**Abstract**

Electric power generation from renewable energy sources such as solar energy, wind energy and geothermal energy is an alternative option to energy generation from fossil fuels. Renewable energy sources are more advantageous when we consider the environmental damage caused by fossil fuels during energy generation. Our country is rich in terms of renewable energy resources with its location. When we consider the daily sunshine duration and the wind force in the flat plains, the number of power plants that generate electrical energy without harming the environment with solar panels and wind turbines is increasing day by day. In this study, as a result of field observations of a power plant that converts solar energy into electrical energy with solar panels in Çorum by instructors who have class B OHS certificate and field experience, the risk score was calculated by determining the hazards and risks by 5x5 L-type Matrix Risk analysis which is a qualitative risk assessment. According to the calculated risk score, twenty-four risks which include four high level risks, fifteen medium-level risks, and five low-level risks were identified and recommendations were made. We think that this study will make a positive contribution to the power plants to be established and to the actively ongoing plants in terms of occupational health and safety.

**Keywords:** Solar energy, Occupational health and safety, Risk analysis, Matrix Method

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**Güneş Enerjisi Santralinde Matris Risk Analiz Yöntemiyile Tehlike ve Risklerin Belirlenmesi**

**Öz**

Güneş enerjisi, rüzgâr enerjisi ve jeotermal enerji gibi yenilenebilir enerji kaynaklarından elektrik enerjisi üretimi fosil yakıtlardan enerji üretimine alternatif seçeneğ olmaktadır. Fosil yakıtların enerji üretimi sırasında çevreye verdiği zararları dikkate alındığında yenilenebilir enerji kaynakları daha avantajlidir. Ülkeümüz sahip olduğu konum ile yenilenebilir enerji kaynakları bakımından zengindir. Güneş eylemlerine göre ve düzlük ovalardaki rüzgâr şiddetini dikkate alındığında güneş panelleri ve rüzgâr gülleri ile çevreye zarar vermeden elektrik enerjisi üreten santrallerin her geçen gün sayısı artmaktadır. Bu çalışmada, B sınıfı ISG belgesine sahip, saha tecrübesi olan öğretim elemanlarıyla birlikte Çorum ilinde güneş santrallerinde güneş enerjisi elektrik enerjisine çevrilen bir santralin saha gözlemlemeleri sonucu, tehlike ve riskler kalıplı bir risk değerlendirme modeli 5x5 L tipi Matris Risk analizi ile belirlenerek risk skoru hesaplanmıştır. Hesaplanan risk skoruna göre dört tane yüksek düzeyde risk, beş tane orta düzeyde risk ve beş tane düşük düzeyde risk olmak üzere ikiye ayrıldı. Dört tane risk tespit edildikten sonra öneriler bulunmamıştır. Bu çalışma ile bundan sonraki kurulacak santrallere ve aktif olarak devam eden santrallere iş sağlığı ve güvenliği yönünden olumlu katkı sağlayacağını düşündükuz.
1. Introduction

Solar energy is one of the world's renewable energy sources, alternative to fossil fuels and not harming nature in terms of waste. The occurrence of formations in nature, the flow of matter and energy are due to solar energy [1, 2]. Due to the location of our country, solar energy potential is high. Therefore, energy generation plants consisting of solar panels have been established in many of our provinces to generate electrical energy from solar energy [3].

It is very important to examine the hazards and risks caused by dangerous movement and situations in terms of occupational health and safety by using the heat and light effect of the Sun instead of manpower in solar energy plants where there are very little human factors. It may be possible to prevent work accidents and occupational diseases as a result of identifying the existing hazards and risks with proactive approaches. Hazard is defined as the potential for harm of anything. This potential could be a situation or a behavior. Risk, on the other hand, refers to the probability of events such as death, injury, and loss of limb that may occur as a result of an event [4, 5].

The aim of occupational health and safety services is to adopt proactive approaches against work accidents and occupational diseases by providing a healthy and safe work environment for employees. Preventing work accidents and occupational diseases is possible with regulatory preventive measures by identifying hazards and risks as a result of risk assessment in workplaces [6].

According to the Occupational Health and Safety Law No.6331, employer / employer representatives are obliged to make a risk assessment or have them done in order to ensure the health and safety of their employees and the continuity of production in the workplace. With risk assessment, it will be possible to prevent work accidents and occupational diseases, and if they cannot be prevented, to reduce their rate [5, 7].

