



RENEWABLE ENERGY TECHNOLOGIES

PREPARING THE CONSTRUCTION MODULE

2022-2-TR01-KA210-VET-000098216

IN RENEWABLE ENERGY TECHNOLOGIES NEW APPLICATIONS ACCORDING TO 4.0 STANDARDS



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DESCRIPTIONS

FIELD	Renewable Energy Technologies
OCCUPATION	Solar Energy Systems
NAME OF THE MODULE	Preparing the Construction
DESCRIPTION OF THE MODULE	It is a learning material that provides knowledge and skills regarding the preparation of the construction used in the installation of solar energy systems.
COMPETENCE	Preparing the construction
PURPOSE OF THE MODULE	<p>General purpose When the solar energy systems workshop environment is provided, you will be able to carry out the construction preparation processes in practice.</p> <p>Purposes</p> <ol style="list-style-type: none"> 1. You will be able to control the foundation concrete of the metal carrier system (Construction). 2. You will be able to make station grounding connections. 3. You will be able to supervise the construction of panel scaffolding and assembly. 4. You will be able to mount the panels to the frame

1. CHECKING THE FOUNDATION CONCRETE OF THE METAL CARRIER SYSTEM (CONSTRUCTION)

Metal carrier systems, which are the basic components of solar energy systems, must be compatible with the ground foundation structure and must be statically balanced to carry the solar panels. Depending on where it will be used, the metal carrier system must be constructed in a way that it will not come out of its fixed place, tip over or slide under environmental load effects, as well as the solar panels it will carry.

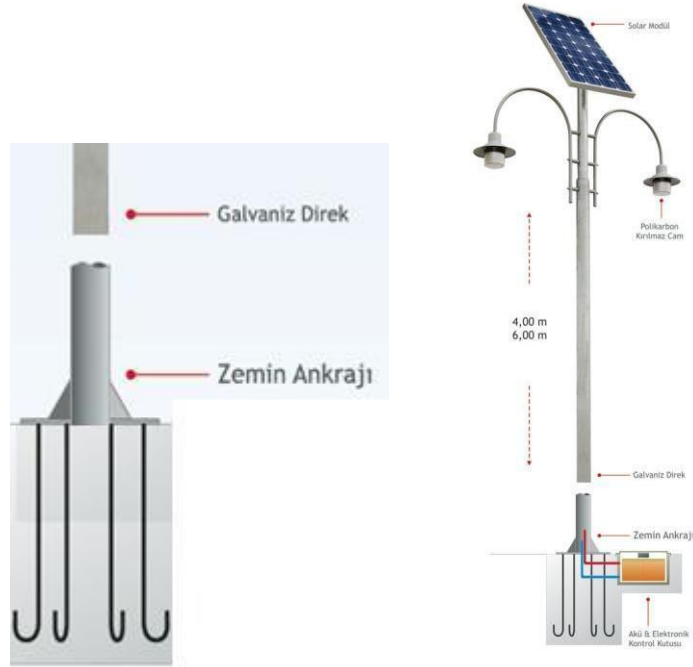
The number, length and thickness of construction anchor shafts should be determined according to the solar panel module structure. In addition to the constantly acting weight load, intermittent loads such as wind and snow should also be taken into consideration. In this case, foundation and fixing dimensions are determined by considering the worst load conditions. In this case, the necessary projects are made by taking into account the geographical and topographic characteristics of the area where the power plant will be installed. Engineers (specialists in statics) are employed to make load calculations for facilities to be established in open areas. Today, computer programs that include engineering processes are used for such determination processes.

1.1. Measuring the Lengths of Anchor Rods

Anchoring is the process of making a structural element work together by fastening it to another material or element by inserting it into it. In other words, if we define anchorage; We can define it as the connection of steel reinforcement into concrete in reinforced concrete structures.



Picture 1.1: Various anchor bars



Picture 1.2: Solar lamp post ground anchor

While planning, care is taken to ensure that the number and length of anchor shafts are kept to a minimum in accordance with the load. Modules that lean on the metal carrier resist air flow. Wind blowing towards the front surface of the panel creates high pressure on the panel. On the other hand, the back side of the panel creates a lower pressure due to wind circulation. In this case, our construction must be strong enough to withstand the force caused by the pressure differences on the front and back surfaces of the panel. The anchor lengths determined in the projects are important in this respect. During assembly, these shafts should be checked by measuring with a tape measure whether they comply with the lengths in the project. Picture 1.2 shows the anchor shafts and anchor foundation of the street lamp.

1.2. Measuring the Level of Concrete and Anchor Shafts

According to the project, after the foot areas of the metal carrier system that will sit on the ground are marked, excavation is carried out and the foot foundation pit is dug according to its size with a pickaxe, shovel, dowel and scoop. The concrete mold is prepared to be placed in the opened pit. A 10 cm thick mortar is poured into the holes opened at the points where the metal carrier legs will sit, a few days before the anchor bar is placed. In some places, pile foundations made of steel can be used instead of concrete foundations (Picture 1.3).



Picture 1.3: Steel foundation piling and driving machine used in solar power plants

The anchor bar of the solar panel construction legs is placed on the pit floor on a suitable scale. After the anchor iron is placed in the pit, the anchor foundation must be made in accordance with the technological rules. In order to ensure that the anchor remains in its position for a long time, the anchor is filled with mortar in accordance with the procedures and a foundation is made. In order for the metal carrier legs to sit properly, the level of the anchor bar is balanced with a spirit level.

In this way, the panels on the metal carrier are mounted in the same alignment to create a smooth surface. Otherwise, an unbalanced installation will distort the surface shape, causing the surfaces to cast shadows on each other and causing losses in the total efficiency of the system. On the other hand, an irregular panel arrangement will reduce the technical assembly quality. Picture 1.4 shows the properly leveled and assembled metal carrier system.



