ABDULMAJID AHMED AMHIMMID BAHROUN

SOLAR HOME SYSTEM: A CASE STUDY IN GÜZELYURT, NORTHERN CYPRUS

NEU 2020

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A THESIS SUBMITTED TO THE GRADUATE SCHOOL OF APPLIED SCIENCES OF NEAR EAST UNIVERSITY

By
ABDULMAJID AHMED AMHIMMID BAHROUN

In Partial Fulfillment of the Requirements for the Degree of Master of Science in Mechanical Engineering

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Approval of Director of Graduate School of

Applied Sciences

Prof. Dr. Nadire ÇAVUŞ

We certify this thesis is satisfactory for the award of the degree of Master of Science in Mechanical Engineering

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I hereby declare that, all the information in this document has been obtained and presented in accordance with academic rules and ethical conduct. I also declare that, as required by these rules and conduct, I have fully cited and referenced all material and results that are not original to this work.

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ACKNOWLEDGEMENTS

First and foremost, I would like to thank my supervisor, Assoc. Prof. Dr. Hüseyin ÇAMUR, for his helpful expertise, encouragements, and advice during the research period. His amiable disposition, penetrating critiques and consistent mentoring have made my study and stay in Sheffield memorable, indeed I am very grateful.

I would like to thank for Assist. Prof. Dr. Youssef Kassem for the many fruitful discussions that contributed to the success of this study. I always feel lucky to be with so many excellent researchers. Thanks are due to all the colleagues of my institute, who were always quite helpful during my stay.

Finally, to my parents, brothers and sisters, I say thank you for all your supports through prayers and advice of encouragements to hold on, especially when my morale was low.

To my parents….

ABSTRACT

The aspects of technology have influenced contemporary architecture, especially those related to the environmental control organization. Wind turbines and Solar systems are one of the environmental control systems. As it is known, Northern Cyprus suffers from an acute energy problem and scarcity due to the greater dependence on Fossil fuel. The research aims to design and solar PV system in Güzelyurt, Northern Cyprus. In order to achieve the objective of the study, the researcher used the descriptive analysis provider, collecting information about the research problem through the available information in books, periodicals, journals, and some specialized Internet sites. The researcher concluded that the solar home system can be considered one of the best solutions to reduce electricity consumption and green gas emissions in the selected region. Therefore, the Techno-economic evaluation of a 1kW grid/grid-off connected PV system has been made. It is found that the average percentage of reduction in electric consumption generated by diesel fuel is about 30% per year. The results concluded that the proposed renewable system could be used as a power generating for small households in Güzelyurt. It is one of the new methods of architectural formation, affecting the overall shape of the building and the outer and inner space as well as Where the color and texture express modernity and sophistication.

Keywords: Güzelyurt; grid/grid-off connected; solar home system; Techno-economic; PV System

ÖZET

Teknolojinin yönü çağdaş mimariyi, özellikle çevresel kontrol organizasyonu ile ilgili olanları etkiledi. Rüzgar türbinleri ve Güneş sistemleri, çevresel kontrol sistemlerinden biridir. Bilindiği gibi, Kuzey Kıbrıs, fosil yakıtlara olan bağımlılığın artmasından dolayı akut bir enerji problemi ve kıtlığından muzdarip. Araştırma, Kuzey Kıbrıs'ta Güzelyurt'ta PV sistemi tasarlamayı ve güneş ışığını tasarlamayı amaçlamaktadır. Araştırmanın amacına ulaşmak için araştırmacı, tanımlayıcı analiz sağlayıcısını kullanarak, araştırma problemi hakkında kitap, dergi, dergi ve bazı özel internet sitelerinde bulunan bilgiler aracılığıyla bilgi toplayarak kullandı. Araştırmacı, güneş enerjisi sisteminin, seçilen bölgedeki elektrik tüketimini ve yeşil gaz emisyonlarını azaltmak için en iyi çözümlerden biri olarak kabul edilebileceği sonucuna varmıştır. Bu nedenle, 1kW grid / grid-off bağlı PV sisteminin Tekno-ekonomik değerlendirmesi yapılmıştır. Dizel yakıtın ürettiği elektrik tüketimindeki ortalama azalma yüzdesinin yılda yaklaşık% 30 olduğu bulunmuştur. Sonuçlar, önerilen yenilenebilir sistemin Güzelyurt'ta küçük haneler için enerji üreten bir güç olarak kullanılabileceği sonucuna varmıştır. Binanın genel şeklini ve dış ve iç mekanı etkileyen, ayrıca renk ve dokunun modernliği ve sofistike ifadesini ifade ettiği yeni mimari oluşum yöntemlerinden biridir.

Anahtar Kelimeler: Güzelyurt; ızgara / ızgara bağlantısı kapalı; güneş ev sistemi; Techno- ekonomik; PV sistem

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INTRODUCTION

1.1 Background

Natural resources available from new renewable energy sources and energy efficiency policies play a key role in energy sustainability and provide the potential and resources, which are utilized according to their technical and economic feasibility to implement a package of policies that take into account the social and economic dimensions of the different groups in each country (Owusu and Asumadu-Sarkodie, 2016; Unesco, 2010).

With the conviction of the need to conserve, the available energy resources and reduce the pollution of the environment calls for the solidarity of everyone - in their respective fields - to reach a specific and clear goal of sustainable energy and more local participation in the manufacture of products.

This works needs to develop projects and raise the standard of living of the citizens in the countries, especially in rural areas, create jobs, attract more foreign investment and encourage the private sector to participate effectively in this area. The availability of energy services to meet human needs is of paramount importance to the three pillars of sustainable development.

The availability of electricity and other modern energy supplies and services are necessary but insufficient requirement for economic and social development (Bergasse et al., 2013). Reducing poverty requires other things such as clean water, adequate health services, a good education system, and communication networks.

Electricity provides the best and most efficient lighting and is essential for the operation of all household appliances. Kerosene and LPG are more efficient than conventional biomass fuels for cooking, and diesel and heavy fuel oil are more economical in heating (Pawłowska, 2017). As for the basic fuels used in transport, diesel and gasoline are still in the lead (Pawłowska, 2017).

Studies show that in 2003, 64.3 million people in some countries (21.4%) of the population did not have access to electricity, which is a serious alarm that needs to start serious and effective efforts to reduce poverty and lack of energy supplies (Nalule, 2018). On the energy production side, the energy sector in most of the countries is characterized by a huge oil and gas sector as well as a large electricity generation sector, dominated by thermal generation systems.

The main dependence in the provision of electric power in most of the countries is focused on the use of thermal plants and thus increasing the use of fossil fuels, which raises the rates of environmental pollution (Pode, 2013).

1.2 The Concept of Renewable Energy

Renewable energy is the energy generated by renewable natural resources quickly and permanently (Sissine, 2006). This is also called permanent energy, as opposed to non-renewable depleted energy from the combustion of fossil fuels in all forms such as petroleum, oil and natural coal as well as natural gas, as well as nuclear fuel used in reactor experiments. The most prominent sources of renewable energy include wind, fallen or running water, sunlight and dam water, as well as seawater movement from waves, tides and geothermal energy.

It can also be produced from agricultural crops and trees that produce oil. The advantage of renewable energy is that it does not leave harmful gas residues such as carbon dioxide and other gases that exacerbate the phenomenon of increasing global warming, compared to what is produced by the means of depleted energy and the burning of fossil fuels (Kuik et al., 2019; Haghi et al., 2018; Iodice et al., 2016; Lian et al., 2019).

Many countries have developed special plans and budgets to increase their production rate and dependence on renewable energy systems to cover at least 20% of all their energy needs until 2020.

In general, it is intended to obtain energy from continuous natural resources that are inexhaustible, inexhaustible and do not require chemical or industrial treatments such as fossil fuels or nuclear energy.

1.3 Features and Characteristics of Renewable Energy

The characteristics of renewable energy according to Misak and Prokop (2018) and Edenhofer et al., (2012) are

- Perennial renewable energy has a number of advantages over combustion of fossil fuels. This energy is a local source and no country can move or acquire it elsewhere.
- It is an economically viable and available means for both governments and people.
- This energy is produced in a clean and environmentally friendly manner, which does not produce any pollutants that disturb the ecosystem.
- This energy can be obtained at any time without fear of depletion after a specified period as in the consumption of fossil fuels.
- Ease of access to energy technologies, even in developing and poor countries.

1.4 Renewable Energy Sources

There are many natural sources that produce renewable energy, the most prominent of which are the following (Michaelides, 2014; Craddock, 2008)

Wind energy

Wind energy: is the conversion of the kinetic energy generated by the rotation of wind fans by the impact of wind, which in turn move the turbines we get through the rotational movement of electric power as shown in Figures 1.1 and 1.2.

Figure 1.1: Horizontal axis wind turbine

Figure 1.2: Vertical axis wind turbine

Geothermal energy

Geothermal energy: is the exploitation of heat energy stored under the surface of the earth in the heating processes in the near-surface layers or the generation of electrical energy through the transfer of high heat to steam turbines in the deep layers (see Figure 1.3).

Figure 1.3: Geothermal energy

Biogas

Biogas: Methane is obtained from fermentation of animal or plant waste (biomass). Biogas is used as an alternative to natural gas in electricity generation, water heating or even in domestic uses (Figure 1.4).

Solar energy

Solar energy: The conversion of sunlight (light + heat) to the earth to heat or electric energy (Figure 1.5).

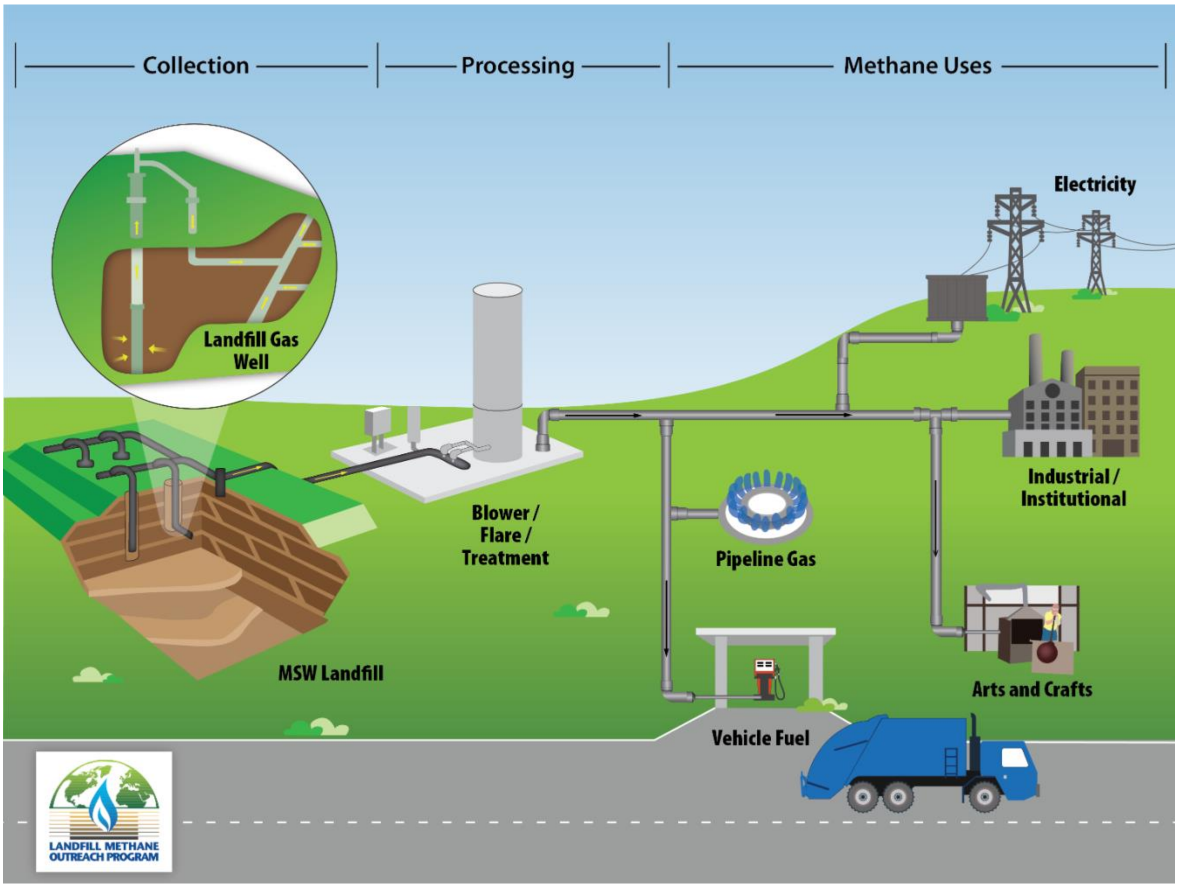


Figure 1.4: Biogas procedure

Figure 1.5: Solar energy

1.5 Aim of the Study

This study aims to propose a 1kW PV system that helps to reduce the electricity consumption which generated by diesel fuel and reduce green gas emissions. Actually, the objectives of this work is divided into three parts

1. Analyzing the solar potential at Güzelyurt location in Northern Cyprus using RETScreen software.
2. Evaluating the performance of 1kW PV system in terms of energy calculation and financial analysis.

1.6 Research Outline

This chapter is discussed the importance of renewable energy to the world. The importance of solar energy and the type of solar panels are presented in Chapter 2. Moreover, the methodology that used to evaluate the solar potential and design a 1kW PV system for generating electricity in the selected region is explained in Chapter 3. In Chapter 4 all test results are displayed for the proposed system. On the end of the dissertation, the conclusions are presented in Chapter 5.

CHAPTER 2
RENEWABLE ENERGY AND SOLAR ENERGY POTENTIAL

2.1 Types of Energy Sources

2.1.1 Non-renewable energy

Non-renewable energy sources have been formed over millions of years due to geological processes (Kang et al., 2019). It is noteworthy that their use is faster than the use of natural energy sources, which made it more reliable than renewable energy sources, such as fossil fuels, oil, and natural gas as shown in Figure 2.1.

Natural gas

Natural gas is often made up of methane, and is found near other fossil fuels, such as coal, produced by methane generation in landfills and marshlands. When it burns, it produces half of the greenhouse gas emissions.

Petroleum

Petroleum or crude oil is defined as a toxic flammable liquid that occurs in geological formations underground, used as fuel oil and gasoline, but is likely to be present in the components of medicines, plastics, and kerosene.

Coal

Coal is a sedimentary rock produced in marshes, where organic matter accumulates from plants, and the aggregation of these materials forms a substance known as peat, which releases volatile components, such as water and methane, resulting from the pressure from peat, and then coal is produced. Coal is also the most widely used fossil fuel in the world to produce electricity. In the United States, about 93% of coal consumed is used to generate electricity, and coal combustion produces almost three times the amount of CO_2 emissions.

Nuclear Energy

Nuclear energy is emitted at nuclear fission, the split of the nucleus of an atom. Nuclear power is a common method of generating electricity worldwide. Although it is a common mineral found in rocks around the world, nuclear energy has many disadvantages, such as the production of radioactive materials. Radioactive waste can be highly toxic and they also increase the risk of blood disease, cancer and bone caries among people at risk.

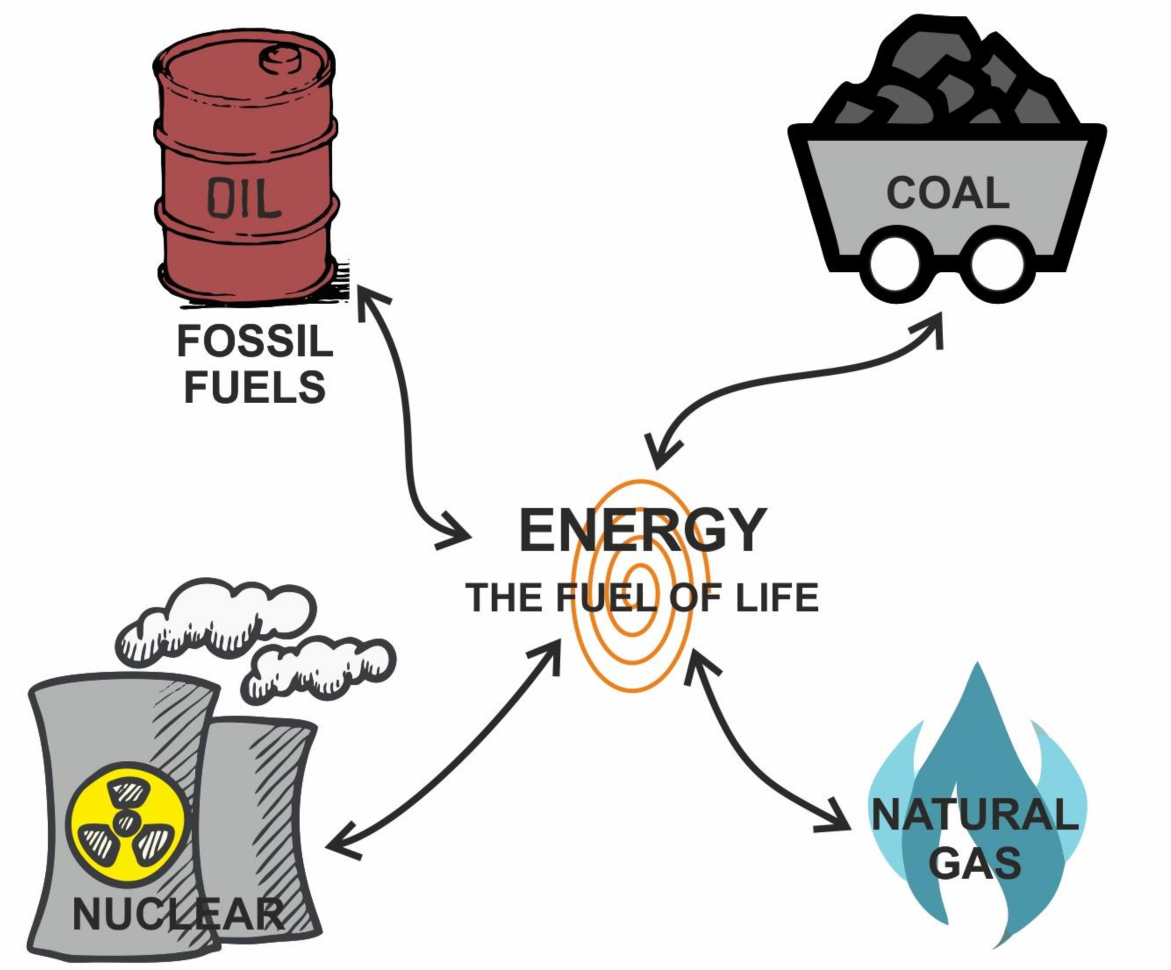


Figure 2.1: Non-renewable sources

2.1.2 Renewable energy

Renewable energy sources are clean sources and are not depleted due to human consumption. Renewable resources include wind, solar, thermal, hydroelectric, and others, with lower greenhouse emissions and other emissions.

Renewable Energy (Figure 2.2), a type of energy that is inexhaustible and depleted and the name indicate that whenever it is nearing completion exists again and comes from one of the natural resources, such as wind, water, sun. The most important characteristics of renewable energy (Toklu, 2013) are

1. A clean and environmentally friendly energy,
2. Does not leave Harmful gases, such as carbon dioxide,
3. Does not adversely affect the surrounding environment and
4. Does not play a significant role in temperature levels.

Renewable energy sources are in stark contrast to their non-renewable sources, such as natural gas and nuclear fuel, which lead to global warming and the release of carbon dioxide when used.

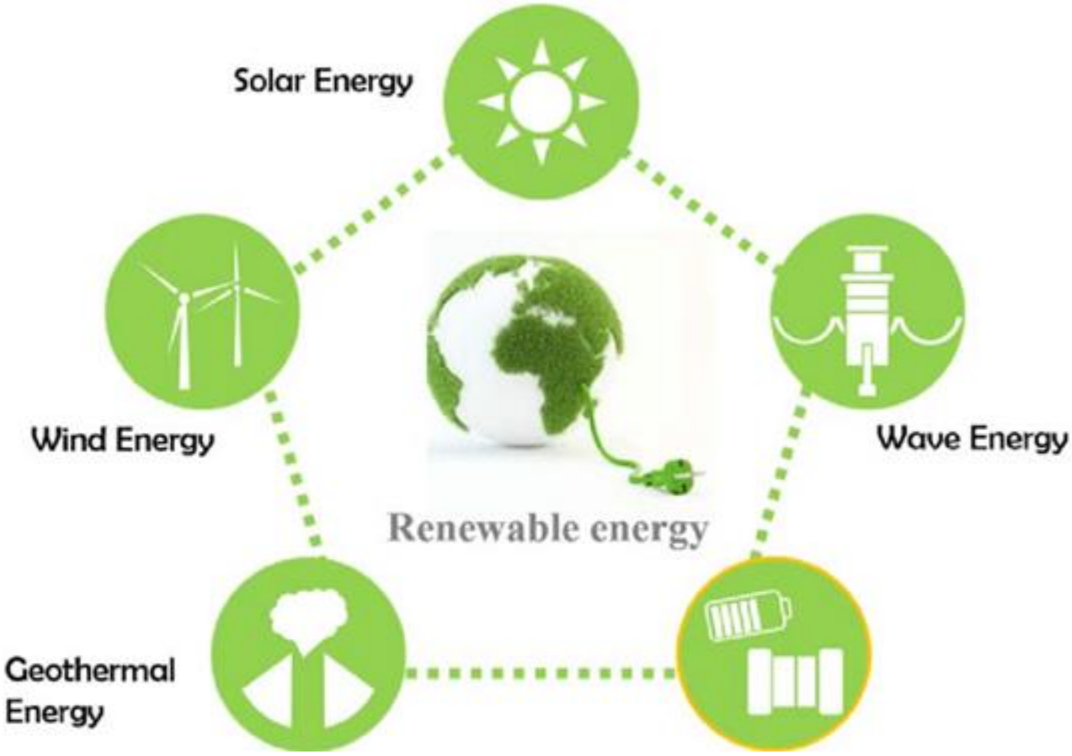


Figure 2.2: Renewable energy sources

1. Advantage of renewable energy

There are a number of advantages that renewable energy has, and makes it a distinct source of energy.

1. Renewable energy is environmentally friendly and clean.
2. They exist permanently and are renewable again.
3. Easy to use using simple techniques and mechanisms.
4. It is very economical.
5. It is an important factor in environmental, social and all fields' development.
6. Helps mitigate the effects of gaseous and thermal emissions.
7. Prevents harmful acid precipitation. Limit waste collection in all its forms.
8. Cultivation is free of chemical contaminants, thus increasing agricultural productivity.

9. It uses uncomplicated technologies and can be manufactured locally in developing countries.

2. Renewable energy sources

Renewable energy has different types, and can be divided into several categories:

Solar energy

The sun's rays and the heat and light they carry with them are a source of solar energy. The sun can be used to generate thermal and electrical energy, whereas electric energy can be generated by solar energy using thermal motors, photovoltaic panels and photovoltaic converters. Solar energy was used in prehistoric times, when monks used gilt surfaces to ignite the altar balance. Archimedes burned the Roman fleet by shining sunlight from a distance, using reflective mirrors in 212 BC. In addition, Weston (1888) came up with a method to convert solar energy into mechanical energy, using the so-called duplex process, generating a voltage between hot and cold contact points between two different metals, such as nickel and iron.

Bioenergy

Bioenergy is derived from the so-called biomass, which is an organic substance that stores solar radiation and then converts it into chemical energy. These sources may be wood, fertilizer, or sugar cane, and the sources of bioenergy are similar to fossil fuels.

Wind Energy

Humans rely on wind turbines to extract energy from wind and generate electricity from it. Wind energy is also used to produce mechanical energy in so-called windmills. Approximately 2% of the sunlight falling on the Earth's surface is converted into wind energy. This is an enormous amount of energy, which overflows the world's need for consumption in any given year.

Hydropower

Hydroelectric is a comprehensive term for both electricity and water. This type of energy is used to exploit hydropower to generate electricity. In the process of exploiting this energy, the energy in the water, or the energy of the situation, is completely relied upon and converted into kinetic energy through the fall and flow of water from top to bottom.

2.2 Solar Energy

The Sun, or the core of the solar system, is the closest star to Earth, estimated at 26,000 light-years. The star is estimated to be 4.5 billion years old. The massive gravity in the Sun is responsible for the stability of the solar system so that all components of the solar system are fixed from large planets too small parts of each Orbit.

Solar energy, the energy emitted by the sun's rays, is mainly in the form of heat and light, is the product of nuclear reactions within the star closest to us, the Sun. This energy is of great importance to the earth and the organisms on its surface. The amount of this energy produced far exceeds the current energy requirements in the world in general, and if properly harnessed and exploited may meet all future energy needs.

The importance of solar energy lies in the fact that the sun’s rays have facilitated the evolution of organisms and is responsible for photosynthesis in plants to produce food and biomass, in addition to the role of these rays in hydropower and wind power. In addition, solar energy is responsible for the so-called renewable energy group, the most important of which is the increasing importance of solar energy as a source of energy.

Scientific researcher's studies are increasingly interested in renewable energy sources because of the growing concerns around the world due to climate change. Renewable energy is characterized by its ability to replenish and not deplete resources. There are a number of disadvantages to renewable energy, as they are limited inflow. This means that energy is not accessible at any time.

In general, this energy is the production of heat by converting the energy inherent in sunlight. This energy attracts the heat of the sun and its photovoltaic cells and transports it to a water cycle to provide homes with hot water or heating. There are several methods for the efficient use of solar energy, which can be classified into three main categories: thermal applications, electricity production and chemical processes, and the most widely used applications in the field of water heating. Electricity is currently being generated by photovoltaic systems and solar thermal technologies, based on the conversion of sunlight into electricity using solar panels (see Figure 2.3). The benefits of photovoltaic cells lie in their ability to convert solar energy directly into electricity and in its ease of use, making it usable, especially in developing countries where there are no large generators.

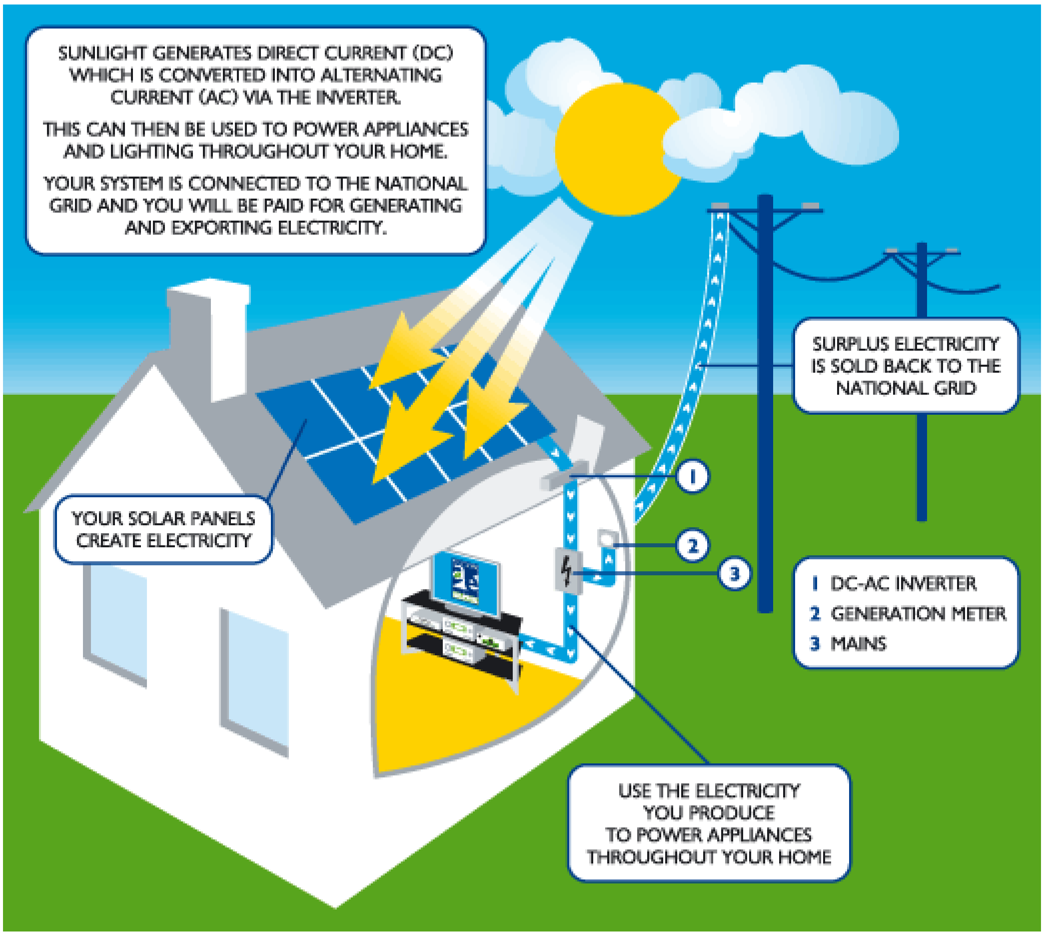


Figure 2.3: Grid-connected solar energy system

2.2.1 Advantage of solar energy

Solar energy is the most abundant and freest source of energy, and humans use it in many of their daily activities.

