----- RENEWABLE ENERGY TECHNOLOGIES -----

OPERATION OF SOLAR POWER PLANTS

Preparation of Training Documents for Installation, Maintenance, Repair and Storage Systems of Solar Energy Systems Supported by Artificial Intelligence and Energy Efficiency Enhancement Support

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Preparation of training documents for the installation, maintenance, repair and storage systems of solar energy systems supported by artificial intelligence and energy efficiency enhancementProject
It is written within the scope of. It is intended to guide vocational education trainers. It is free for users, cannot be sold. Reproduced. It will be published as an e-book on the Project Website (http://www.digienergy40.com).

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EXPLANATIONS

AREA	Renewable Energy Technologies
BRANCH/PROFESSION	Solar Energy Systems
NAME OF THE MODULE	Review of Electrical Systems
DESCRIPTION OF THE MODULE	This module covers the renewable energy system and what these systems will be complex with, and other systems as a whole. It will be about the interaction.
DURATION	40/32
PREREQUISITE	There are no prerequisites for this module.
SUFFICIENCY	Panel arrangements of solar energy systems are autonomous to the system It makes power saving (following the sun) and panel connections**.**
PURPOSE OF THE MODULE	General Purpose When the solar energy systems workshop environment is provided, you will be able to perform solar panel system installation and detauli panel binding solar tracking system in practice. Purposes You will be able to recognize the elements of the

	installation system and install it. Increasing energy efficiency by using the system as sun tracking by using motors.
EDUCATIONAL ENVIRONMENTS AND EQUIPMENT	**Environment:** Renewable energy technologies area, renewable energy systems workshop **Equipment:** Basic electrical knowledge, Basic electronics knowledge, Basic mechanics knowledge, stepper motor, servo motor, electrical panel and gear system.
MEASUREMENT AND EVALUATION	After each learning activity in the module, you will evaluate yourself with the assessment tools provided. At the end of the module, the teacher uses the measurement tool (multiple-choice test, true-false test, fill-in-the-blank, matching, etc.) and It will evaluate you by measuring skills.

INTRODUCTION

Dear Student,

The importance of Solar Energy Systems is increasing day by day. With the increase in the importance of these systems, the importance of electrical systems comes to the fore. In this context, the installation, reliability and performance of the system and its continuity are important, and it is obvious that in the future, there will be a tendency towards systematization, control and automatic solar power in the industry and many enterprises and institutions of the world countries, and it is necessary to learn the electrical system.

With this module, you will learn about the material feasibility study to be used in the examination of electrical systems, which is one of the issues related to your profession in the field of Renewable Energy Technologies, autonomous systems. When you receive this module; You will learn about the general status of systems, electrical solutions. It is always aimed to carry out the analysis as quickly as possible with the least error, in complete safety. This can only be achieved by controlling the discipline and control systems in the work area. When you successfully complete this module, you will further increase your professional competence and become an employee with the qualifications required by the sector.

In this module, you will learn the Examination of Solar Electrical System

LEARNING ACTIVITY –1

PURPOSE

What is a system, its components and definitions of these components will be discussed.

RESEARCH

Share your observations with your teacher and friends.

1. STOCK TRACKING IN SOLAR POWER PLANTS

Tracking the Amount of Materials: The materials in the warehouses should be checked and recorded regularly. This ensures that missing materials are detected in a timely manner.

Critical Stock Level Determination: Critical stock levels are determined for each material. When this level falls below, an order can be placed automatically.

Order and Supply Management: An order is opened for the missing materials and the incoming materials are added to the warehouse and recorded in the system.

Digital Tracking Systems: AI-powered software automates stock tracking, reducing the error rate and speeding up processes.

1.1 PRODUCTION FORECAST FOR SOLAR POWER PLANTS (SPP)

Sunshine Duration and Radiation Data: SPP production estimation is based on the analysis of the annual sunshine duration and radiation potential of the region. This data forms the basis for estimating power generation capacity.

Weather and Environmental Factors: Environmental factors such as air temperature, humidity, pressure are taken into account in the forecast of energy production. This data can be analyzed with AI-powered algorithms to make more accurate predictions.

Simulation and Software: Simulation software used in SPP projects provides predictions by modeling energy production performance. For example, parameters such as the inclination of the system, azimuth angle, and ghosting factors are evaluated in these simulations.

Artificial Intelligence and Machine Learning: Artificial intelligence analyzes historical production data to determine future energy production.

This is especially useful for quick adaptation to weather changes.

1.2 TRANSFERRING SOLAR POWER PLANTS (SPP) OPERATING INFORMATION

To ensure the efficient operation of the system and to monitor its performance:

Data Collection and Monitoring: Data such as power generation data, weather information and equipment status of the SPP are collected regularly. This data is transferred to the business management system.

Artificial Intelligence Supported Analysis: The collected data is analyzed with artificial intelligence algorithms, the performance of the system is evaluated and possible problems are detected.

Remote Monitoring Systems: SPP operating information can be monitored in real time through remote monitoring systems. This allows operators to intervene quickly.

Reporting and Performance Evaluation: Business information is regularly reported and performance evaluation is made. This determines the measures to be taken to improve

the efficiency of the system.

1.3 SCADA PRODUCTION AND OTHER CONTROL

SCADA (Supervisory Control and Data Acquisition) systems are used to monitor and control energy production processes in solar power plants (SPP). SCADA systems play a critical role in ensuring that the SPP operates efficiently and safely. These systems collect, analyze, and present energy production data to operators in real-time. In addition, SCADA systems detect possible malfunctions, provide rapid intervention and optimize energy production performance

SCADA systems use a variety of sensors and devices to monitor and manage the performance of solar power plants. These sensors continuously monitor the solar panels' power generation data, weather information, and equipment status. The collected data is analyzed through SCADA software and presented to the operators. In this way, energy production processes are managed more efficiently and possible problems are solved quickly

SCADA systems enable remote monitoring and control of solar power plants. This allows operators to monitor the plant's performance from any location and intervene as needed. In addition, SCADA systems regularly report energy production data and perform performance evaluation. This helps to determine the measures to be taken to improve the efficiency of the power plant.

1.3.1 SPP SWITCH GEAR MANOEUVRE

SPP switchgear maneuvers manage energy generation and transmission safely and efficiently in solar power plants. Cutter maneuvers are used to interrupt or start the flow of energy in the event of maintenance or breakdowns. Disconnector maneuvers are critical for isolating the circuit, while grounding disconnector maneuvers are

necessary to ground the circuit and ensure safety. Transformer maneuvers, on the other hand, control the flow of energy during the maintenance and repair of transformers. The control elements and control systems used in these processes monitor and control the flow of energy, so that energy production and transmission are managed efficiently.

1.3.2 SPP MAINTENANCE

The maintenance of the SPP energy transmission line is critical for the efficient and safe operation of solar power plants. Damage, dirt or moisture on the outer surface of the line should be checked. The tightness of the fasteners and the strength of the insulation are important; Loose connections can lead to electrical faults and fire. Regular cleaning of internal and external surfaces prevents the accumulation of dirt. It is necessary to check the temperature level and make sure that the safety equipment is working properly. Periodic maintenance ensures long-lasting and safe operation of the line.

1.4 COMMUNICATION FOR THE MAINTENANCE OF TEVZİ PANELS

Switchboards are vital components that ensure the distribution and control of electrical energy. These panels are used to ensure the safe and effective transmission of electrical energy.

Visual Inspection: Inspect the outer surface of the switchboards for any damage, dirt, or moisture. The clean and intact condition of the panels provides a safe working environment.

Connection Check: Make sure that the fasteners inside the switchboards are tight and secure. Loose connections can cause electrical failures and risk of fire. Insulation Check: Check the strength of the insulation of the cables inside the switchboards. Damage to the insulation increases the risk of short circuits and electric shock.

Cleaning: Regularly clean the inner and outer surfaces of the switchboards. The accumulation of dirt and dust can interfere with the efficient operation of the boards.

Temperature Control: Monitor the temperature level inside the switchboards. Excessive temperature can lead to damage to the elements inside the boards and lead to malfunctions.

Safety Equipment: Verify that the safety equipment (fuses, switches, relays) inside the switchboards are working properly. This equipment is important to prevent electrical failures.

Periodic Maintenance: Perform periodic maintenance of the dispatch panels regularly. This ensures long-lasting and safe operation of the boards.

Distribution panels are important components used to ensure the distribution and control of electrical energy. These panels are used to ensure that electrical energy is transmitted safely and effectively. Maintenance of switchboards is a critical process to ensure the safe and efficient operation of the system.

1.5 SYSTEM

1.5.1 Description of the System

Systems are the basic building blocks of a whole to be created, structures that emerge when they work in unity towards their general purpose. According to Ackoff, a **system** is a group of elements that interact with each other to achieve a specific goal.

1.5.2 System Approach

The system approach is considered as a framework in which we can examine the events, situations and problems as a whole, and expresses the approach from the perspective of systems view and systems thinking. System; It can be defined as a coherent whole that interacts with the environment to determine the inputs and outputs associated with the system, with a boundary separating internal and external factors. Features of the System The system is a whole. Systems are related to each other, systems express more than the sum of the subsystems that make up them. Every system has an environment. Subsystems are parts of the system that affect each other and there is a complex structure between them. Subsystems can be added and removed from systems. The structure of the system constantly shows a cyclical change in accordance

with its environment and its own characteristics. The system creates outputs with the inputs it receives. Since the systems are related to each other, it is impossible to determine the boundaries of the systems precisely.

1.6 System Types

1.6.1 Open and Closed Systems:

An open system becomes an open system when it receives inputs of matter, energy, or information and provides output from that information, and open systems depend on the environment.

A closed system is a system that is open only for information input and is independent of the environment in all other activities.

Purpose of the System

The aim of the system is to reach the determined target in the shortest time, with the least cost and with the least loss. If the system is considered as a whole, it is seen that there should be a joint work to achieve the goals. Elements are both part of the system and subsystems of the system.

1.6.2 System Benefits

The system is a small system created for a whole, and as a benefit, we can consider it as the basis of automatic structure formation in our globalizing world. Systems are generally referred to as the beginning of autonomous structures.

Systems play an important role in mass production and facilitating human life in the fields of industry and machinery, the development of these systems will make life easier and increase production, in this module, we will examine the combination of systems with renewables.

1. System Analysis

Another issue of systemic structures is that they are analyzed, even if the systems are open or closed systems, they are analyzed as a result and we examine the outputs and inputs for more technology development in the way of analyzing

değerlendirilmektedir. Biz systems, and if we take the renewable energy sector as a basis, it is important for the analysis part to operate it more in the installation of solar power plants.

2. System Structure

The structures of the systems depend on what the input and output of that system is. The powers, dimensions of the systems can be linked to their purpose. As the systems include a wide scope, they are in question even in the smallest area depending on the development of technology.

The structure and examination of systems can also be discussed with the analysis part, in this module, we will evaluate the structure, definitions and analysis of systems in terms of renewable energy sources.

Photovoltaic systems and another module of renewable energy, which we have basically explained in the installation of Temel, we will now consider it as a system and autonomous remote control.

1.6.3 Photovoltaic Systems and Components

A photovoltaic system that generates solar electricity; Solar panels are made up of accumulators, inverters, battery charge controller, system control unit (SCU) and various circuit elements, depending on the application.

A photovoltaic (PV) system has two basic components: a solar panel and a DC/AC converter. While the charge control unit and battery are added to this in island systems, only the MPPT (Maximum Power PointTracer) unit is added in grid-connected systems.

Parts such as cables, switches, relay-contactors, fuses, which are involved in the transmission of PV system energy and the combination of units, are also important

elements of the system.

The most important issue that we will pay attention to when choosing the above-mentioned system elements in PV system design is the compatibility of the elements with each other. If this is not achieved, the system will work inefficiently.

1.6.4 MODULES

Photovoltaic cells are sensitive to sunlight of a certain wavelength. It is the smallest unit of photovoltaic systems.

Working like a semiconductor diode, the solar cell converts the energy carried by sunlight directly into electrical energy through a photoelectric reaction.

The highest voltage generated in cells produced in standard sizes of 100x100, 125x125 or 156x156mm and 0.2-0.4 mm thickness is 0.6V. Of these cells,

Modules are created by connecting 36-54-60 or 72 in series. The modules are produced to supply a 12V or 24V DC system.

1.6.5 PANELS

solar panels are modules that convert certain wavelengths of sunlight into DC electrical energy.

They are manufactured in standard sizes of 100x100, 125x125 or 156x156mm. Cell thicknesses are 0.2-04 mm. Depending on the voltage and power values in which they are produced, they contain 36-54-60 or 72 series cells.

In their crystalline panels, the system voltage is produced to supply the 12V or 24V DC system.

12V panel voltage 17Vmax-22Voc,

In 24V Systems, the average is 33Vmax – 44Voc. The solar system voltage to be installed can be adjusted in various ways and with series/parallel connections (12-24-48-200 or 400V etc.) according to the solar panel.