Picture 1.4: Metal bearing concrete and anchors balanced on a scale in the solar power plant

1.3. Determining Irradiance Angle

Sunlight falling on the earth can be direct (direct radiation) or diffuse (diffuse radiation). Direct radiation comes from the direction of the sun, while diffuse radiation spreads through the sky layers and has no specific direction. Thus, sunlight coming from the sky consists of the sum of direct and diffuse radiation. This total radiation is called global radiation or total radiation. In this case, total radiation;

Total Radiation = Direct Radiation + Diffuse Radiation (Figure 1.1).

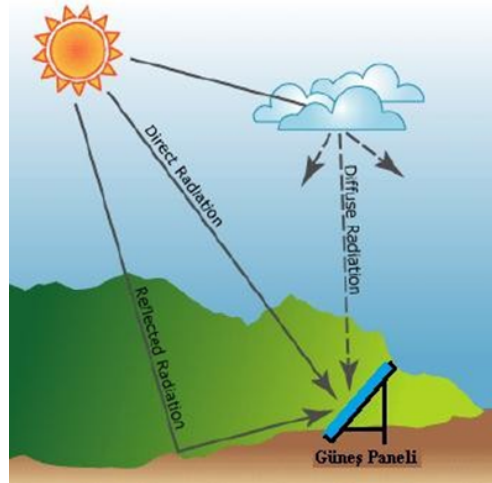


Figure 1.1: Direct and diffuse radiation

It is very important to determine the radiation angle in facilities that will be established to generate electricity from solar energy. To determine the radiation angle, the orbit of the sun must be known. In this case, the position of the sun is seen differently all over the world.

The position of the sun in the region where the solar power plant will be installed is determined by the altitude of the sun and the azimuth angle of the sun. Solar radiation is measured with pyranometers and photovoltaic sensors. In order to maximize the amount of energy obtained from a solar panel, the sun's rays must come at a right angle to the panel surface. To achieve this, the solar panel is placed inclined to the ground at a certain angle, making it perpendicular to the radiation coming from the sun (Picture 1.5).



Picture 1.5: Inclined placement of solar panels to receive the sun's rays vertically

1.4. Checking whether the south direction is at 90 degrees with the concrete

We know that in order to maximize the amount of electrical energy obtained from the sun's rays, solar panels should be kept at a steep inclination towards the sun's rays. The solar panel arrays used to generate electricity from solar energy are mounted with the direction directed towards the south.



Picture 1.6: Metal carrier concrete shapes where solar panels are mounted

While the direction of the constructions carrying the solar panels is placed towards the south, the ground concrete on which the anchors of the construction legs are fixed is at a 90 degree angle with the south direction (Picture 1.6 and Picture 1.7). In this case, the concrete

foundation and ground should be measured and checked before pouring the concrete to ensure that it is 90 degrees south. Otherwise, the direction of the construction carrying the solar panels will be placed incorrectly and the energy obtained from the panels will also cause losses. These losses will always exist as long as the system operates.



Picture 1.7: Connection methods of metal carriers to concrete foundations

2. MAKING STATION GROUNDING CONNECTIONS

2.1. Combining the Grounding Leads Left with the Feet of the Metal Carrier System

Photovoltaic systems that produce electrical energy from solar energy carry the risk of lightning strikes due to the location and installation area. Photovoltaic systems that produce a voltage greater than 50 volts DC must be grounded. Protection of buildings and photo-voltaic systems is important in terms of increasing the operating time of the facilities and the safety of investments. Solar panels are grounded with solid copper and flexible copper conductors depending on the installation location. The biggest factor in the failure of photo-voltaic systems is generally high voltage resulting from lightning strikes. In such cases, the user of the photo-voltaic system faces high repair costs as well as the damage caused by the system stopping. To prevent these damages, lightning and high voltage protection designed to suit each other should be used.

Figure 2.1 shows the grounding principle diagram of a photovoltaic system connected to the grid.

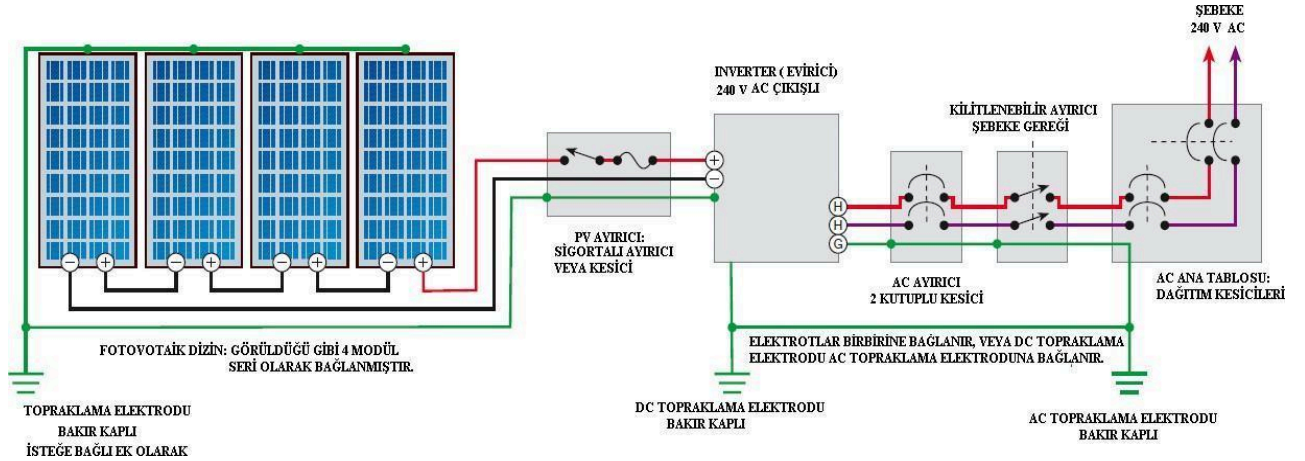


Figure 2.1: Grounding diagram of a grid-connected photovoltaic system



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To play the video, click on the image or click the link below and open it with your browser.