1. Costs for homeowners and real estate can be reduced through the use of solar energy.
2. Many jobs are available due to the increase in companies in the renewable energy sector.

3. Solar plants are environmentally friendly compared to nuclear power plants, by reducing emissions of harmful chemicals to the environment.
4. Excess energy can be stored and distributed in months that do not receive much sunlight.
5. It has the potential to innovate and develop compared to the methods of producing energy from other sources.
6. Cars can use solar energy instead of fuel, eliminating the need for oil.

2.2.2 Disadvantage of solar energy

It is undeniable that solar energy is one of the most important sources of energy. However, it is not without its negatives. The following are the main downsides of solar energy

1. The large cost of solar panels to produce large amounts of energy.
2. Recycling solar panels is considered to be a cause of water pollution, as this negativity can be avoided if organic materials are used in the manufacture of solar panels.
3. Relying on battery systems during the night and times when panels cannot absorb enough solar radiation.
4. Solar energy systems take time to become mainstream and widely accepted as an alternative to energy production.

2.2.3 Solar Energy uses

Solar energy can be converted into electrical energy and thermal energy through photovoltaic conversion and thermal conversion of solar energy as follows (Greeley, 1979; Foster et al., 2010):

Solar thermal uses

- Solar water heating

It is an integrated system consisting of several parts used to collect the solar radiation falling on them and converted into heat energy to be used to heat water during the hours of sunshine where hot water is stored in a heated tank for use during the day as shown in Figure 2.4.

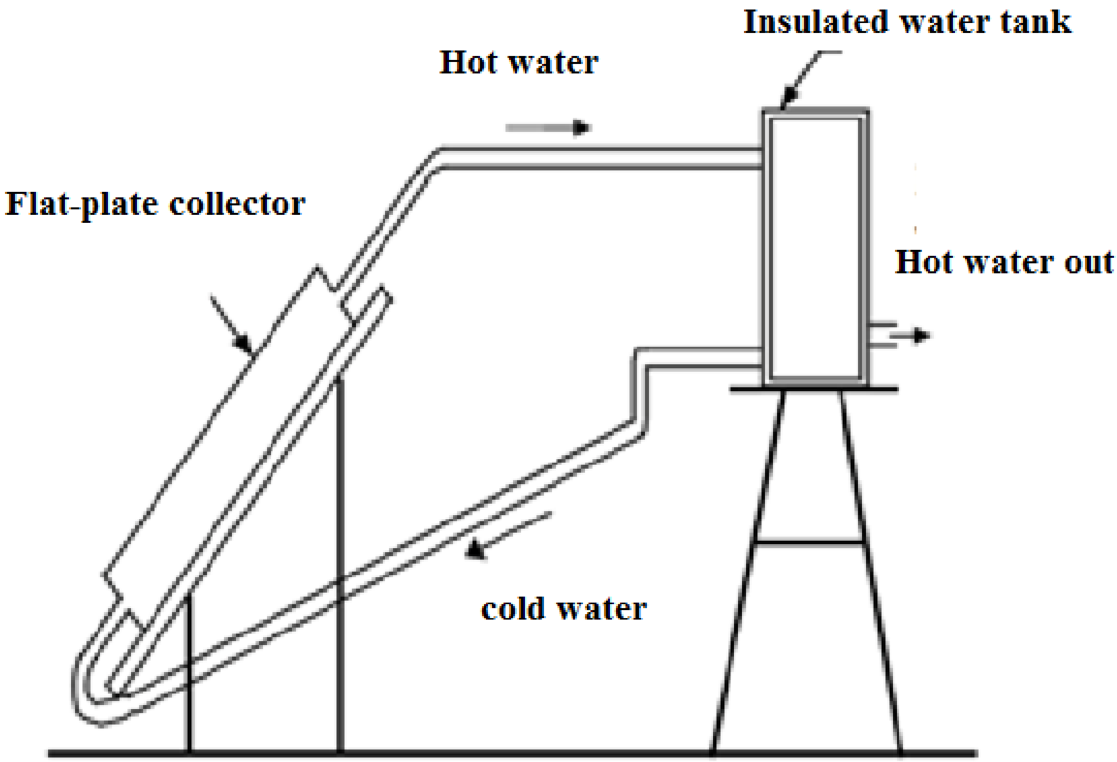


Figure 2.4: Solar water heating

- Solar swimming pool heating

Solar water heaters can also be used to heat the pool water (Figure 2.5). Solar collectors heat pool water to temperatures slightly above ambient temperature For this purpose, cheap unglazed solar collectors, which are usually made of plastic materials specifically designed for this purpose are used for the heating of pool water.

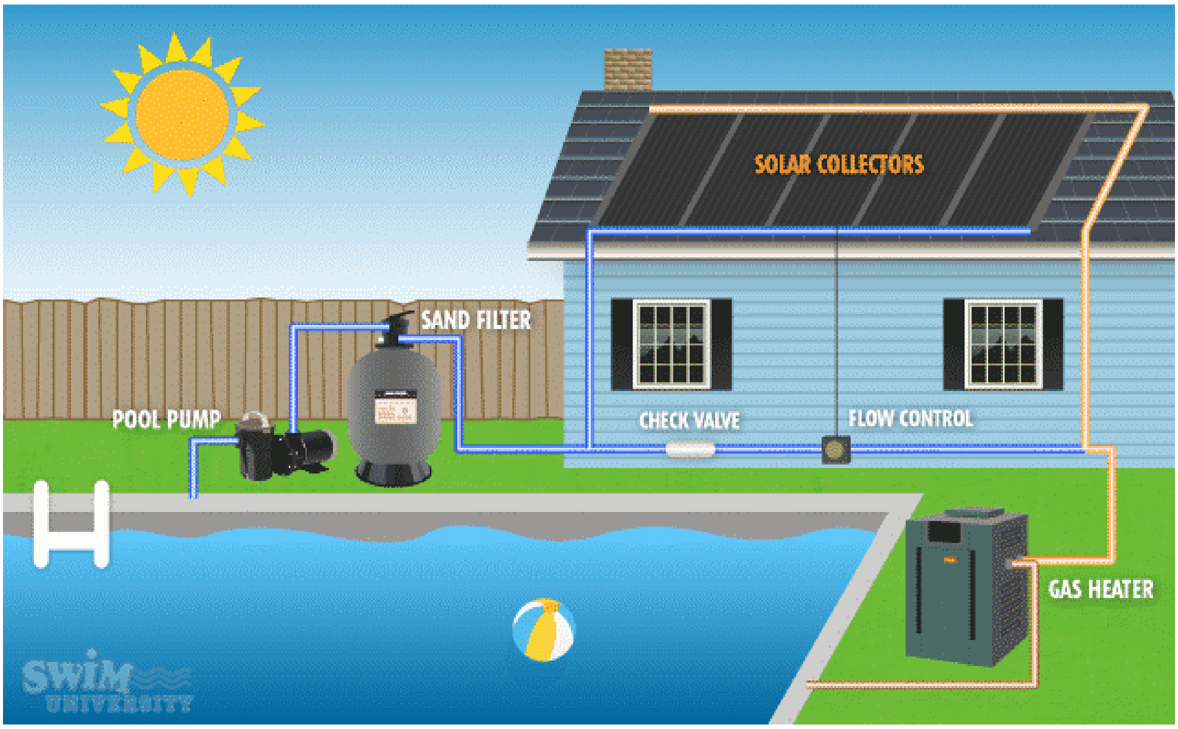


Figure 2.5: Solar swimming pool heating system

- Sewage Treatment

Solar energy is also used to remove toxins from contaminated water using photo degradation.

- Solar cooking

The solar cooker is a device that uses sunlight to cook, dry and pasteurize. For example, Figure 2.6 shows the parabolic solar cooker.

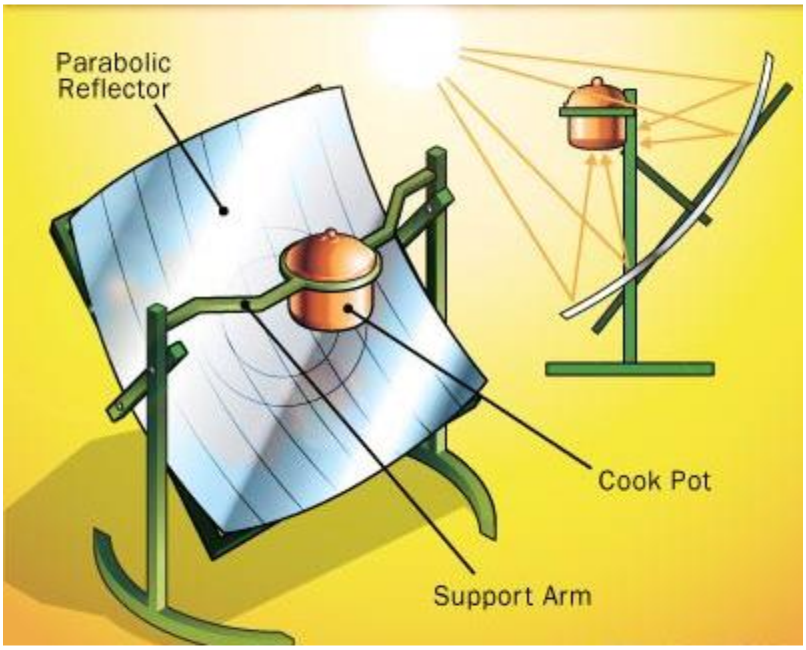


Figure 2.6: Parabolic solar cookers

Use of solar energy to generate electricity

Electricity is one of the energy carriers that can be used for many purposes. Solar energy can be converted into electrical energy through photovoltaic conversion. It is intended to convert solar or light radiation directly into electrical energy using photovoltaic solar cells as shown in Figure 2.7.

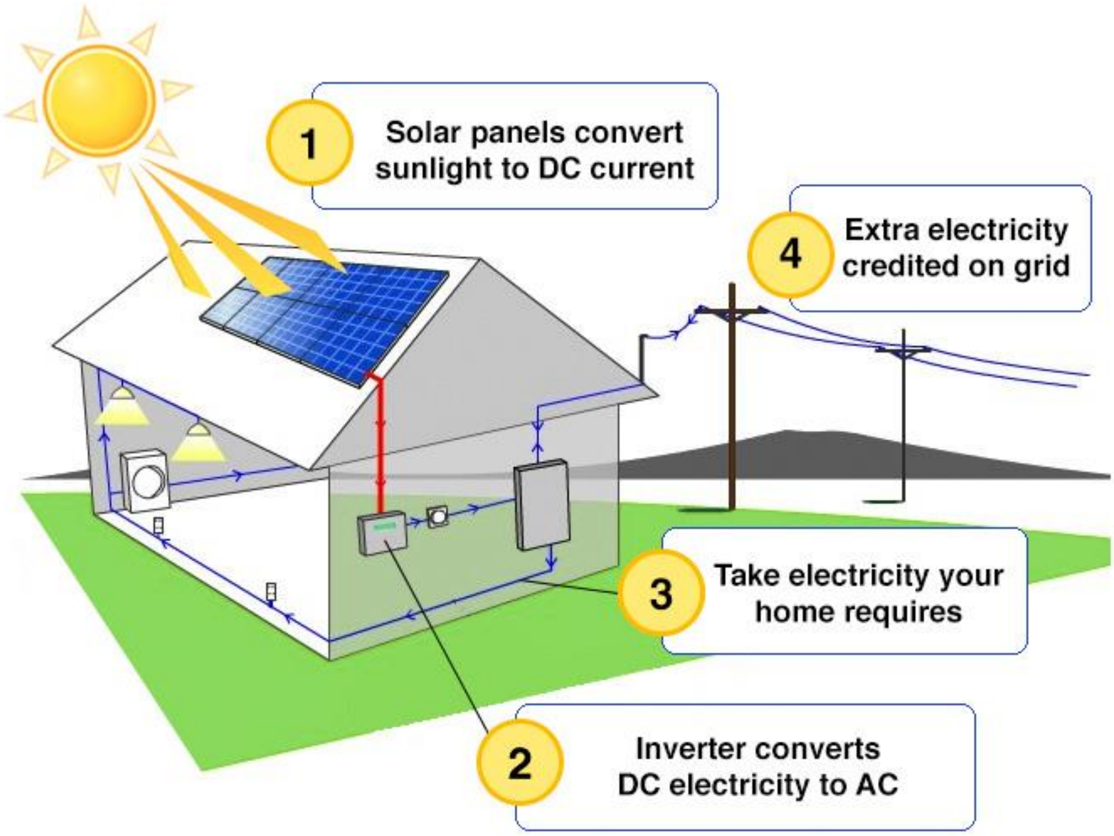


Figure 2.7: Use of solar energy to generate electricity

2.2.4 Solar panels work (Photovoltaic)

With the increasing interest in renewable energies in general and solar energy in particular, there have been attempts to provide solar energy technologies with an amount of energy equal to or close to the amount of energy spent (Chel and Kaushik, 2018). It has become popular, transforming buildings from energy-consuming plants into productive buildings that rely on the sun as an economical source of energy, and are commonly used even in areas with high levels of solar radiation or areas characterized by short hours of sunshine.

The solar system for electric power generation consists of four basic elements as follows (see Figure 2.8):

- PV photovoltaic
- Charger controllers
- Invertors
- Batteries

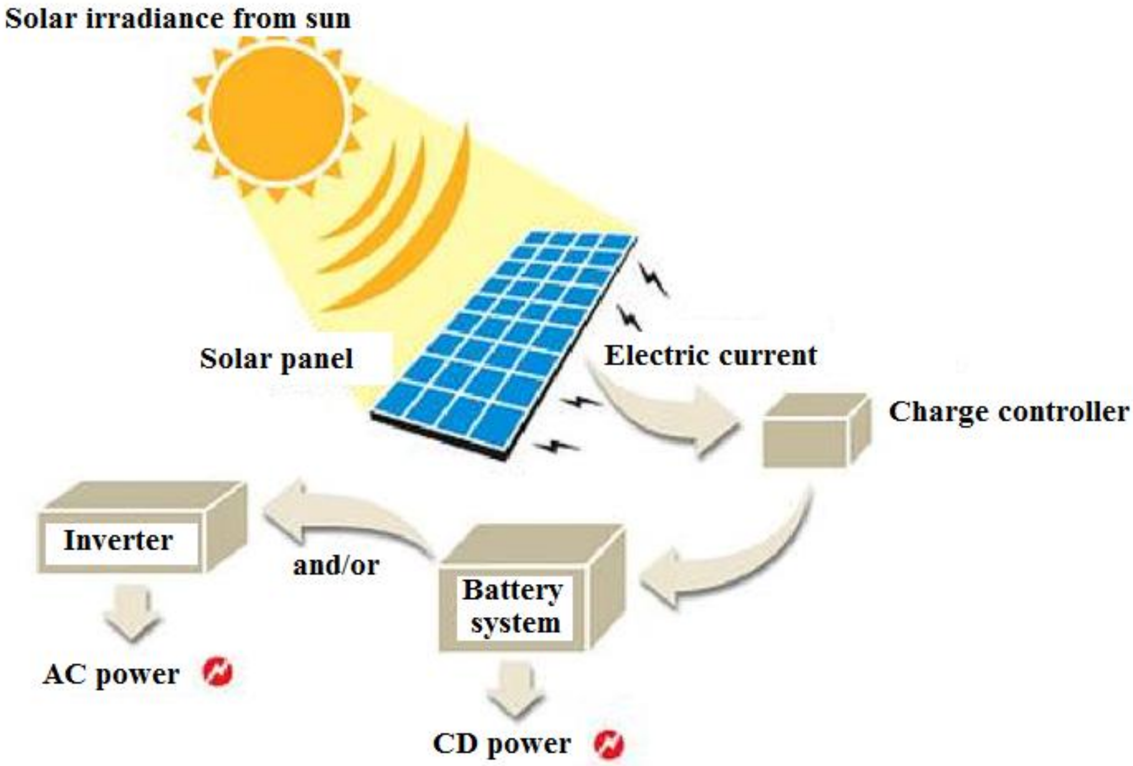


Figure 2.8: Elements of PV system

PV photovoltaic

It is the visible part of the solar system that is installed on the roof of the building and it is used to generate electric power. The components of solar panels are shown in Figure 2.9. The solar panel is solar cell grouped together produce DC electricity that can be used to operate some equipment or stored in batteries recharged, which can be used more than once. The unit of the measured power of the cells is Watt.

To illustrate how solar panels work, the main component of the solar system which is the solar cell is explained.

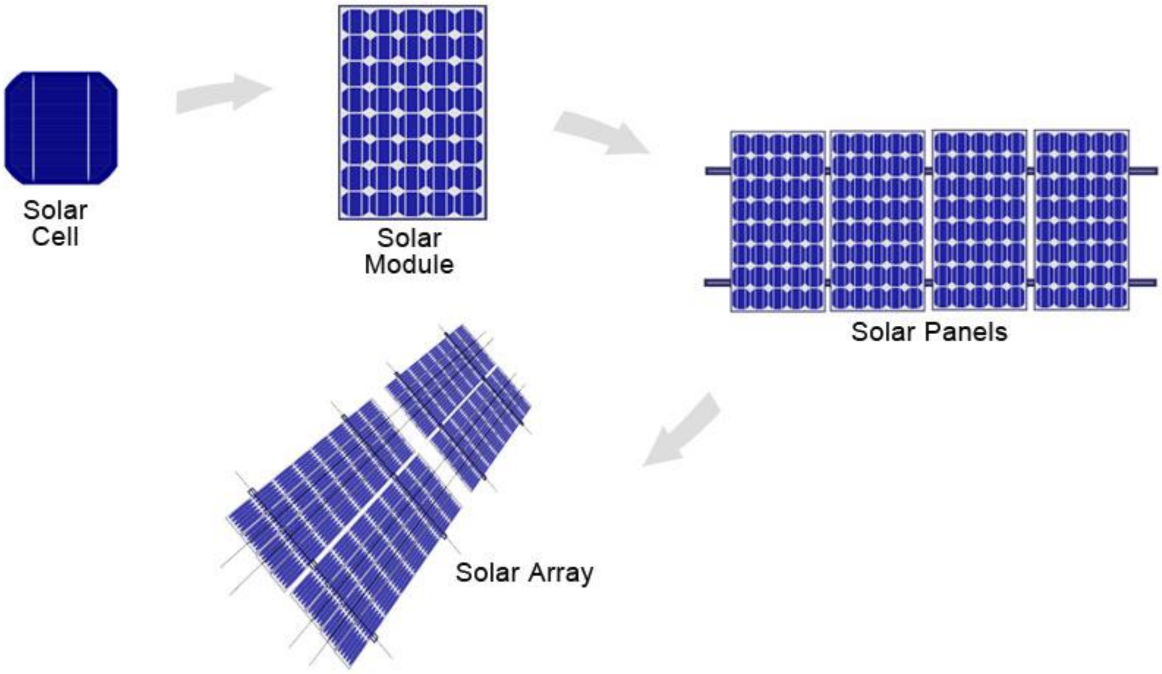


Figure 2.9: Components of PV panel

PV cell

It is the main component of the solar system and is the smallest part of it. They respond to direct and indirect solar radiation by converting radiation energy into electrical energy. Solar panels take advantage of sunlight that activates electrons within a cell to produce current (Marsh, 2019). Photovoltaic cell consists of semiconductors; often elections that are compressed into a specially treated chip to form an electric field, positive on one end and negative on the other end (see Figure 2.10) (Marsh, 2019).. Electrons are stimulated to a higher state of energy to generate electricity, and electrons are collected as electric current if electrical conductors are connected to the negative and positive ends (Marsh, 2019).. The resulting electrical energy is DC energy and that energy is stored in batteries of different capacity so that it can be used during the sun's demise (Marsh, 2019).

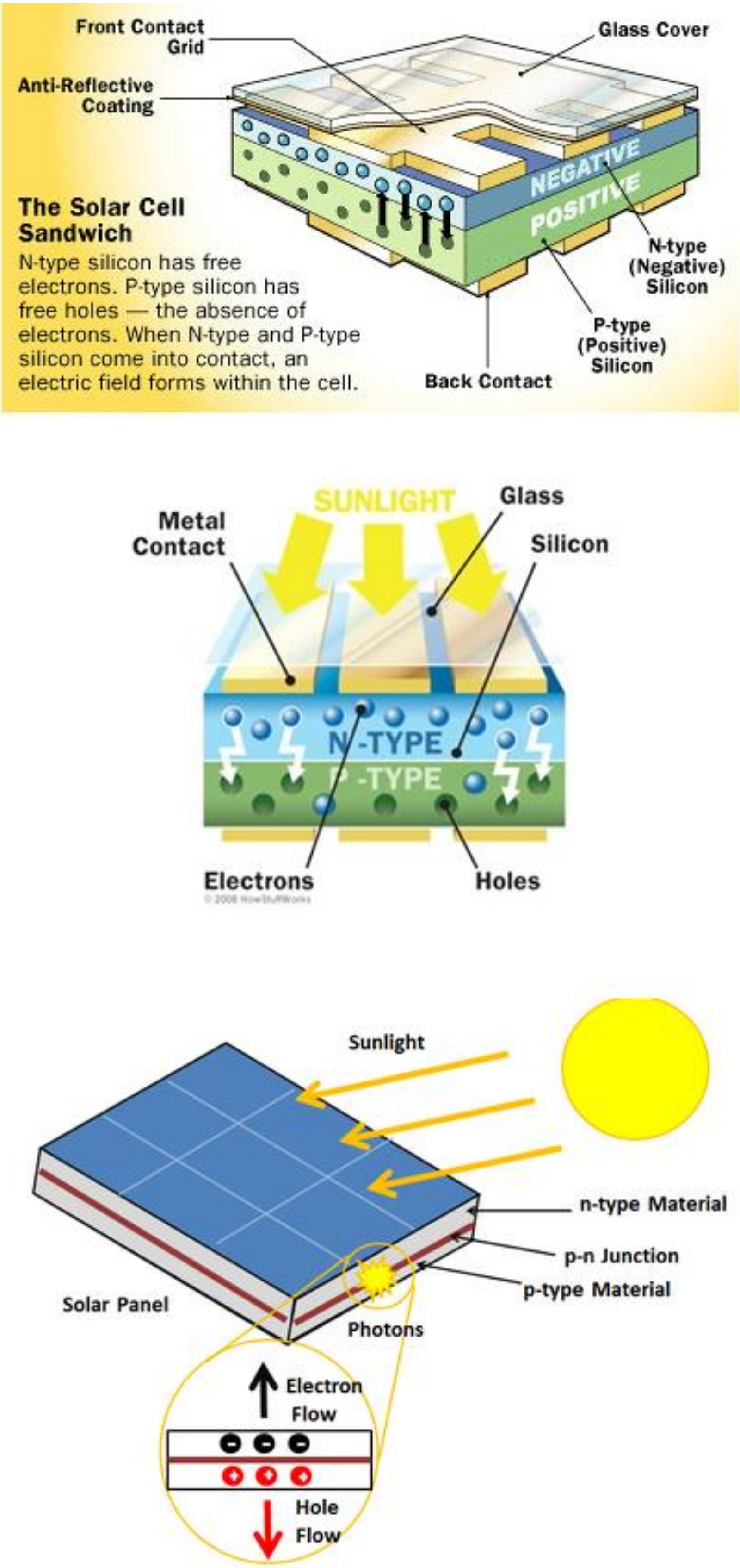


Figure 2.10: PV cell working principle

Initially, the solar cells, which are placed directly under the sun, absorb these rays and convert these rays to electrical energy for human use in many purposes and fields, and thus serve as sunlight alternative to what normal generators do, when the sun shines, which contains large energy Here, solar panels attract this energy, which contains many solar cells arrayed next to each other, and these solar cells are composed of semiconducting materials (often silicon), and these cells receive solar energy and start The electrons are released from the semiconductor material or silicon to accumulate in the form of electrical energy, resulting in DC electricity (such as electricity produced chemically in batteries), which is then converted from DC electricity to DC. AC electricity, the electricity in our lives today, through a transformer called "Inverter".

Types of solar cells

Although all solar panels work in the same way, there are several types of solar panels in the market, which differ among several variations to be identified to choose the right type of site (Green-Match, 2015), and the most common types of solar panels:

- Mono-crystalline, known as monocrystalline panels (Figure 2.11), is characterized by the purity of the silicon crystals from which the cells are made. The panels need to provide the same amount of electricity as other types, and also have the ability to work efficiently in low light, in addition to a high lifetime.
- Solar panel type (poly-crystalline): It is called polycrystalline solar panels (Figure 2.12), and different from the monotype in the form, where the cells are squares compact, and their efficiency is medium, which leads to the need for more of them to get the same electricity, which is less expensive than the monotype with high lifetime.
- The third type is called thin film solar panel (Figure 2.13). This type is flexible and easy to install. On the same amount of electrical energy that can be obtained from other species, as well as it has low lifetime.