1.7 PANEL MAINTENANCE

Maintenance of solar panels is of great importance to ensure efficient and long-lasting operation of the system. Regular cleaning of the panels increases efficiency and maximizes energy production. Dirt, dust and other foreign substances accumulated on the surface of the panels can prevent the sun's rays from reaching the panel surface; Therefore, the cleaning of the panels should not be interrupted. In addition, it should be ensured that the fasteners of the panels are tight and strong. Loose connections can lead to electrical failures and risk of fire. It is also vital to check that the insulation of the cables inside the panels is intact. Damage to the insulation increases the risk of short circuits and electric shock. Regularly cleaning the inner and outer surfaces of the panels helps to prevent the accumulation of dirt and dust, which can interfere with its efficient operation. Besides this, it is necessary to monitor the temperature level inside the panels. Excessive temperature can cause damage to components inside the panels and cause malfunctions. It must be ensured that the safety equipment (fuses, switches, relays) inside the panels is working properly; This equipment is critical to preventing electrical faults. Finally, regular periodic maintenance of the panels is effective in ensuring long-lasting and safe operation.

1.7.1 ARRAYS

When it is desired to make a directory in accordance with the requirement;

$P_{panel}=V_{panel} \times I_{panel}=(V_{indeks}/N_s) \times (I_{indeks}/N_p) = P_{indeks}/N_s x N_p$ If we solve for P, the expression is, = P= N x N x P become

By using this expression, panel arrays can be designed with the desired value and configuration.

1.7.2 CONVERTERS

The second important element of the photovoltaic system is inverters, electronic devices that convert DC power into AC power. Converters with MPPT feature, They are smart devices that can also communicate remotely.

1.7.3 TYPES OF TRANSLATORS

Converters are of three types according to the Alternating Current wave-AC shape they produce. Square wave Sine Analogy (Modified) Full sine wave According to the usage area, there are two types Mains convertersInverters used for off-grid systems.

1.7.4 ACCUMULATORS

They are the elements that support the use of solar energy.

They store electrical energy chemically. There are dry, aqueous and Gel varieties.

Solar Battery Types and Detailed Explanations Gel Batteries

1. **Structure:** Gel batteries contain a gel-like liquid that is formed by mixing the electrolyte with the silicone components. This structure prevents the leakage of electrolyte and seals the battery completely.
2. **Durability: Suitable** for operation at high temperatures and deep discharge conditions. It is also highly resistant to vibration and impacts.
3. **Maintenance:** Maintenance-free. It can be used in confined spaces because there is no gas release.
4. **Lifespan:** Their average lifespan varies between 7-10 years.
5. **Usage Areas:** Vineyard houses, small-scale solar energy systems and mobile applications.

AGM (Absorbed Glass Mat) Batteries

Structure: The electrolyte liquid is retained in the glass fiber matrix. This matrix

prevents the electrolyte from leaking out and ensures that the battery is completely sealed.

Performance: With its fast-charging structure, it offers higher performance than other batteries. Since they have low internal resistance, energy loss is minimal.

Lifespan: They have a lifespan of about 5-8 years.

Uses: Caravans, boat systems and medium-sized solar energy projects.

Lithium-Ion Batteries

Structure: Lithium-ion batteries have a lighter and more compact structure thanks to their chemical structure. Their energy density is quite high compared to other batteries.

Advantages:

- It charges faster.
- It is extremely resistant to deep discharges.
- It has a long service life (10-15 years) with low environmental impact.

Disadvantages: It has a higher cost compared to other batteries.

- **Uses:** Large-scale energy storage systems, electric vehicles, and off-grid energy systems.

Deep Cycle Batteries

Construction: Deep cycle batteries are designed to withstand regular charge and discharge cycles.

Performance: It retains energy for a long time with a low discharge rate.

Lifespan: It varies between about 3-6 years.

Usage Areas: Off-grid systems and backup energy systems.

Functions of Solar Batteries Energy Storage:

In solar energy systems, batteries store the energy produced by the panels. This energy can then be used when it is needed.

Example: To meet the energy needs at night when there is no sun.

Uninterruptible Power Supply:

It provides energy in the event of a power outage or when solar panels are insufficient. Especially in critical systems (e.g. hospitals or data centers) this feature is vital.

Energy Efficiency:

It prevents waste by storing excess energy production. It provides more efficient energy management.

For example: The excess energy produced during the day can be used for consumption in the evening.

Sustainability: It allows the storage of energy from renewable energy sources. This reduces the carbon footprint and provides an environmentally responsible energy solution.

1.7.5 SOLAR CHARGE CONTROLLERS

They are smart electronic circuits that perform and manage the charge-discharge process according to the status of the system energy and loads, and automatically select the operating mode.

Thanks to their microprocessors, they constantly control the solar panel, battery and loads, directing the most efficient energy flow.

1.8 CHARGING UNITS MAINTENANCE

Maintenance of charging units should be carried out preventively like any other maintenance. In this period when energy efficiency is of great importance, necessary arrangements should be made to ensure lossless production and prevent malfunctions. First, it is important to check the exterior of the charging unit for any damage, dirt, or moisture. The unit is clean and robust, ensuring a safe working environment. In addition, it should be ensured that the fasteners inside the charging unit are tight and

secure. Loose connections can lead to electrical failures and risk of fire. It is also vital to check that the insulation of the cables inside the charging unit is intact. Damage to the insulation increases the risk of short circuits and electric shock. Regularly cleaning the inner and outer surfaces of the charging unit can prevent it from working efficientl

1.8.1 FASTENERS

Panels should be securely set to the floor or bodies and their electrical connections with other elements should be made in accordance with the specified standards.

As can be seen in the figures, solar system fasteners are specially designed and manufactured.

1.8.2 GRID-DEPENDENT & STAND-ALONE SYSTEMS

When creating the system in the renewable energy installation, it is created in two ways. These are the systems we call on grid and of grid, that is, they are of two types, dependent and independent of the grid.

1.8.3 On Grid System (Grid Connected System)

Grid-connected photovoltaic systems, instead of storing the generated electricity in batteries. It works based on the principle of consumption at the place of production. While designing the project The amount of energy desired or needed to be produced is determined. The sun from the atmosphere DC electrical energy is produced by the contact of the rays on the solar modules. Produced Energy central city with inverters

with high cycle power that can be connected to the central grid,

It is connected to the mains system. Thus, the energy generated from the panels is directly transferred to the grid system is sent If the area and radiation conditions are suitable, it is possible to produce electrical energy at the desired power with the grid-connected electricity generation system.

Electricity generation with solar energy is an easy-to-install power generation tool, as well as a long time

It is a priority for reasons such as being durable, cost-free, practical and mobile

It is preferred.

1.8.4 BASIC COMPONENTS OF THE SYSTEM;

•Photovoltaic Panel

•Inverter

It is a Bidirectional meter (Network meter).

Grid-connected systems can be installed in high-power-power plant size or in smaller-power installations for domestic needs. For example, this while the electricity requirement of a house can be met in the systems, the excess energy produced is given to the electricity grid, and in cases where sufficient energy is not produced, energy is taken from the grid. In such a system, there is no need for energy storage, only the generated DC electricity must be converted to AC electricity and be grid compatible.

1.8.5 ADVANTAGES OF GRID-CONNECTED SYSTEMS:

- Since storage units such as batteries will not be used in the system, there is no additional cost for storage.
- Since there will be consumption in close proximity to the system and there is no storage, the loss will be minimal due to the fact that the energy cycle is less.
- Since the energy produced is connected to the grid, at the same time, when the energy produced is not enough, the grid will be activated and the energy will feed the load completely
- While designing the system, it has the flexibility to design according to the desired amount or area, as there is no obligation to meet the entire load.
- If the area is sufficient, the installed power of the system can be increased.

1.8.6 OFF GRID BATTERY POWERED SYSTEM (OFF GRID)

Off-grid systems can be called island systems, off grid systems or battery powered systems. The basic equipment used in the system is solar panel, battery, charge controller, inverter and tracker. In places where there is no network line or there is no functional electricity network, the healthiest solution is to install an off-grid system that is correctly calculated according to the needs. Installing battery-powered systems in places where the power line is located increases the system cost and increases the system turnaround times.

For this reason, the places where these systems are installed are mostly places where there is no mains electricity or more than 800m away from the transmission line. Especially in plateau-mountain houses, farms, signaling systems, remote information systems (highway signs), base stations, etc., such installations are frequently encountered.

Drawing the transmission line to such places creates a serious cost of transformers, poles and cables. The most important advantages of the systems are;

1. It is an economical solution in the absence of a network,
2. Convenient and achievable compared to the installation cost of the grid connection,
3. There are no fuel costs,
4. Qualified but few personnel are sufficient in the installation,
5. The duration of the board is short,

• Systems can be increased according to energy needs

•Systems can be installed step by step, so they have flexible installation costs: The points to be considered when designing the system can be listed as follows:

The first thing to do is to replace the existing equipment where the system will be used with economical products. In this way, the amount of energy consumed will decrease.

In some applications, system costs are reduced by half in this way.

Then what needs to be known is how much its daily consumption is. In order to calculate this, it is necessary to list which household appliances are operated approximately how many hours a day at the installation site. Thanks to this list, the daily/weekly energy needs of the house will be determined and the system calculation will be carried out in line with this information.

It is important to carry out preliminary work at the place where the system will be installed in terms of installation design and determination of connection equipment. In addition, the presence of objects-structures that may cast shadows on the panels at the installation site should be carefully examined. In addition to this information, if the panels are to be lined up one after the other, the distance between the panels should be selected appropriately and the panels should be prevented from shading on each other.

Whether the place where the system is designed is a summer house or a place where you live all year round also seriously affects the system design and costs. If it is a place to be used all year round, the panel design is made according to the worst seasonal conditions.

If the place used is a seasonal or summer house, the first thing to know is between which months the house is used. In the sizing, system calculations are made based on the radiation values in the summer months.

In this case, the calculated system cost corresponds to almost half of the system cost made according to bad conditions. The design should be calculated according to the duration and season of use, so that the cost of the system is optimized.

When designing the system, it is important to choose the inverter with the appropriate power. According to the devices to be used, the inverter should be calculated with the voltage and power appropriate to the amount of energy drawn. To be selected

the most important point to be considered in the inverter is that the devices used (motorized appliances such as refrigerators) are strong enough to handle the demarcation current. The demining current can reach up to almost 3-4 times the nominal current. The inverter supply must be strong enough to handle this current according to the characteristics of the device.

If the area where the system will be installed will be a roof, the roof direction and slope should be calculated in detail. The construction to be installed should be mounted in such a way that it does not damage the roof insulation. If the system is to be installed in the garden, it can be mounted with fixed legs or by installing systems that follow the sun. Depending on whether the tracker is uniaxial or biaxial, the amount of energy produced can be increased by 15-35%.

The storage of the battery packs is very important for the life of the batteries. For this reason, when designing the batteries, the place where the batteries will be placed should be seriously considered as well as the autonomy period. The fact that the place where the batteries are placed is airy is very effective in preventing the batteries from heating up.

During the transportation of energy as DC, the amount of energy lost can reach very significant amounts as the distance increases. For this reason, the distance between the devices to be used (solar panel-battery-inverter) should be minimal. In addition, cables of the appropriate cross-section should be used.

After the system calculation is completed, the autonomy period will be determined according to the annual/seasonal use of the house and the energy needs of the house.

Hybrid systems

When an electric generator powered by wind or oil and biogas is added to photovoltaic systems, they are called hybrid systems.

APPLICATION ACTIVITY

Process Steps	Suggestions
➢ Create system wiring diagrams.	➢ It is useful to have separate schemes.
➢ Draw and explain the ten grid system.	1. Set up the circuit by drawing.
➢ Draw and explain the grid system.	➢ Set up the circuit by drawing.
Electrical System design to do Think about what equipment we can use.	➢ The design will be carried out according to the electrical equipment.
➢ Share the project you are considering with your friends.	➢ Evaluate the management and monitoring activities with your friends.

CHECKLIST

With in the scope of this activity, evaluate yourself by ticking the skills you have gained from the behaviors listed below in the Yes box and the skills you have not gained in the No box (X).

Evaluation Criteria	Yes	No
➢ Have you gained general information about the system and what electricity is for?		
➢ Have you learned the definition and scope of the system? ?		
➢ Do you understand what the system and its subdomains do?		
➢ Have you learned about the functions of electrical systems?		
➢ Have you learned about system on grid and of grid networks? ?		

Read the following questions and write the appropriate words in the blank spaces are the questions of the learning activity 1 unit.

Read the following questions carefully and select the correct option.

1. It is called the sequence of inputs, processes and outputs in which the parts form a whole .....

2. The system ..... …….is examined in two ways, ……..... and it is called a grid-dependent system .

3. This is what it is called if it is included in the renewable energy system in the hydraulic power plant .....

EVALUATION

Compare your answers with the answer key. Repeat the topics related to the questions that you answered incorrectly or that you hesitated to answer by returning to the activity. If all of your answers are correct, move on to the next learning activity.