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The constructions carrying the photovoltaic panels are grounded via the grounding line and the grounding shoes mounted on them, and all conductors are finally combined in the grounding system. Picture 2.1 shows the grounding stage of metal carriers.

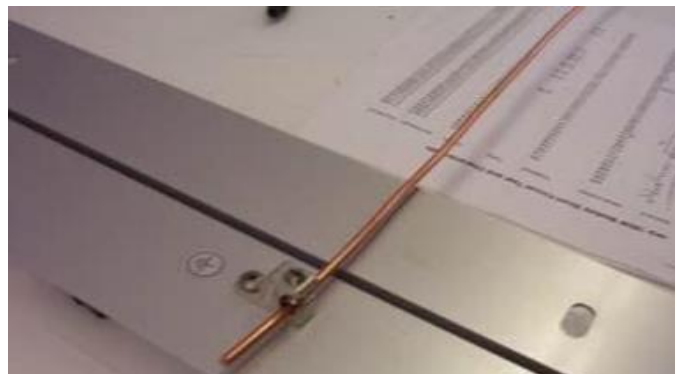


Picture 2.1: Grounding of metal carrier system legs

2.2. Connecting the Grounds of Solar Panels Together

Photovoltaic (PV(Photo Voltaic)) modules; Each module must be grounded via the mounting rails or by grounding lug or equipment grounding screws. In another method, the grounding wire is connected to the grounding shoe on each module, and then the same wire is connected to the grounding shoe on the carrying rails.

All module frames must be properly grounded in countries where module grounding is mandatory. Equipment specified for grounding the metallic frames of photovoltaic modules must be connected to ground the exposed metal frames of the module. In all cases, ground screws, bolts or other parts must be used separately from the module mounting parts. Picture 2.2 shows the correct and incorrect ways of connecting photovoltaic panels to each other.



Resim 2.2:a) Use of wrong lug and wire

Resim 2.2 b) Correct continuous grounding connection with stainless grounding screw

Photovoltaic systems that produce renewable energy carry the risk of lightning strikes due to the location and installation area. Protection of buildings and photo-voltaic systems is important in terms of increasing the operating time of the facilities and the safety of investments. Solar panels are grounded with solid copper and flexible copper conductors depending on the installation location. The biggest factor in the failure of photo-voltaic systems is generally high voltage resulting from lightning strikes. In such cases, the user of the photo-voltaic system faces high repair costs as well as the damage caused by the system stopping. To prevent these damages, lightning and high voltage protection designed to suit each other should be used.

Since the metal frames of the solar panels are on the metal carrier mounting rail, grounding the the mounting rails of the solar panels will also ground the solar panels.

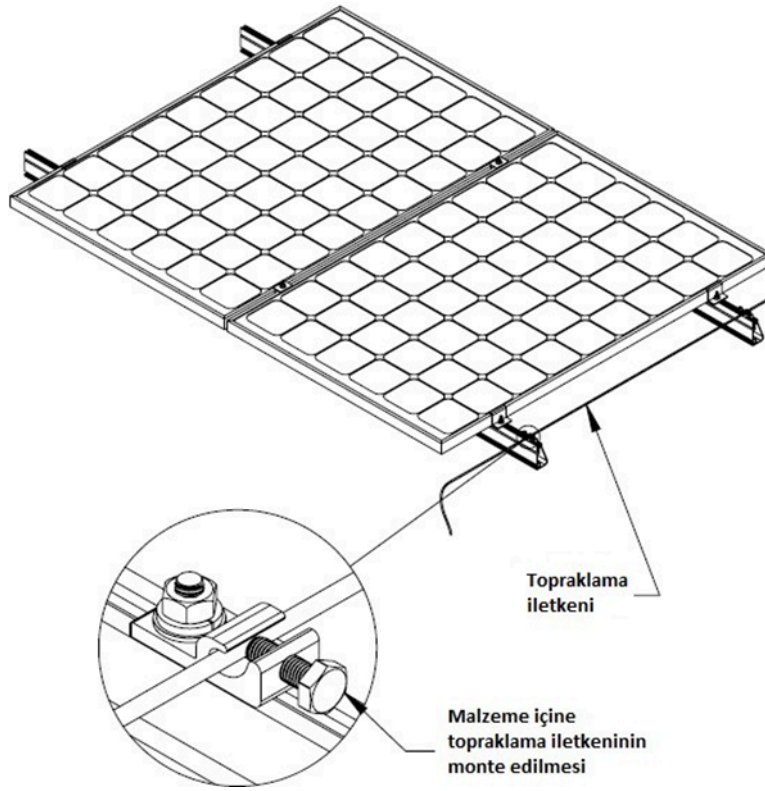


Figure 2.2: Connecting the grounding conductor to solar panels

Since the application areas of photo-voltaic systems are always designed to cover the entire available surface, they must be integrated with the existing grounding system. In the TT (Plant Grounding) system, protection grounding is done next to the receiver and only phase and neutral cables are pulled to the transformer.

Solar panels are mounted on metal mounting rails. Since the metal frame and mounting rail of the solar panels are conductive and contact each other, grounding the solar panel mounting rail will also ground the solar panel. The joints of the solar panel mounting rails must also be electrically connected to each other (Figure 2.3).