![Fig. Risk Assessment Process Stages](image_url)

During the identification of hazards and risks of a business, risk assessment is divided into two in terms of quality and quantity [8]. In the risk assessment application, a change is observed from qualitative approaches to semi-quantitative and traditional quantitative approaches [9]. According to Altenbach (1995), there are differences in the way of implementing risk assessment due to various reasons such as manpower, time, management perception, opinion of the OHS expert, applicability and understandability [10].

In the literature, risk analysis methods are divided into three groups as numerical (quantitative), verbal (qualitative) and mixed. Mathematical theorems are used when calculating the risk score with quantitative risk analysis, while performing qualitative risk analysis, the probability of occurrence of the threat and its potential effect in case of existence are calculated and the results obtained are processed with mathematical and logical methods and the risk score and degree are obtained [11]. Some of the risk analysis methods in the literature are classified as follows by dividing them into two groups as qualitatively and quantitatively [12].

### Qualitative Risk Assessment Analysis;

- Preliminary Hazard Analysis – PHA
- Job Safety Analysis – JSA
- What if?
- Risk Assessment Decision Matrix
- Failure Mode and Effects Analysis - FMEA
- Hazard and Operability Studies - HAZOP
- Fault Tree Analysis - FTA
- Event Tree Analysis - ETA
- Hazard Analysis and Critical Control Points
- Preliminary Risk Analysis - PRA
- Preliminary Risk Analysis Using Checklists - PRA
- Safety Audit

### Quantitative Risk Assessment Analysis;

- Monte Carlo Simulation
- Markov Analysis,
- Bayesian Networks,
- Decision Tree,

Occupational health and safety experts in our country use qualitative 5x5 Matrix and Finney-Kinney Risk analysis in identifying hazards and risks, calculating the risk score and categorizing the results, creating regulatory and preventive action plans [14].

#### 1.1.1. Matris Risk Analysis

Although the matrix risk analysis X-Matrix is shown in 5x5 Matrix and L-Matrix shapes, it is the same in logic. It occurs only when the difference is calculated with 5x5 and the results are shown different in shape [13-14]. Matrix risk analysis is a method used to explain the relationship between two or more variables. It is an easier method in terms of being understandable and evaluating the results by the risk assessment team [15].

#### 1.1.2. L-Type Matris Risk Analysis

It is a simple understandable method used in interpreting cause and effect relationship [16]. L matrix is implemented as 3 * 3, 4 * 4, 5 * 5. It is a method based on evaluating the data obtained as a result of multiplying probability and severity each other which are the concrete components of risk analysis, within a logical framework. In this method, probability and severity factors are taken into account while the risk score is calculated.
It is calculated as Risk Value (R) = Probability = (P)  X Severity (degree of damage).

Probability, the state that a danger occurs in a timeframe; violence, on the other hand, is defined as the degree of damage to the workplace if danger occurs [15-18].

Table 1. L-Type Matrix Analysis Probability Table

| Value | Categorization | Frequency       |
|-------|----------------|-----------------|
| 1     | Very low       | Once a year     |
| 2     | Low            | Every three months |
| 3     | Medium         | Once a month    |
| 4     | High           | Once a week     |
| 5     | Very high      | Everyday        |

Table 2. L-Type Matrix Analysis Loss Level Table

| Value | Result                | Rating                              |
|-------|-----------------------|-------------------------------------|
| 1     | Insignificant         | No loss of working hour requiring first-aid |
| 2     | Minor                 | No loss of working day, requiring first-aid |
| 3     | Moderate              | Mild injury requires treatment       |
| 4     | Major                 | Death, Serious injury, occupational disease |
| 5     | Catastrophic          | Multiple deaths, permanent incapacity |

1.1.3. X Type Matrix Risk Analysis

It is a risk analysis that requires a disciplined work done as a team with the establishment of a risk team. L type matrix and X type matrix risk analysis are similar. There is only a difference in shape. The most preferred in practice is 5x5 Risk Matrix Analysis. The risk score is the same in both methods, but the order and shape are different from each other.