LEARNING ACTIVITY –2

PURPOSE

When the necessary environment and equipment are provided, you will be able to determine the location of the solar panel inverter system.

RESEARCH

Research electrical panels. Gather information about the dialer.

2 LOCATING THE TRANSLATOR

Determination of Mounting Location

The inverter converts the DC energy produced by the solar panels into AC energy (220V-50 Hz) used in homes. In general, inverters are divided into modified sine wave inverters and full sine wave inverters in terms of output waveforms (Figure 1.1). It is difficult to distinguish the subtle difference between the two waveforms, but their performance should be looked at in terms of the devices they operate.

Modified sine inverters: A modified sine wave is an imitation of a complete sine. With square wavelets, a sine-like wave is obtained. The advantage is that it is cheap;

TV, computer, small appliances, lamps, etc. Some televisions and computers, especially professional and industrial devices, can very finely understand this difference. This will not harm the device, but it can be annoying. For example, on some televisions, a thin line may appear on the screen.

Full sine wave inverters: A full sine wave is the output we get from the grid, just like in the house. Very clean, neat and the best. Therefore, it can be used in all applications without any problems, your devices will heat up less. The full sine feature is necessary to meet and not disturb inductive loads such as washing machines, dishwashers and refrigerators. If you are going to run a motor, air conditioner, refrigerator as a load, or for industrial devices and applications, a full sine wave inverter is definitely recommended.

The power of the inverter (inverter) should be selected according to the instantaneous total power of the devices that are thought to work at the same time. For example, if you want to operate a 2 kW washing machine, a 300 W television and a 200 W lamp at the same time, a 2500W (2000W + 300W + 200W) inverter will be required.

Inverters used in solar energy solar PV systems can be divided into three groups. These; Central inverters to which the whole system is connected, Array to which the panel strings are connected

Inverters (inverters) are products that are the heart of the system that convert solar energy sources that produce direct current into alternating current (mains current).

These are divided into two as on-grid (on-grid) and off-grid (off-grid).

2.1 On Grid and Off Grid Grid

On-grid: These are inverters that can convert the direct current from the solar panels into alternating current and sell to the grid or give it to the grid.
Off-grid: These are inverters that charge the batteries with direct current from solar panels and convert the direct current from the batteries into alternating current.
Connection between the RS 232 port on some inverter types and the computer

System data can be obtained by installing. Especially in inverters used in grid-connected PV systems, the power and the electrical energy value produced can be seen on the screen on the device.

The inverter, which is one of the basic elements of the solar panel system, must be inside the solar panel system power panel (Figure 1.1). In the power panel of the solar panel system, there is a charge controller along with the converter. In some cases, there may be battery groups inside the solar panel system panel, and sometimes there may be external battery boxes outside the panel.

Solar panel system power panel, in buildings in buildings; In open areas, it should be in a place that can be controlled in accordance with the project.

When installing the inverter in the solar panel system power panel, the following warnings should be observed:

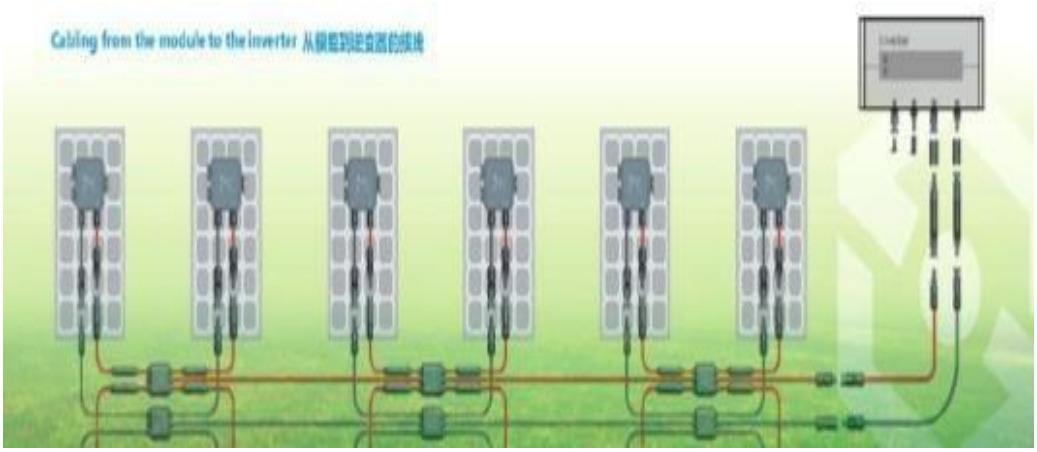
The inverter is only installed in a vertical position and on a solid floor, safely with bolts.

It is checked whether the distance between the two inverters and whether the cooling

is sufficient.

The place where the inverter will be installed must be protected from direct sunlight, high temperature and high humidity.

The inverter should never be installed in the immediate vicinity of easily flammable materials.



Switch off the mains voltage and observe a waiting time of at least 10 minutes before starting inverter wiring or maintenance work. This time is used so that the capacitors can discharge to a non-hazardous voltage value after the mains voltage is turned off. Measure the voltage between the P/+ and N/− terminal blocks with a measuring tool.

If the connection work is not carried out in a voltage-free condition, there is a danger of electric shock.

Keep the signal cables 10 cm away from the power cables to avoid noise problems when connecting the inverter cable. After the cable connections are finished, there should be no cut cable pieces inside the inverter. For example, cut cable parts can cause an alarm or malfunction. Do not allow chips or foreign matter to enter the inverter

when drilling the mounting holes.

Be careful to set the current/voltage input selector switch correctly. An incomplete adjustment can result in faulty functions. Tighten the attachment screws to the specified torques. If a screw is tightened looser than specified, it may cause a short circuit or malfunction. In the event that a screw is tightened more strongly than specified, it can lead to a short circuit, malfunction, ıt may cause cracking or breakage. Use insulated cable ferrule/lug for power input and motor connections. Long-distance cable(Especially shielded motor cable) The inverter may be affected by the charging current caused by the capacitance in the cables.)

2.2 INVERTER SELECTION IN SYSTEMS

2.2.1 INVERTER SELECTION

The choice of inverter is made according to the capacity of the installed system, but in some cases, inverters of different sizes are selected by going beyond the capacit

As we have explained in the previous topics, while making the connections of the battery system (series-parallel) according to the current and voltage value requested from us, we determine the capacity in line with the values requested from us, otherwise we will see that the system does not work properly or that malfunctions occur in the system, so inverters are selected according to the power of the system or within other desired parameters, except for the on grid or of grid systems.

2.3 REGULARIZATION

While regulating, a full and wave-free regulator is required for the output voltage rather than the system being independent, otherwise the system will produce errors and malfunctions.

IMPLEMENTATION ACTIVITY

Sun Mount the inverter in the panel system power panel and make the cable connections

Process Steps	Suggestions
1. Select the appropriate inverter to be installed in the cabinet. ➢	Take safety precautions related to work and wear work clothes, work gloves and work shoes before starting work. Prepare the working environment and provide the necessary tools and equipment for the working environment. ➢ Pay attention to the occupational safety required for the application to be made.
1. To mount the inverter, march the panel and drill the appropriate holes. 2. Provide screws, bolts and nuts to be used for assembly. ➢ Only install the inverter in the permitted installation position.	Only install the inverter in fire-resistant materials such as metal or concrete. Mounting on flammable material may cause a fire. ➢ Make sure that the mounting location will withstand the weight of the inverter.
➢ Mount the inverter to the cabinet.	1. Which can be caused by static electricity A nearby metal before touching the inverter to prevent damage

CHECKLIST

Within the scope of this activity, evaluate yourself by ticking the skills you have gained from the behaviors listed below in the Yes box and the skills you have not gained in the No box (X).

Evaluation Criteria	Yes	No
1. Have you put on the work apron and taken the necessary safety precautions?		
2. Have you selected the appropriate inverter to be installed in the cabinet?		
3.Did you measure the inverter mounting location correctly?		

At the end of the evaluation, review your "No" answers again. If you do not consider yourself sufficient, repeat the learning activity. If all your answers are "Yes", proceed to "Measurement and Evaluation".

Read the following questions carefully and fill in the blanks.

1. When connecting panel wiring..... Should be used.

2. It is called the part of the system that converts the energy it receives from the panel ……..

3. Inverters that charge the batteries with direct current from solar panels and convert the direct current received from the batteries into alternating current…….. .....are called inverters.

4. It is called the system element that regulates energy.....

5. It is called intercresis that gives clean output…….....

EVALUATION

Compare your answers with the answer key. Repeat the topics related to the questions that you answered incorrectly or that you hesitated to answer by returning to the activity. If all of your answers are correct, move on to the next learning activity.

LEARNING ACTIVITY–3

PURPOSE

When the necessary environment and equipment are provided, you will be able to connect the converter control panel elements and assemble the control panel.

RESEARCH

Collect information about the control panel elements. Research the control panel supply cables and present them to your other group mates as information.

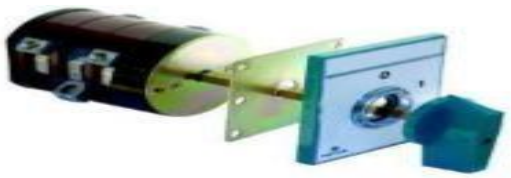
3 CONVERTER CONTROL PANEL

3.1 Control Panel Elements and Layout

Control panel elements; package switches, control buttons, signal lamps,

It consists of contactors, fuses, charge controller and inverter. In addition to these, fasteners are the elements used in the panel in cable trays, carrier rails and terminal blocks.

Package switches: Multi-position switches consisting of many contact slots arranged and packed one after the other on a shaft that can rotate around an axis are called package switches.



Control buttons: These are the elements used to start or stop the operation of a circuit. Start, stop, and it is divided into three as jog (two-way) buttons.

Signal lamps: The element that indicates whether a control element or its circuit is working with light is called a signal lamp.

Contactors: Large powerful electromagnetic switches that are used to open and close electrical circuits and can be controlled remotely by a drive system are called contactors.

Fuses: It is a circuit element used to protect electrical supply lines and receivers working in the circuit against overloads, high currents caused by short circuits and possible accidents that may occur to the people using them.

Charge controller: The direct current received from the solar panels will prevent the batteries from being overcharged thanks to the charge controller, preventing damage to the batteries and consequently reducing the performance and service life of the batteries. The charge controller controls the charge level in the batteries and prevents the batteries from being damaged by regulating the charge in case of any exceedance.

Inverter: Converts 12 volts of DC voltage obtained from solar panels into 220 volts of AC voltage in the placement of control panel elements, it is necessary to comply with the following rules:

Before placing the panel elements, it should be determined how many sections the panel will consist of according to the characteristics of the panel. The entry and exit points of energy to the panel should be determined. Measuring instruments should be placed near the top of the board and on the front cover to make it easier to read.

Signal lamps should be on the upper side of the ammeters. A residual current relay should be placed at the output of the main switch. Fuses and switches must be placed according to the direction of arrival of the energy.

If the energy supply is from above and the outlet is from below, the fuses should be put at the top.
Signal lamps should be located at the top of the switches. Signal lights and switches must be on the front cover. Fuses must be located inside. Contactors should be put in the central part.

3.2 Control Panel Installation

Before the panel is assembled in place, the equipment of the panel must be installed in place. The equipment of the panels is first mounted on the platforms of the panel, the other parts of the panel

When the processes are finished, these platforms are put into the board.

In order to mount wall-mounted panels on the wall, the mounting process is carried out with the help of wall mounting holes located at the back of the panel. For the assembly process, first of all, the wall must be drilled with the help of a drill. In order to securely fix the panel to the wall, the panel assembly process is completed with the help of dowels and screws of the appropriate length.

When installing the control panel, it is necessary to pay attention to the following instructions: The control panel must be mounted vertically and on a flat surface.

Since the panel will heat up while it is active, all four sides should be open and should not be blocked in any way. The enclosure must not be mounted inside another control cabinet or in a narrow enclosure. The accompanying screws and dowels and the hanging part of the panel should be firmly fixed to the wall and then hung on the panel hanger. Connecting the Control Panel Supply Cables The channels used in the panel should be selected according to the amount of cable. The small size of the duct causes the cables to be over-tightened and as a result, they heat up. If the channel is too large,

it will both take up more space in the panel and increase the cost. It is more preferable that the power cables are located in the open, rather than in the channel.

Since the power cables carry a large current continuously, their exposure provides ease of cooling. Power cables with a diameter of more than 6 mm2 are fed directly from the busbar and the panel

It goes openly in it. If both the power and the control cable will pass through the same channel, it is recommended that the power cable be at the bottom and the control cable at the top, because the control cables create a more numerous and complex appearance than the power cables. Control

Their cables are more likely to fail. Sometimes there is a need to make changes to the control structure. For all these reasons, keeping the control cable on top provides ease of intervention.