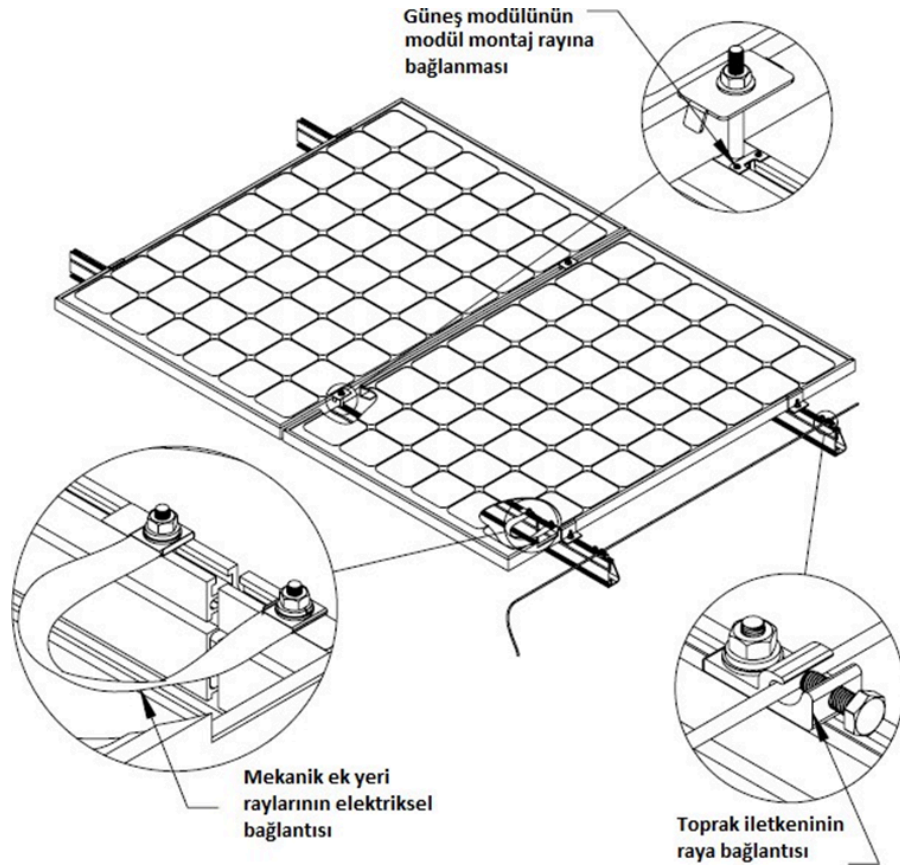


Figure 2.3: Connection of solar panels to the mounting rail



Picture 2.3: Grounding fasteners

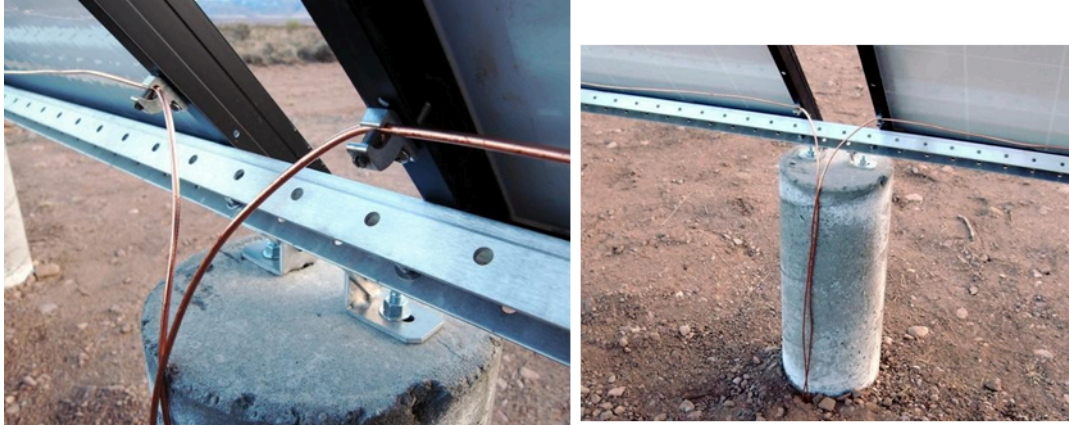
2.3. Connecting Grouped Grounding Unit to Field Grounding

The grounding electrode used in the system can be as many as the number of different devices in the system. The commonly used ground electrode is a copper-coated steel rod with a length of 2.4 meters and a diameter of 16 millimeters, which is driven into the ground.

The grounding rod must be in contact with the ground along its entire length. To connect the cable to the grounding electrode, connection clamps are used to remain underground. The resistance between the ground electrode and ground should be 25 ohms or less. To make these measurements, grounding resistance measuring devices are needed. If the resistance in measurement is greater than 25 ohms, then a second grounding electrode to be connected must

be at least 1.8 meters away from the first. If it is a rocky soil, the grounding electrode can be driven at a 45 degree angle to the normal and at a depth of 76 cm from the surface.

They are grounded by making connections to the field grounding as in the specified applications (Picture 2.3).



1. Picture 2.4: Field grounding

3. MAKING THE PANEL SCAFFOLDING AND ASSEMBLY

3.1. Metal Manufacturing and Welding Works

The metal carrier system is the skeleton of solar power plants. The basic ground metal carrier systems that will be used to transport the solar panels and make their electrical connections. The area where the metal carrier systems will be installed is determined in advance

as a result of a long-lasting feasibility study. In line with the measurements and data, the shape, size and basic details of the metal carrier system to be used are revealed.

