**	**2.24**	**3.67**	**4.87**	**4.76**
5.55	**0.00**	**4.17**	**5.21**	**5.88**	**5.26**	**3.15**	**4.25**	**4.59**	**4.52**	**4.48**	**4.73**
5.30	**0.00**	**4.68**	**5.57**	**5.25**	**4.82**	**4.61**	**4.43**	**3.55**	**4.03**	**4.54**	**4.52**
5.09	**0.00**	**4.54**	**4.04**	**4.35**	**3.78**	**3.97**	**4.73**	**3.56**	**4.82**	**4.52**	**5.16**
5.06	**0.00**	**4.73**	**2.70**	**4.52**	**4.16**	**3.39**	**3.54**	**2.10**	**5.69**	**4.55**	**4.59**
4.75	**0.00**	**5.24**	**5.77**	**4.47**	**4.93**	**3.46**	**2.80**	**4.75**	**4.91**	**4.57**	**4.68**
5.64	**0.00**	**3.66**	**5.41**	**3.79**	**2.39**	**3.44**	**4.93**	**4.47**	**5.34**	**5.11**	**4.84**
5.44	**0.00**	**4.13**	**5.33**	**5.37**	**3.64**	**4.39**	**4.44**	**3.75**	**4.77**	**5.49**	**4.89**
6.33	**0.00**	**3.22**	**2.76**	**4.95**	**2.57**	**4.24**	**4.66**	**1.40**	**2.25**	**5.47**	**4.81**
6.09	**0.00**	**4.42**	**0.00**	**4.39**	**0.00**	**3.85**	**5.18**	**0.00**	**4.10**	**0.00**	**5.42**
5.74	**0.00**	**4.95**	**0.00**	**5.14**	**0.00**	**4.09**	**4.21**	**0.00**	**3.83**	**0.00**	**5.46**
5.68	**0.00**	**5.39**	**0.00**	**4.81**	**0.00**	**3.49**	**3.96**	**0.00**	**5.15**	**0.00**	**5.15**
5.17	**0.00**	**4.55**	**0.00**	**4.30**	**0.00**	**3.72**	**4.58**	**0.00**	**5.16**	**0.00**	**4.58**
5.00	**0.00**	**4.76**	**0.00**	**4.31**	**0.00**	**4.18**	**4.10**	**0.00**	**5.01**	**0.00**	**4.23**
5.59	**0.00**	**4.85**	**0.00**	**3.12**	**0.00**	**3.91**	**4.39**	**0.00**	**5.29**	**0.00**	**4.45**
5.69	**0.00**	**4.34**	**0.00**	**4.73**	**0.00**	**3.11**	**2.49**	**0.00**	**4.94**	**0.00**	**4.72**

APPENDIX 2 ; Data from NASA showing solar insolation for high and low insolation months for the university of Benin