The control cables are laid in the duct and laced after the installation work is finished. In this way, the cables gain a smoother appearance. At the same time, flexibility is provided. For the lacing process, after the cables are connected with clips, they are attached to the clip hooks mounted with rivets or bolts at the bottom of the channel. The number of cables is low

On the other hand, squeeze macarons that shrink themselves as they heat up are used for the lacing process. After the cables are laid in the duct, the ducts are closed with the duct cover

Control cables are soft and difficult to shape. It is also not very important that they are shaped, since they go through the channel. Therefore, it is collected with clips or tubing

and fixed on the rail. While connecting the control cables to the devices, some excess is left in the cable, considering the possibility of shortening the cable in case of subsequent location change and malfunction in the device. This excess is removed by shaping the cable.

In the installation of cables that are cut to size and attached to the shoe/ferrule, to the device and terminal block.

It is necessary to pay attention to the following points:

- Elements such as lugs, ferrules, jacks must be attached to the end of the cable or soldered The cables must be connected to the terminal specified in the project.
- The cables should be given a certain form, and the cables standing next to each other should have the same shape.
- The bare part of the cable inside the terminal block must not remain outside.
- The insulated part of the cable or lug/ferrule must not enter the terminal block.
- In terminal blocks that are tightened with a single screw, such as a contactor, the cable should be inserted to the left of the screw according to the tightening direction.
- The terminal screw should not be loosely tightened, it should not come out when the cable is pulled by hand.
- Only one cable should enter each terminal block, if double entry is mandatory, the hub bridge
- Terminal block duplication should be used to do so.
- The terminal screws must be tightened with the appropriate screwdriver.
- When installing the power cables on the main busbars, they must be tightened at the ruler value with a torque wrench.

The internal connection of the panel, which has been placed with material, is made using control cables in accordance with the panel connection diagram. When making

conductor connections, the conductor ends should be carefully stripped, the conductor part should not protrude out of the connection and the connection points should be tightened well. Cable for easy circuit tracking later

Inputs and outputs should be numbered with the same number, and different cables should be numbered with a separate number. After the connection process is completed, the board should be tried and the device should be made sure that it is working. If the control elements are working properly, the cables should be clipped for a neat appearance and placed in the conduit and the conduit cover should be tightly closed.

The installation of the power cabos of the electrical panels is done with the help of busbars and cable lugs in large (large current) panels, and by connecting the appropriate lug to the power cable in other panels.

3.3 BREAKDOWN AND MAINTENANCE OF LV/MV PANELS

There are some important considerations in the maintenance of LV/MV panels. These considerations are important to ensure that the boards operate safely and efficiently.

- **Visual Inspection:** Check the exterior of the boards for any damage, dirt, or moisture. The clean and robust panels provide a safe working environment.
- **Connection Check:** Make sure the fasteners inside the boards are tight and secure. Loose connections can lead to electrical faults and risk of fire
- **Insulation Check:** Check whether the insulation of the cables inside the cabinets is intact. Damage to the insulation increases the risk of short circuits and electric shock
- **Cleaning:** Clean the inner and outer surfaces of the boards regularly. The accumulation of dirt and dust can make the boards efficient It can interfere with its operation
- **Temperature Control:** Check the temperature level inside the boards. Excessive

temperature can lead to damage to the elements inside the boards and lead to malfunctions.

- **Safety Equipment:** Make sure that the safety equipment (fuses, switches, relays) inside the cabinets is working properly. This equipment is important to prevent electrical faults
- **Periodic Maintenance:** Perform periodic maintenance of the panels regularly. This ensures long-lasting and safe operation of the boards

3.4 SOLAR SYSTEMS ARRAY COLLECTION PANE

In a photovoltaic system, the modules are arranged in arrays and areas, depending on the type of inverter used, the total power of the modules, and their technical characteristics. The connection of serial modules is done in the module itself, while the parallel connection of the strings is done inside the string collection boxes, which also include interconnect systems, surge protective devices, disconnectors and surge arresters.

String collection boxes, which can be standardized according to the number of strings, voltage and rated current systems.
For utility-scale installations, combiners are equipped with monitoring devices to measure current, voltage, and temperature to ensure the availability of arrays and maximize production.

ABB offers a range of different products, each dedicated to specific installation conditions with typical configurations.

3.5 Main benefits

Plug and play

Widest range for residential, commercial and utility-scale installations at 1000V and 1500VDC Global availability for on-site delivery, anywhere in the world

3.6 Major Features

Mechanical properties: IP66, IK10, GWT 750°C, UV and chemical resistant Electrical properties: double insulation (Class II), Ui/Ue: 1000V DC/1500V DC Wide range (in terms of number of sequences and monitoring systems)

3.6.1 Array combiner boxes without tracking

The installation of a photovoltaic system often occurs in complex logistical situations that are environmentally and time-critical. The availability of tested and certified, pre-assembled components prevents the installer from performing unnecessary field assembly, wiring, and certification activities for string boxes. String boxes include functions such as string protection, overvoltage protection and disconnection, as well as suitable components for various voltage levels and the number of connected strings.

3.6.2 Array boxes with tracking

Sequence monitoring is an important function in the operation of medium and large sized installations, because it improves the efficiency and maintenance of the system. ABB offers a range of pre-connected string boxes for all installation conditions: these are available for both string protection, surge protection and disconnection

It is equipped with the necessary devices as well as useful devices for string monitoring to measure string current, voltage and temperature within enclosures.

3.6.3 Multi-output array boxes

The development and increasing adoption of multi-string inverters, mostly in residential applications, has made it necessary to combine multi-wires with protective

devices and splitters in a single combiner box, taking the necessary measures to reduce costs and clearance in string boxes. It is intended to be connected to a specific inverter input.

Multi-wire inverters are solved in the conditions of an easy and low-cost system, which is characterized by modules installed in different bending and exposure positions, minimizing the problems associated with systematic shading of system parts.

3.7 SPP ENERGY TRANSMISSION LINE MAINTENANCE

SPP power transmission line maintenance is a critical process to ensure the efficient and safe operation of solar power plants. There are some important points to be considered in this process. First, it is important to check the outer surface of the power transmission line for any damage, dirt, or moisture. The clean and robust line ensures a safe working environment. In addition, it must be ensured that the fasteners inside the power transmission line are tight and secure. Loose connections can lead to electrical failures and risk of fire. It is also important to check whether the insulation of the cables inside the power transmission line is intact. Damage to the insulation increases the risk of short circuits and electric shock. Regularly cleaning the inner and outer surfaces of the power transmission line prevents the accumulation of dirt and dust, which can interfere with the efficient operation of the line. In addition, it is necessary to check the temperature level inside the power transmission line. Excessive temperature can lead to damage to the elements inside the line and lead to malfunctions. It must be ensured that the safety equipment (fuses, switches, relays) inside the power transmission line is working properly. This equipment is important to prevent electrical failures. Finally, performing periodic maintenance of the power transmission line on a regular basis ensures that the line operates in a long-lasting and safe manner move the solar panel system power control panel to the appropriate place and install it.

APPLICATION ACTIVITY

Observe an example scale implementation

Process Steps	Suggestions
Move the panel to the installation site in accordance with the rules. Place the control panel on a flat surface	1. Prepare the working environment. Organize your board by wearing your work apron. ➢ Take occupational safety precautions.
Install the cover locks of the panel. Since the panel will heat up when it is active, all four sides should be open, ➢ There shouldn't be anything around it.	Use hand and power tools (pliers, screwdrivers, side chisels, pocket knives or small knife blades, control pens) for their own purposes. ➢ Be meticulous and check every transaction you make.
Control the installation of cabinet covers, glazing, gaskets, hinges and door locks Please.	➢ Review each assembly process you do and check whether it complies with the standards.
➢ Clean the material.	➢ Do the cleaning work with solutions.

CHECKLIST

Within the scope of this activity, evaluate yourself by ticking the skills you have gained from the behaviors listed below in the Yes box and the skills you have not gained in the No box (X).

Evaluation Criteria	Yes	No
1. Have you moved the panel to the assembly site in accordance with the rules??		
2. Have you placed the control panel on a flat surface??		
3. Have you installed the cover locks of the panel??		
4. Have you checked the most recent installation?		

EVALUATION

At the end of the evaluation, review your "No" answers again. If you do not consider yourself sufficient, repeat the learning activity. If all your answers are "Yes", proceed to "Measurement and Evaluation".

MEASUREMENT AND EVALUATION 3

Read the following questions carefully and mark the correct sentences (D) at the beginning and the incorrect ones (Y).

1. ( ) Multi-position switches consisting of many contact slots arranged and packed in a row on a shaft that can rotate around an axis are called package switches.

2. ( ) An element that indicates whether a control element or its circuit is working or not is called a control button.

3. ( ) The element that converts 12 volts DC voltage obtained from solar panels into 220 volts AC voltage is called a charge controller.

4. ( ) Measuring instruments should be placed near the top of the board and on the front cover to make it easier to read.

Compare your answers with the answer key. Repeat the topics related to the questions that you answered incorrectly or that you hesitated to answer by returning to the activity. If all of your answers are correct, move on to the next learning activity.

LEARNING ACTIVITY–4

PURPOSE

To learn the structure of electrical machines and motors and to mount them in PV systems.

RESEARCH

Collect information about the engines.

Record the information you have acquired and share it with your teacher and friends.

4 ELECTRICAL MACHINES

4.1 GENERATOR (ALTERNATOR)

They are systems that convert motion energy into electrical energy. It is the phenomenon of the rotation of the alternating wheels with another power and the production of electrical energy at the winding poles as a result of the magnetic field formed in the system

4.2 ELECTRIC MOTORS

Electrical machines, as it is known, are an ongoing and developing dimension of developing technology with electricity. Machines have been offered to services in all

sectors and have made life easier. The part that we will examine in this module is the motors part of electrical machines.

Electric motors, on the other hand, have established themselves as indispensable for technology in all parts of life, converting electrical energy into circular motion energy.

Diversity in this module

Let's examine the engines and the systems that will be included in renewable energy.

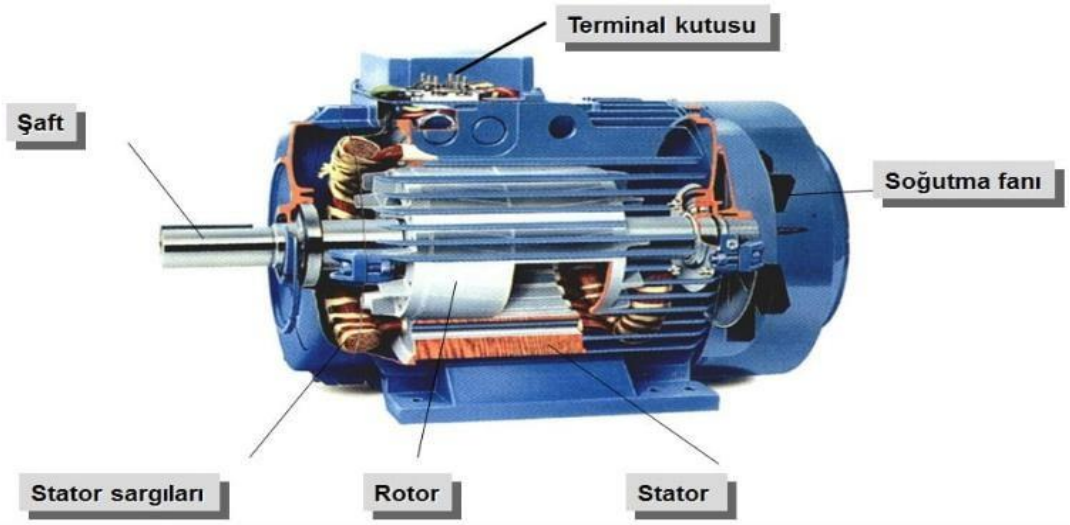
4.3 Alternating Current Motors

Alternating current is a current that consists of phases and whose direction is constantly changing and is not constant. Motors operating with alternating current are used in industrial applications where high power is required.

For example; In the trains produced to carry us, this power is synchronous working with alternating current.

Provided by motors now, we will talk about asynchronous and **synchronous motors** that work with **alternating**current

4.3.1 Asencron Motor



Above we see a cross-section of an asynchronous motor. Asynchronous motors; **It consists of two main parts called rotor** and **stator**. The stator is formed by compressing high-permeability steel laminates and placing them on a steel or cast chassis.

It is the part that surrounds the rotor along with housing the coil windings. The rotor, on the other hand, is the name given to the rotating part that is surrounded by the stator but does not contact the stator. There are two types of rotors, the squirrel cage rotor and the ring rotor.

The heat released by the energy losses in asynchronous motors increases the temperature and a cooling fan is used to dissipate it. The movement of the rotor is transferred out through the shaft, and the connections necessary for the operation of the motor are made in the terminal box.