During the project phase, metal carrier systems are designed by taking into account the environmental conditions such as wind, rain and snow that the area where the power plant will be installed will likely be exposed to. Another burden of the metal carrier system is the specific gravity of the solar panels. These are also taken into consideration when performing joint welding works.

While manufacturing metal parts of metal carrier systems, cleaning the welding areas before and after welding is often one of the most important processes of welding. For this purpose, chemical methods such as resistance welding or mechanical methods such as electric arc welding are used. On the other hand, in order for the weld joints of thick parts to have the desired strength, it should be noted that the weld bead must be opened on the edges to be joined. One of the most important issues is to make metal fabrication in accordance with the dimensions specified in the project.

3.2. Arrangement of the Working Environment

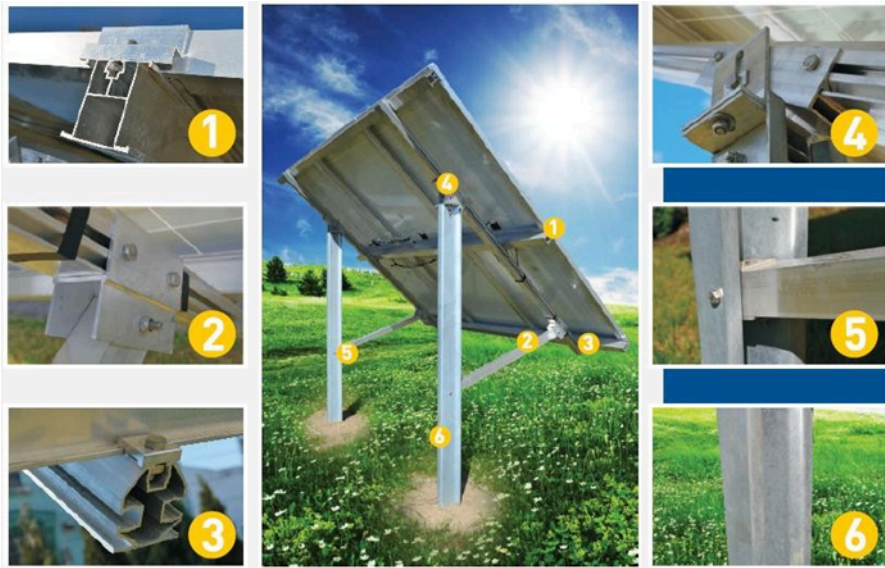
It is the elimination of materials that are left over or unsuitable for use in metal manufacturing processes. In terms of cleanliness and order of the work area, unusable materials should be eliminated. Recycling should be prioritized and the material should be separated according to its type and recycled. This type of operation is also extremely important in terms of operating safety. Arranging the working environment in accordance with safety measures will prevent possible work accidents in advance.

3.3. Determining the Orientation of the Metal Skeleton

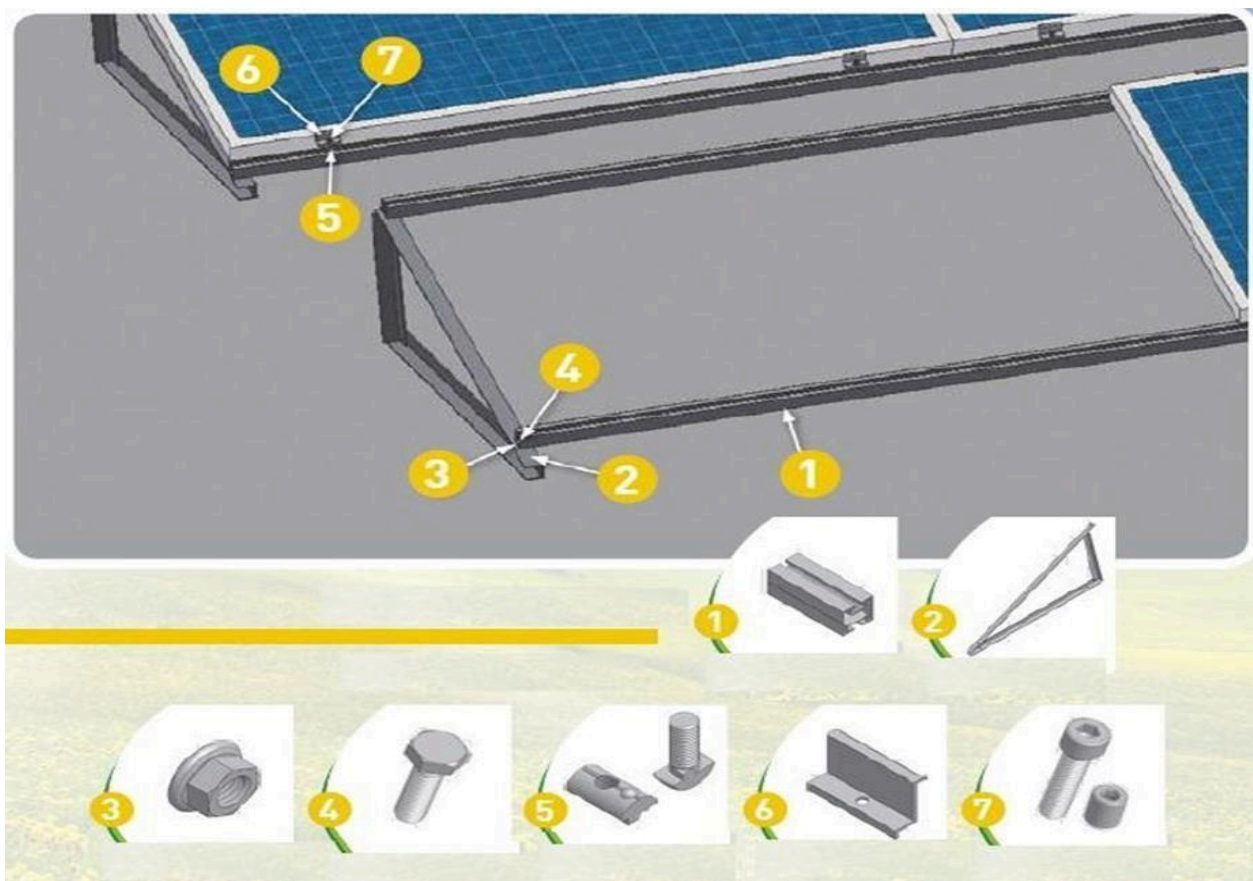
In order to maximize energy production from solar panels, systems are needed so that the metal skeleton carrying the solar panels sees the sunlight at the right angle from sunrise to sunset. These solar energy systems maximize the production of electricity from solar energy by holding the solar panel at the right angle in many different ways.