Tablo 4. A Sample Risk Assessment Analysis

| Risk no | Sample photos | Activity / Risk area / department | Work done / hazard / risk | Impact / Result | Before the measure is taken | Measure to be taken | Contact person | Deadline | Result | Signature | After the measure is taken |
|---------|---------------|-----------------------------------|---------------------------|-----------------|--------------------------|-------------------|-----------------|----------|--------|-----------|---------------------------|
| 1       | FIRE EXTINGUISHERS | Lack of fire extinguisher | Aggravation of the situation | 4 5 | 20 | COMPANY | IMMEDIATELY | 1 5 5 | 5 | 5 | |
1.2. Fine Kinney Risk Analysis

It is one of the risk analysis methods used in occupational health and safety. Although it is a bit more complicated than the matrix risk analysis, it is a more ordered risk analysis in terms of separating the business lines from each other by frequency factor. It was first put forward by Fine in 1971, and then, in 1976, Fine's proposal was developed by Kinney and Wiruth and became a risk analysis method [19]. It was first used to protect against explosives in the military field, and then became the most preferred risk analysis method in dangerous and very dangerous enterprises such as construction and mining when it began to be used in the OHS profession,[19-20].

Although Fine Kinney Risk Analysis is more complex than Matrix risk analysis, it has higher accuracy and frequency factor. In this analysis method, the risk score is obtained by multiplying three variables, namely probability (P), severity (S) and frequency (F).

\[ \text{RISK} = \text{P} \times \text{S} \times \text{F} \]

### Table 5. Risk Score Calculation Table

| R: Size of the Risk | P: Possibility of Hazard Occurrence | S: Potential Violent Damage of the Hazard | F: Frequency of repetition of work |
|---------------------|-------------------------------------|------------------------------------------|----------------------------------|
| RISK = P \times S \times F | P | S | F |

### Table 6. Probability Value Chart

| Probability | Definition   | % | Probability |
|-------------|--------------|---|-------------|
| 10          | Expected / Certain | 50 | 50          |
| 6           | High / Quite Possible | 10 | 10          |
| 3           | Possible     | 1 | 1           |
| 1           | Rarely but Possible | 10-3 | 10-3         |
| 0.5         | Unexpected but Possible | 10-4 | 10-4        |
| 0.2         | Practically Not Possible | 10-5 | 10-5        |
| 0.1         | Only Theoretically Possible | 10-6 | 10-6        |

### Table 7. Severity value definition table

| S Value | Severity – Scoring The Damage / Element (V) (Estimated damage to human and / or environment) |
|---------|------------------------------------------------------------------------------------------------|
|         | Definition                                                                                     |
|         | Loss of work                                                                                   |
| 100     | Multiple fatal accidents environmental disaster                                               |
| 40      | Fatal accident / Serious environmental damage                                                   |
| 15      | Permanent damage / injury, loss of work                                                          |
| 7       | Creating environmental barriers, significant damage / injury from the immediate environment, getting external first aid |
| 3       | Minor damage, injury, internal first aid, limited environmental damage on land                  |
| 1       | Escape with little or no harm / no environmental damage                                         |
|         | Material loss                                                                                  |
|         | > 10.000.000                                                                                   |
|         | 1.000.000 – 10.000.000                                                                         |
|         | 100.000 – 1.000.000                                                                           |
|         | 10.000 – 100.000                                                                             |
|         | 1.000 – 10.000                                                                                |
|         | 100 – 1.000                                                                                   |

### Table 8. Frequency value definition table

| F Value | Definition                                                                                   |
|---------|------------------------------------------------------------------------------------------------|
| 10      | Almost continuously (several times in an hour)                                               |
| 6       | Frequently (once or several times a day)                                                     |
| 3       | Occasionally (once or several times a week)                                                  |
| 2       | Not often (once or several times a month)                                                    |
| 1       | Rarely (several times a year)                                                                 |
| 0.5     | Hardly ever (once a year or less)                                                            |

### Table 9. Risk Score Definition Table
2. Material And Method

This study was made as a result of the field observations of OHS experts who have Class B occupational safety certificates in the profession of occupational health and safety of a power plant consisting of solar panels where manpower is not used. It is a study that consists of calculating the risk scores of the hazards and risks identified as a result of the observations using the 5x5 Matrix qualitative risk analysis method and recommending regulatory preventive actions. Calculation method for 5x5 Matrix Risk score analysis is as follows.

