T.C.
ANKARA YILDIRIM BEYAZIT UNIVERSITY
FACULTY OF ENGINEERING AND NATURAL SCIENCES
ENERGY SYSTEMS ENGINEERING DEPARTMENT

ESE – 40… ENERGY SYSTEMS LABORATORY -…

Examining the characteristic of solar cell

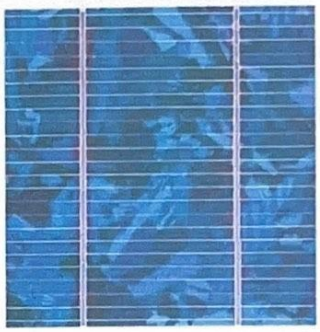
Student No :
Name-Surname :
Experiment Date :
Grade :

DEVICE USER GUIDE

1. Cover the solar cells when the device is not in use.
2. Cover the wind turbine when not in use.
3. Clean the solar cells with a damp cloth and place them in a place where they can easily receive sunlight.

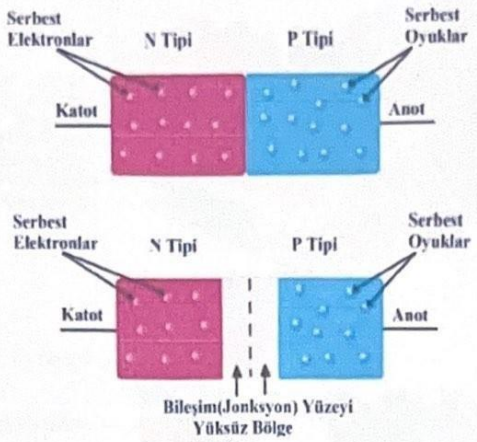
1) Electricity Generation from Solar (Photovoltaic Panels)

Although it is possible to produce electricity from solar energy by different methods, the most technologically advanced method in this regard is the production of energy through solar panels (photovoltaic panels). In this technology, energy conversion is achieved by using semiconductor materials when sunlight reaches the panel surface..



2) Working Principle of Solar Cells

The photovoltaic effect is a simple physical process by which Solar Cells convert sunlight into electrical energy. Sunlight, photons, or solar energy, consists of particles. Photons from sunlight consist of different wavelengths and contain various amounts of energy corresponding to these different wavelengths.



Bir yarıiletkende p-n ekleminin gösterimi

There are three possible situations that can occur when photons hit the PV surface. The photon can be reflected, absorbed or transmitted directly. Only absorbed photons can produce electricity. In this case, the energy of the photon is transferred to the electron in the cell it hits. With this energy, the electron escapes from its normal position and forms a part of the current in an electrical circuit, converting sunlight into electrical energy.

3) Structure of Solar Cells

To generate the electric field within a PV cell, two separate semiconductors are sandwiched together. Pure semiconductor materials neither conduct electricity well nor poorly. This is because the number of electrons in the valence band is limited. The conductivity of a pure semiconductor can be increased by increasing the number of electrons and holes. This is created by adding a dopant to a pure semiconductor. There are two types of semiconductors created by adding dopants. These are positive (p) and negative (n) type semiconductors. A PV cell consists of positive (p) and negative (n) type semiconductor material.