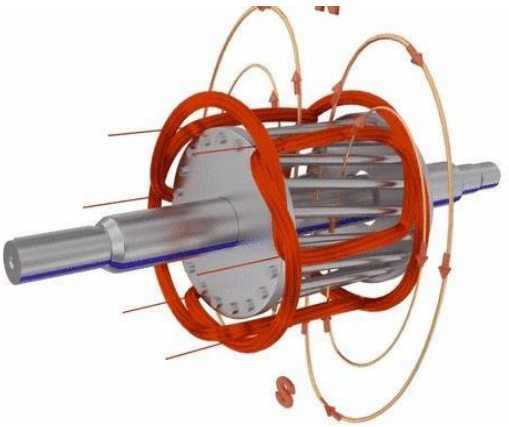
4.3.1.1 How Do Asynchronous Motors Work?

In the stator part of the induction motor, there are coils that receive input from three phases. An interesting situation occurs when current flows through these coils. Every conductor through which current flows creates a magnetic field around it. If the magnitude of the passing current changes with time, the magnitude of the magnetic field formed around the conductor also changes with time.

So, what happens if we apply the three-phase alternating voltage to three separate coil windings positioned at 120° degrees between them? The amounts of current to the coils change continuously and regularly. While the amount of current going to a coil decreases, the amount of current going to the next coil increases, and a rotating magnetic field is formed because it becomes continuous and regular. **The speed of this rotating magnetic field is called "synchronous speed".**

The synchronous speed depends on the frequency of the electricity coming to the coils and the number of poles of the motor. The rotating magnetic field created by the coils in the stator will cause the conductor in the rotor **to create a current on it in accordance with Faraday**'s Law.

Because; According to Faraday's Law, conductors in a variable magnetic field produce induction current. When current passes through the conductor in the rotor, it causes a magnetic field to form around that conductor. According to **Lorentz**'s Law, two magnetic fields exert force on each other and the rotor starts rotating.

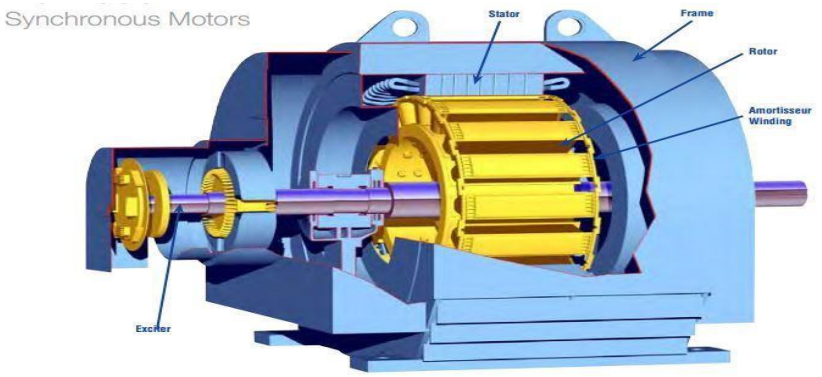


The speed of rotation of the magnetic field determines the speed of the rotor. After the rotor starts to rotate with the field due to the effect of the rotating magnetic field, it accelerates and its speed finally becomes equal to that of the rotating magnetic field. However, in this case, there is no magnetic field that "rotates" relative to the rotor **because** they both rotate at the same speed, so their speed relative to each other **is zero**. In this case, the net force acting on the rotor becomes zero and the rotor begins to slow down.

When the speed of the rotor decreases, it accelerates because it will be exposed to a rotating magnetic field again. What we mean here is that the speed of the rotor can never be equal to the speed of the rotating magnetic field. Therefore, the rotor and the rotating magnetic field move asynchronously. It is this phenomenon that gives this type of engine its name. The rotor always rotates slightly slower than the speed of the rotating magnetic field.

4.3.2 Synchronous Motors

Synchronous motors are used where speed control is more important and high precision is required. For example; If the place where the motor will be applied is a car or train, then a synchronous motor is selected



The parts of synchronous motors are the same as asynchronous motors; the stator that creates a rotating magnetic field through the voltage received from the three phases**,**

the rotor that interacts with the stator and performs the rotational movement**, the** cooling fan **that dissipates the heat generated**, the terminal box **where the connections are made** and the shaft where the movement is transmitted are the same, but here the situation that distinguishes the synchronous motor from the asynchronous motor is the same **It is caused by** the different structure of the rotor .

4.3.2.1 How Do Synchronous Motors Work?

Above we see the rotor of a synchronous motor. The windings on the rotor are connected to the direct current source to be fed from an external source, and when the rotating magnetic field created through three phases in the external direct current stator windings comes together with the electromagnets in the rotor, **a different situation occurs compared to the asynchronous motor.**

The poles of the electromagnet, which is formed by applying direct current to the windings in the rotor of the synchronous motor, match the rotating magnetic field. **Thanks to the pulling force they exert on each other on the principle of opposite poles attracting each other, the magnetic field and the rotor hold on to each other and rotate synchronously at the same speed.**

As a result of this situation, the shift in the asynchronous motor *(the frequency* of the magnetic field and the frequency of the rotor is different, the rotor frequency is less, slipping*)* does not occur in synchronous motors.

4.3.3 Direct Current Electric Motors

Direct current consists of high potential positive and low potential minus poles. Such motors are preferred in systems where direct current is used.

Vibration motor in phones, laptop cooling fans are examples of DC motors. They *are preferred because they can be operated by small batteries / batteries,* especially in places where working with alternating current may be dangerous *(*for example, in

toys**).** Direct current motors are basically ***divided into four as*** **brushed** DC motors, brushless ***DC*** motors, servo motors and stepper motors.

4.3.3.1 Brushed DC Motors

In general, electric motors convert the electrical energy they receive into motion energy thanks to some electromagnetic effects. Manufacturers group them in terms of some usage requirements. One of these groups, brushed DC motors, works on a similar principle to other types of motors. Therefore, although the parts it contains may contain some structural differences, they are mostly the same in name. **Rotor**, **stator**, **shaft**, **connection (terminal) box** and **cooling fan** (small it is not needed in motors) It is also found in DC motors. However, the main point that distinguishes DC motors from AC motors is this: Let's remember that in AC motors, we feed the coils in the stator with three-phase alternating current, creating a rotating magnetic field.

Since the DC current is constant and unchanging, it is not possible to create a rotating magnetic field for the stator of DC motors. In order to eliminate the deprivation of this and make the system work, some changes are made by adding brushes and commutators.

Of course, the brush we are talking about is a spring-loaded and conductive part. The commutator, on the other hand, is the part that comes into contact with the brushes and is fixed to the rotor.

4.3.3.2 How Do Brushed DC Motors Work?

Brushed DC motors have a magnet in the stator that is positioned to take the rotor between its poles. When direct current is applied to the rotor between this magnet, current flows through the conductor in the rotor. A torque acts on the conductor, which is exposed to the magnetic field created by the magnet and through which current

flows, and starts to rotate because if the conductor through which current flows is placed in a magnetic field, force acts on that conductor. Here, the indispensable thing to ensure the continuity of the movement is the brush.

Let's try to understand this situation by looking at the picture above. When the metal plate with the positive and negative poles connected is energized, a clockwise current passes through the plate and a force acts on the plate according to the **right-hand rule**. According to the picture, this force is clockwise.

When the metal sheet rotated 180° degrees, if there were no brush, this time the current would be counterclockwise and the force would act counterclockwise. As a result, the rotor would return to where it went. Meaningless movements formed in this way would render the system unusable. Thanks to the brushes used, even if the metal plate rotates, the current is always given to flow clockwise through the plate, and thus the motor rotates continuously.

4.3.4 Brushless DC Motors

The brushes of brushed motors come out over time due to friction and can create sparks. Therefore, this type of motor never guarantees longevity and reliability. At the same time, the friction created by the brushes reduces the efficiency of the motor because the amount of energy that will be converted into heat increases. Brushless **type DC motors**, which do not have these negative effects, are preferred to make operations safer and less noisy.

4.3.5 Servo Motors

All the motors we have mentioned so far are engines that make continuous rotational movement. When energized, the rotor of the motor will constantly rotate around itself. However, sometimes we may want to control the action of the motor, fix its speed or

make the motor rotate only as much as we want. Let's imagine a situation like this: Let's say we have a solar panel on the roof of our house and we want to set up a system where we aim to get maximum efficiency by allowing this solar panel to follow the sun.

4.3.5.1 In the mechanism we will set up

When we want the motor we will use to rotate a certain amount at certain times and adjust the solar panel to always face the sun, if the motor in the system rotates continuously, we cannot run what we plan as we want. We need to use the motor in such a system that we can adjust the position of the motor and rotate it at certain angles and always look towards the sun. The system that provides this is servo motors.

The reason why we call it a system is that servo motors are actually mechanisms that contain more than just motors. Servo assemblies detect the movement of the motor with a feedback mechanism and allow us to control the action of the motor. Simply a servo motor; **It consists of three parts**: the motor**,** the feedback system **and** the control circuit.

The motor used here can be AC or DC, brushed or brushless, and any size. For feedback, that is, to detect the movement of the motor, a potentiometer used by taking advantage of the change in the resistance on it, the Hall sensor that measures using the presence of a magnetic field, or any sensor that can help us to determine the position of the motor can be used. In order to complete the servo system, there is a control electronic circuit to which the sensor that receives data from the motor is connected and makes sense of those values.

4.3.5.2 How Do Servo Motors Work?

The rotation of the DC motor connected to the system allows the trimpot to rotate through the gears, and the amount of resistance falling on the trimpot changes as the

motor moves. By reading these change values with the control circuit, we can have information about the position of the motor, and if we want, we can bring the motor to the desired position through the codes we will write. Let's think about it this way; Let's have a potentiometer with a resistance of 10K ohms. Let's connect the potentiometer to a motor through gears when the resistance value is zero.

For the values we read through the control circuit, we can aşk the motor to take the following action: Start moving, rotate the motor until the resistance value of the potentiometer reaches 10k ohms, and finally stop the motor when it reaches. As you can see, we determined the position of the motor while moving through the potentiometer and made the specific movement we wanted.

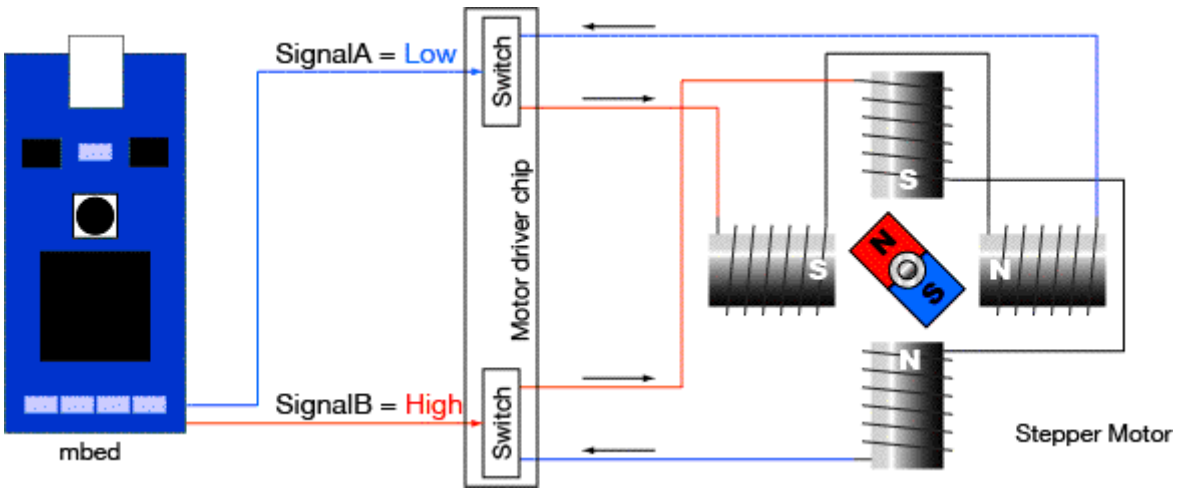
As another example of a servo motor, **we can give cruise *motor, vehicles***. As can be seen, the cruise control mechanism, in which the existing speed sensor interprets the data it receives from the motor and gives the necessary energy to the engine and keeps its speed constant, is an example of a servo motor. The rotation amount of the servo motors can be adjusted by the PWM signals given over the PWM output pin, the motor can be rotated to the desired position.

4.3.6 Stepper Motors

Stepper motors, as can be noticed from their name, are motors that move step by step. This allows them to move very precisely indeed. They are preferred in many areas such as printers, CNC machines, 3D printers, laser cutters, pick and place machines where precision is important. There are very advanced and complex stepper motors used today, but in order to learn the working principle, let's try to understand the way it works by examining the operation of a four-stage stepper motor.

4.3.6.1 How Do Stepper Motors Work?

Stepper motors are created by placing four coils on the stator. Each of the coils in the stator has an output that can be energized alone. If it is in the rotor there is a permanent magnet. When any coil is energized, the magnet moves towards the energized coil. This is how the movement of the rotor is achieved, and this is equal to one step. If two consecutive coils are energized at the same time, the rotor is positioned between the two coils. In this case, the rotor has taken half a step.