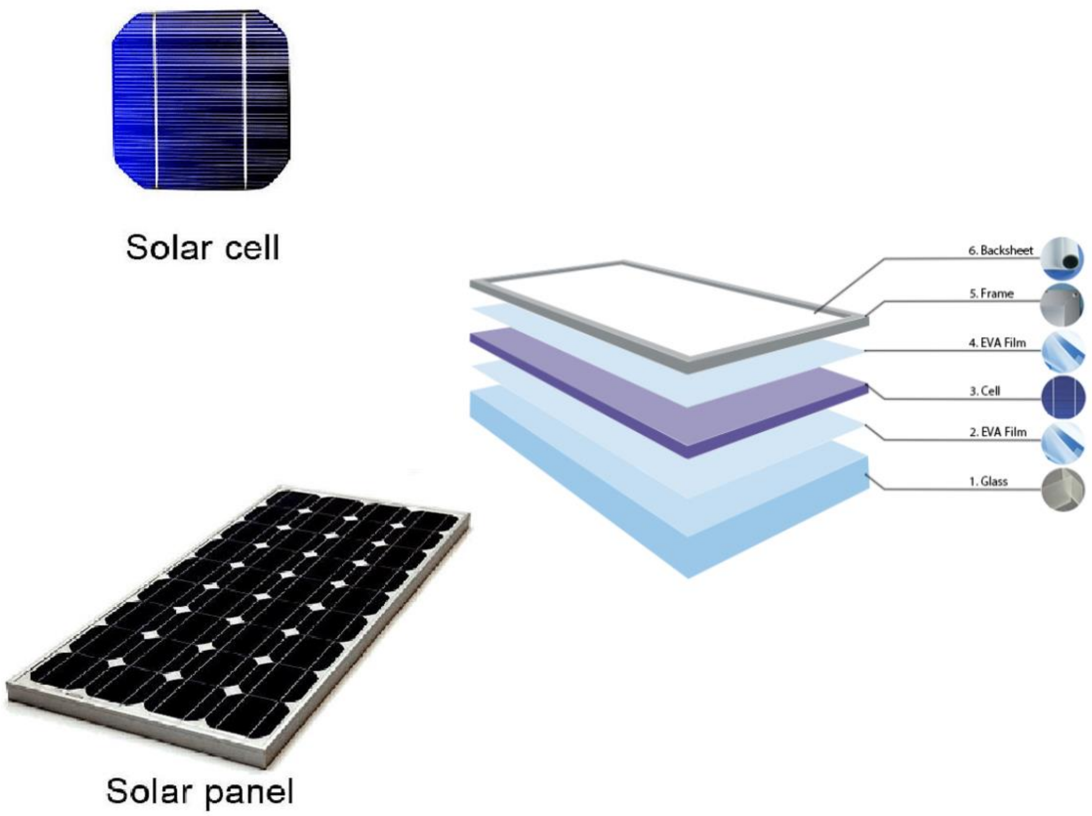


Figure 2.11: Monocrystalline solar panels

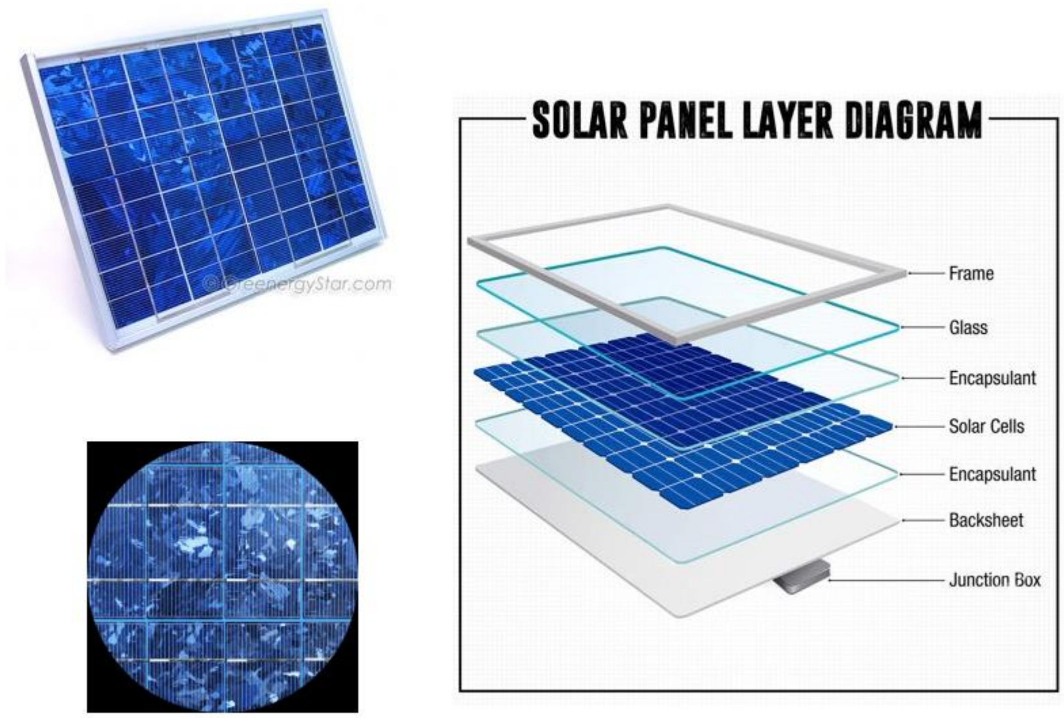


Figure 2.12: Polycrystalline solar panel

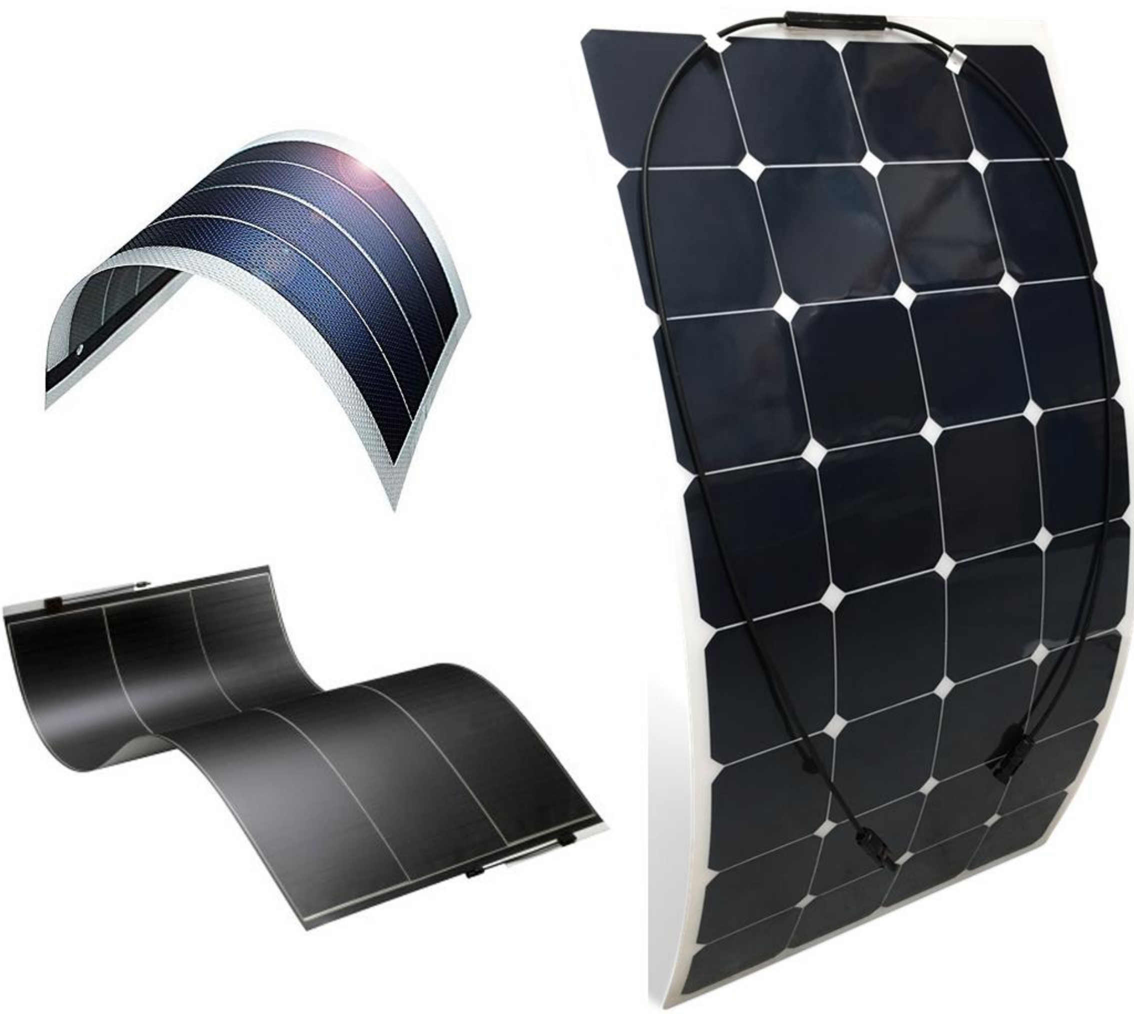


Figure 2.13: Thin film solar panel

2.3 Factors Affect the Solar Radiation Values

Solar radiation is the actual fuel for all solar energy systems, so the efficiency of solar panels producing electricity as well as thermal systems producing hot water depends on the availability and density of solar radiation. The radiation above the atmosphere is relatively constant, but the amount reaching the surface of the Earth varies very differently. In fact, there are many factors; however, the most important factors affecting the quality of solar radiation falling and thus the efficiency of the productivity of solar panels are (Krzyścin and Jarosławski, 1997)

Geographical presentation

Because of the spherical Earth, the rays falling on the surface are more intense and stronger as we get closer to the equator and because it is the shortest way of radiation to reach the surface perpendicular and thus the radiation lost due to collision with the atmosphere less. If we move away from the equator north or south, it will increase the period of fusion between radiation and the envelope, causing dispersion and thus weaken the intensity and strength of radiation.

Cloud coverage

Clouds are a significant factor relative to the amount of solar radiation falling on the surface because they reflect and absorb a large part of the sun's rays. Therefore, if there are two positions on one latitude, the difference in incident radiation may be significant depending on seasonal cloud coverage. In average, clouds absorb and reflect 20% of the total rays coming from the sun.

The suspended particles

Normally, the Earth's atmosphere has suspended particles of dust or products of human industrial activity and pollution, and the quantities and concentration of these bolds vary depending on the place and time of year. Its importance for solar radiation is that it filters and reduces radiation. While this affects the performance of solar panels, it is more detrimental to the performance of the radiation concentrates used in giant solar systems.

Height

The distance traveled by the radiation before reaching the surface of the Earth is less as the height of the Earth above sea level. Therefore, radiation loss rates are reduced and this results in better performance of all types of solar generators.

Shadow and angle

The place of installation and installation of solar panels is one of the most important things to consider if we are to absorb the maximum amount of incident radiation, considering that any shadows on solar panels or concentrates should be avoided by neighboring buildings or others during the daytime. An angle should be set for panels that meet the sun as much as possible throughout the day and often the ideal angle depends on your location for longitude, latitude and annual seasons.

CHAPTER 3
MATERIAL AND METHOD

3.1 Solar Home System

PV is direct way to convert the solar radiation into electricity, and the electricity amount available for daily use will be determined based on the array size and sunlight availability. The PV solar panels can be mounted on the rooftops to generate electrical power. Figure 3.1 illustrate the configuration of solar home system, which utilized to electricity for domestic household in order to reduce the fuel consumptions and air pollution. A simple solar home system consists of the PV module, lead battery, and inverter, as well as the directly connected DC appliances.

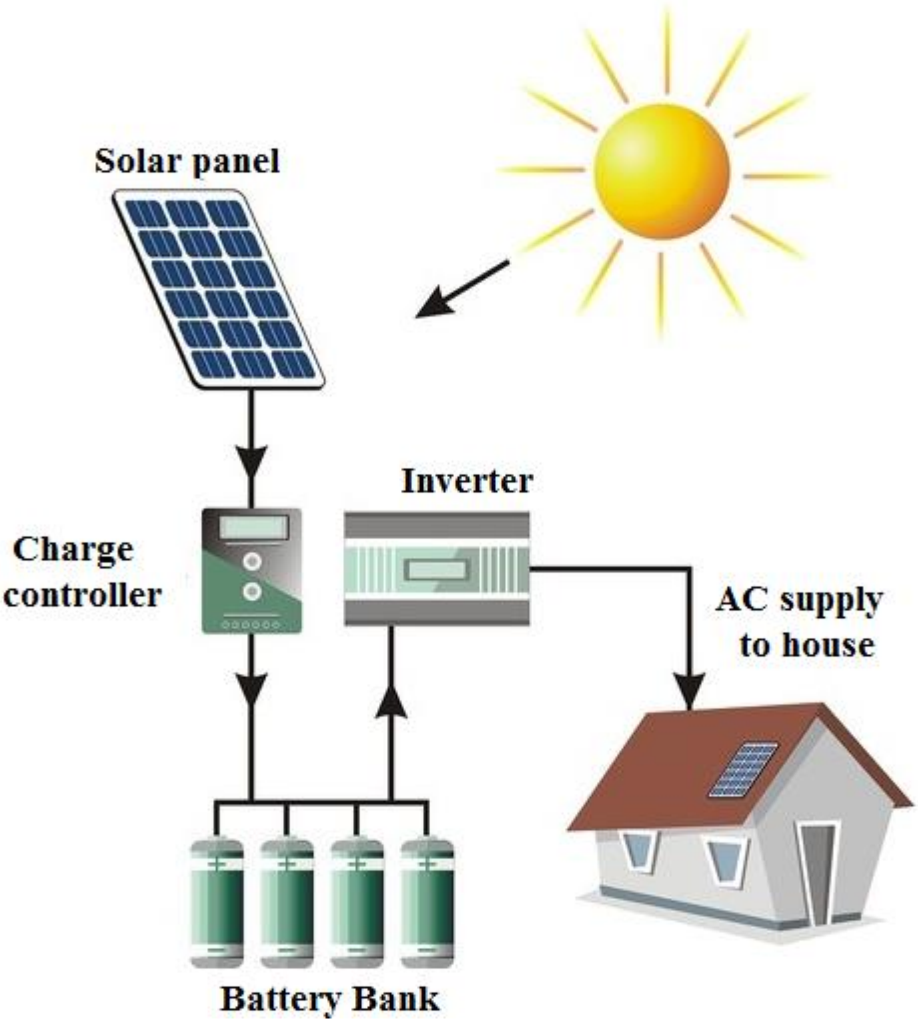


Figure 3.1: Configuration of solar home system

3.2 Selected Region and Electricity Feed-In Tariff in Northern Cyprus

In this study, the data are collected from household in Güzelyurt, Northern Cyprus. Güzelyurt is located in the northwestern part of Cyprus. The location and area-specific information are shown in Figure 2 and Table 1, respectively. This city has low populations compared to other cities in Northern Cyprus as shown in Figure 3.3. Recently, regarding the development technologies, related activities, and policy making have increased. For instance, the Feed-in tariffs for residential electricity have increased and the value of Feed-in tariffs are summarized and listed in Table 3.2.

Figure 3.2: Map of Cyprus (▭ selected region)

Table 3.1: Güzelyurt, Northern Cyprus information

Region location	
Latitude (°N)	35° 12' 3.528"
Longitude (°E)	32° 59' 26.808"
Elevation (m)	49

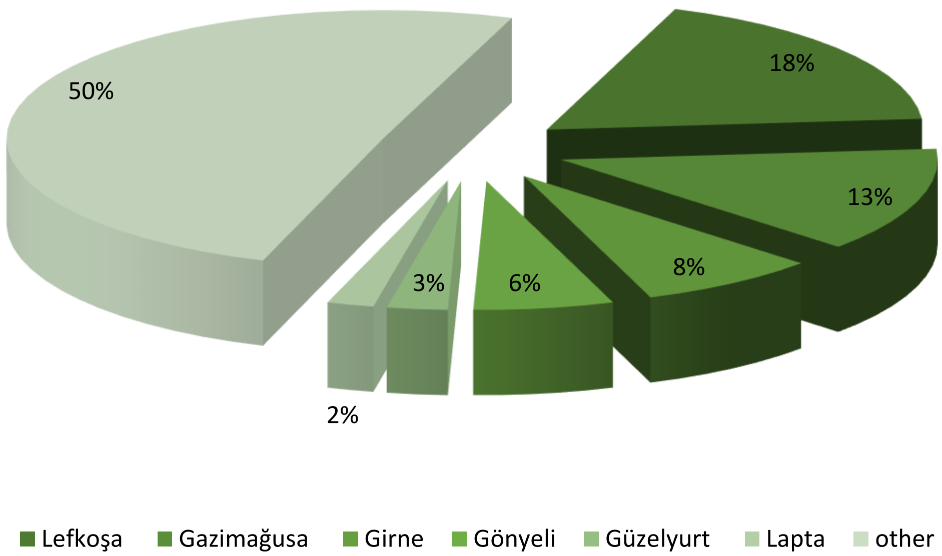


Figure 3.3: Population density in major cities in Northern Cyprus

Table 3.2: Electricity Feed-in tariff in Northern

Residential Tariff	Period	Value [TL]	Residential Tariff	Period	Value [TL]
0-250kWh	01/01/2015 - 1910/2015	0.44	0-250kWh	20/10/2015 - 31/03/2016	0.44
251-500 kWh		0.48	251-500 kWh		0.48
501-750 kWh		0.52	501-750 kWh		0.52
> 750 kWh		0.54	> 750 kWh		0.54
0-250kWh	01/04/2016 - 20/10/2016	0.40	0-250kWh	21/10/2016 - 20/12/2016	0.44
251-500 kWh		0.45	251-500 kWh		0.49
501-750 kWh		0.49	501-750 kWh		0.53
> 750 kWh		0.2	> 750 kWh		0.56
0-250kWh	21/12/2016 - 30/04/2018	0.52			
251-500 kWh		0.60			
501-750 kWh		0.67			
> 750 kWh		0.75			

3.3. PV system for Residential Building

Renewable energy systems can be improved energy efficiency and reduced energy demand to provide the dominant contribution to tackling global climate change. Increasing energy demand, environmental pollution, and global warming are the main factors that increase the tendency towards renewable and clean energy resources.

Table 3.3 lists the electrical equipment available in the studied residential home along with their average hours of use daily period of use in hours. The residential house is a typical two bedroom for small family.

Table 3.3: Electrical load available in the residential houses

Selected house	Description	Ratings	Hours of use per day	Energy
House 1	32’’ LED TV	80	12	660
	Washing Machine	480	1	480
	Satellite Receiver	12	12	144
	Refrigerator	300	24	7200
	Laptop	200	5	250
	Vacuum Cleaner	800	1	800
	LED lamps	63	7	1323
	Air-conditioner	750	5	3750
	Clothes iron	1000	1	1000
	Microwave oven	1200	1	1200
	Water pump	500	1	500
	Toaster	800	1	800
House 2	32’’ LED TV	55	10	550
	Washing Machine	480	1	480
	Satellite Receiver	12	10	120
	Refrigerator	750	24	18000
	Laptop	50	10	500
	Vacuum Cleaner	800	1	800
	LED lamps	63	7	1323
	Air-conditioner	750	12	9000
	Clothes iron	1000	1	1000
	Microwave oven	1200	2	2400
	Water pump	500	1	500
	Toaster	800	1	800
	Hair dryer	1000	1	1000

The selected location for this study is a residential Building with small space available on rooftop area (roughly 100 m^2). Figures 3.4-3.6 show the mean monthly electricity consumptions for a period of January 2016- December 2017 for three chosen household with different capacity in selected regions. It is noticed that the highest amount of electricity are recorded in summer and winter seasons. In addition, the average electricity consumption for the selected house is about 512kWh/yr for house 1 and 473kWh/yr for house 2.

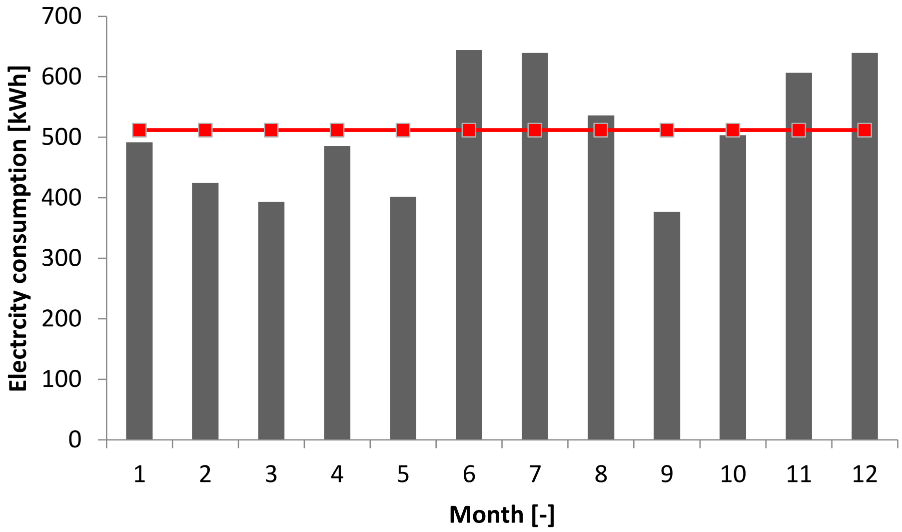


Figure 3.4: Mean monthly electricity consumption for house 1

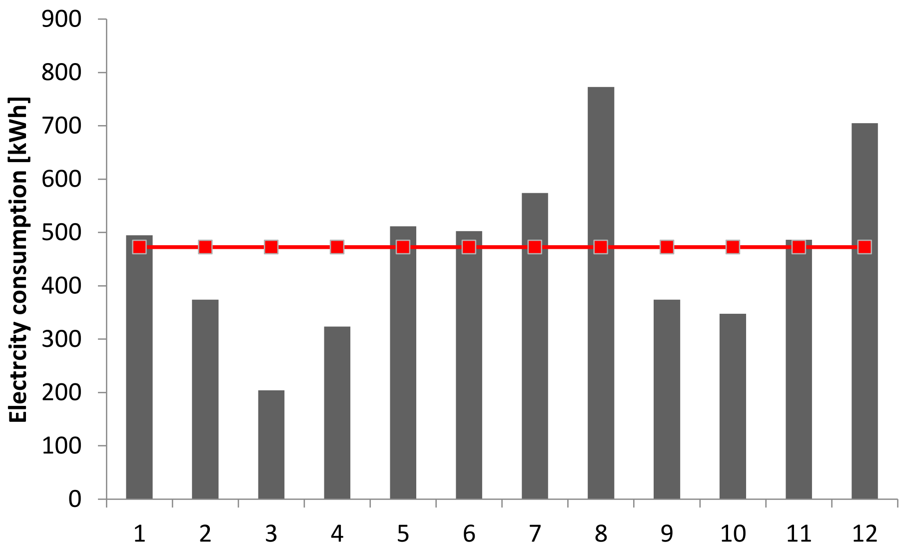


Figure 3.5: Mean monthly electricity consumption for house 2

3.4 Materials

3.4.1 Photovoltaic solar panels

The solar panels, composed of a number of solar cells, are used to change the sun light into direct current using semi conducting materials. In general, when the solar radiation falls on the solar cell, the anti-reflective layer effectively traps the incident light by enhancing its transition to the next layers. On the other hand, the positive gaps move to the conduction area of the positive strip, resulting in a potential difference between the surfaces of the two-link. The two surfaces can be connected by an electrical conductor to obtain an electric current in an electrical circuit, where electrons pass through the negative to the positive link in the electrical circuit, thus, light energy has been converted into electrical energy. In this study, mono crystalline PV panels are used. Table 3.4 tabulates the characteristics of used PV panels.

Table 3.4: Characteristics of used PV panels

Electrical characteristics at (STC)	Value
Nominal power	250W
Open circuit voltage	29.2V
Short circuit current	9.67A
Voltage at nominal power	31.2V
Current at nominal power	8.97A
Module Efficiency	17.2%
Operating temperature	-40℃ to 85℃
Maximum system voltage	1000V DC
Maximum Series Fuse Rating	15A

3.4.2 Battery

Solar batteries are utilized to store the electrical energy generated by panels during the daylight. Batteries play an important role in load supply during the night or any time that solar irradiation is not sufficient. Table 3.5 lists the characteristics of the batteries used in this study.

Table 3.5: Characteristics of used batteries

Battery company name	Voltage	Capacity
Varta	12	50Ah

3.4.3 Charge controller and inverter

The charge controller is used to control the current from PV panels to the battery. The charging controller can be used as a protection against overcharging or deep charging in PV systems. Specifications of the applied inverter used in this study are presented in Table 3.6.

Table 3.6: Charge controller characteristics

Type	**Modular power switch**
Nominal charging current	45 A
Nominal voltage	12 V/24 V/48 V
Max panel voltage	30 V in 12 V system 50 V in 24 V system 95 V in 48 V system
Self-power consumption	< 6 mA
Ambient temperature range	25℃ to 50℃
Case protection	IP22
Normal charge temperature	< 80℃

3.5 Energy and Economic Assessment of PV System

RETScreen software is used to assess the economic and energy of PV solar system for single house family. In this study, Güzelyurt region in Northern Cyprus was selected for the installation of the system. After selecting the location area the complete RETScreen analysis has been conducted. This analysis consist four main steps:

I. Selection of facility type (i.e. single family house as shown in Figure 3.6),
II. Energy analysis (see Figure 3.7)
III. Emissions analysis (see Figures 3.8),
IV. Financial analysis (see Figures 3.9).