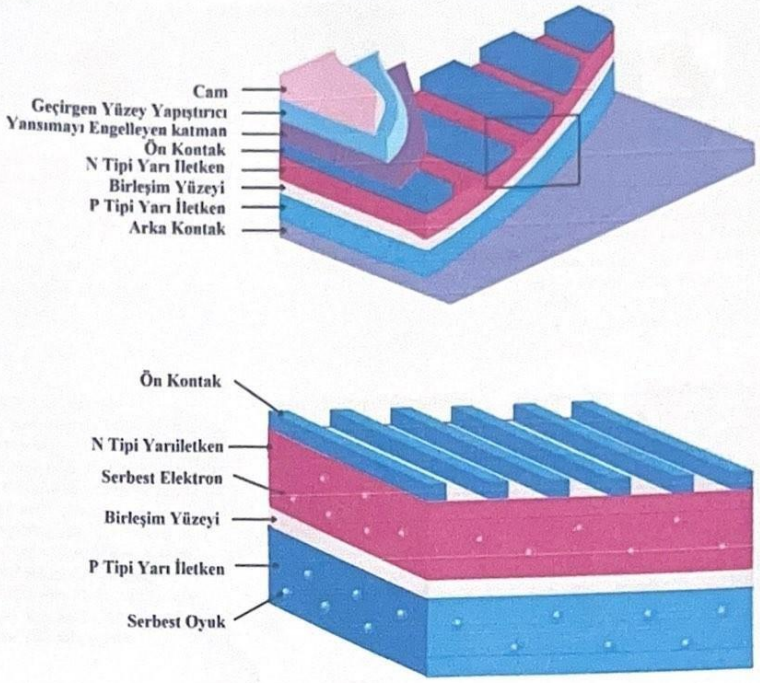


Illustration of the layers of a solar cell

4) Types of Solar Cells

There are different types of solar cells depending on the materials used in their production. Comparisons of solar cell types are given in the table.

	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 kısmı 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 m²	8-9 m²	13-20 m²	11-13 m²	9-11 m²
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		

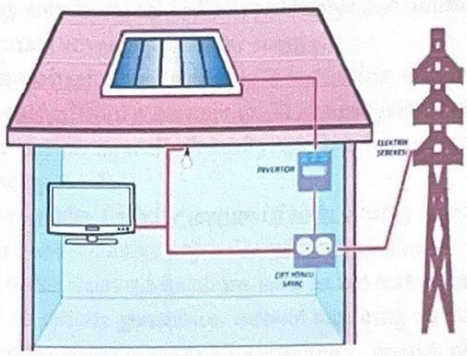
5) Solar Cell Systems

Solar Cell Systems can be used in every application where people need electrical energy. Depending on the applications, the solar cell module is created with control devices such as inverters, accumulators, regulators and various electronic support circuits. Solar cell system applications can be divided into two main groups;

i. Grid connected Systems (On Grid)
ii. Off-grid systems (Off-Grid)

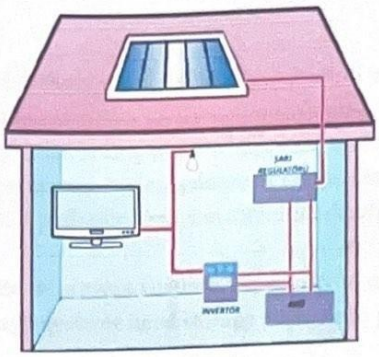
i. Grid Connected Systems (On Grid):

Grid-connected solar cell systems can be in the form of large power systems (power plant size) or in the form of small power systems in buildings. After the energy obtained in small powerful systems meets the electrical energy requirement of the system in which it is installed, the excess electrical energy is sold to the electrical network. Only in this case, the DC electricity produced is converted to AC and made suitable for the grid. If sufficient electrical energy cannot be produced, electrical energy is taken from the grid. Since there is no storage in these systems, there is no need for a battery group.



ii. Off-Grid Systems (Off-Grid):

The power obtained from solar panels covers the systems, and the excess energy is stored in batteries. This stored energy is used when solar energy is insufficient, especially during the night. A regulator is used to prevent damage to the battery in cases of overcharging and derating. The function of the regulator in the systems is to stop the battery or system current from being drawn or to cut off the current from the solar cell.



6) WHY SHOULD WE USE SOLAR ENERGY?

In order to popularize solar energy-powered systems, it is necessary to have sufficient knowledge about these systems. Naturally, as with every energy source and production system, solar energy systems have advantages and disadvantages. For this purpose, the advantages and disadvantages are listed below.