Before assembling the metal carrier frame (construction), direction should be checked and the system should be mounted facing south. In addition, care should be taken to place the area where the metal framework will be installed in an area that will not be shaded by other metal frameworks, trees and buildings. Before installing the system, direction and shadow calculations must be made with the help of a compass. In order for solar panels to work efficiently, they must face south.

While the direction of the constructions carrying the solar panels is placed towards the south, the ground concrete on which the construction legs are fixed is at a 90 degree angle with the south direction. Otherwise, the direction of the construction carrying the solar panels will be placed incorrectly and the energy obtained from the panels will also cause losses. These losses will always exist as long as the system operates. Picture 3.1 shows all the details of a system installed in the south direction and in a position to receive the best sunlight.



Picture 3.1: Metal skeleton system assembled towards the south



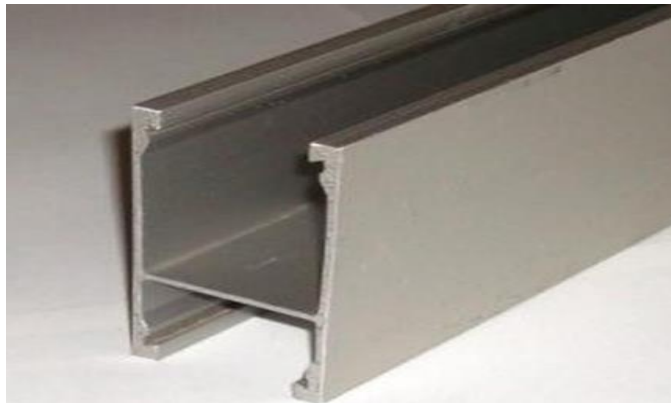
Picture 3.2: Metal carrier system and components

3.4. Ensuring the Combination of Metal Components with Appropriate Materials

Using appropriate materials when assembling the metal carrier system will help the assembly system to be long-lasting and more resistant to damage caused by the external environment. The issue of joining metal components that are exposed to wind, rain, snow and the weight of the panels is more important. The most important thing to remember is to install the right materials with appropriate tools and in the most robust way.

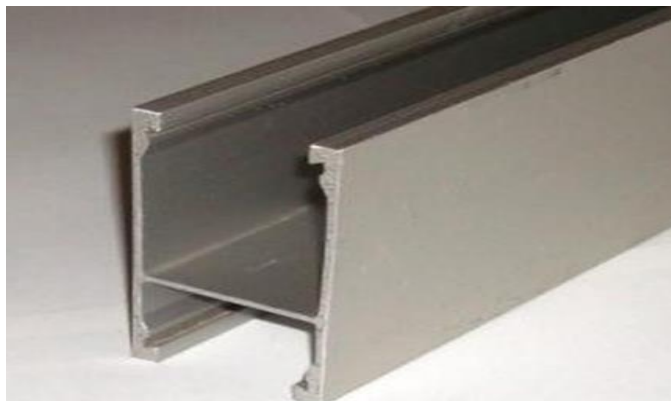
The variety of metal components is quite large. In this regard, there are more than one type of materials that serve the same purpose in the production sector. Each manufacturer uses and sells elements of its own design. In this case, knowing the usage area of the material and carefully examining the manufacturer's catalogs will facilitate the installation. Picture 3.2 shows the details of a metal carrier and its components.

In metal carrier systems, rails are used to mount the panels to the construction. These rails are also one of the basic materials from which the grounding process is carried out (Picture 3.3).



Picture 3.3: Panel fixing and grounding rail

Another element used in the assembly of panels and metal systems in metal carrier systems is the channel nut. With the help of this element, the panels are fixed with the nut fixing pieces placed inside the rail (Picture 3.4).