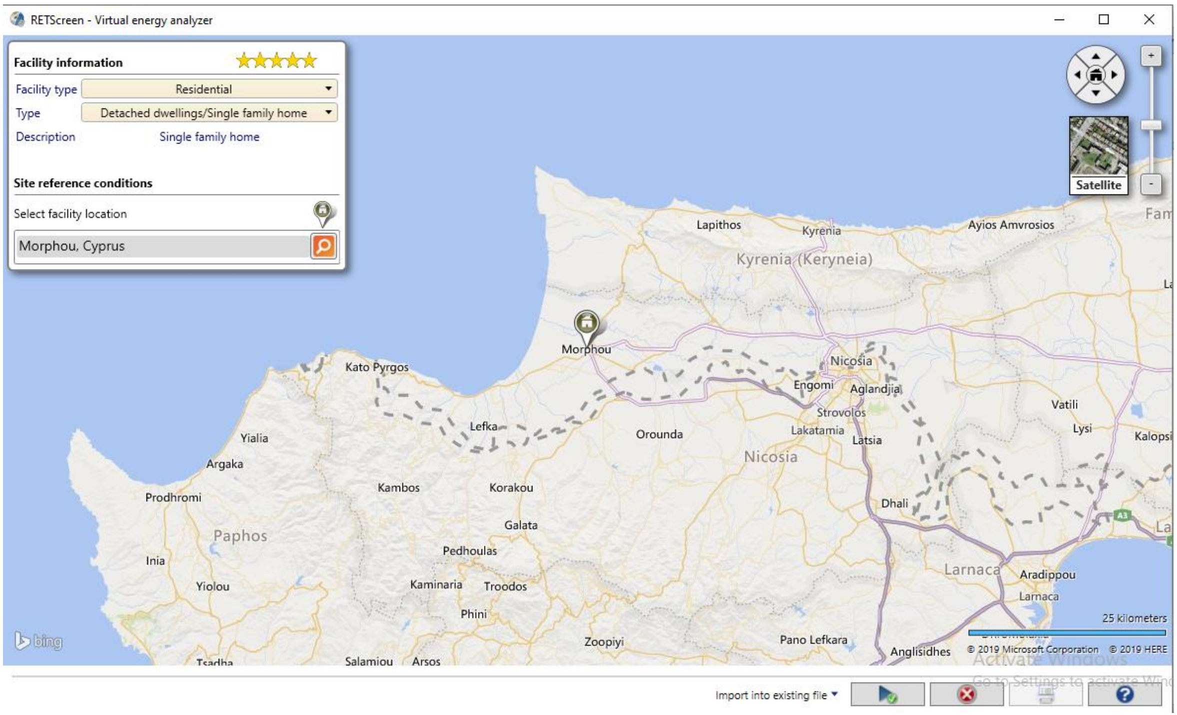


Figure 3.6: Selection of facility type

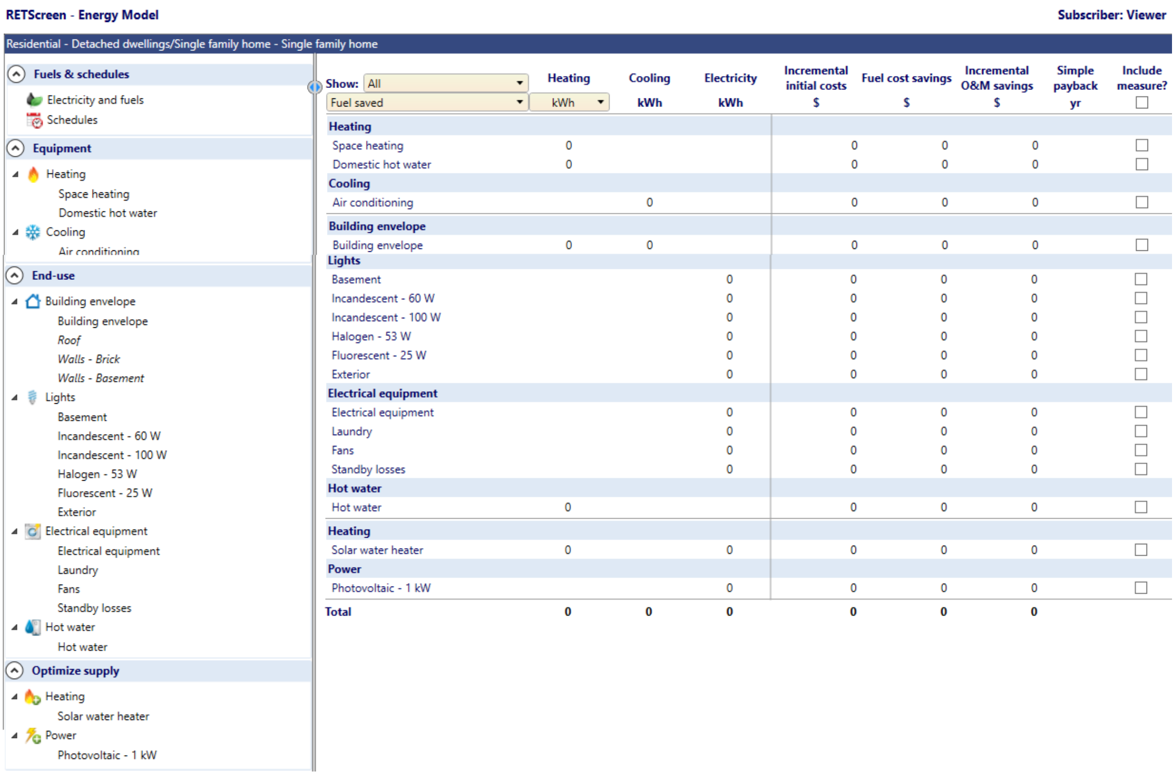


Figure 3.7: Energy analysis

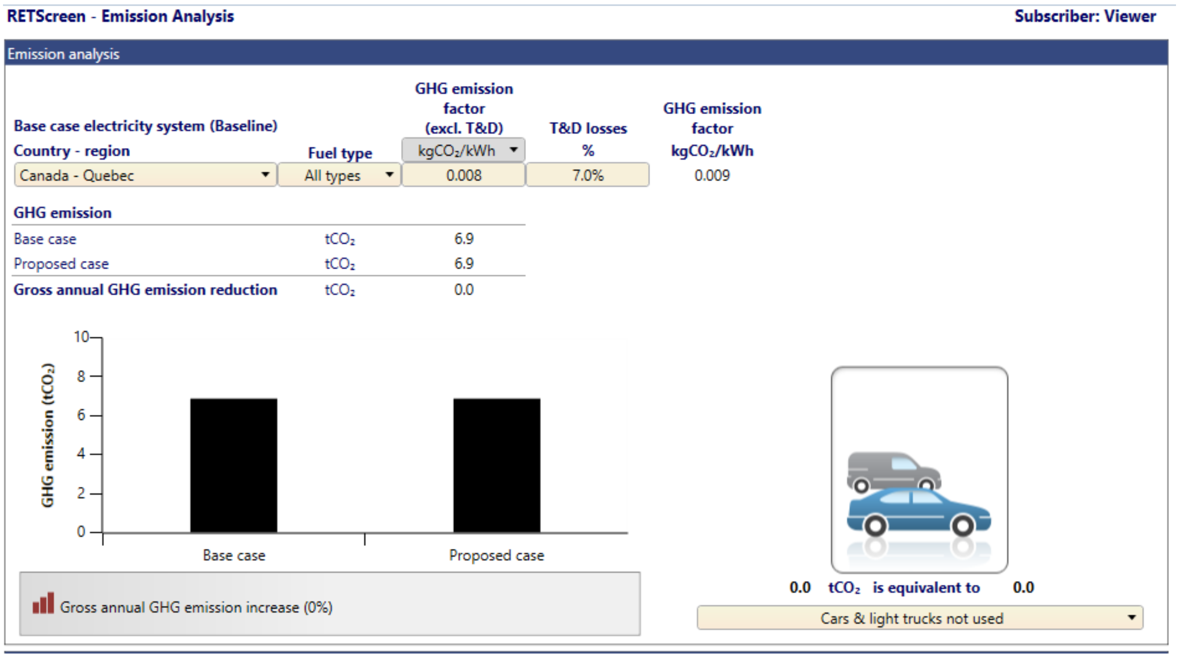


Figure 3.8: Emissions analysis

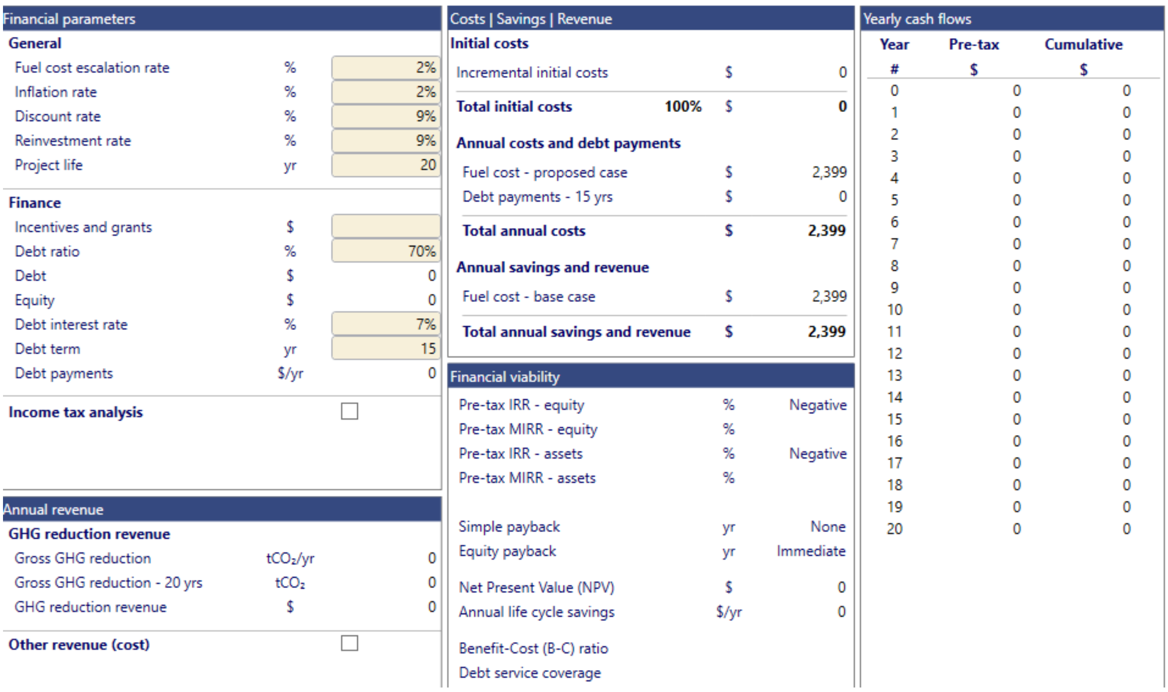


Figure 3.9: Financial analysis

CHAPTER 4
RESULTS AND DISCUSSION

4.1 Description of Weather Data

In fact, the air temperature and relative humidity are important factors that affect the power generation of the solar panels. Therefore, the descriptive statistics of the selected location including maximum, minimum, mean, standard deviation (SD) and coefficient of variation (CV) is presented in Table 4.1. It is found that the mean air temperature, relative humidity and global solar radiation are 20.416℃, 68.148% and 226.06 W/m^2, respectively. Furthermore, the annual mean GHI is found to be 226.06W/m^2, indicating that the selected location has high solar radiation. Moreover, Figures 4.1 and 4.2 illustrate the monthly variation for climate data including air temperature, relative humidity and daily global horizontal irradiance. It is noticed that the highest daily global horizontal irradiance of 8.41 kWh/m^2/d and lowest relative humidity of 52.9% are recorded in August and July, respectively.

Table 4.1: Descriptive statistics of weather parameters

Variable	Mean	SD	Variance	CV	Minimum	Maximum
T	20.416	3.86	14.9	18.91	11.4	29.93
RH	68.148	13.343	178.031	19.58	0.5	99
GHI	226.06	311.58	97082.81	137.83	0	1059
DNI	254.04	332.23	110373.5	130.78	0	1010.06
DHI	68.44	87.6	7673.797	128	0	475
IRD	338.89	36.3	1317.84	10.71	250.59	431.6
WS	2.511	1.4053	1.9749	55.96	0.59	10.71
AP	100633	557	310287	0.55	99315	102348

T	Air temperature [℃]
RH	Relative Humidity [%]
GHI	Global horizontal irradiance [W/m^2]
DNI	Direct normal Irradiance [W/m^2]
DHI	Diffuse horizontal irradiance [W/m^2]
IRD	Infrared radiation downwards[W/m^2]
WS	Wind speed [m/s]
AP	Air pressure [Pa]

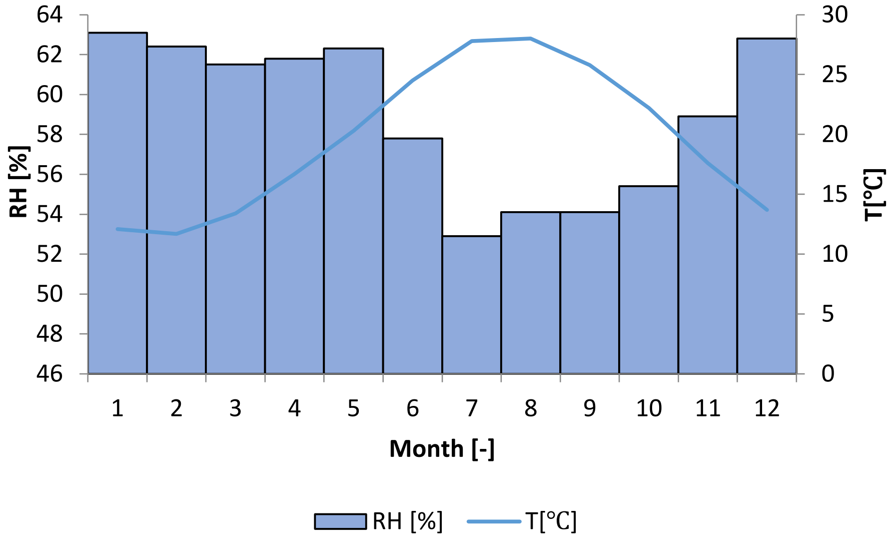


Figure 4.1: Monthly variation of relative humidity and air temperature

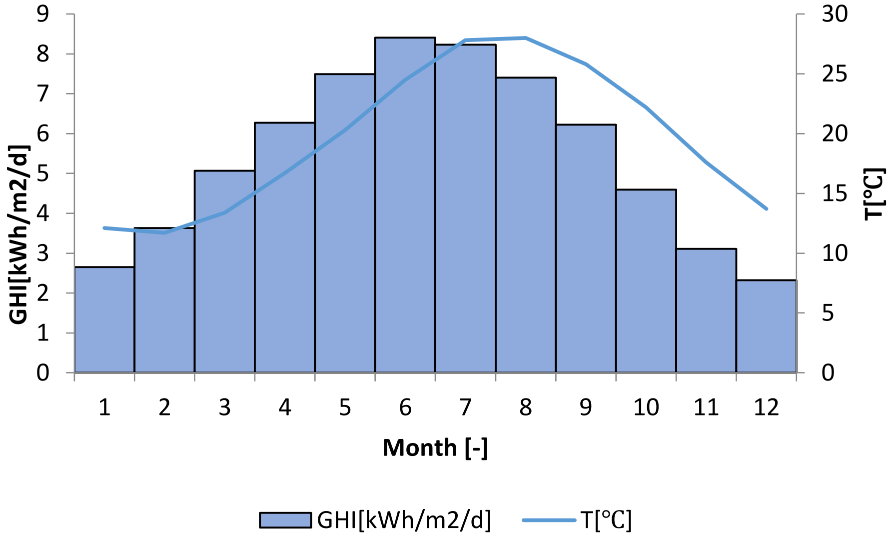


Figure 4.2: Monthly variation of daily global horizontal irradiance and air temperature

4.2 Effect of Slop Angle on Solar Radiation

Figure 4.3 shows the monthly global solar radiation for different slope angles based on simulation and experimental results. In addition, the annual global solar radiation for five selected slope angles is shown in Figure 4.4. In fact, the chosen angle was selected based on the angles of water solar system and PV plant in Northern Cyprus. Moreover, the optimum angle for free standing system was chosen based on PVGIS (Photovoltaic Geographical Information System) simulation tool. The maximum solar irradiation is recorded for slope angles 32° with a value of 2351kWh/m^2. Additionally, the highest and lowest solar irradiation values are obtained in August and January, respectively.

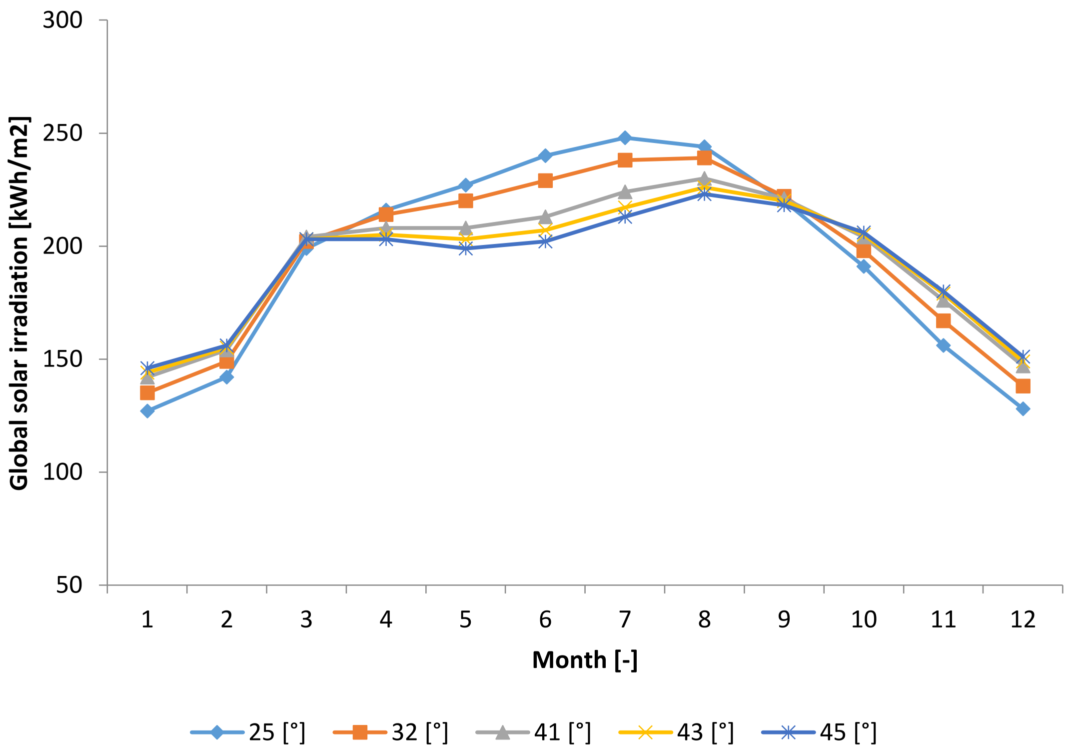


Figure 4.3: Solar radiation vs month for different slope angles

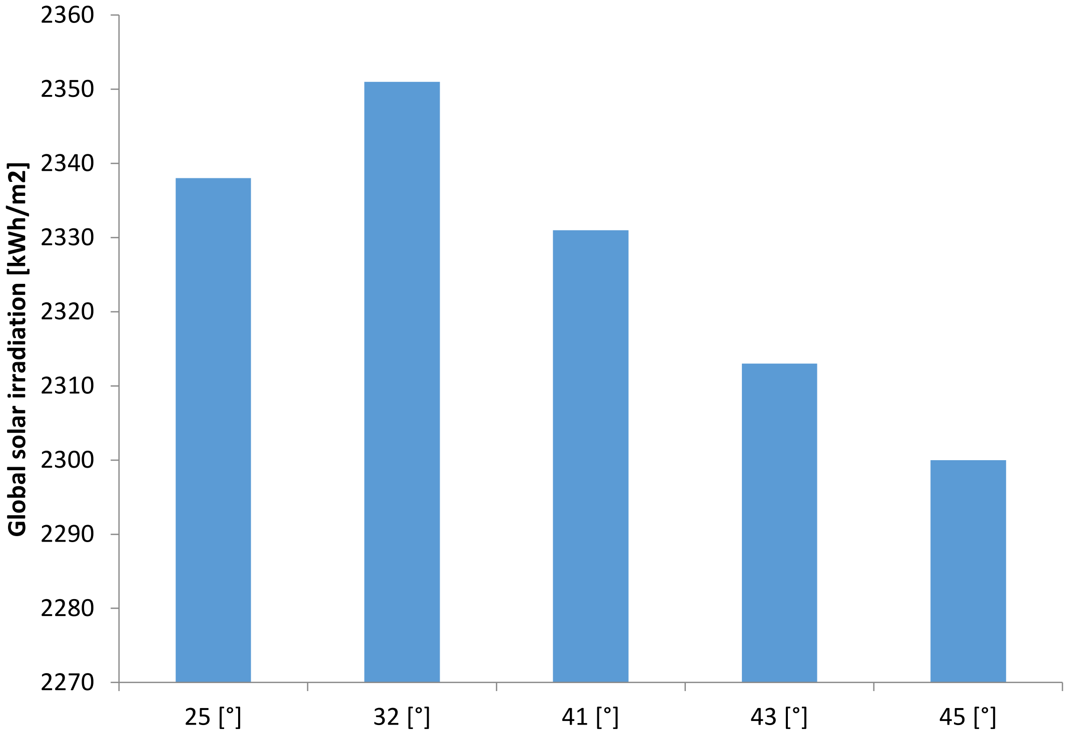


Figure 4.4: Annual solar radiation vs slope angles

4.3 Effect of Slop Angle on Energy Production

Figure 4.5 shows the monthly energy production for different slope angles based on simulation results. In addition, the annual energy production for five selected slope angles is shown in Figure 4.6. The maximum solar irradiation is recorded for slope angles 32° with a value of 914kWh. Additionally, the highest and lowest solar irradiation values are obtained in August and January with a value of 90kWh and 55.1kWh, respectively for optimum angle (32°).

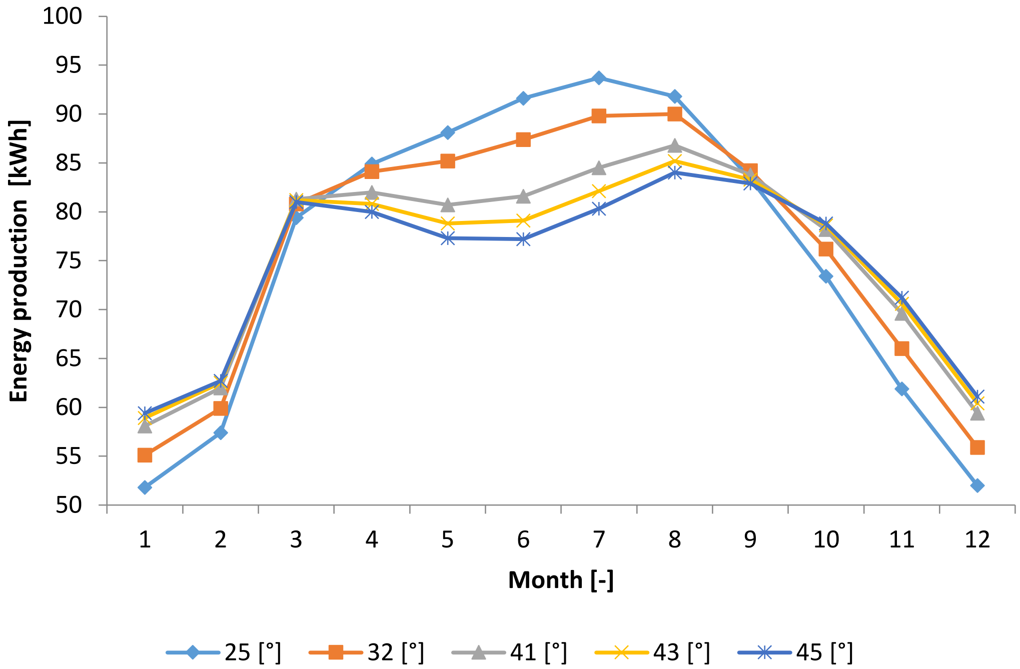


Figure 4.5: Energy production vs month for different slope angles

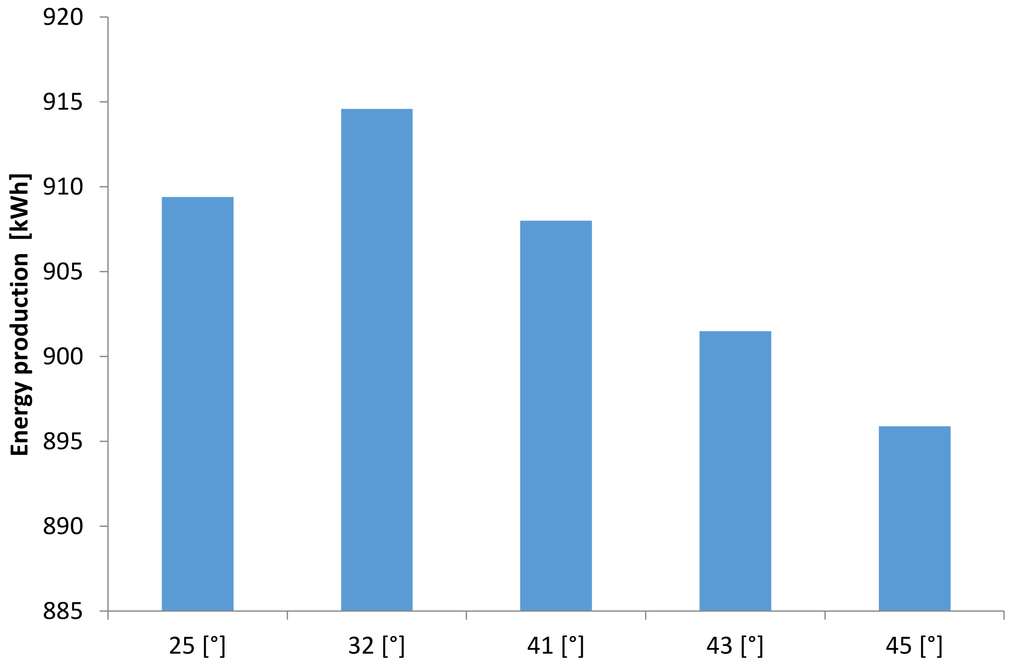


Figure 4.6: Energy production vs slope angles

4.4 AC and DC Output of 1kW System

As mentioned previously, the best angle for the proposed 1kW free-standing system is 32° and the maximum and minimum energy production are achieved in August and January, respectively. In this study, the AC and DC outputs of the proposed system are measured experimentally (see Appendix 1). Therefore, Figures 4.7-4.10 illustrate the AC and DC output for the proposed system for August and January. Moreover, it is noticed that the maximum energy output in terms of AC and DC output is recorded for the first day and last day in August and January, respectively. The AC and DC output for these days are shown in Figures 4.11 and 4.12. It is observed that the system starts storage electricity or generate electricity during the period of 06:00 am-19:00 pm for August and 06:00 am-17:00 pm for January. In addition, it is found that the maximum AC and DC output is recorded at 12:00 pm for both months (i.e. AC = 142W and DC = 150W for January, AC = 506W and DC = 526W for August) as shown in Figures 4.11 and 4.12.