A four-stage stepper motor **has 5** outputs. One is the common pole, while the others are outputs that control each coil individually. By energizing each output in a certain order, it is ensured that the motor moves in a meaningful way. Of course, it does not make sense to do this by human hands, so the control of the stepper motors is done by

an external microcontroller. According to the code written in it, it is ensured that the motor moves in the desired way by energizing the outputs in a certain order. To read similar articles, you can take a look at the "Power Quality" category on our site.

This engine is used in the tracker systems made as a project in systems that automatically follow the sun with solar panels. Thanks to the retractor, it is the most preferred motor in operations, and we will examine autonomous systems with this motor in the next teaching activities

APPLICATION ACTIVITY

CONTROL LİST

Within the scope of this activity, evaluate yourself by ticking the skills you have gained from the behaviors listed below in the Yes box and the skills you have not gained in the No box (X).

Evaluation Criteria	Yes	No
Have electrical machines been inspected? ?		
Have you learned the types of electric motors??		
Servo motor learned??		
Has the stepper motor been examined? ?		

EVALUATION

At the end of the evaluation, review your "No" answers again. If you do not consider yourself sufficient, repeat the learning activity. If all your answers are "Yes", proceed to "Measurement and Evaluation".

Read the following questions carefully and fill in the blanks.

1. With the given voltage, the motor windings are called the motor that follows the rotary area from behind .....

2. It is called a motor that moves step by step…….

3. The magnetic field formed around a conductor causes it to produce voltage in that conductor……. Called. It is called the system that converts electrical energy into circular motion……..

EVALUATION

Compare your answers with the answer key. Return to the activity and repeat the topics related to the questions that you gave wrong answers or hesitated to answer. If all your answers are correct, proceed to the next learning activity.

LEARNING ACTIVITY–5

PURPOSE

You will know the systems in renewable energy and the solar tracking system.

RESEARCH

- Collect information about light sensors (LDR).
- Record the information you have acquired and share it with your teacher and friends.

5 SOLAR ENERGY SYSTEMS SOLAR TRACKING SYSTEM AND APPLICATIONS

5.1 SOLAR ENERGY SYSTEM APPLICATIONS GENERAL INFORMATION

In this module, which we have written under the name of the continuation of the basic installation and the application of the developing technology to the renewable energy system, we have shown solar energy systems as a basic installation in the previous module, let's explain what are the system developers in order to make the systems more efficient.

5.2 SOLAR TRACKER APPLICATIONS IN SOLAR POWER PLANTS

With the widespread use of solar energy systems in recent years, great importance is

attached to the applications made to increase the efficiency in these systems (solar tracking system).

There are many factors that affect efficiency in solar energy systems. Due to the inability to benefit from solar energy continuously and the fact that photovoltaic cells give maximum efficiency when the sun's rays are upright, it becomes difficult to get maximum efficiency from permanently installed panels. One of the most effective ways to prevent loss of efficiency for this reason; They are solar tracker systems that allow you to increase efficiency by up to 40%.

It is a known fact that it is important for fixed systems to face south in order to benefit from the sun throughout the day and increases energy efficiency. However, tracker solar systems (ges tracking system) take this efficiency one click further and increase the time to benefit from the sun throughout the day. Thanks to the solar tracking system, it is possible to benefit from solar energy throughout the day, and the lost part can be re-integrated into the system and the efficiency can be increased.

Solar tracking systems differ according to the tracking axis and control methods. In general, we can classify solar tracking systems as follows:

According to the number of axes;

Single-axis control Dual-axis control

According to the control method;

Passively controlled systems (closed loop) Actively controlled systems (open loop)

Solar Tracking Systems According to the Number of Axes Used Single Axis Control Systems

In these control systems, the panel moves only on one axis. Solar tracking system Thanks to this, it is possible to increase productivity by about 20-25%. In single-axis control systems, the panel is placed in the north-south line and its movement is made on the east-west axis.

Two-Axis Solar Tracking Systems

In two-axis control systems, tracking is carried out with two angle values indicating the position of the Sun in the sky. In this control system, one of the axes moves on the azimuth axis and the other on the zenith axis. With the two-axis control system, panel efficiency can be improved by 30-40%.

5.3 SOLAR TRACKING SYSTEMS ACCORDING TO THE CONTROL METHOD USED

5.3.1 Passive Controlled Systems

The location information required for the system to follow the sun is provided by sensors and they are closed-loop systems. In systems that work with the principle of directing solar panels in the direction where the light is intense, light-sensitive sensors or specially developed sensors can be used as sensors. The sensor placed on the front of the solar panel (ldr or photo diode, etc.) detects the direction in which the light comes more intensely according to the changing hours of the day and produces a signal accordingly. This signal is processed by the controller and the movement of the system in one axis or in two axes is realized. The advantage of passive-controlled systems is that their algorithms are not complex. However, the sensors used in the system can be very affected by environmental conditions and can make incorrect measurements. As a result, the position of the sun may be determined incorrectly, and the system may become unstable.

These systems operate in a closed loop, as the data received from the sensor is continuously monitored by the controller and a control signal is generated accordingly. After explaining the general working structure, we will examine the sensors for solar tracking.

5.3.2 Active Controlled Systems

It is an open loop tracking system that does not use any sensor system to determine the position of the sun and where location information is obtained with the help of mathematical algorithms. The position of the Sun can be modeled mathematically with some approximations according to its annual and daily behavior. According to the obtained mathematical model, the angle values form the control variables of the system.

It is more complex than passive control systems, but it gives more reliable results. The sensors are closed to the outdoor air, contamination, rain and errors caused by similar disruptive factors do not exist in these systems. Even if the weather is cloudy or overcast, since the position of the Sun is known mathematically, the panels can be positioned in such a way that they receive continuous perpendicular rays.

Active-controlled systems can also be designed as uniaxial or biaxial. While creating the control structure, it is sufficient to know the latitude, longitude and local time information of the region where the panels are located, as well as a few more variables, to determine the location.

There are two ways of working that are valid for both control methods. These ways of working are continuous work and fragmented work. In continuous operation, the position information of the sun is monitored instantly by the controller and the instant motion information is transmitted to the motors. In this way, the position of the sun is constantly monitored. In the form of partial operation, the controller receives the location information instantly, but the process of tracking the sun is carried out at certain time intervals. The reason for this is to reduce the energy consumption of the tracking system.

How much energy the solar tracking system consumes is an important parameter. The last thing that is desired is for an energy-producing system to spend extra energy on

the energy it produces. In particular, the mechanical and related electrical components required for the movement of large-sized systems can require high energy. In such systems, the sun is monitored by feeding the control systems directly from the grid or by controlling them partially.

5.3.3 Protection Against Wind

In addition, these systems protect the panels against possible damage by fixing them in the position that will be least affected by the wind in adverse weather conditions (high intensity wind).

5.4 OPTICAL TRANSDUCERS AND SENSORS

Optical element to elements that change the current passing over it depending on the light falling on it

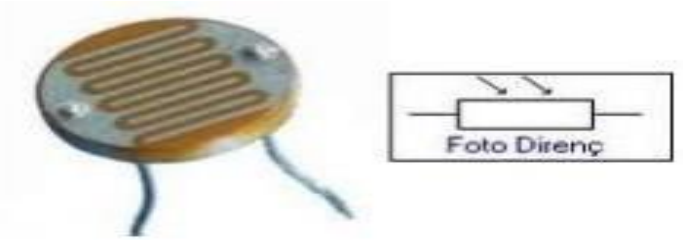
Called. Optical transducers convert changes in the amount of light into electrical signals. These elements are usually small current elements. Optical transducers

They usually do not carry the currents of the receiver, but only control the elements that operate the receiver.

5.4.1 Photo Resistor (LDR) Working Principle

The element whose resistance decreases when light falls on it and whose resistance increases in the dark is called photoresistance. Photoresistors are called LDR (Light Dependent Resistance). Some substances, such as calcium sulfate and cadmium selenide, show resistance changes in inverse proportion to the light falling on them. The resistance of LDR is very high (10 Mohm) as long as it does not get any light on it. As the applied light intensity increases, this resistance value decreases (75-300

Ohms).



5.4.1.1 Uses

It can be used in all circuits that want to be controlled depending on the light. It is used in alarm circuits, counters, flash cameras, park, garden and street lighting.

5.4.1.2 Robustness Test

The avometer is set to the ohm stage. LDR shows a very small value in illuminance. This value is approximately 100 ohms. When the LDR is covered, the resistance value shown by the avometer will increase. Otherwise, the LDR is broken.

5.4.1.3 Photo Diode Working Principle

Photodiodes are diodes that conduct in the opposite direction with the effect of light. They are connected to the circuit in reverse. A negative voltage is applied to the anode and a positive voltage is applied to the cathode.

5.4.1.4 Uses

Photodiodes, transistor and thyristor triggers, light-controlled circuits, alarm circuits They are used in electronic flashes, light measuring devices, oprtcouplers and counter circuits.

5.4.1.5 Robustness Test

We set the avometer to the ohm stage. After connecting the photodiode to the avometer leads in reverse, we need to see that the resistance of the photodiode is high in the dark and the resistance is low in the light. Otherwise, the photodiode is defective.

5.5 LDR AND ENGINE MOUNTING

The sensors that should be included in the tracker system are LDR sensors. It is convenient and ergonomic. For the Tracker system, the number of sensors will be determined and used on all four sides of the panel to be monitored for the tracker system, and the number will be determined and used, and the panel will be guided step by step by using the motors (stepper motor) in the panels, and this system is supported by both the electronic card and the ardunio software.

The motor will be used in two ways, the first determines the anchor direction, while the second determines the direction of the panel up and down.

5.6 SOLAR TRACKING SYSTEM (GTES)

Although solar energy is an energy source that can be easily reached in nature among renewable energy sources, there are many factors that have a negative effect on electricity production from the sun's rays reaching the earth.

The efficiency of PV systems depends primarily on the solar radiation value, which depends on climatic conditions, it depends on environmental temperature changes and

wind speed, the compatibility of the designed electrical converter system with the load and the correct positioning of the solar panels.

Since most of the systems used today are stationary, it is clear that PV panels cannot produce the maximum electrical energy that they can produce with the radiation reaching their surface. The sun-tracking system (GTES) is a system that follows the sun throughout the day with various methods and ensures that the sun's rays are perpendicular to the PV system where they are integrated. In this way, the PV panels will start to produce maximum energy with the radiation falling on them.

Before the development of solar trackers, PV systems were installed at an acceptable angle considering the location of the system on the earth. This angle of inclination may vary depending on which of the radiation values that the sun will produce in winter or summer is selected when designing the system. Because the angle of the sun's rays with the earth varies depending on the seasons.

For example; Positioning a system planned to be established in the southern hemisphere "to the south" and a system planned to be established in the northern hemisphere to the "north" will increase the amount of energy to be produced.

The fact that a PV panel produces the highest energy it can produce with the radiation reaching the panel surface depends on the sun's rays coming to the panel surface at an angle of 90◦.

Therefore, since we cannot control the direction of the sun's rays in order to maximize the energy to be produced, PV panels can be mounted on moving devices and the system can follow the sun and the angle of incidence of the sun's rays falling on the panel can be 90◦. In the last 20-30 years, studies related to GTES have shown that smart solar trackers increase energy production to the highest possible level within the capacity of the PV system.

And although their costs are decreasing day by day, electricity generation from PV

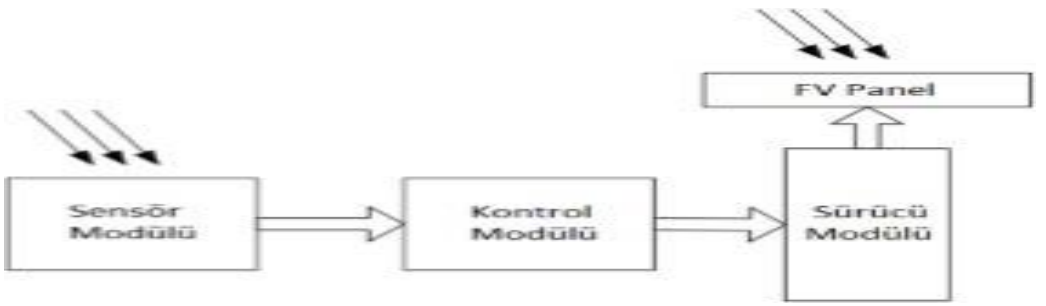
systems is still significantly expensive at the moment. For this reason, in addition to the negativities caused by atmospheric conditions in a PV system to be installed, not being able to get full efficiency from the system will prolong the recovery period of the investment made. Therefore, it is important to get the maximum energy that can be obtained from an installed PV system. One of the most cost-effective and easy methods to use for this is to use the sun tracking system (GTES).

Studies have shown that a well-designed solar tracking system increases the efficiency of the PV system by 20% to 50% compared to a fixed-positioned PV system.