Picture 3.4: Channel nut

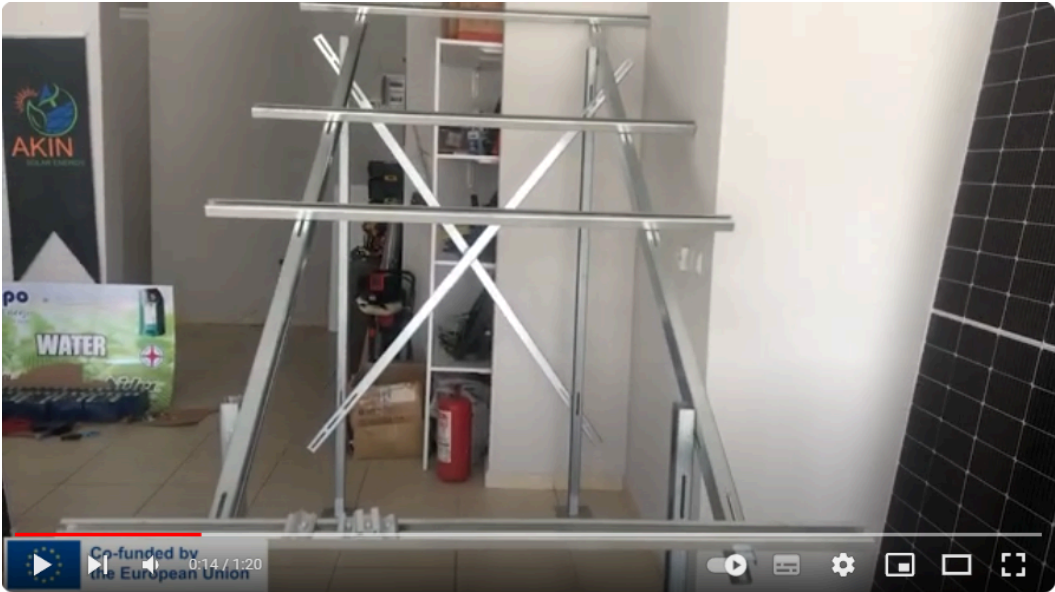
Clamps are used in joining metal construction. Thus, metal systems are strengthened and fixed with these elements. The clamps used may vary depending on the type of construction and the manufacturing company in order to fulfill the same function. Pictures of various handcuffs can be seen in Picture 3.5 and Picture 3.6.



Picture 3.5: General end clamp



Figure 3.6: Mounting clamp used for pipe type constructions



To play the video, click on the image or click the link below and open it with your browser.
<https://www.youtube.com/watch?v=bCvDjVPY8Xk>

4. INSTALLING THE PANELS TO THE FRAME

4.1. Laying Panels on Profile

During the solar power plant installation, the metal carriers (construction) on which the panels would be placed were positioned by adjusting the panel surface direction and angle to receive the most energy from the sun. After all this, solar panels selected according to the project should be carefully placed on the construction to be assembled. Solar panels must be mounted on the construction using appropriate equipment to prevent wind load, snow load and their own specific gravity from affecting the system negatively and causing damage. The panels must be in proper alignment during assembly (Picture 4.1).



Picture 4.1: Keeping solar panels aligned while arranging them

After the first row of solar panels is properly arranged and fixed on the construction, the next row is moved on. During fixing, the final fixing element is used and the intermediate fixing element is used between the panels.



Picture 4.2: Solar panels laid on profiles

4.2. Securing Panels with Fasteners

Binding or fixing elements are used when fixing the panels on the construction. These fasteners come in two forms: terminator and middle fixing element (clamp).

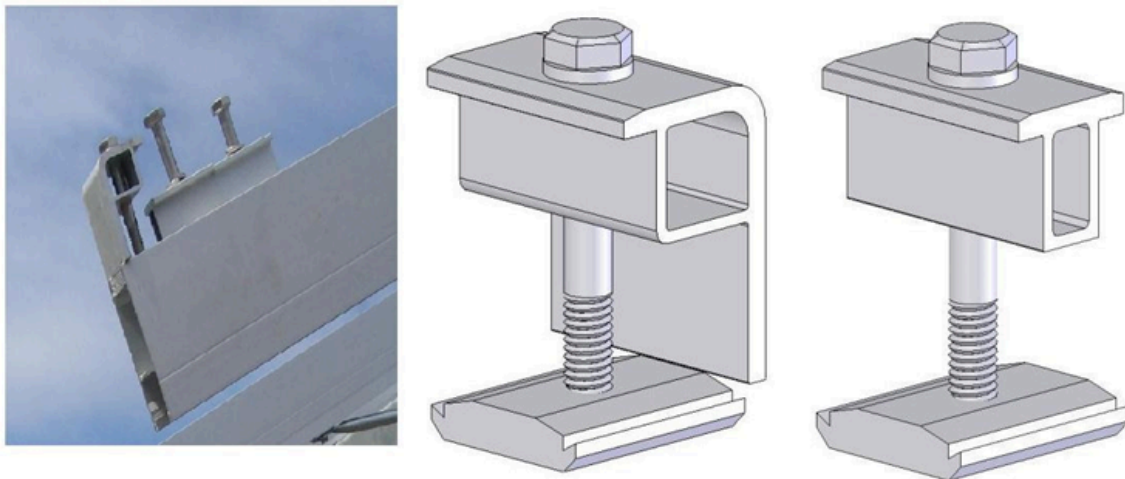


Figure 4.1: Terminator and intermediate fixing fasteners

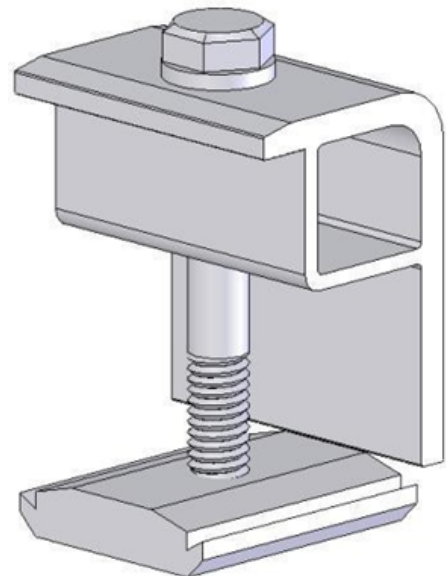
Interconnectors or clamps used between panels must be installed very well. For this, appropriate hand tools should be used and screws should be tightened to the appropriate torque. During assembly, connection gaps must be removed by re-tightening. This will increase the resistance of the system against wind forces.