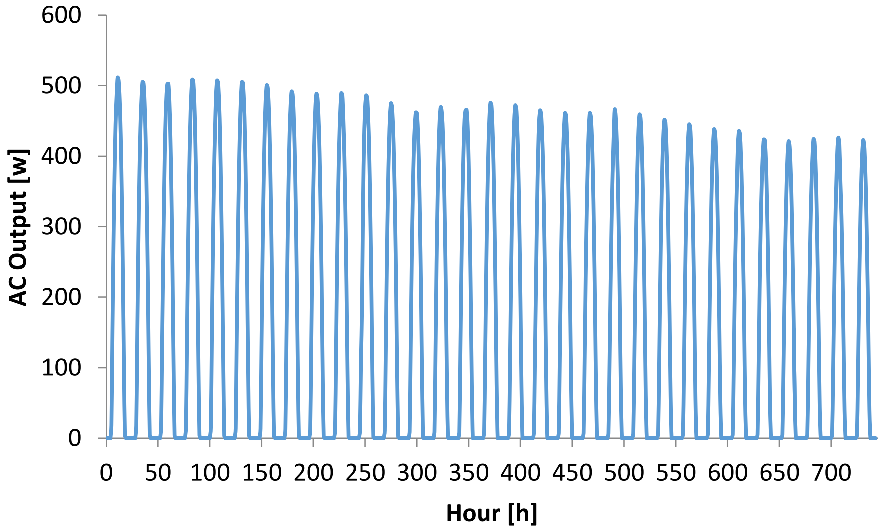


Figure 4.7: AC output for August

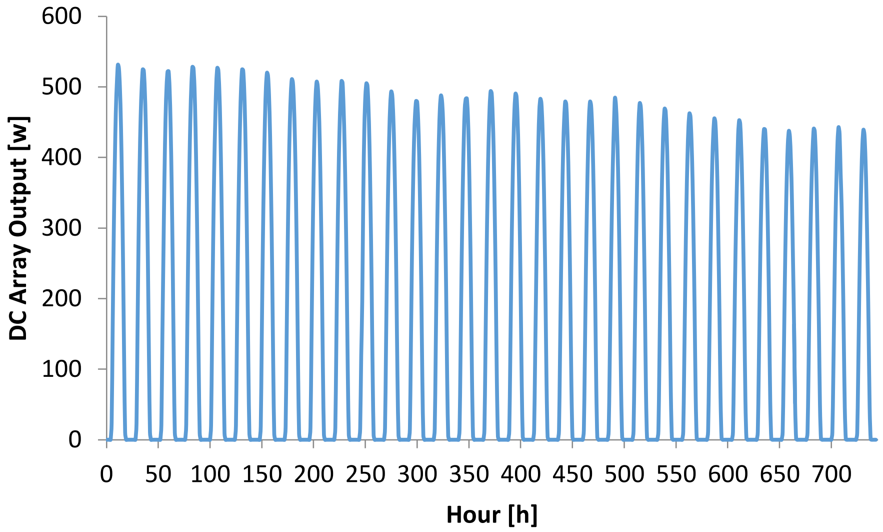


Figure 4.8: DC array output for August

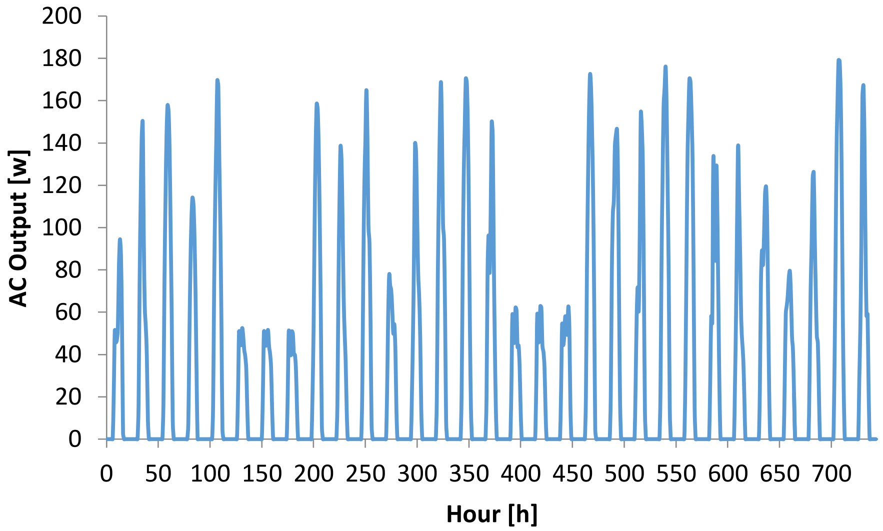


Figure 4.9: AC output for January

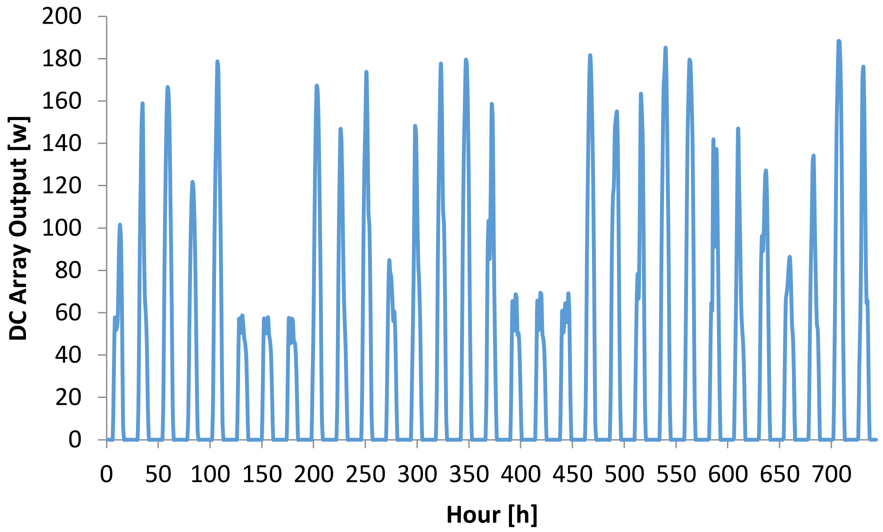


Figure 4.10: DC array output for January

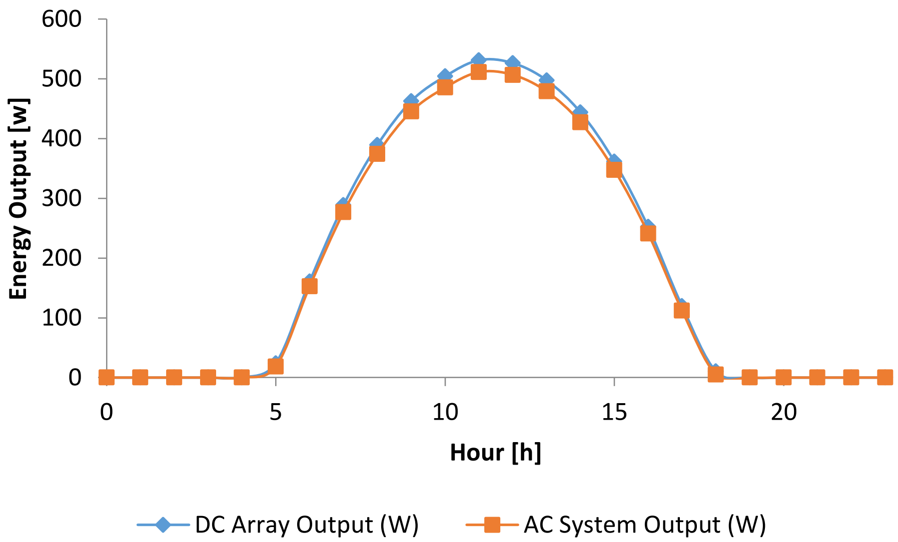


Figure 4.11: AC and DC output for first day in August

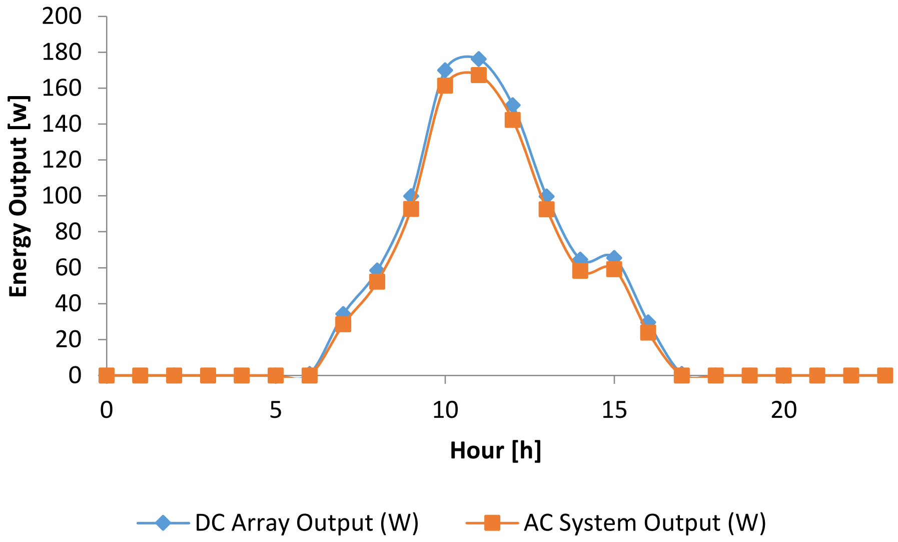


Figure 4.12: AC and DC output for the last day in January

4.5 Economic Analysis

In order the estimate the solar potential in the selected region, the geographical location of the selected study is entered. Figure 4.13 shows the coordinate and weather parameters of the selected study. The results indicate the selected region has hug solar potential (i.e. selected region has a daily solar radiation of 5.46 kWh/m^2/d, air temperature of 19.5°C and relative humidity of 58.9%.

	Unit	Climate data location	Facility location	Source
Latitude		35.2	35.2	
Longitude		33.0	33.0	
Climate zone		3A - Warm - Humid		NASA
Elevation	m	40	0	NASA – NASA
Heating design temperature	°C	7.6		NASA
Cooling design temperature	°C	31.1		NASA
Earth temperature amplitude	°C	14.6		NASA

Month	Air temperature	Relative humidity	Precipitation	Daily solar radiation - horizontal	Atmospheric pressure	Wind speed	Earth temperature	Heating degree-days 18 °C	Cooling degree-days 10 °C
	°C	%	mm	kWh/m²/d	kPa	m/s	°C	°C-d	°C-d
January	12.1	63.1%	81.44	2.65	98.8	4.3	14.5	183	65
February	11.7	62.4%	72.97	3.63	98.6	4.5	14.5	176	48
March	13.4	61.5%	48.09	5.07	98.5	4.0	16.5	143	105
April	16.7	61.8%	51.25	6.27	98.4	3.5	20.1	39	201
May	20.3	62.3%	24.15	7.49	98.3	3.1	24.4	0	319
June	24.5	57.8%	4.94	8.41	98.1	3.3	28.8	0	435
July	27.8	52.9%	0.36	8.23	97.8	3.4	32.1	0	552
August	28.0	54.1%	1.90	7.40	97.9	3.4	32.2	0	558
September	25.8	54.1%	14.19	6.22	98.3	3.4	29.5	0	474
October	22.2	55.4%	40.53	4.59	98.6	3.2	25.2	0	378
November	17.6	58.9%	79.10	3.11	98.7	3.7	20.0	12	228
December	13.7	62.8%	103.15	2.32	98.8	3.9	16.0	133	115
Annual	**19.5**	**58.9%**	**522.07**	**5.46**	**98.4**	**3.6**	**22.9**	**686**	**3,478**

Figure 4.13: Weather data of selected region

In this study, 20 solar panels of 250Wp are used for a total power generation capacity of 1kW with an efficiency of 11.4% (see Figure 4.14). Two inverters with a capacity of 500W are used. The simulation results indicate that the capacity factor of the proposed PV plant is 18.4%. In addition, the initial cost of the proposed system is about 1000$ as shown in Figure 4.14.

Photovoltaic		
Type		mono-Si
Power capacity	kW	1
Manufacturer		BP Solar
Model		mono-Si - BP 250/1 od./2
Number of units		20
Efficiency	%	11.4%
Nominal operating cell temperature	°C	45
Temperature coefficient	% / °C	0.4%
Solar collector area	m^2	8.8
Miscellaneous losses	%	15%
Inverter		
Efficiency	%	95%
Capacity	kW	4.5
Miscellaneous losses	%	1%
Summary		
Capacity factor	%	18.4%
Initial costs	$	1,000
O&M costs (savings)	$/kW-year	0
	$	0
Energy saved	kWh	1,616

Figure 4.14: Technical data of solar panels and selected inverters

This work describes the free-standing PV system for a single-family house in Northern Cyprus. The electrical equipment along with the load and number of hours used during a day in the selected house is shown in Figures 4.15 and 4.16.

Electrical equipment

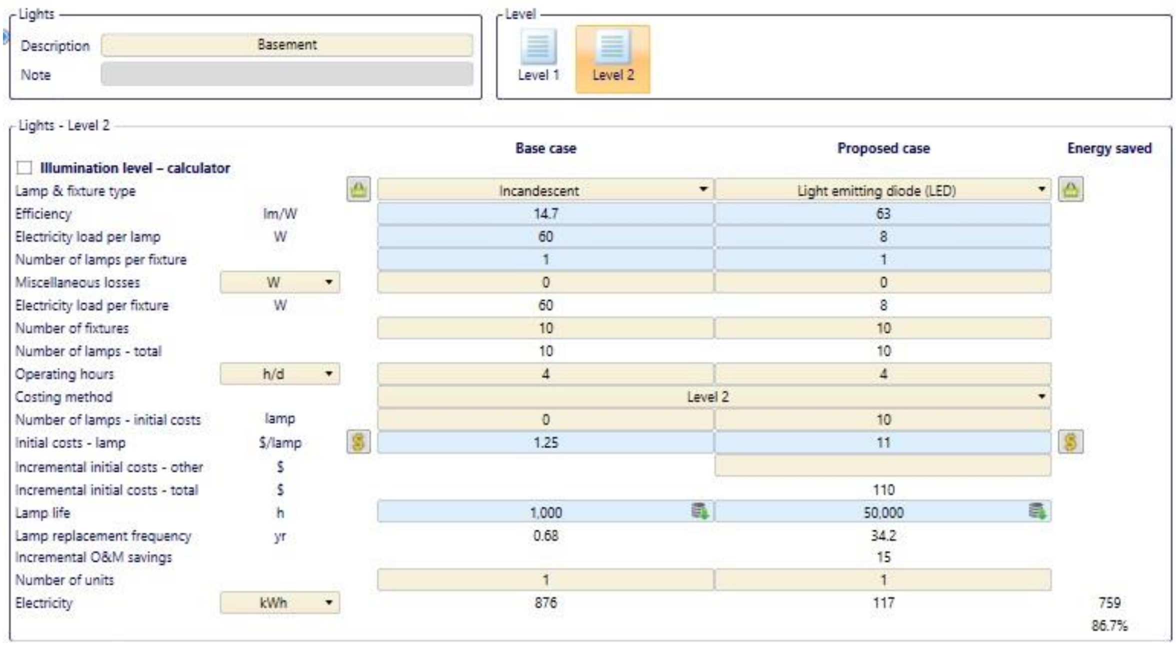
Description	Electrical equipment
Note	

Electrical equipment

Description	Electricity load - typical W	Base case Quantity	Base case Operating hours h/d	Base case Electricity load W	Base case Duty cycle %	Proposed case Quantity	Proposed case Operating hours h/d	Proposed case Electricity load W	Proposed case Duty cycle %	Incremental initial costs $
TV	80 - 300	1	12	80	100%	1	12	80	100%	
Clothes washer	350 - 500	1	1	480	30%	1	1	480	30%	
Refrigerator	300 - 725	1	24	300	30%	1	24	300	30%	
Computer	200 - 300	1	5	200	100%	1	5	200	100%	
Vacuum cleaner	800 - 1440	1	0.5	800	30%	1	0.5	800	30%	0
Air-conditioner - window unit	750 - 1100	1	5	750	75%	1	5	750	75%	
Clothes iron	1000 - 1800	1	0.2	1,000	50%	1	0.2	1,000	50%	
Microwave oven	750 - 1200	1	1	750	100%	1	1	750	100%	
Receiver		1	12	12	100%	1	12	12	100%	
Water pump	250 - 1100	1	3	250	100%	1	3	250	100%	
Toaster	800 - 1400	1	1	800	100%	1	1	800	100%	
Total										0

		Base case	Proposed case	Energy saved
Incremental initial costs	$		0	
Incremental O&M savings	$			
Electricity	kWh	3,555	3,555	0 0%

Figure 4.15: Electrical equipment's in the selected house



Lights

Description	Basement
Note	

Level: Level 1, Level 2

Lights - Level 2

Illumination level – calculator		Base case	Proposed case	Energy saved
Lamp & fixture type		Incandescent	Light emitting diode (LED)	
Efficiency	lm/W	14.7	63	
Electricity load per lamp	W	60	8	
Number of lamps per fixture		1	1	
Miscellaneous losses	W	0	0	
Electricity load per fixture	W	60	8	
Number of fixtures		10	10	
Number of lamps - total		10	10	
Operating hours	h/d	4	4	
Costing method		Level 2		
Number of lamps - initial costs	lamp	0	10	
Initial costs - lamp	$/lamp	1.25	11	
Incremental initial costs - other	$			
Incremental initial costs - total	$		110	
Lamp life	h	1,000	50,000	
Lamp replacement frequency	yr	0.68	34.2	
Incremental O&M savings			15	
Number of units		1	1	
Electricity	kWh	876	117	759 86.7%

Figure 4.16: Lamp characteristics used in this study

The analysis of emissions of greenhouse gases, a proposed case is determined by using 1kW PV system. Figure 4.17 shows the analysis of CO_2 emissions avoided by using photovoltaic solar energy. It is found that CO2 emission is reduced by 13%. And the reduction of total annual emissions of greenhouse is 143$/tCO2 as shown in Figure 4.18. Moreover, the cumulative cash flows and Pre-tax are shown in Figure 4.19. This reflects that investment in proposed system based in PV, is profitable with positive profit margins after 4.1 years of operation.

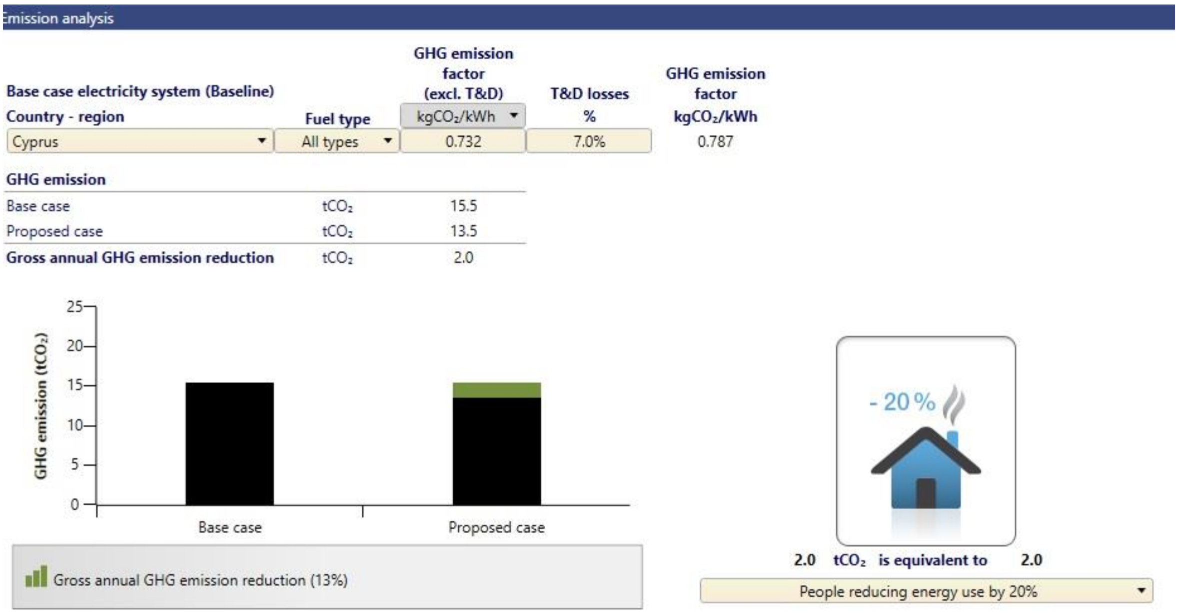
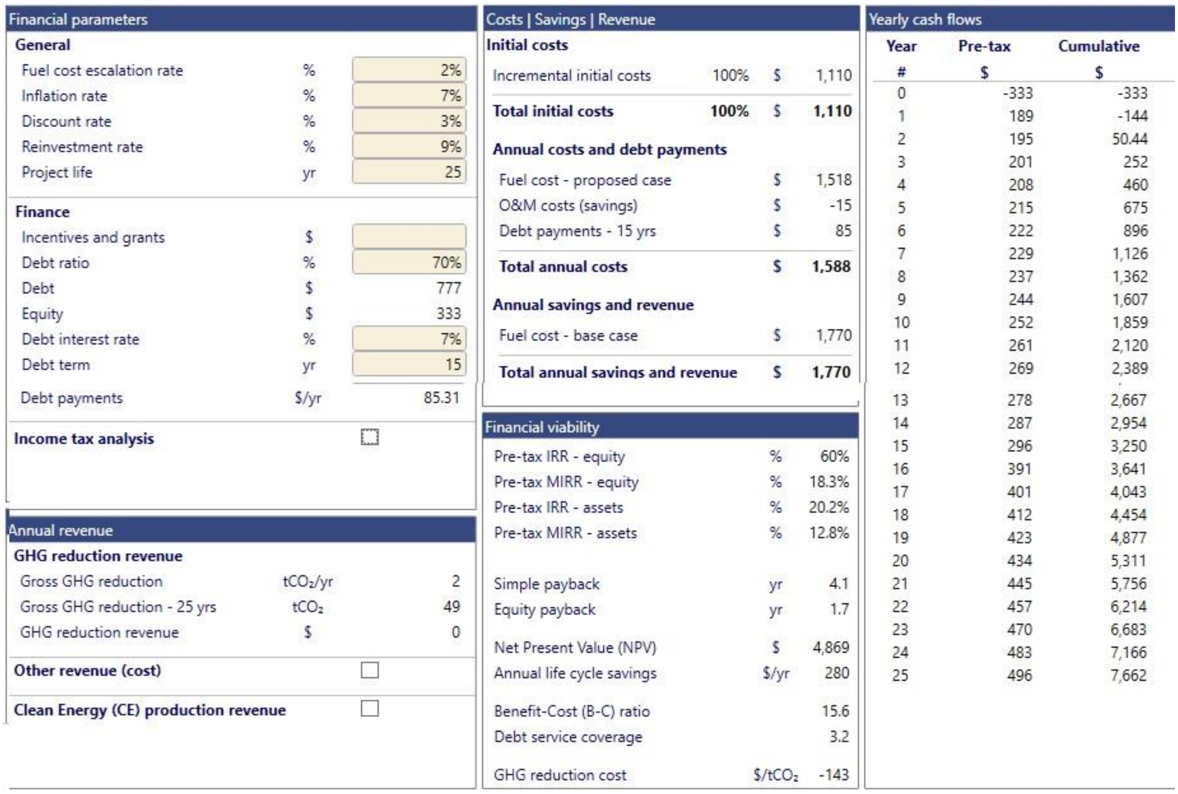


Figure 4.17: Analysis of CO2 emissions avoided by the use of solar energy



Financial parameters

General		
Fuel cost escalation rate	%	2%
Inflation rate	%	7%
Discount rate	%	3%
Reinvestment rate	%	9%
Project life	yr	25
Finance		
Incentives and grants	$	
Debt ratio	%	70%
Debt	$	777
Equity	$	333
Debt interest rate	%	7%
Debt term	yr	15
Debt payments	$/yr	85.31
Income tax analysis		☐

Annual revenue

GHG reduction revenue		
Gross GHG reduction	tCO_2/yr	2
Gross GHG reduction - 25 yrs	tCO_2	49
GHG reduction revenue	$	0
Other revenue (cost)		☐
Clean Energy (CE) production revenue		☐

Costs | Savings | Revenue

Initial costs			
Incremental initial costs	100%	$	1,110
Total initial costs	**100%**	**$**	**1,110**
Annual costs and debt payments			
Fuel cost - proposed case		$	1,518
O&M costs (savings)		$	-15
Debt payments - 15 yrs		$	85
Total annual costs		**$**	**1,588**
Annual savings and revenue			
Fuel cost - base case		$	1,770
Total annual savings and revenue		**$**	**1,770**

Financial viability

Pre-tax IRR - equity	%	60%
Pre-tax MIRR - equity	%	18.3%
Pre-tax IRR - assets	%	20.2%
Pre-tax MIRR - assets	%	12.8%
Simple payback	yr	4.1
Equity payback	yr	1.7
Net Present Value (NPV)	$	4,869
Annual life cycle savings	$/yr	280
Benefit-Cost (B-C) ratio		15.6
Debt service coverage		3.2
GHG reduction cost	$/tCO_2$	-143

Yearly cash flows

Year	Pre-tax	Cumulative
#	$	$
0	-333	-333
1	189	-144
2	195	50.44
3	201	252
4	208	460
5	215	675
6	222	896
7	229	1,126
8	237	1,362
9	244	1,607
10	252	1,859
11	261	2,120
12	269	2,389
13	278	2,667
14	287	2,954
15	296	3,250
16	391	3,641
17	401	4,043
18	412	4,454
19	423	4,877
20	434	5,311
21	445	5,756
22	457	6,214
23	470	6,683
24	483	7,166
25	496	7,662

Figure 4.18: Analysis of financial for proposed system

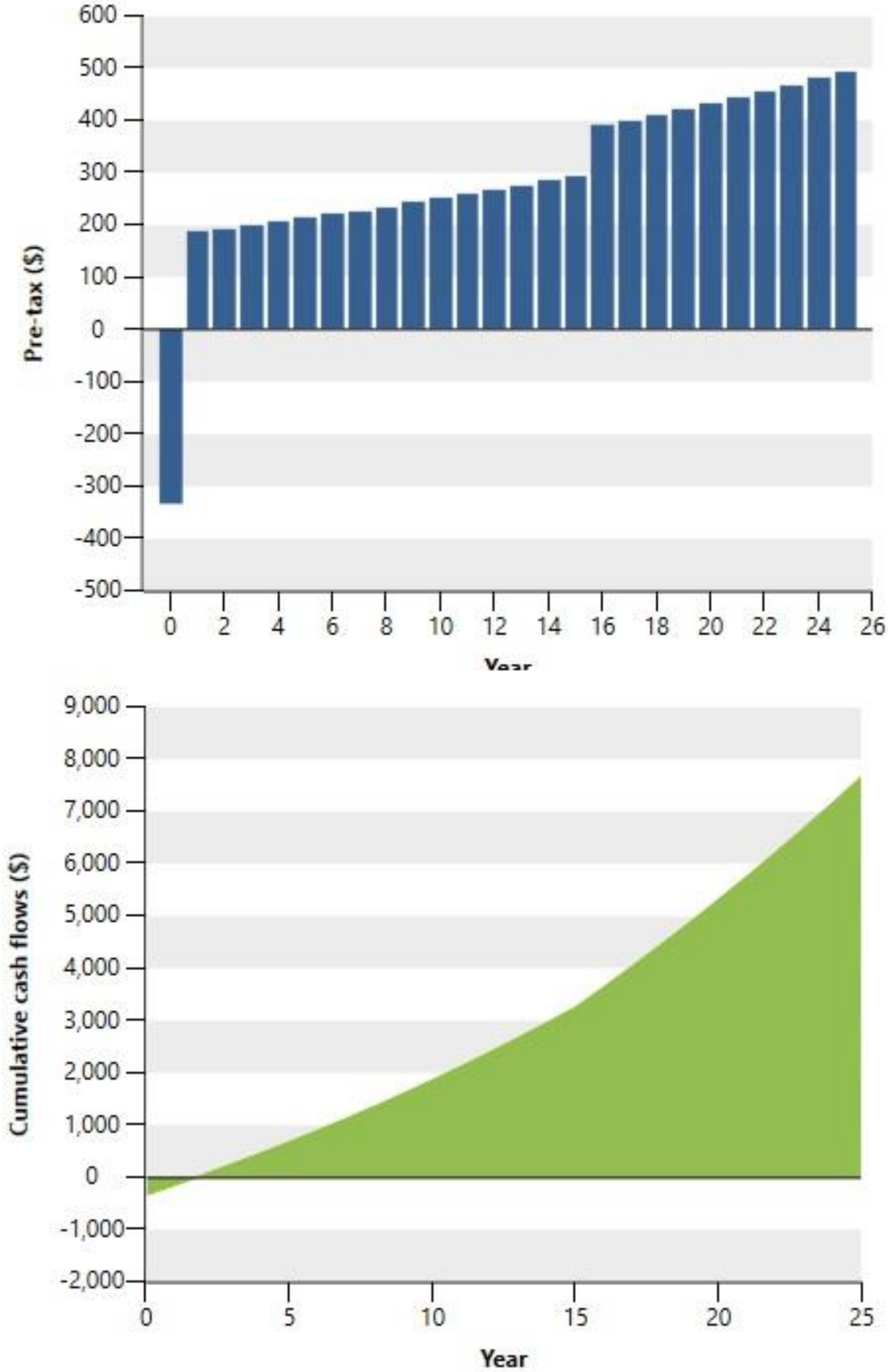


Figure 4.19: Cumulative cash flows and Pre-tax

4.6 Diesel Fuel vs PV system

Figures 4.20 and 4.21 illustrate the monthly electricity consumption using diesel fuel and electricity production using PV system for the selected houses. It is found that the annual PV electricity production is 1617kWh. In addition, it is observed that the maximum electricity production for the proposed system is recorded in summer season (June, July and August).

Moreover, the percentage of reduction is shown in Figures 4.18 and 4.19 for both houses. It is found that the average percentage of reduction is about 30% per year. It is concluded that Due to the high energy demand of the house, the use of solar energy can be helped to reduce the demand into 100% of clean energy.

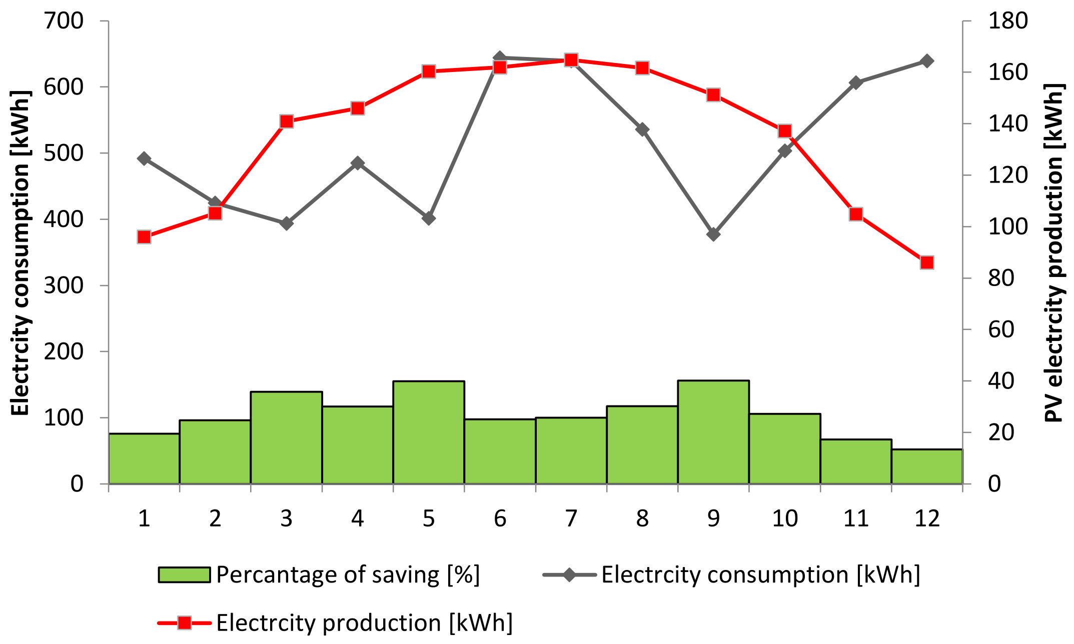


Figure 4.20: Percentage of electric reduction for house 1

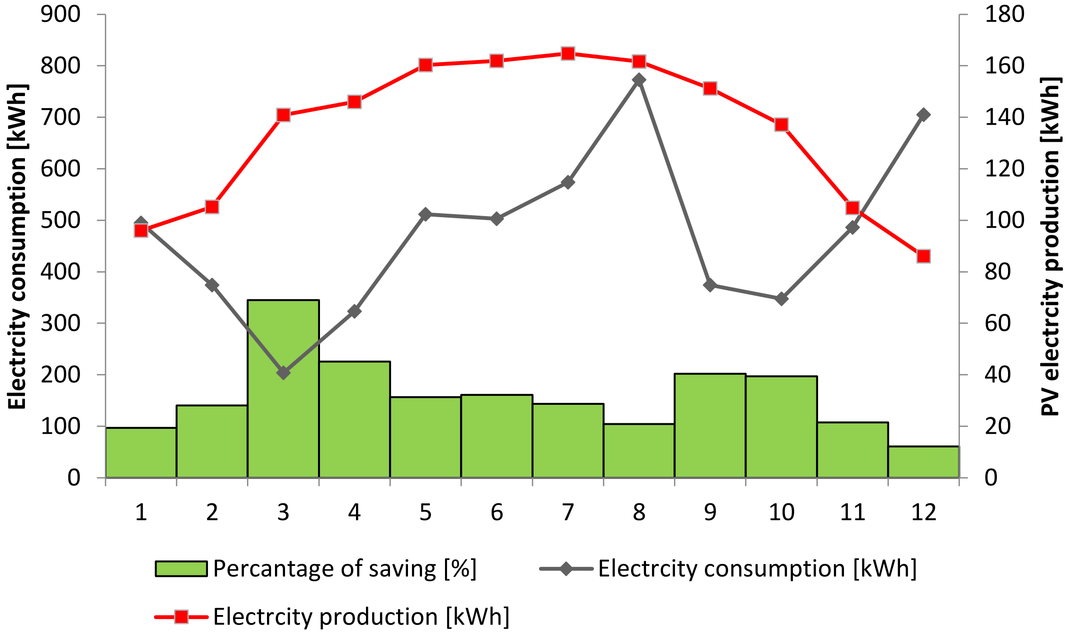


Figure 4.21: Percentage of electric reduction for house 2

CHAPTER 5
CONCLUSIONS

5.1 Conclusions

The manifestations of technology have influenced contemporary architecture, especially those related to the environmental control organization. Solar systems are one of the environmental control systems. They fall within the conceptual set of integrating the building with the environment due to its use of environmentally friendly renewable energy sources.