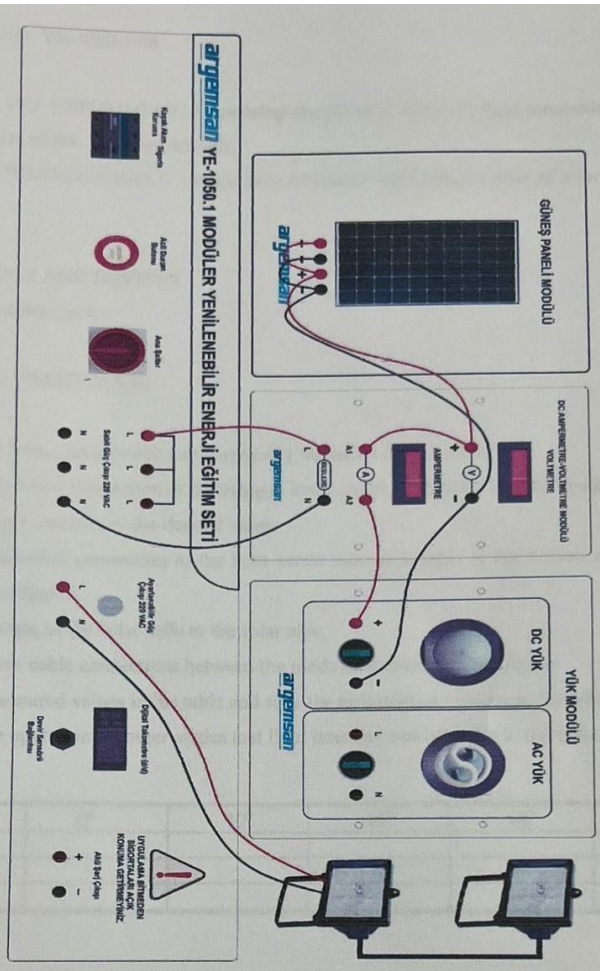
Advantages

- In our world where fossil fuels are beginning to run out, solar energy, like other renewable energy sources, is an endless, renewable and unlimited energy source. This is the most important advantage of solar energy.
- In an environment where global warming is increasing, carbon emissions do not occur when obtaining energy from solar energy. They are systems that do not pollute the environment, are environmentally friendly, and can be easily changed when necessary, depending on energy needs.
- Another environmentally friendly feature of solar energy is that it does not cause noise pollution since it does not make any noise while operating.
- Solar energy provides many applications such as hot water, heating, cooling, industrial applications and electricity generation without requiring fuel costs.
- Solar energy systems are easy to install according to energy needs. Additionally, if energy needs increase, systems can be expanded quickly and easily.
- After the production and installation costs in solar energy systems, it does not cause much maintenance cost in use. Systems powered by solar energy can be easily transported and installed. The use of solar cells may be more economical in rural areas where there is no electricity grid line or where it is expensive to install a grid line.
- Although the initial installation and production costs of solar systems are high, when considered in the long term, the initial cost is reversible compared to fossil fuels.
- Solar cell is durable, reliable and long-lasting. Every house can provide its own energy with solar cells installed on its roof. Thus, transmission and energy transportation costs and losses are eliminated.

Disadvantages

- The most important disadvantage is the high production and installation costs of photovoltaic panels and collectors with tracking systems. However, with technological developments, energy is becoming more widespread and its cost is decreasing.
- The efficiency of solar energy systems depends on the condition of the sun. Cloudy weather, environmental pollution, and sun direction directly affect the efficiency of some systems.
- Large areas are needed to prevent shading, especially in collector types that produce electricity. Solar energy systems need storage systems to provide energy continuity at night.
- Solar Cells have low efficiency (around 15%).
- Solar collectors used in buildings may cause some problems in terms of appearance and location.
- Semiconductor materials used in photovoltaic cells may cause environmental pollution after their lifetime.
- Solar energy technology does not yet have sufficient efficiency for transportation applications. It is an emerging technology.

EXPERIMENT SETUP



THINGS TO BE CONSIDERED WHEN USING THE TRAINING SET

1- Do not connect to the battery module when the solar panel is connected in series.
2- When the solar panel is connected in series, do not connect to the 12V off grid inverter module.
3- Never connect AC and DC energies to each other (example: Do not connect circuit elements such as battery, inverter, charge regulator, DC loads, solar panel, etc.)
4- Make all connections on the training set while the power is off.

EXPERIMENT REPORT

1. Calculate the powers.
2. Draw your graph (Angle-Power).
3. Conclusions.

DATAS

Angle(°)	Volt(V)	Amper(A)	Power(W)
0°			
30°			
60°			
90°			

P=I*V