To play the video, click on the image or click the link below and open it with your browser:
<https://www.youtube.com/watch?v=afds8iyZKk0>

4.3. Securing Panels with Finisher

After the solar panels are arranged on the carrier metal system, they are fixed after the carrier rails. During fixing, different shapes of fixing elements, or in other words, terminator fixing clamps, are used. The terminator fixing element can be seen in Picture 4.4.

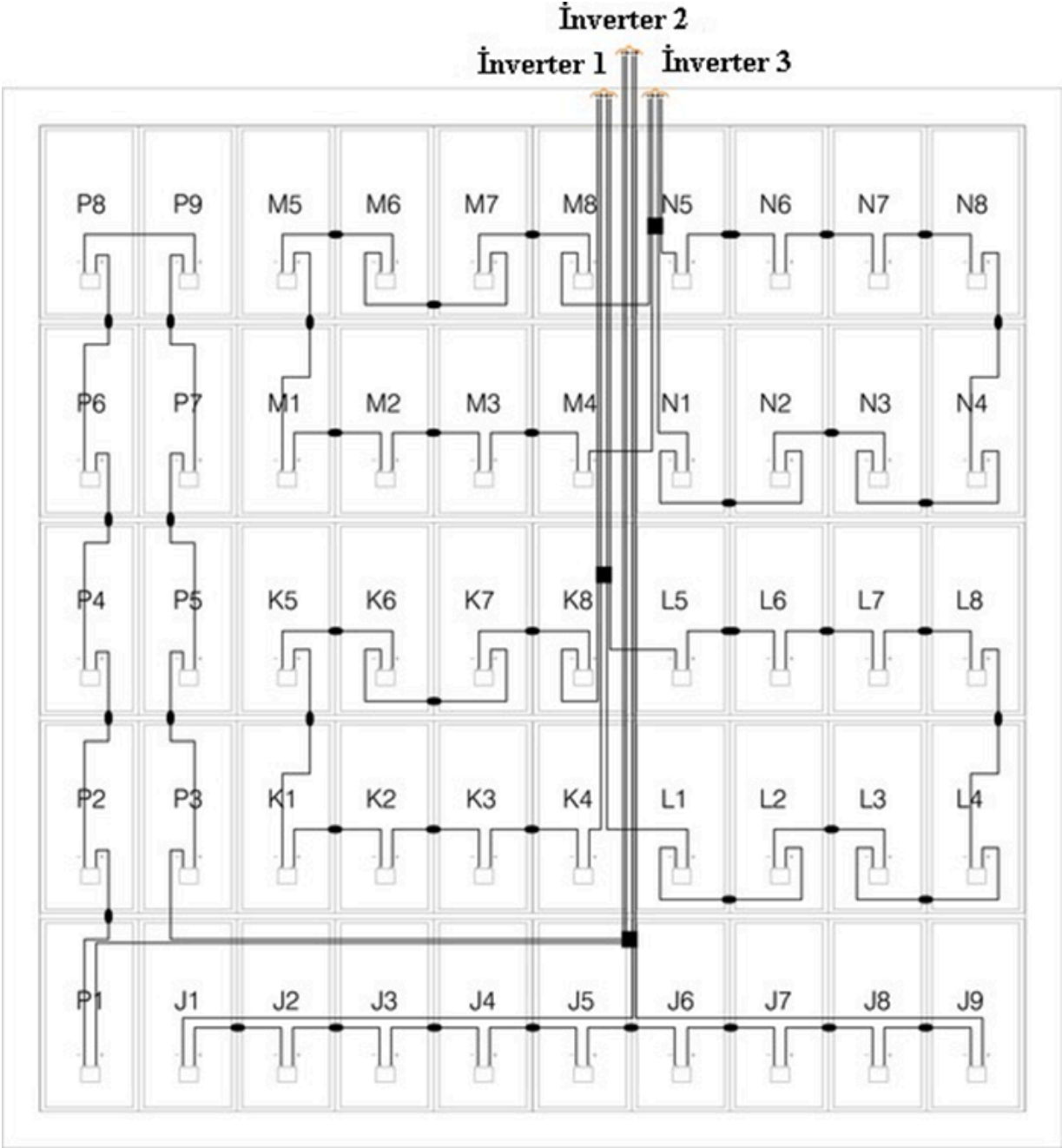


Resim 4.3 : Finisher fixing element

4.4. Making Transition Connections of Panels According to the Electrical Project

After the assembly of the carrier metal system, the panels are lined up neatly on the rails on the metal carrier system and fixed with fasteners. After all these mechanical processes, it is time for the electrical connections of the panels. The connections of the panels must be made by following the instructions specified in the project.

As you know, solar modules are connected to each other in groups in series and parallel to obtain different levels of voltage and current. The shape of the connection is made during project planning to achieve the targeted power of the system. Solar panels listed according to the project are connected to each other according to this plan. Figure 4.3 gives the connection diagram between the solar panels that will be connected to 3 Inverters.



Şekil 4.4: Inter-panel connection diagram

Solar cables and connectors or sockets used in solar systems are used for connection (Picture 4.5).



Figure 4.5: Solar cable sockets

Solar panels are connected to each other as specified in the project. The connection process is carried out after the sockets are attached to the connection cables. The most important thing to consider here is that the panels are in daylight and produce energy during connection. This is an important situation for life safety. Working under energy is a dangerous situation. To prevent this, the panels are sometimes covered and their contact with light is cut off. However, this is not possible for very large power plants. Therefore, care should be taken when making connections in such facilities and appropriate insulating materials should be used. Picture 4.5 shows the cable connection between panels.



Figure 4.6: Cable transitions between panels

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