5.7 GTESCompits and Types SystemStructures

GTES structures are structures that consist of both mechanical and electrical parts. Mechanical equipment consists of the appropriate construction that will provide the PV panel movement and the equipment that will provide the connection between this structure and the electrical elements.

The electrical part simply consists of the motor, motor driver, controller and various sensors (e.g., photosensitive sensor). A block diagram of a sample GTES in its most general form is shown below.

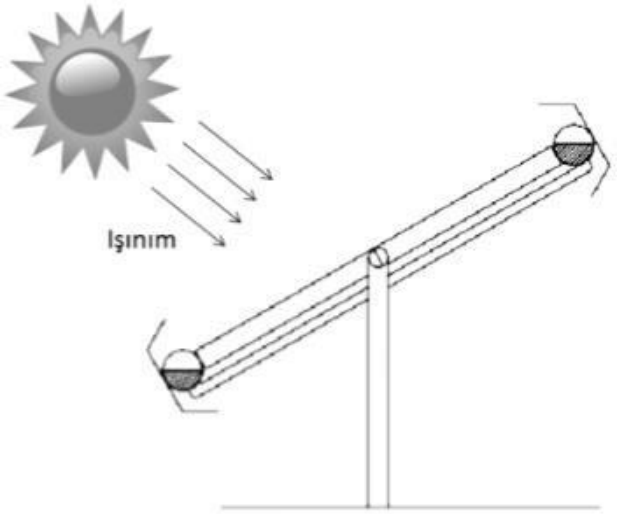


In some GTES structures, systems for storing energy in the electrical part (e.g. battery, accumulator) and electronic systems to charge these systems can also be used. In this way, it can be ensured that GTES follows the sun without being de-energized.

5.8 Types of Systems

If a GTES can track all the positions of the sun, the PV system will provide the highest level of electricity production. This will be possible if the solar tracker follows both the daily horizontal movement of the sun and the seasonal vertical movement of the sun. For this reason, we can divide solar followers into two main categories: passive (mechanical) followers and active (electrical) followers. Let's remember again mentioned above.

Of these, passive followers work mainly on the principle of thermal expansion of matter or on the basis of shape memory alloy. These types of systems usually have two actuating mechanisms that act opposite each other. When these systems are illuminated differently from each other, the resulting unbalanced force difference activates the system in such a way that it creates a balance between the forces. An example passive follower is seen below.



Active trackers can be microprocessor and electro-optical sensor-based, computer-controlled date and time based, bifacial solar cell based, and a combination of these three systems.

Electro-optical systems can consist of at least two photosensitive sensors or solar cells, usually located non-parallel to each other. Thus, system movement is ensured until all sensors perceive the sun's rays equally. The DC motor to which the system is connected is controlled with the help of a microprocessor and moved in the desired direction.

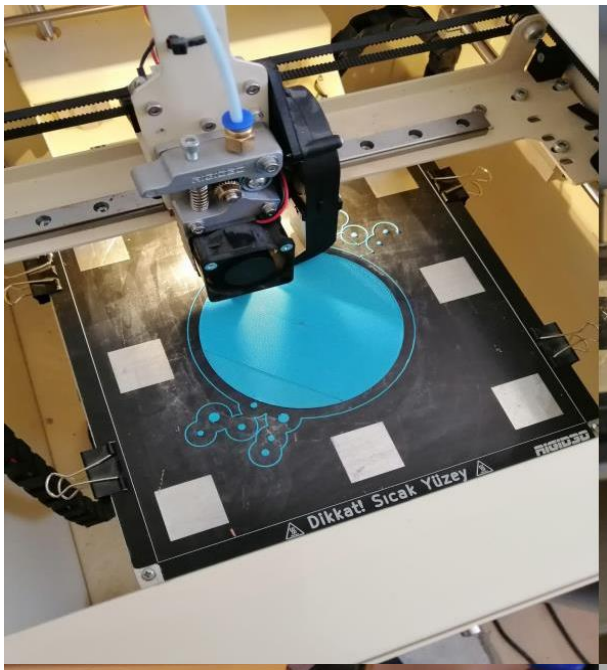
The two-sided solar cell, on the other hand, detects the position of the sun and moves the system to the desired position. In these systems, solar cells (panels) are directly connected to the DC motor that provides system movement. Therefore, electronic equipment such as batteries and motor drives in the system are eliminated. Therefore, these systems offer a simple and reliable application for space and land applications.

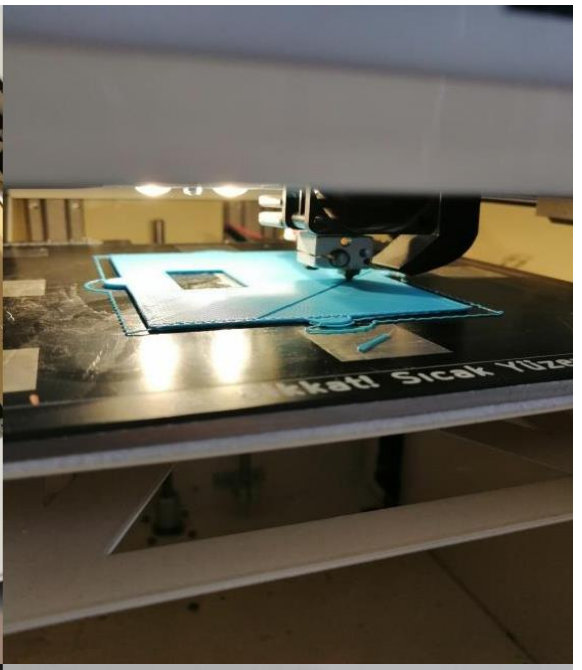
In computer-controlled date and time-based systems, the computer tries to calculate the position of the sun using various time and date algorithms, and as a result, a control signal is produced that will enable the system to move towards the specified position. It is also described in detail above in the sensors section.

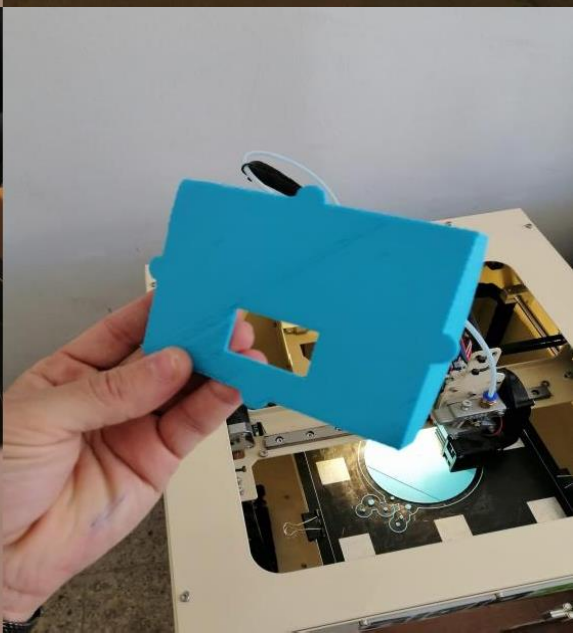
5.9 TRACKER SYSTEM DESIGN AND IMPLEMENTATION

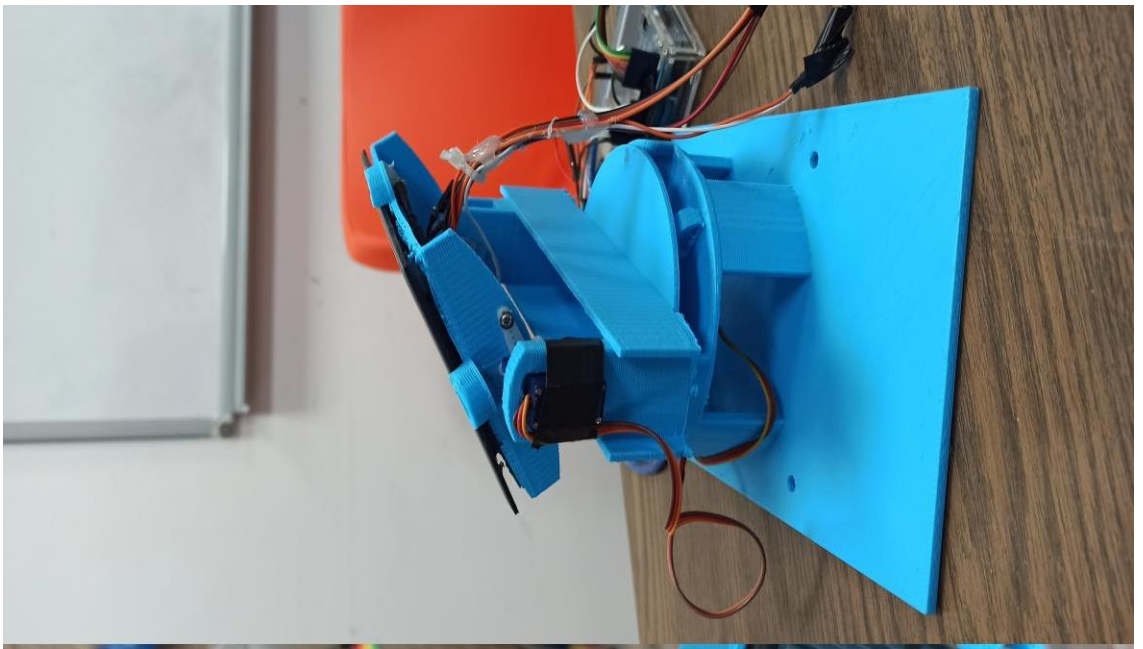
In the process of designing the system, panel holder construction and anchors were made as a model in the external movement, this system was made to work with a 3D printer. In the interior design, only motors and panels were used, servo or stepper motors can be used in the system, if the system is large, repellent motors will be more suitable, stepper is preferably used in small systems. Sunbathing data is calculated and entered in advance.

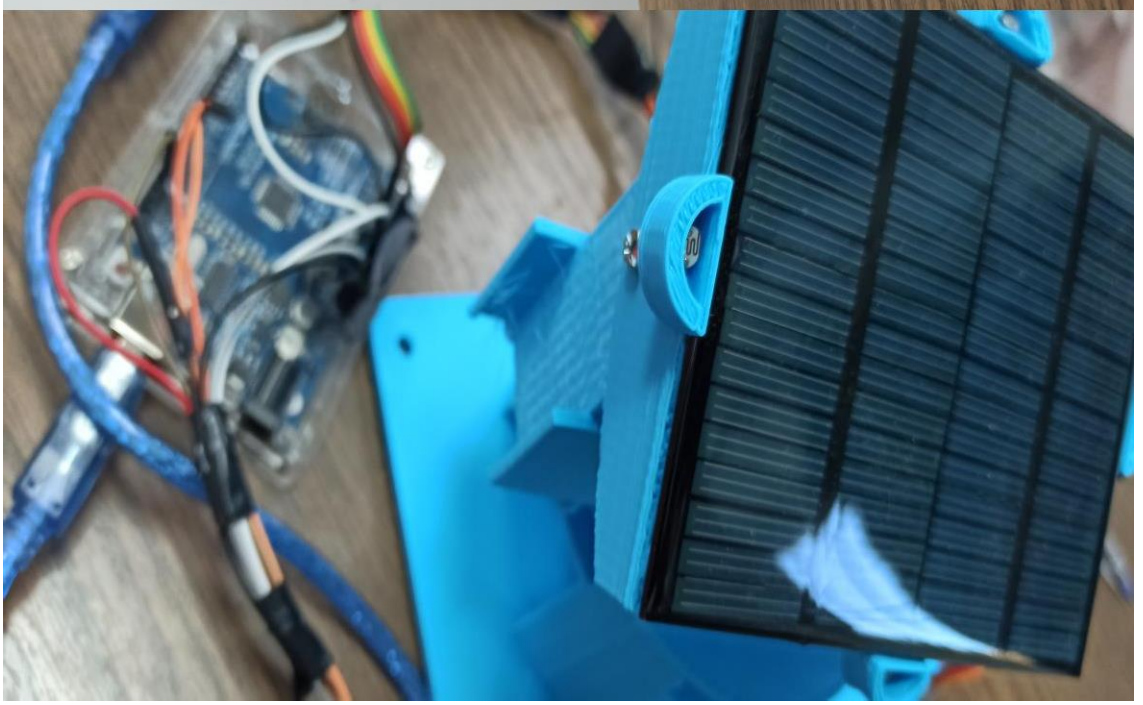
Using 4 LDR sensors, 1. Stepper motor, north and south direction 2. The stepper motor was activated, the motors were driven with the electronic driver card in the system and the operation took place.


Dikkat! Sıcak Yüzey









IMPLEMENTATION ACTIVITY

Process Steps	Suggestions
Move the measuring instrument to the appropriate position to measure the tension at the ends of the sensors.	➢ Give the light intensity intense enough and examine the sensor status.
➢ Apply voltage to test motors for the tracker system.	➢ Put the measuring instrument on the volt stage.
Associate the LDR with the electronic board and apply light.	➢ Adjust the angles and try it that way.
Mount the motors to the tracker system.	➢ When the installation is complete, try it and make a note if the system is working properly.