Therefore, the evaluation of the techno-economic of 1kW gird/grid-off connected PV system for a small household was made in this study. The AC and DC output of the proposed system were measured experimentally and the RETSCreen simulation tool was used to estimate the reduction of CO2 emissions. In order to investigate the performance of the proposed system, the generated electricity is compared with the electrical consumption of two selected houses in the chosen region. The significant findings are summarized below.

- It is found that the mean air temperature, relative humidity and global solar radiation are 20.416℃, 68.148% and 226.06 W/m^2, respectively. Furthermore, the annual mean GHI is found to be 226.06W/m^2, indicating that the selected location has high solar radiation.
- The maximum solar irradiation is recorded for slope angles 32° with a value of 2351kWh/m^2. Additionally, the highest and lowest solar irradiation values are obtained in August and January, respectively.
- the highest and lowest energy production from the proposed system is obtained in August and January with a value of 90kWh and 55.1kWh, respectively for optimum angle (32°).
- It is observed that the system starts storage electricity or generate electricity during the period of 06:00 am-19:00 pm for August and 06:00 am-17:00 pm for January. In addition, it is found that the maximum AC and DC output is recorded at 12:00 pm for both months (i.e. AC = 142W and DC = 150W for January, AC = 506W and DC = 526W for August)

- The simulation results indicate that the capacity factor of the proposed PV plant is 18.4%.
- It is found that CO_2 emission is reduced by 13%. And the reduction of total annual emissions of greenhouse is 143$/t$CO_2$. This reflects that investment in proposed system based in PV, is profitable with positive profit margins after 4.1 years of operation.
- It is found that the average percentage of reduction for electricity consumption produced by diesel generators is about 30% per year.

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APPENDICE

RENEWABLE ENERGY

YE-1050 WIND AND SOLAR ENERGY (COMBINED) TRAINING SET

GENERAL EXPLANATION

This training set is designed to teach the combined working system of simple wind turbines and photovoltaic panel circuit

EXPERIMENTS

1. Wind turbine power generation-air velocity relationship
2. Calculation of turbine efficiency
3. Calculation of solar cell electrical capacity
4. Experimental study of solar cell angle dependent of current-angle change

DIMENSIONS

Control Panel
A x B x H : 880 x 450 x 1500 mm

Solar Panel
A x B x H : 1270 x 750 x 1130 mm

Wind Turbine
A x B x H : 800 x 750 x 1595 mm

OPTIONAL FEATURES

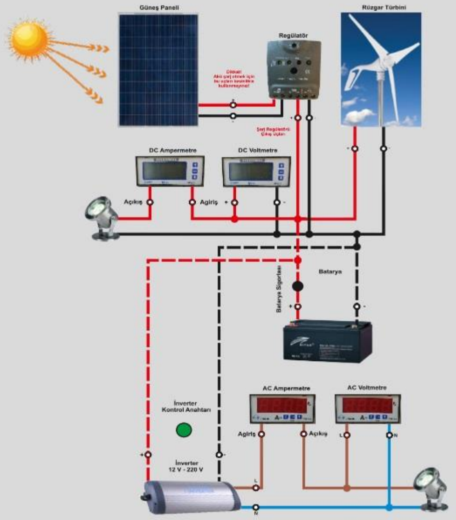
- Touch LCD Display
- USB Computer Connection
- Computer Control

PACKAGE INCLUDED

Device, device cover, 1 printed experiment report, circuit diagram and product catalog

TECHNICAL SPECIFICATION

The combined training set teaches the connection of wind turbine and solar panel. Calculation the power generation and the efficiency of the wind turbine depend on the air velocity and the change of the power, efficiency and power of the solar cell is examined.



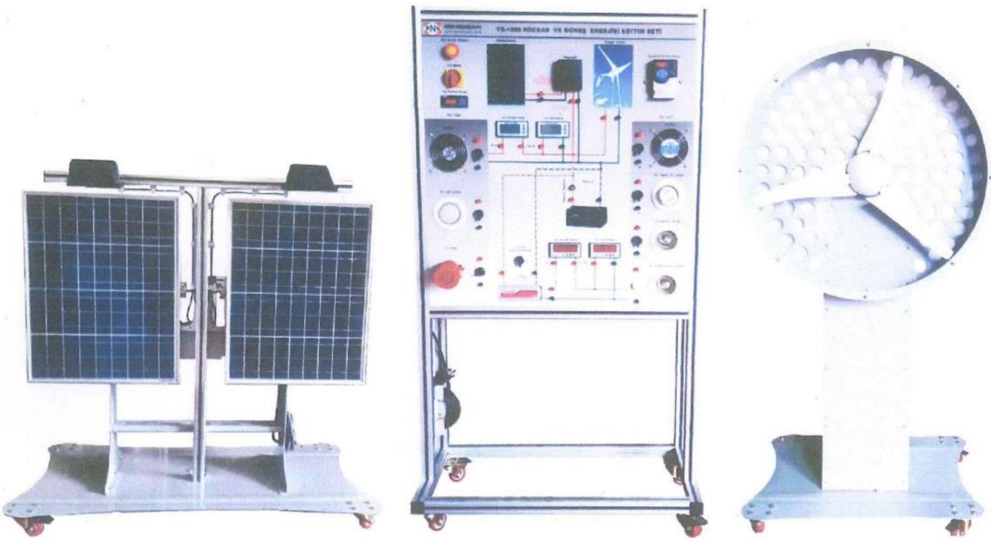
TECHNICAL DETAILS

- Wind turbine
- Solar panel
- Regulator
- Inventors
- Fan
- Siren
- Lamp
- Halogen lamp
- Battery

DENEYSAN

YE-1050 WIND AND SOLAR ENERGY (COMBINED)TRAINING SET

EXPERIMENTAL MANUAL



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BALIKESİR-2019

CONTENTS

TECHNICAL FEATURES

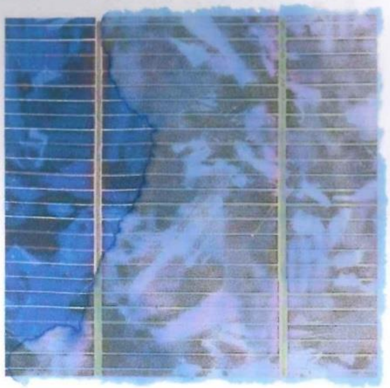
MATERIALS	FEATURES
Wind Turbine	Rotor diameter: 1.15 m, voltage: 12 VDC, power: 400 W
Inside regulator	Monthly kWh energy: 38 kWh 5.4 m/s
Solar cell	50 W, 2 pieces
Inverter	Mono phase, output power 300 W, output voltage 220 VAC
Accumulator	Eurostar 12V, 7Ah

DEVICE USER MANUAL

1. Close the top of the solar cells when the device is not in use.
2. When the wind turbine is not used close the wing.
3. Clean the top of the solar cells with a damp cloth and place them where the sun's rays are comfortable to see.

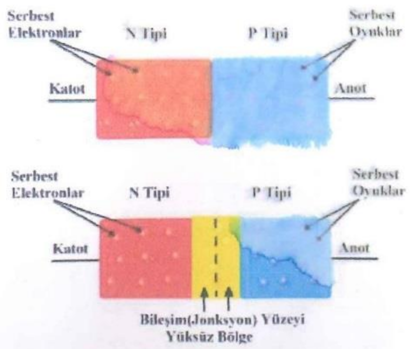
Generate electricity from the sun

In addition to being capable of generating electricity from solar energy in different ways, the most advanced technology in this regard is the generation of energy through solar panels (photovoltaic panels). In this technology, energy conversion is achieved by the use of semiconducting materials when the sunlight reaches the panel surface.



Working principal of solar cells

The photovoltaic effect is a simple physical process in which the Solar Pole transforms the sun's rays into electrical energy. It consists of particles of sunlight, photon or solar energy. Photons from the sunlight are composed of different wave lengths and contain various amounts of energy corresponding to these different wave lengths.

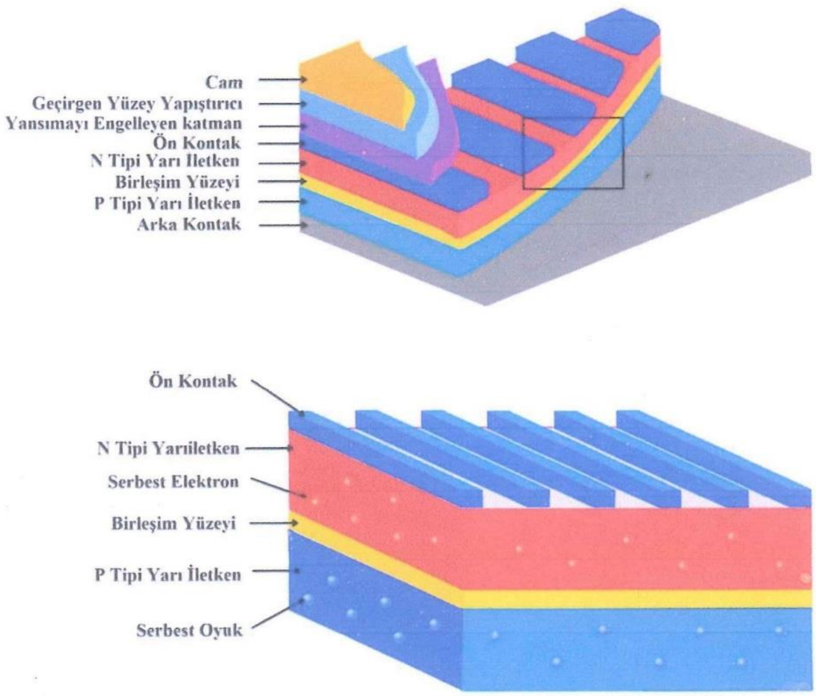


Bir yarıiletkende p-n ekleminin gösterimi

There are three possible conditions that can occur when the photons strike the PV surface. The photon can be reflected, absorbed, or passed directly. Only absorptive photons can produce electricity. In this case, the photon's energy is transferred to the electron in the struck cell. With this energy that the electron acquires, it escapes its normal position and transforms the sunlight into electric energy by forming a part of the current in an electric circuit.

The structure of solar cells

To bring the electric field inside a PV cell into the square, the two separate semiconductors are compressed together. Pure semiconductor materials do not transmit electricity well nor badly. For this reason, the number of electrons in the valence band is limited. Conductivity can be increased by increasing the number of electrons and cavities of a pure semiconductor. This is done by adding a pure semiconducting additive. There are two types of semiconductors formed by adding additive material. These are positive (p) and negative (n) type semiconductors. A PV cell consists of positive (p) and negative (n) type semiconducting materials.

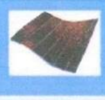


Display of layers of a solar cell

Types of solar cell

Different types of solar batteries are available depending on the materials used in production. Solar cell types are given comparative examples.

	Tek kristalli	Çok Kristalli	İnce Film
			
Avantajları	• Yüksek dereceli silikondan yapıldığı için en yüksek verimlilik • Yer kazanımı, ince film güneş pillerinin ürettiğinin 4 katına kadar üretim yapabilir • En uzun ömür, 25 yıl garanti • Düşük ışınım durumlarında en iyi performans	• İmalat süreci daha basit ve ucuzdur • Tek kristalli hücrelerle kıyaslandığında daha az atık silikon vardır	• Seri üretim daha basit, potansiyel olarak kristal esaslı hücrelere göre daha ucuz • Homojen görüntüleri görsel olarak daha estetiktir • Bir çok yeni uygulama alanına sebebiyet verecek şekilde esnek imal edilebilirler • Yüksek sıcaklıklar ve gölgeleme güneş paneli performansını daha az etkiler • Yer problemi olmayan durumlarda ünce film güneş panellerini kullanmak avantajlıdır
Dezavantajları	• En pahalı hücrelerdir • Eğer güneş paneli kısmi olarak gölge, kir veya kar ile kaplanırsa tüm devre kesilebilir (elektrik üretimi durabilir) • Tek kristal silikon imalatı için The Czochralski yöntemi kullanılmaktadır. Çok büyük silindirik silikon bloklar halinde üretilmektedirler. Bu silindir blokların dört köşesi silikon alttaş yapımı için kesilir. Önemli miktarda silikon atık haline gelir	• Düşük silikon saflığı yüzünden, çok kristalli hücreler tek kristalli güneş hücreleri kadar verimli değildirler. • Düşük yer verimi • Parçalı mavi görünüme sahip çok kristalli güneş hücrelerine göre, tek kristalli ve ince film güneş hücreleri daha düzgün bir yapıya sahip olduklarından estetik olarak daha güzel görünürler	• Genel olarak konutlarda kullanım için çok uygun değildirler. Ucuzdurlar ancak çok fazla yere ihtiyaç duymaktadırlar. • Düşük yer verimi demek PV ekipmanlarının fiyatlarının artacağı anlamına gelmektedir (örn. destek malzemesi ve kablolar) • Tek kristalli ve çok kristalli hücrelere göre daha hızlı degrade olurlar. Bu yüzden daha kısa süreli garantiler ile satılırlar

	Tek kristalli	Çok kristalli	Amorf	CdTe	CIS/CIGS
					
Tipik modül verimi	%15-20	%13-16	%6-8	%9-11	%10-12
En iyi araştırma hücresi verimi	%25,0	%20,4	%13,4	%18,7	% 20,4
1 kWp için gerekli alan	6-9 m^2	8-9 m^2	13-20 m^2	11-13 m^2	9-11 m^2
En düşük fiyat	0,75 $/W	0,62 $/W	0,69 $/W		
Sıcaklık dayanımı	Yüksek sıcaklıklarda performansı %10-15 düşmektedir	Tek kristalli hücrelere göre sıcaklık dayanımı daha azdır	Yüksek sıcaklıklara dayanabilir	Diğerleriyle kıyaslandığında göreceli olarak performans üzerinde etkisi daha azdır	
İlave detaylar	En eski ve en yaygın kullanılan hücre teknolojisidir	İmalat aşamasında daha az silikon atığı vardır	Kristal esaslı güneş hücrelerine göre daha hızlı performans kaybı olmaktadır Piyasada bulunması zordur		

Solar cell systems

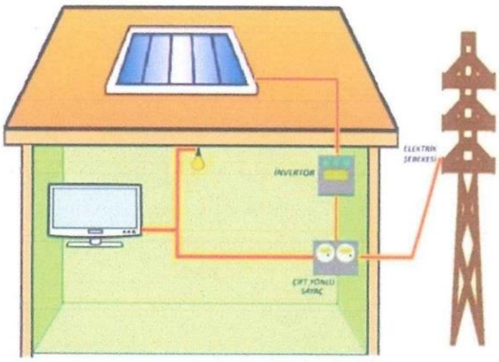
Solar battery systems can be used in any application where people need electrical energy. Depending on the applications of the solar cell module, it is built together with control devices such as inverters, accumulators, regulators, and various electronic support circuits. Applications of the solar system can be divided into two main groups;

i. On grid systems

ii. Off grid systems

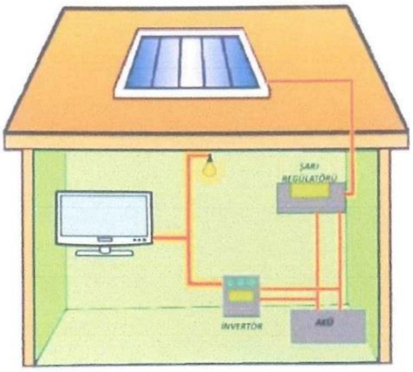
i. On grid systems:

Grid-connected solar cell systems can be in the form of large power systems (power plant size) or small power systems in buildings. Once the energy obtained in the small power systems meets the electric energy requirement of the system in which it is installed, the excess electric energy is sold to the electricity grid. In this case, however, the generated DC electricity is converted to AC and made suitable for the network. In the case where sufficient electricity cannot be produced, the electricity from the network is taken. There is no need for a battery pack because there is no storage in these systems.



ii. Off grid systems

The power obtained from the solar panels meets the needs of the system, while the excess energy is stored in the cells. This stored energy is used when solar energy is inadequate, especially during the night. A regulator is used to prevent damage to the battery due to overcharging and discharging. In systems, the regulator's task is to either stop the current draw of the system or cut the current from the solar cell by looking at the current situation.



Why should we use solar energy?

It is necessary to have enough knowledge about these systems in order to spread the systems working with Solar Energy. Naturally, solar energy systems also have advantages and disadvantages, as each energy is in the mirror and in the production system. The advantages and disadvantages for this purpose are listed below.

Advantages

- As in other renewable energy sources in our world where fossil fuels are starting to be consumed, solar energy is also an infinite, renewable and unlimited source of energy. This is the most important advantage of solar energy.
- In an environment of increasing global warming, carbon emissions do not come into play as they generate energy from solar energy. Environment is a system that does not have pollutant wastes, is environmentally friendly, and can be easily changed depending on energy need when needed.
- Another environmentalist feature of solar energy is that it does not cause noise pollution since it does not produce sound during operation.
- Solar energy provides many applications such as hot water, heating, cooling, industrial applications, electricity production without fuel cost.
- Solar energy systems are easy to install systems according to energy needs. In addition, systems can be expanded quickly and easily in case of increased energy requirements.
- It does not create much maintenance cost in use after production and installation costs in solar energy systems. Solar powered systems can be easily transported and installed. The use of solar batteries is more economical in rural areas where there is no electricity grid or where the mains line is expensive.
- Although solar systems have high initial installation and production costs, there is a recycling of initial cost relative to fossil fuels when considered in the long run.
- The solar battery is durable, reliable and long lasting. Each house can meet its energy with solar batteries installed in its roof. Thus, transmission and energy transport costs and losses are coming to an end.

Disadvantages

- The most important disadvantage is that the production and installation costs of photovoltaic panels and tracking system collectors are high.
- It depends on the sunshine state of the solar energy systems. Cloudy weather, environmental pollution, sunshine direction directly affect the efficiency in some systems.
- Especially in collectors who produce electricity, large areas are needed to prevent shading. Solar energy systems need storage systems to provide night energy continuity.
- The efficiency of the solar cells is low (around 15%).
- The solar collectors used in the buildings can cause some problems in appearance and space.
- Semiconducting materials used in photovoltaic cells can cause environmental pollution after the end of life.
- Solar energy technology is not yet enough for transportation applications. It is a developing technology.

What is Wind Energy?

It's hard to imagine that air is a fluid. Because the air is invisible. Unlike liquids, the air moves more quickly and covers every part of the environment. With the rapid placement of air, the particles move quickly. The process of converting this characteristic of air into kinetic energy is called wind energy.

In the same sense, hydroelectricity is called hydroelectricity by using the displacement property of liquids such as water, and the produced center is called hydroelectric power plant. The centers that produce electricity from wind energy are also called wind power plants.

After the wind power plants have been installed, the propellers turn the curtain they are attached to by the movement of the wind (air). With a suitable generator this energy is converted into electricity energy.

Wind energy starts with the sunrise. Near parts of the cold air layer that is formed at night begin to warm up with the rays of the sun. As you recall from the physics classes, the warming air expands and rises. The cold air layer in the atmosphere descends to this place. Wind is generated by the change of hot and cold air.

Wind turbine

Propeller Wings

When the wind blows, the wind hits the wing of the propeller and starts to rotate it. In this view, kinetic (motion) energy is obtained by wind energy. Propellers are designed to turn in the same direction when the wind is blowing.

Shaft

When the propellers turn, the shaft connected to it also begins to turn. Rotation of the shaft also creates movement in the motor and electrical energy is provided at the output of the motor.

Generator

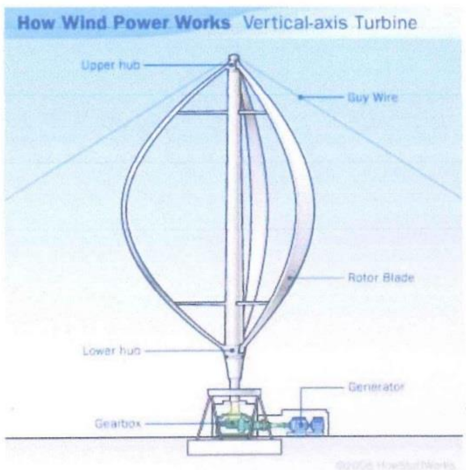
There is a very simple way of working. Electric energy is produced by electromagnetic induction. Small toy cars are similar to the electric motor. There are magnets in it. In the middle of these magnets is also a section wrapped with thin wires. When the propeller shaft rotates, this winding region in the engine begins to rotate in the middle of the magnets around it. This results in an alternating current (AC).

Today's wind turbines are more complex than windmills that are used in fields. Windmills are not widely used in our country. Now let's continue to recognize modern wind turbines.

How Wind Turbines Work

Modern Wind Turbine Technology

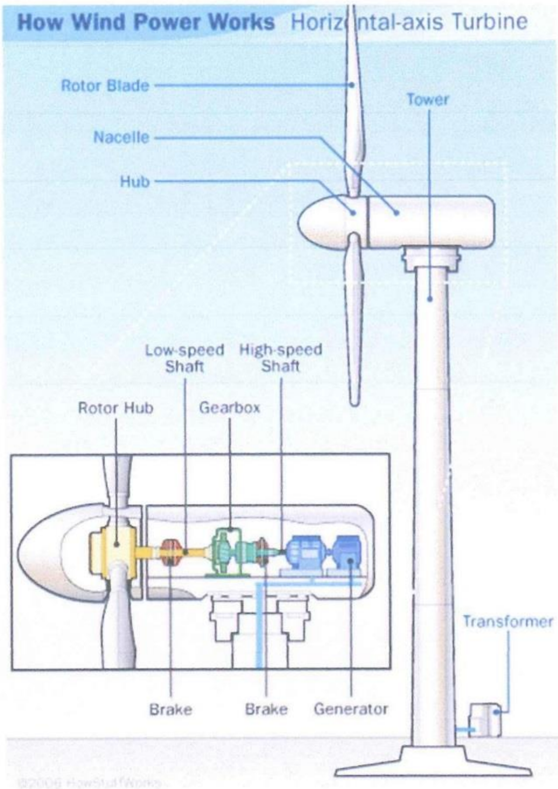
Wind Turbines now face two different designs. The first one is the design that turns around the vertical axis as you see it in the bottom photo.



Vertical Axis Wind Turbine

The vertical axis is designed to be perpendicular. It is always adjusted according to the direction of the future of the wind. There is no need to adjust the earth axis according to the wind. In general, it requires an electric motor as the first movement. The turbine is fixed through the auxiliary wire axis. In places near the sea level, the efficiency of the device is lower because it receives less wind. However, although all necessary equipment is an advantage at the ground level, the negative impact on agricultural land is high.

Another important design is the horizontal axis wind turbine. The rotation axis is designed parallel to the axis. With the help of an electric motor, the direction of the propeller can be adjusted according to the direction of the wind. Structurally, it is not different from an electric motor. It must be about 80 meters above sea level to be able to operate efficiently.



Rotor Blades: It turns wind energy into rotational motion.
Shaft: It transmits the rotational motion to the generator.
Gear Box: It increases the speed between the propeller and the shaft and helps to transmit a faster movement.
Generator: The part that generates electricity from the rotational motion.
Breaks: It helps to stop the propeller when there is an overload and a problem.
Electrical Equipment: It ensures that the electricity generated is transmitted to the relevant centers.

Advantages

1. Wind energy is not a new discovery. It is the best known method for generating mechanical energy using kinetic energy (wind). For thousands of years the Persians and then the Romans were using windmills to draw water and grind grain.

2. The meaning of wind energy in the sense of renewable energy is that the planet is constantly generating wind and this energy is infinite and it is not an obstacle for people to use it by transferring it to the system.

3. Wind energy is cheap. Considering factors such as the manufacturer, distribution network and installation site, it can be bought at an average of 4-6 cents / kWh (USA).

4. The use of wind energy instead of electricity production with coal means the reduction of the gases released to the environment, and thus the contribution to the environment.

5. The wind is available everywhere in the world, maybe some countries or places get more wind, but they are generally available everywhere. Natural gas, oil, coal, etc. to obtain energy transfer is not required, so even the most remote corner can be established.

6. In general, wind farms take up less space than coal-fired power plants. Although some people are against the wind turbines, there will certainly not be a coal plant behind their homes.

7. Wind turbines can fit into any climate and can use agricultural areas, animal areas. The wind turbines do not need to be alone, they can share the area.

8. The wind energy is advantageous in the places where there is no network, in the mountains and in the third world countries to give electricity to the region.

9. Wind turbines are not only used for commercial purposes and need not be used, and at the same time their use in household needs is increasing rapidly.

Disadvantages

1. Wind energy is not an uninterrupted or balanced source of energy, thus providing unbalanced power to the grid. Turbines can be damaged in very strong windy regions of the wind and in areas where there are many hurricanes, such as the American Gulf region.

2. For some people, it disrupts their view. The images are not good.

3. Wind power is not the same in every region and country. For this reason, wind maps with more accurate measurements are needed.

4. Although government subsidies support tax reductions (in some countries), the high initial investment cost and return on investment is a question.

5. Generally, the distances from the settlement areas constitute the problem of network connection.

6. More research and development is needed to use batteries, hydrogen or other systems to store the energy produced in wind turbines.