| Risk Rating | R Value         | Risk Class       | What to Do                                      |
|-------------|-----------------|------------------|------------------------------------------------|
| 1           | R \leq 20       | Minor risk       | Precaution is not a priority                   |
| 2           | 20 < R \leq 70  | Acceptable risk  | Should be applied under observation            |
| 3           | 70 < R \leq 200 | Moderate risk    | Should be improved in the long term            |
| 4           | 200 < R \leq 400| Significant risk | Should be improved in the short term (within a few months) |
| 5           | R > 400         | Unacceptable risk| Necessary precautions should be taken immediately or the facility, building, production or its surroundings should be closed.

| Tablo 10. Risk Score Calculation Table |
|----------------------------------------|
| Risk Factor Calculation System: The one with a higher risk parameter will be taken. |

| Probability (Exposure-Incident frequency) | Severity (Possible Losses) |
|------------------------------------------|----------------------------|
| Parameter | Probability | Occurrence Frequency | Parameter | Severity | Rating (For Human) |
|-----------|-------------|----------------------|-----------|----------|-------------------|
| 1         | Very low    | Once a year          | 1         | Negligible | Absent            |
| 2         | Low         | Once every three months | 2        | Minor     | First-aid required |
| 3         | Medium      | Once a months        | 3         | Moderate   | Loss of labour force <3 Days |
| 4         | High        | Once a week          | 4         | Severe     | Death, Loss of limb |
| 5         | Very high   | Every day            | 5         | Critical   | Multiple deaths    |
Risk Score = Probability X Severity

In the light of the above data, the hazards and risks identified in the solar power plant, the regulatory and preventive actions to be taken and the risk score that can be reduced as a result of the actions are as follows. There are no part-time or full-time employees in this solar power plant. Only technical personnel coming from outside can enter the power plant. The system is remotely controlled.
| No | Department | Action | Hazard | Risk | Who may be affected by the risk | Probability | Severity | Risk score | Risk definition | Measures to be taken |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | WORKING AREA (GENERAL) | Emergencies | Fire extinguishers are not in suitable places, have obstacles in front of them, fire extinguishers are not indicated with signs, expiration dates of fire extinguisher loss of functionality | HIGH-LEVEL RISK | ALL EMPLOYEES, MATERIAL LOSSES IN THE BUSINESS | 3 | 5 | 15 | HIGH-LEVEL RISK | Fire extinguishers will be placed in visible and accessible places in the workplace and there will be no obstacles in front of them. It is required to have a suitable type of 6 kg fire extinguisher by adding one in number for each independent section and one in number for 200 m² floor space. The locations where the fire extinguishers are located will be marked in accordance with the Safety and Health Signs Regulations. It should be ensured that fire-fighting signs are rectangular or square; while pictogram-red parts on red background cover at least 50% of the area of the sign. The functionality and expiration dates of fire-fighting equipment should be constantly checked. Periodic control and maintenance of fire extinguishers should be continuously implemented. |
| | | | | | | | | | | Contact person |
| | | | | | | | | | Deadline |
| 2 | WORKING AREA (GENERAL) | Maintenance - Repair | Maintenance and repair done by unauthorized and uninformed persons | HIGH-LEVEL RISK | ALL EMPLOYEES | 2 | 5 | 10 | MEDIUM LEVEL RISK | Maintenance and repair done by unauthorized and uninformed persons. Attention should be increased with warning signs and unauthorized persons should be prevented from entering the maintenance section. Panels and transformers should be kept locked and surrounded to prevent unauthorized people from approaching. |
| | | | | | | | | | Contact person |
| | | | | | | | | | Deadline |
| 3 | WORKING AREA (GENERAL) | Maintenance - Repair | Electric shocks, fire, injury, death | HIGH-LEVEL RISK | ALL EMPLOYEES | 3 | 5 | 15 | HIGH-LEVEL RISK | In case of emergencies, as a result of delay fire fighting injury, death, damage to machinery-equipment-materials |
| | | | | | | | | | Contact person |
| | | | | | | | | | Deadline |
| 4 | WORKING AREA (GENERAL) | Maintenance - Repair | Maintenance and repair done by unauthorized and uninformed persons | MEDIUM LEVEL RISK | ALL EMPLOYEES | 4 | 5 | 20 | MEDIUM LEVEL RISK | Maintenance and repair done by unauthorized and uninformed persons. Attention should be increased with warning signs and unauthorized persons should be prevented from entering the maintenance section. Panels and transformers should be kept locked and surrounded to prevent unauthorized people from approaching. |
| | | | | | | | | | Contact person |
| | | | | | | | | | Deadline |
| No. | Department | Action | Hazard | Risk | Probability | Severity | Risk definition | Measures to be taken | Contact person | Deadline | Explanation / situation |
|-----|------------|--------|--------|------|-------------|----------|----------------|---------------------|----------------|----------|-------------------------|
| 3   | WORKING AREA (GENERAL) | Electric transmission cables and connection points | Wearing off cables and loosening of their connections | Lift of personnel/vehicles in the facility | 2 | 5 | MEDIUM-LEVEL RISK | The strength of the connection points of the electrical cables should be checked continuously. Deformed cables and fasteners should never be used and should be replaced as soon as possible. Electrical installation checks should be carried out periodically. | EMPLOYER / REPRESENTATIVE OF THE EMPLOYER | In a month at the latest | |
| 4   | WORKING AREA (GENERAL) | Underground Cables | Injury, loss of limb, death | ALL EMPLOYEES, MATERIAL LOSSES IN THE BUSINESS | 3 | 3 | MEDIUM-LEVEL RISK | The locations of the AC cables going underground should be located and prevented harm in uncontrolled excavations. The AC cables from the inverters to the transformer center go under the inverter house vehicle road. However, the place where the line crosses is not marked. In addition, it is recommended to use remarkable materials such as sand around the cables. | EMPLOYER / REPRESENTATIVE OF THE EMPLOYER | In a month at the latest | |
| 5   | WORKING AREA (GENERAL) | Entering the facility | Lack of personal protectors | ALL EMPLOYEES | 2 | 5 | MEDIUM-LEVEL RISK | In order to ensure the safety of visitors during the visit of the work environments, visitors should be given personal protective equipment and these protectors should not be removed during the visit. People who have not taken security measures by the security unit should be warned and taken out. Visitors should be ensured to reach the interview area safely within the framework of precautions. Visitors are not given personal protective equipment. Visitors should be given the necessary personal protective equipment to be used during the field visit. | EMPLOYER / REPRESENTATIVE OF THE EMPLOYER | In a month at the latest | |