CHECKLIST

Within the scope of this activity, evaluate yourself by ticking the skills you have gained from the behaviors listed below in the Yes box and the skills you have not gained in the No box (X).

Evaluation Criteria	Yes	No
Is the motor mounted stationarily??		
Is the LDR fixed?		
Is the panel fixed to the construction?		
Does the tracker work and get the data in a healthy way? ?		

EVALUATION

At the end of the evaluation, review your answers as “No”. If you do not think you are proficient, repeat the learning activity. If all your answers are “Yes”, proceed to “Assessment and Evaluation”.

Read the following questions carefully and mark the correct sentences (D) at the beginning and the incorrect ones (Y).

( ) The system that follows the sun and generates electricity is called a tracker.

( ) The sensor that is sensitive to light is called LDR (photoresistor).

( ) The tracker system is only one-way.

( ) Asynchronous motor is used in tracker systems.

EVALUATION

Compare your answers with the answer key. Return to the activity and repeat the topics related to the questions that you gave wrong answers or hesitated to answer. If all your answers are correct, proceed to the next learning activity.

INTEGRATION OF ARTIFICIAL INTELLIGENCE INTO

RENEWABLE ENERGY

Energy Production Forecasting: Artificial intelligence can predict the energy production of solar panels by analyzing weather data. For example, an app called Nnergix uses satellite data and machine learning algorithms to make energy production predictions more accurate.

Efficiency Optimization: Google's DeepMind technology has been able to reduce the energy consumption of data centers by 40%. Similarly, artificial intelligence algorithms can be used to improve the efficiency of solar panels.

Predictive Maintenance: Artificial intelligence can optimize maintenance processes by detecting potential failures in solar panels in advance. This reduces costs and minimizes system downtime.

Weather Adaptation: Artificial intelligence can optimize the angles of solar panels by analyzing weather forecasts. For example, on cloudy days, the angle of the panels can be adjusted to ensure maximum energy production.

Energy Storage and Management: Artificial intelligence optimizes energy storage systems and ensures the balance of energy supply and demand. This increases the security of energy supply while reducing energy costs.

The integration of artificial intelligence (AI) in renewable energy systems greatly improves efficiency, making energy production processes more optimized, reliable, and flexible. The integration of artificial intelligence offers several advantages in energy production, storage, and distribution processes.

Let's focus on the effects of this integration on productivity and examine the technical details that support it:

Optimization of Energy Production with Artificial Intelligence

Predictive Models and Data Analysis: AI improves production forecasts, especially in variable sources such as solar and wind power. Advanced machine learning algorithms predict fluctuations in energy production using weather data, historical energy production data, and demand forecasts.

Efficiency Impact: These forecasts more accurately match energy demand and production capacity, preventing unnecessary energy loss. For example, in a solar power plant, AI optimizes the panel angle based on sunlight levels during the day, ensuring maximum energy production.

Smart Grid Management: AI enables the optimization of smart grids that connect power generation centers. It monitors and controls energy flows from different sources in real time. For example, it directs to storage systems when energy demand is low.

Efficiency Impact: This smart balance in the grid minimizes energy losses and allows for more efficient use of the energy produced. In addition, small grid-connected energy generators (e.g. solar panels in homes) are directed more effectively.

Developing Energy Storage with Artificial Intelligence

Battery Management and Energy Storage: Artificial intelligence plays a huge role in energy storage systems (especially battery management). By balancing storage capacity and usable energy, energy is returned to the system when demand is high.

Efficiency Effect: The life and usage capacity of the batteries are optimized with artificial intelligence. The use of the stored energy at the most appropriate time is possible with the correct management of the charge and discharge cycles. This is critical for meeting energy needs at night, especially in solar energy.

Demand Forecasting and Dynamic Storage: AI can dynamically predict energy demand and route storage systems based on demand. In variable sources such as solar and wind power, it optimizes the timing of energy storage.

Efficiency Impact: When the balance of demand and supply is achieved correctly, energy loss is reduced, thus increasing efficiency throughout the system.

Use of Artificial Intelligence in Maintenance and Repair Processes

Predictive Maintenance: Artificial intelligence determines the maintenance needs of equipment in solar and wind power plants in advance and ensures maintenance before failure. The data collected through the sensors is processed by AI algorithms and it is determined when the system needs maintenance.

Efficiency Impact: Detecting equipment failures in advance prevents interruptions in energy production and therefore less disruption to the energy production process. Reduced downtime ensures continuity of production capacity.

Fault Prediction and Autonomous Repair: AI uses remote monitoring and analysis systems to detect faults that occur on solar farms, especially in remote locations. Autonomous drones or robots can speed up oubleshooting

and repair processes.

Efficiency Impact: Autonomous repair systems allow problems to be resolved quickly without the need for human intervention. This minimizes production downtime and increases system uptime.

Reducing Cost and Reducing Carbon Footprint with Artificial Intelligence

Optimization of Energy Costs: AI reduces overall operating costs by identifying the most cost-effective strategies in energy production. It saves money by optimizing storage and energy transfer, especially when energy demand is low.

Efficiency Impact: Lower energy costs both make the production process more sustainable and provide more affordable energy for consumers.

Reducing Carbon Footprint: Artificial intelligence reduces reliance on fossil fuels by increasing efficiency in energy production processes. Especially as the use of renewable energy sources increases, carbon emissions decrease and environmental impacts are minimized.

Efficiency Impact: AI-powered energy systems increase efficiency, making it possible to consume fewer resources to produce the same amount of energy. This provides a great advantage in terms of environmentally friendly energy production.

Case Studies for AI-Powered Energy Optimization

Google's Energy Optimization: Google's data centers have saved 15% energy by optimizing energy consumption with artificial intelligence algorithms. Similarly, renewable power plants can be optimized with AI, making them more efficient.

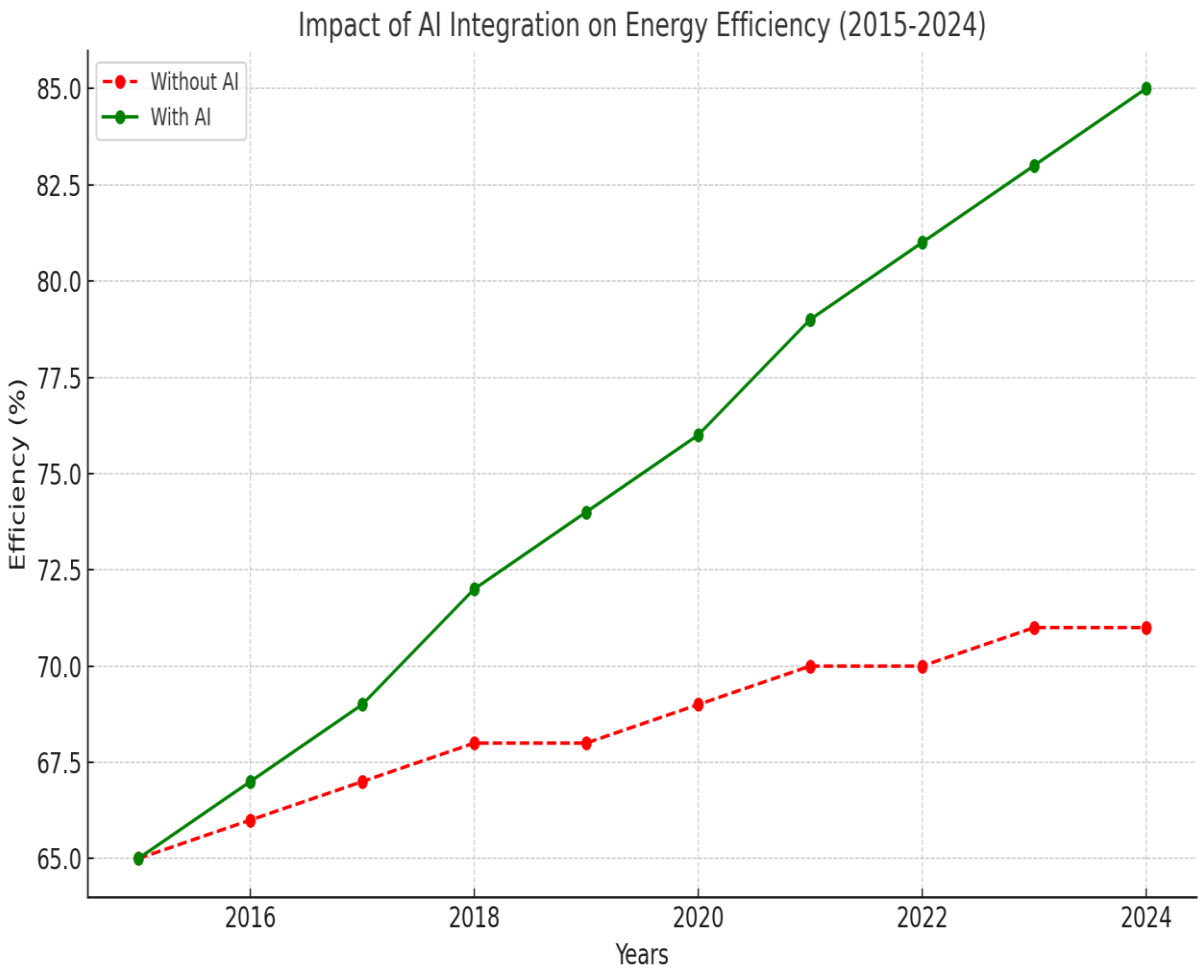
Efficiency Impact: Large-scale power generation and distribution centers are made more efficient with AI, saving energy and reducing carbon emissions.

Tesla Powerwall and AI-Powered Battery Management: Tesla's Powerwall system is supported by artificial intelligence, allowing solar energy to be stored and used efficiently in homes. AI meets the energy needs of the home with stored energy by predicting energy demand.

Efficiency Impact: AI-optimized energy use at home scale increases individual energy savings while reducing the load on the overall grid.

AFTER ALL

Artificial intelligence is a critical technology that increases efficiency at every stage in renewable energy systems, from energy generation to storage, from grid management to maintenance. Thanks to AI, energy losses are minimized, costs are reduced, and environmental impacts are made more sustainable. This technology optimizes the performance of renewable energy systems, while making it possible to apply them more widely around the world.


Impact of AI Integration on Energy Efficiency (2015-2024)
Without AI
With AI
Efficiency (%)
85.0
82.5
80.0
77.5
75.0
72.5
70.0
67.5
65.0
2016
2018
2020
2022
2024
Years

MODULE EVALUATION

In the parentheses left blank at the beginning of the following sentences, write D if the information given in the sentences is correct and Y if it is incorrect.

( ) The sequence in which the parts form a whole iscalled a system.

( ) Systems are divided into open and closed.

( ) Machines that convert motion energy into electrical energy are called electric motors.

( ) Electric motors stator has magnet.

( ) Tracker systems are advantageous systems.

( ) Electrical machines are long-lasting magnetic systems if maintained.

EVALUATION

Compare your answers with the answer key. Return to the activity and repeat the topics related to the questions that you gave wrong answers or hesitated to answer. If all your answers are correct, proceed to the next performance test.

APPLICATION ACTIVITY

CHECKLIST

Within the scope of this module, evaluate yourself by ticking the Yes box for the skills you have gained from the behaviors listed below, and No for the skills you have not gained.

Evaluation Criteria	Yes	No
Is the system defined??		
Have systems and subsystems been identified?		
GES de teknolojik oluşumlar dikkate alındı mı?		
Is the installation of the tracker system planned?		
Is the system controlled autonomously? ?		

EVALUATION

Compare your answers with the answer key. Return to the activity and repeat the topics related to the questions that you gave wrong answers or hesitated to answer. If all your answers are correct, proceed to the next performance test.

ANSWER KEYS

ANSWER KEY OF LEARNING ACTIVITY-1

1	Sistem
2	Open and closed system
3	On grid
4	Hybrid

ANSWER KEY OF LEARNING ACTIVITY-2

1	Connector
2	Converter
3	Off grid
4	Regulator
5	Full-wave

ANSWER KEY OF LEARNING ACTIVITY-3

1	True
2	Mistake
3	Mistake
4	True

ANSWER KEY OF LEARNING ACTIVITY-4

1	Asencron Motor
2	Step motor
3	Principle of induction
4	Electric motor

ANSWER KEY OF LEARNING ACTIVITY-5

1	True
2	True
3	Mistake
4	Mistake

ANSWER KEY OF MODULE EVALUATION

1	True
2	True
3	Mistake
4	Mistake
5	True
6	True

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8. MASTER'S THESIS

9. JUNE 2016

10. MAXIMUM TRANSFER OF ENERGY TO THE LOAD WITH SUN-FOLLOWING SYSTEM DESIGN AND MPPT CONTROL IN PV SYSTEMS

11. Muhammad Iqbal ORT