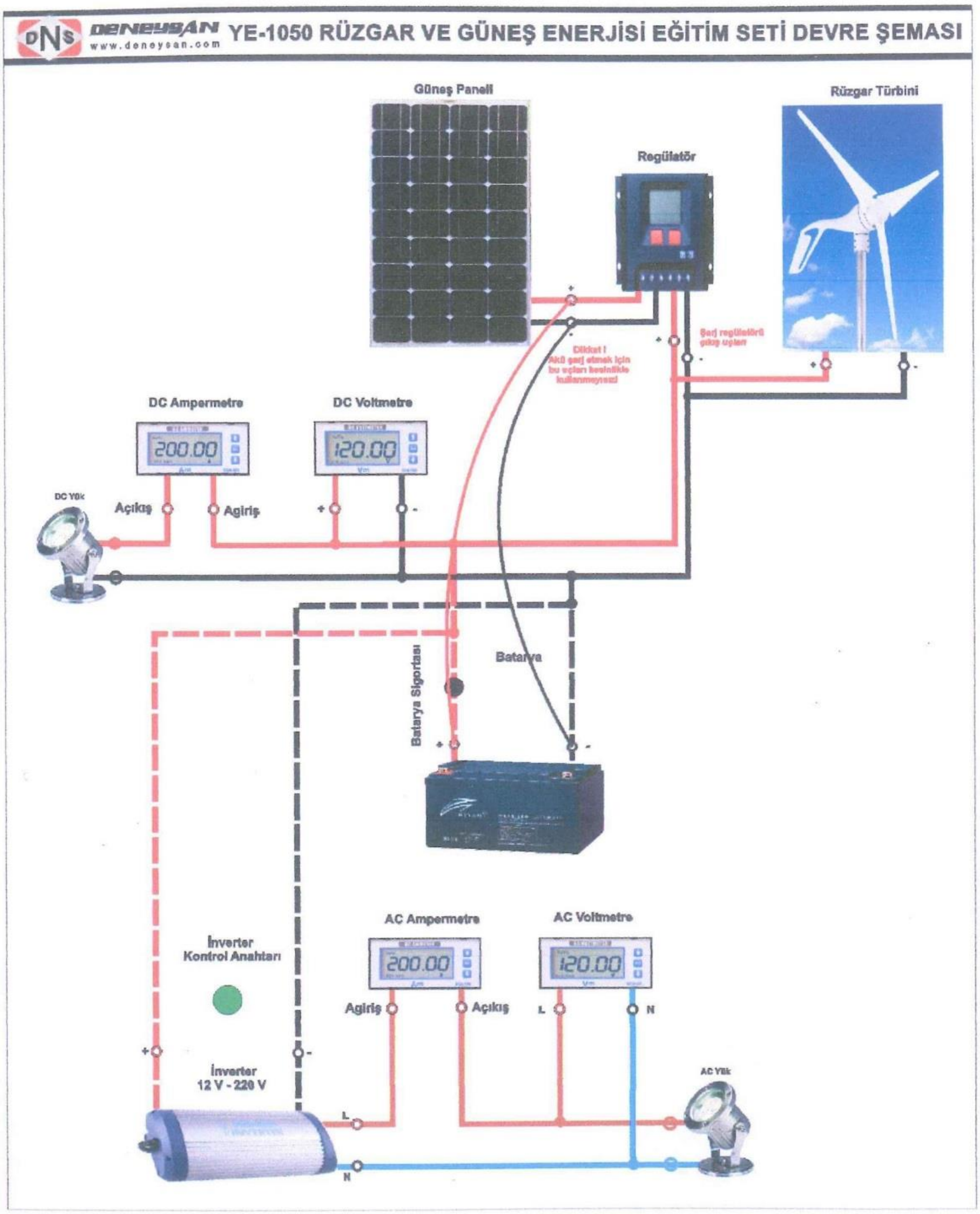
7. Some environmentalists believe that large-scale wind turbines will change the flight paths of migratory birds.

8. The wind turbine may be a factor in living near or difficulty working because of the noise caused by the tap.

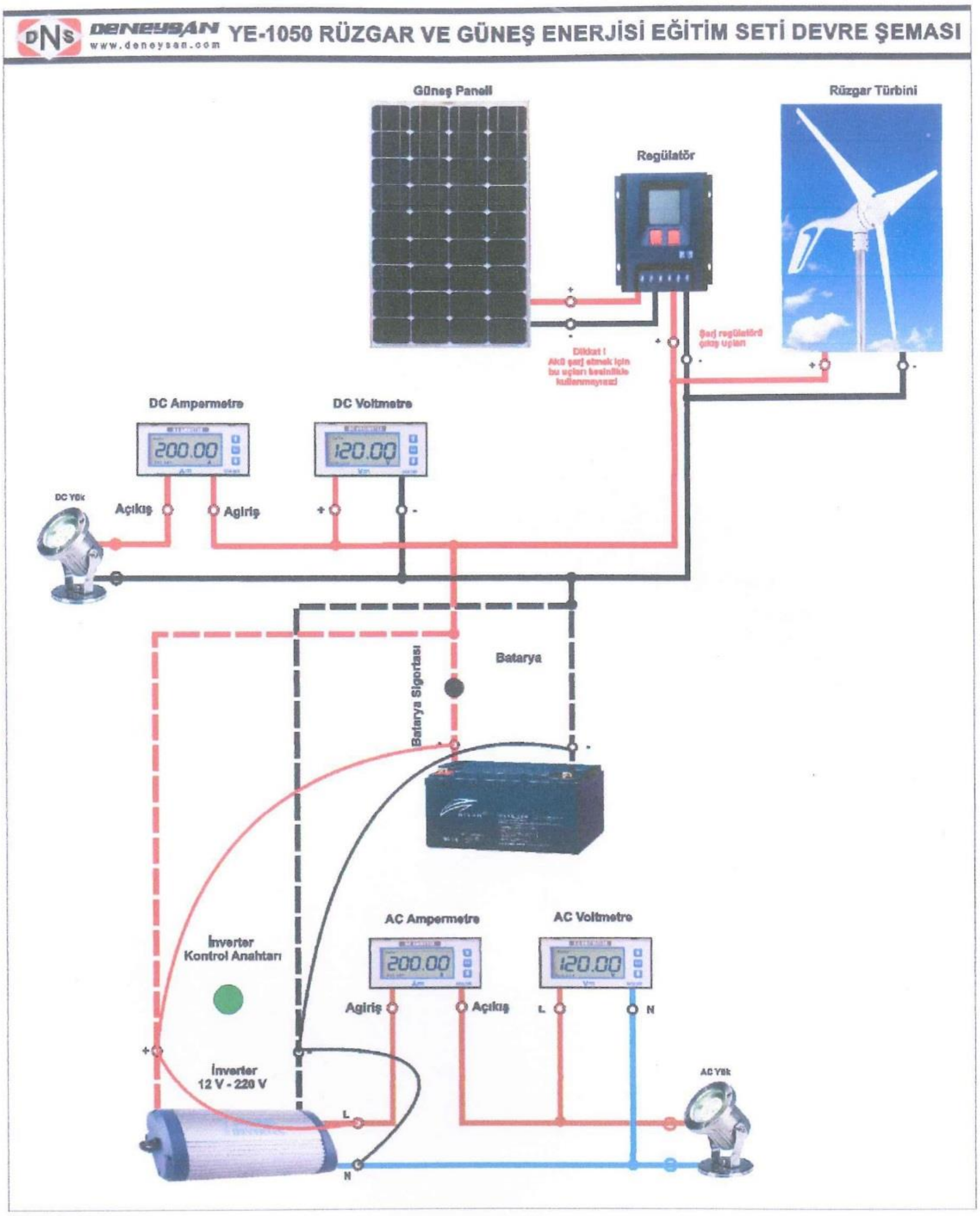
9. Although wind power has reduced electricity production costs, it still does not have an advantage over low-cost fossil-based fuels.

10. Large-capacity wind farms may cause degradation of the area TV signals around 2-3 km.

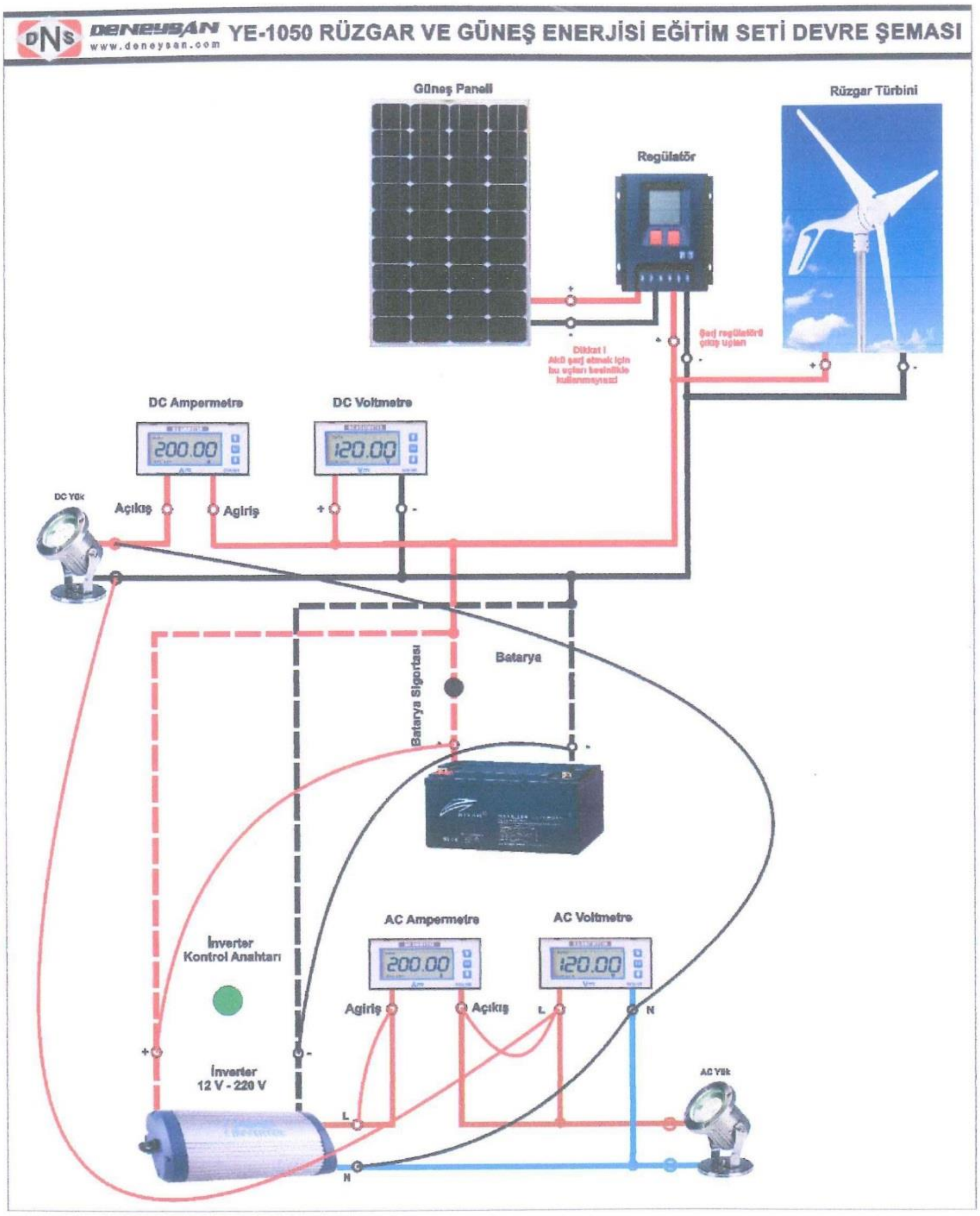
IMPORTANT NOTES:



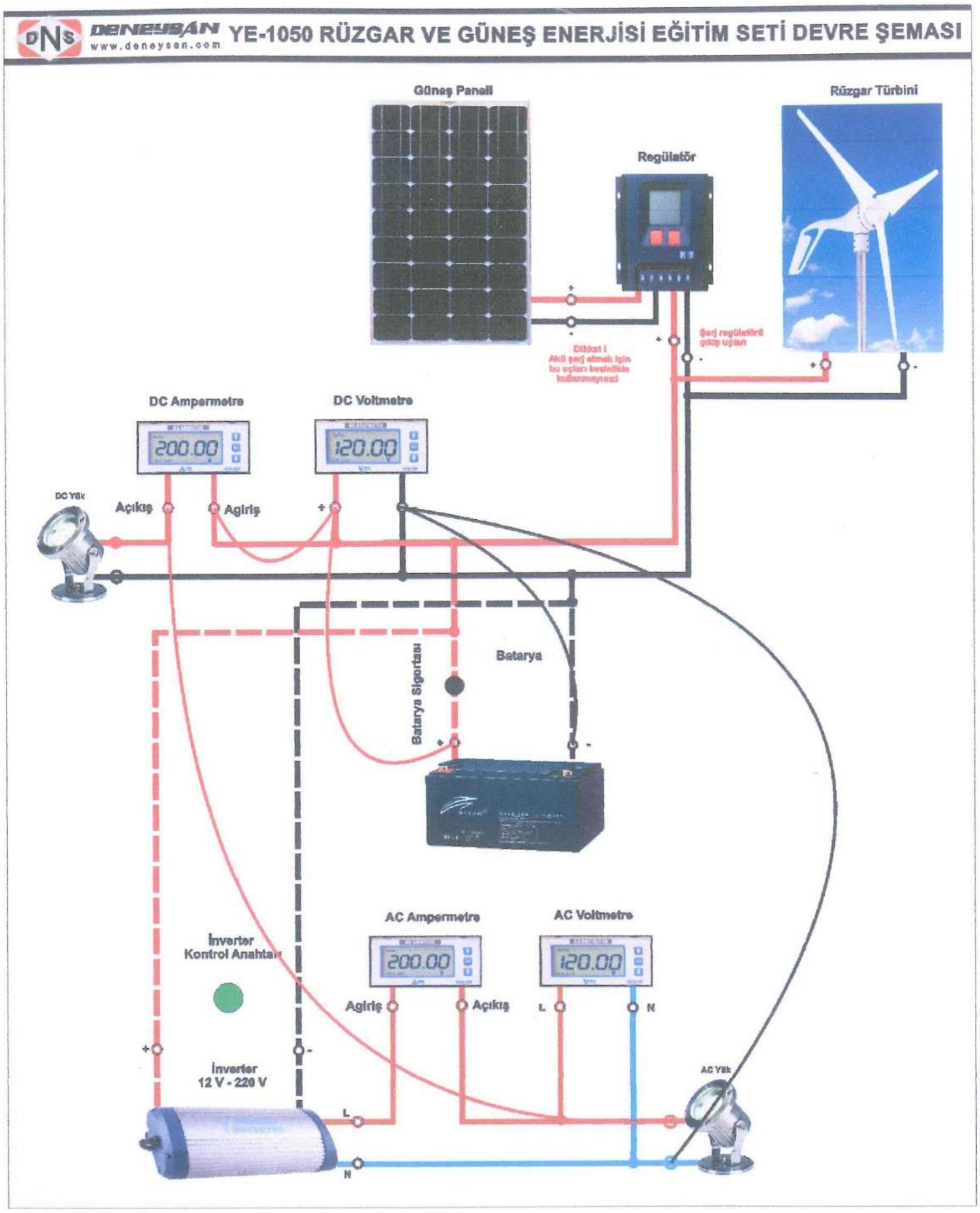
To charge the battery certainly do not connect to the solar panel. This is because the battery draws a certain current according to the incoming voltage, which can cause the battery to overheat or fuse explosion if it rises above normal. In addition, if you make such a connection, the battery will continuously charge itself and will not apply any interruption. In this case the same hazards may arise.



Never make connections to the L (phase) and N (Neutral) terminals of the inverter from the connection to the + and - terminals of the battery inverter. Because either the battery fuse or the fuse inside the inverter will damage the system.



If AC connections are made, attempting to operate a DC lamp or DC fan will cause the voltage to be too high, causing the lamp to explosion or cause the fan to burn.



If DC connections are made, if the AC lamp or the AC fan is tried to be operated, the incoming voltage will be low so that the lamp can be fried or not at all, and the fan will not turn at all.

When the motor is de-energized and re-energized, the motor drive F004 trips and stops output. For this reason, system energy is cut and after being expected 15-20 sec. should be given again.

EXPERIMENT NO: YE-1050-01

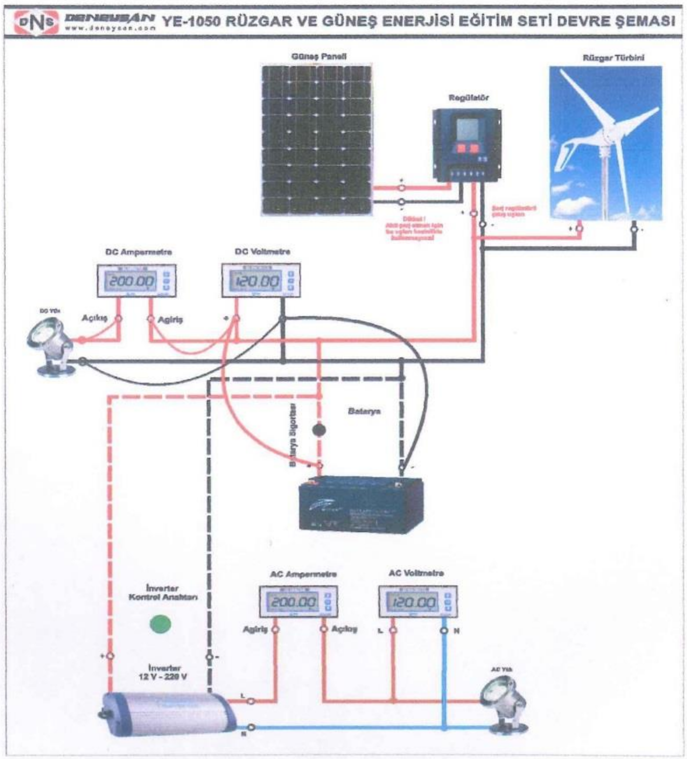
EXPERIMENT NAME: **Wind turbine and solar panel working principle connection diagram**

PURPOSE OF EXPERIMENT: To learn the connection of the wind turbine and the solar panel.

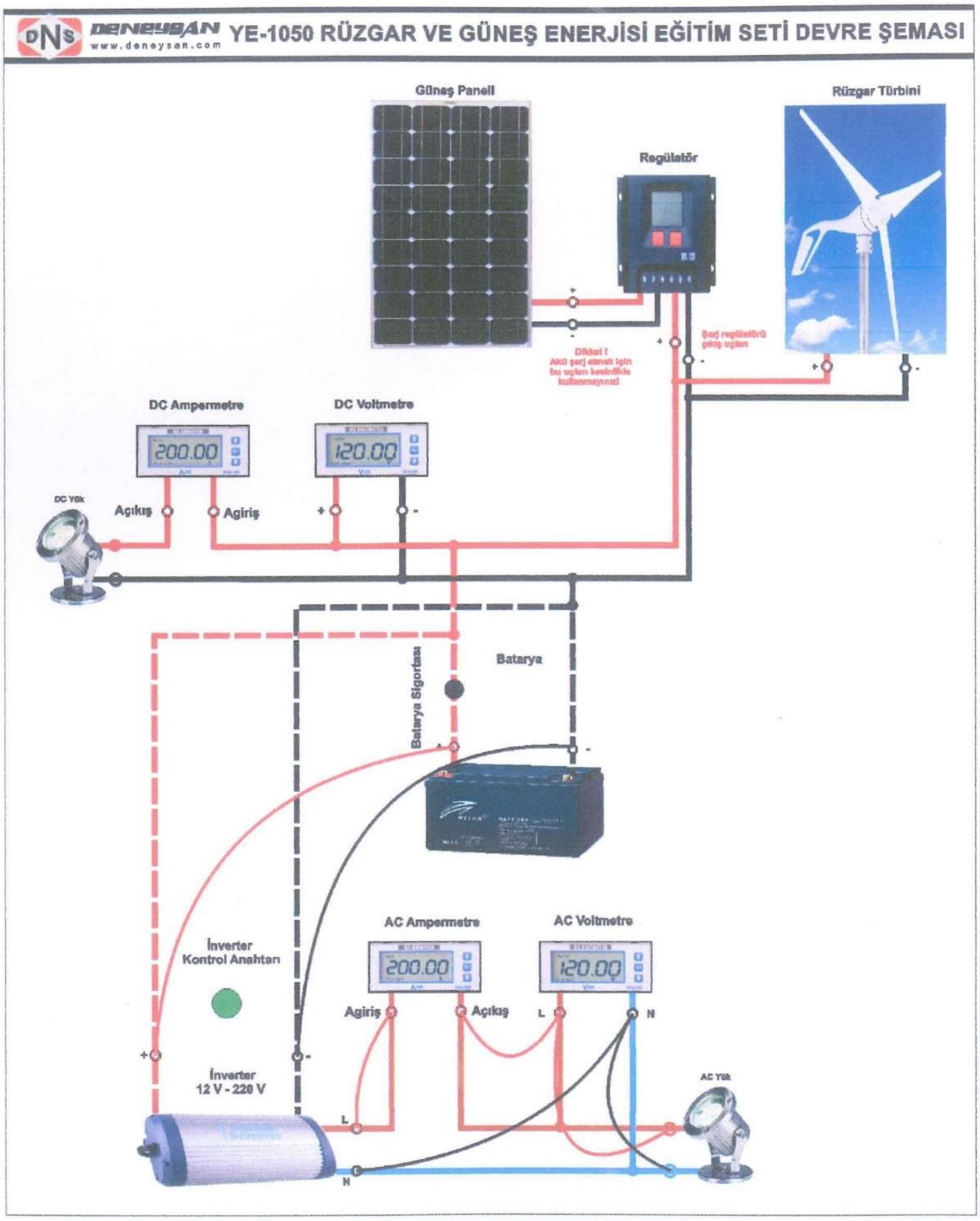
NECESSARY TOOLS AND MATERIALS

- Cable connection jacks

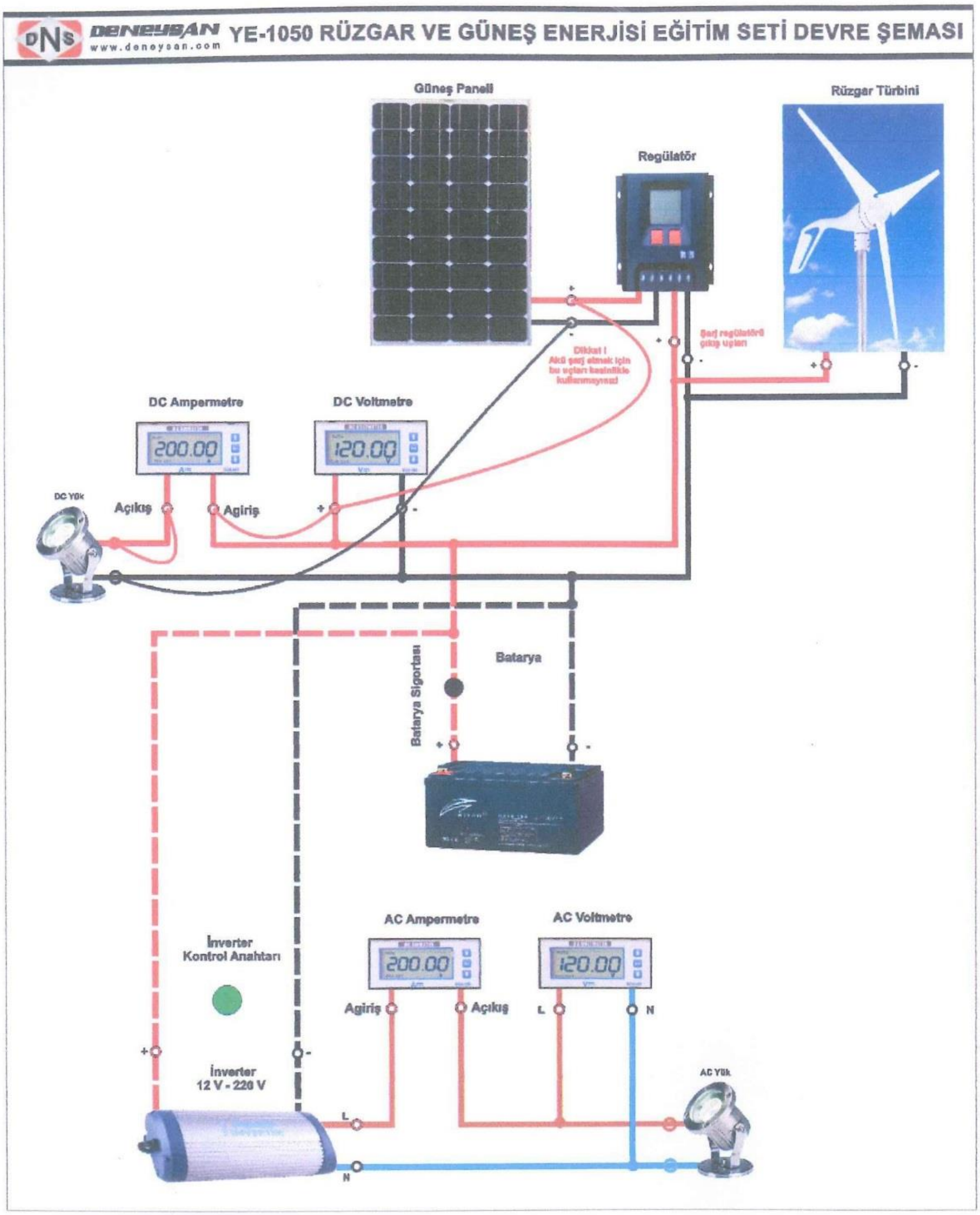
EXPERIMENT PROCEDURE:



The DC load connection via the battery can be made in the same way for other components (DC lamp, fan and siren).



The AC load connection via the battery can be made in the same way for other components (AC lamp, fan and siren).



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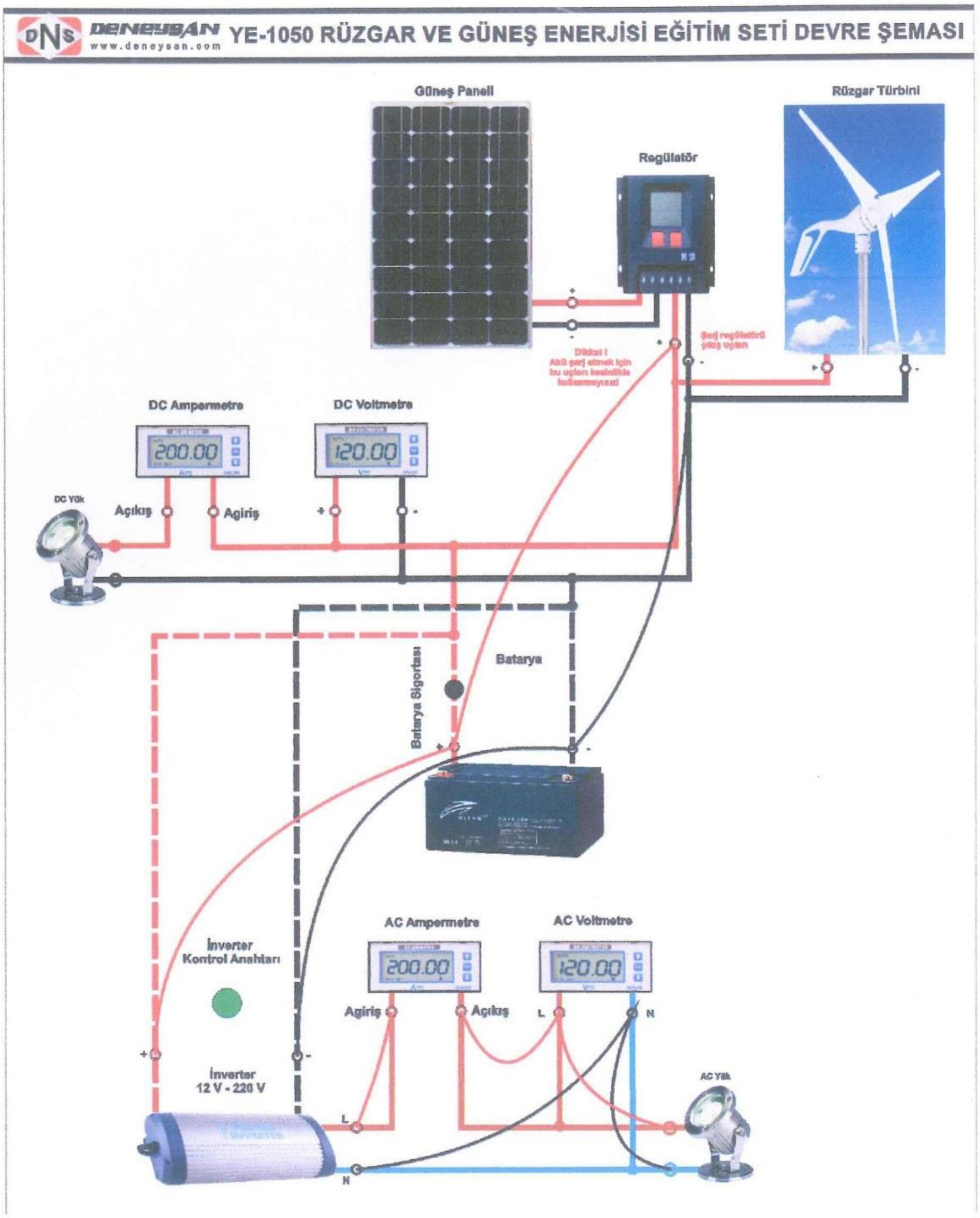
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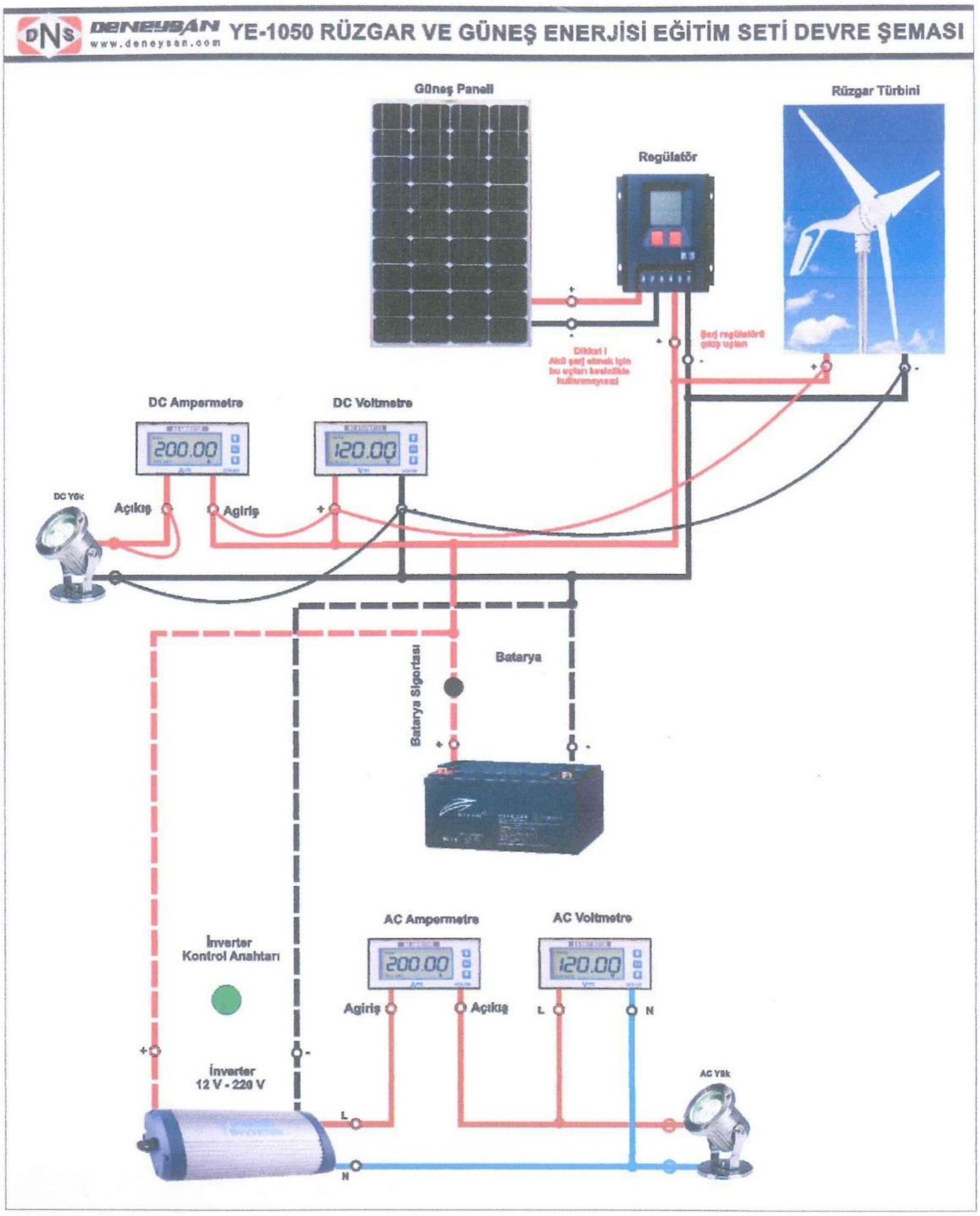
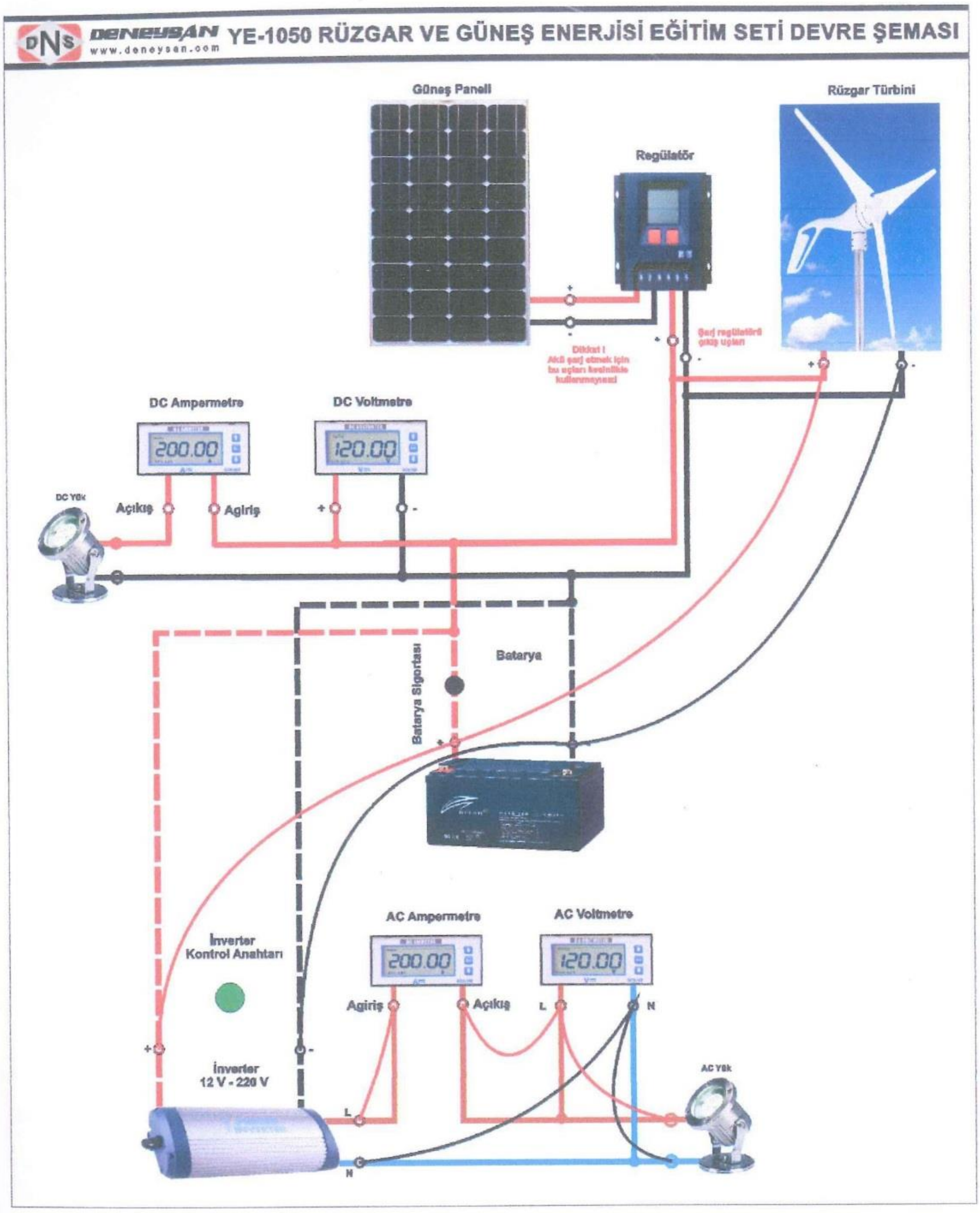


The DC load connection via the wind turbine can be made the same for other components (DC lamp, fan and siren). (Make sure the panel connection of the wind turbine is done.)



The AC load connection via the wind turbine can be done in the same way for other components (AC lamp, fan and siren). (Make sure the panel connection of the wind turbine is done.)

EXPERIMENT NO: YE-1050-02

EXPERIMENT NAME: **Wind turbine power generation-air velocity relationship**

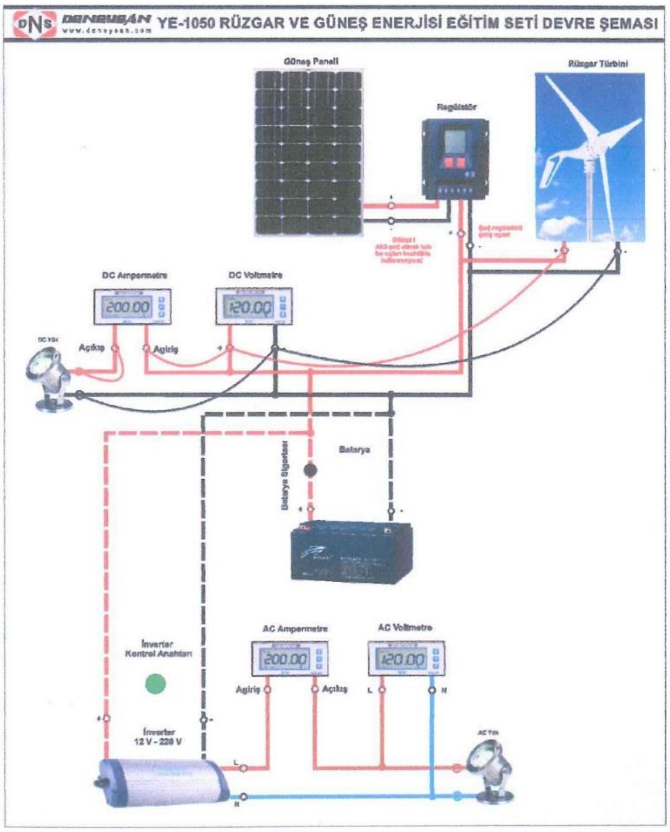
PURPOSE OF EXPERIMENT: To interpret the current and voltage values generated by a wind turbine at a certain air velocity.

NECESSARY TOOLS AND MATERIALS

- Cable connection jacks

EXPERIMENT PROCEDURE:

1. Make the cable connection to the wind turbine.
2. On the inverter doing cable connections of wind turbine.
3. Apply the following connection scheme by the help of jack cables.
4. Record the measurement values in the table
5. Calculate the efficiency at different air speed.



NOTE: This schematic is given as an example. Other DC loads can also be used if wanted.

REQUESTED ON REPORT: Experiment no, name and purpose, efficiency calculations and interpretation based on air speed.

Number of Measurement	1	2	3	4
Average wind velocity, (V) m/s				
Voltage, (U)				
Current, (I_c)				
Power (P) kW				

CALCULATION

Power Inlet: P=U*I (kW)

Speed (average wind speed)	3	4	5	6	7	8	9	10	11	12	12,5

Velocity that using in the calculations can be taken from table below.

EXPERIMENT NO: YE-1050-03

EXPERIMENT NAME: **Calculation of turbine efficiency**

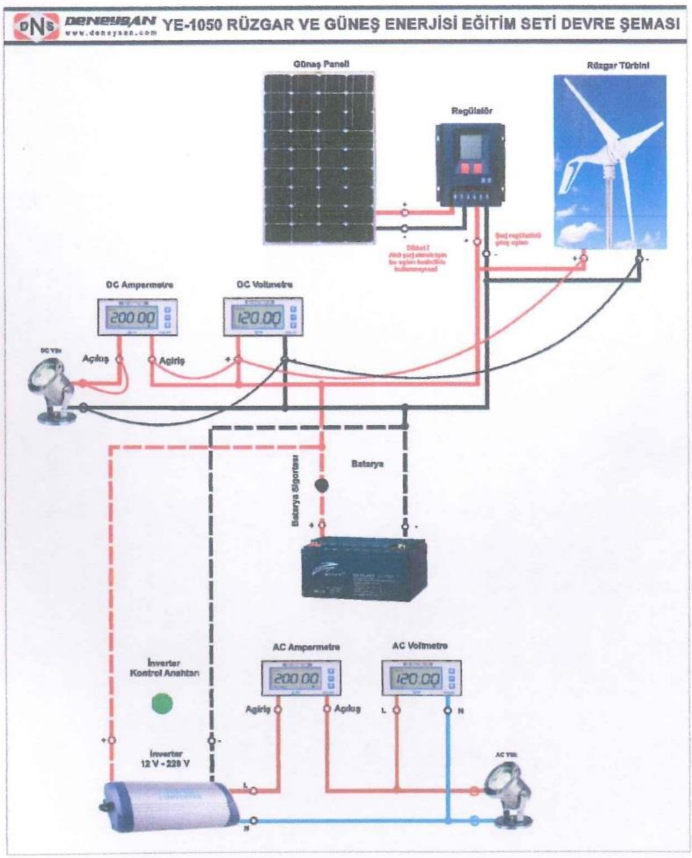
PURPOSE OF EXPERIMENT: Understanding the calculation methods of turbine efficiency.

NECESSARY TOOLS AND MATERIALS

- Cable connection jacks

EXPERIMENT PROCEDURE:

1. Make the cable connection to the wind turbine.
2. On the inverter doing cable connections of wind turbine.
3. Starting the turbine by potentiometer on the inverter.
4. Apply the following connection scheme by the help of jack cables.
5. Record the measurement values in the table
6. Calculate the efficiency at different air speed.



REQUESTED ON REPORT: Experiment no, name and purpose, efficiency calculations and interpretation based on air speed.

Measurements	1	2	3	4
Average wind speed, (V) m/s				
Voltage, (U)				
Current, (I_c)				
Power (P) kW				

CALCULATIONS:

$$C_{PBetz} = \frac{P}{0{,}5\ q\ A\ V_r^3}$$

P= Power (W)
C_{pBetz} = Efficiency (Betz efficiency coefficient)
q = Density of air, (kg/m^3)
V_r^3 = Average wind speed (m/s)
A= Cross sectional area, (m^2)
A= π.D^2/4
D= Diameter (m)

EXPERIMENT NO: YE-1050-04

EXPERIMENT NAME: **Calculation of solar cell electrical power**

PURPOSE OF EXPERIMENT: Investigation of current, voltage values of solar cells at certain angles.

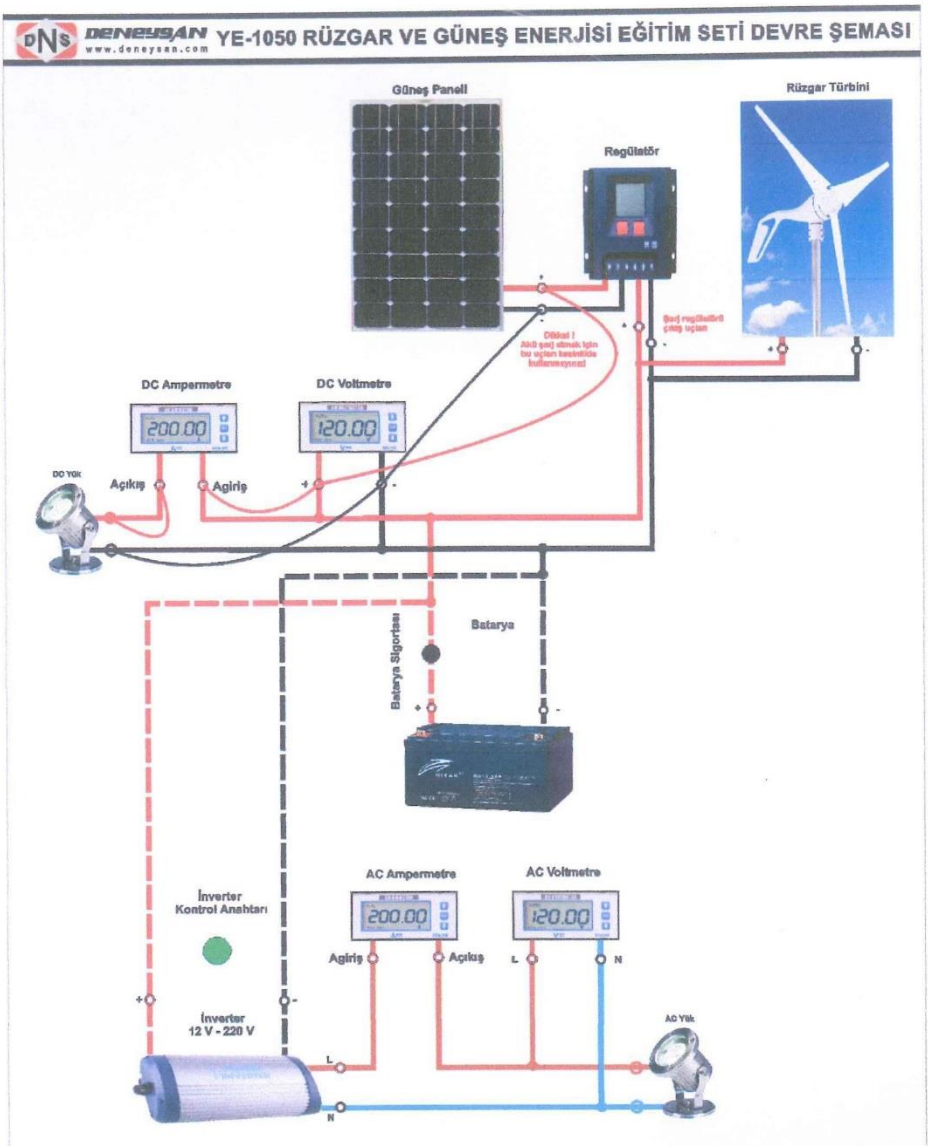
NECESSARY TOOLS AND MATERIALS

-Cable connection jacks

EXPERIMENT PROCEDURE:

1. Make the solar cell cable connection.
2. Adjust the tilt angle so that the sun lights come with a 90° angle.
3. Connect the cables as shown in the following figure
4. Record the measured values in table.
5. You can repeat the above operations with fan connection.

REQUESTED ON REPORT: Experiment no, name and purpose, transfer of the results of the current-voltage values at the specific angle onto the graph and table



CALCULATIONS:

Power input: P=U*I (kW)

MEASUREMENTS	1	2	3
Voltage, (U)			
Current, (I_c)			
Power (P) kW			

EXPERIMENT NO: YE-1050-05

EXPERIMENT NAME: **Finding solar cell efficiency**

PURPOSE OF EXPERIMENT: Investigation of how yield values of solar cells are calculated.

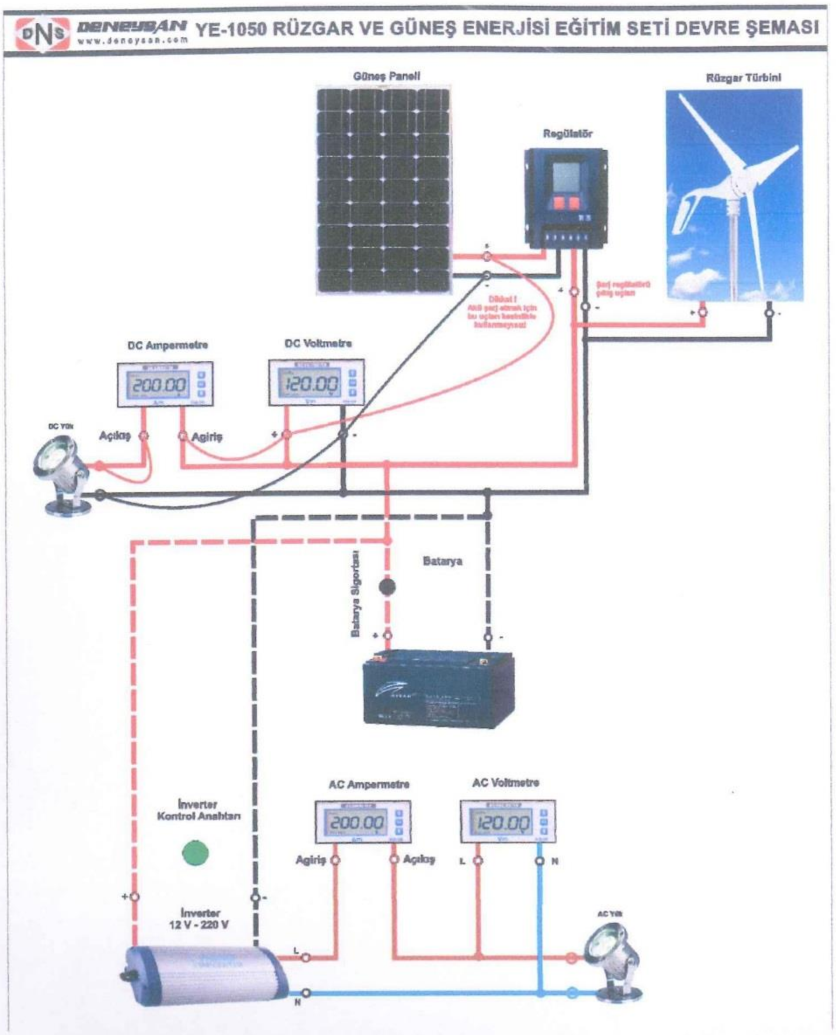
NECESSARY TOOLS AND MATERIALS

- Solar radiation sensor and indicator

EXPERIMENT PROCEDURE:

1. Make the solar cell cable connection.
2. Adjust the tilt angle so that the sun lights come with a 90° angle.
3. Connect the cables as shown in the following figure
4. Record the measured current and voltage values in table..
5. Calculate the efficiency.
6. You can repeat the above operations with fan connection.

REQUESTED ON REPORT: Experiment no, name and purpose, comparison of electrical output values at certain angles.



MEASUREMENTS	1	2	3
Voltage, (U)			
Current, (I_c)			
Solar radiation sensor measurement, R (W/m^2)			
Efficiency (%)			

CALCULATIONS:

$$1\ lux = 0.0081\ W/m^2$$

$$\textit{Panel area} = 0{,}312\ m^2$$

$$\textit{Efficiency:}\ \eta = \frac{U\, I_c}{R}\ [\%]$$

EXPERIMENT NO: YE-1050-06

EXPERIMENT NAME: **Investigation of the change of solar cell power depending on angle**

PURPOSE OF EXPERIMENT: Investigation of current, voltage values of solar cells at certain angles.

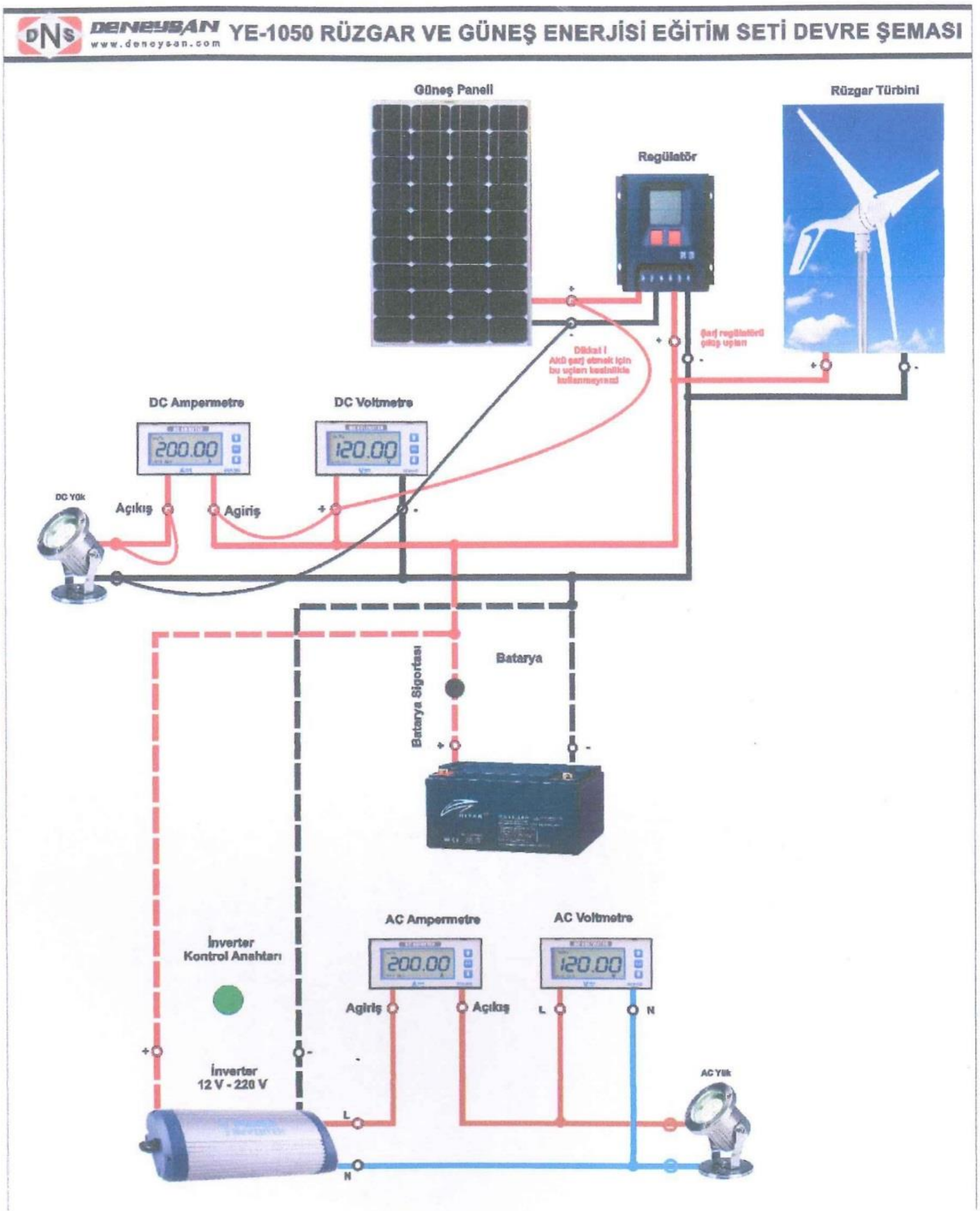
NECESSARY TOOLS AND MATERIALS

- Cable connection jacks

EXPERIMENT PROCEDURE:

1. Make the solar cell cable connection.
2. Adjust the tilt angle so that the sun lights come with a 90° angle.
3. Connect the cables as shown in the following figure.
4. Record the measured current and voltage values in table.
5. Do the same procedure at other angles and record the table.
6. You can repeat the above operations with fan connection.

REQUESTED ON REPORT: Experiment no, name and purpose, comparison of electrical output values at certain angles.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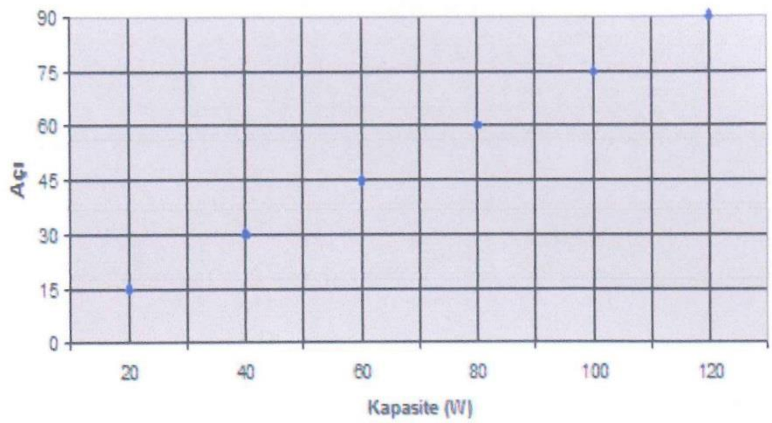
Angles	0^0	30^0	45^0	60^0	90^0
Voltage, (U)					
Current, (I_c)					
Power ($U.I_c$)					



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