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**Explanation / situation**

The strength of the connection points of the electrical cables should be checked continuously. Deformed cables and fasteners should never be used and should be replaced as soon as possible. Electrical installation checks should be carried out periodically.
| No | Department | Action | Hazard | Who may be affected by the risk | Probability | Severity | Risk score | Risk definition | Measures to be taken | Contact person | Deadline | Explanation, situation |
|----|------------|--------|--------|--------------------------------|-------------|----------|------------|----------------|---------------------|----------------|----------|-----------------------|
| 1  | WORKING AREA (GENERAL) | Electricity | Non-control of grounding | ALL EMPLOYEES | HIGH LEVEL RISK | Electric shock, fire, injury, death | Risk assessment after measures | There should be an insulating mat in front of the panels and transformers. | Fire sensing detectors (heat and smoke sensitive detectors) and the siren system must be placed in the entire work area at certain intervals. | EMPLOYER / REPRESENTATIVE | In a month at the latest | Foreign materials should not be put in the panel cabinets and pollutions such as spider web should be cleaned. |
| 2  | WORKING AREA (GENERAL) | Electricity | Lack of fire detection and | ALL EMPLOYEES, MATERIAL LOSSES IN THE BUSINESS | MEDIUM-LEVEL RISK | Electric shock, fire, injury, death | Risk assessment after measures | There is no insulating mat in front of the business panels. By providing mats with suitable properties, panels and transformers should be accessed by stepping on the mat. | There should be an insulating mat in front of the panels and transformers. | EMPLOYER / REPRESENTATIVE OF THE EMPLOYER | In a month at the latest | There are groundings in panel, transformers and lightning rods throughout the enterprise. Conformity checks are done with annual periods. |
| 3  | WORKING AREA (GENERAL) | Electricity | Being late in the intervention | ALL EMPLOYEES | MEDIUM-LEVEL RISK | Electric shock, fire, injury, death | Risk assessment after measures | There is no insulating mat in front of the business panels. By providing mats with suitable properties, panels and transformers should be accessed by stepping on the mat. | There should be an insulating mat in front of the panels and transformers. | EMPLOYER / REPRESENTATIVE | In a month at the latest | It is thought that it would be beneficial to establish a system that sends a warning to the fire sensing detector and remote control system in order to notice and interfere in the fire early. |

**Note:**
- **No:** Sequential number.
- **Department:** Work area.
- **Action:** Safety requirement.
- **Hazard:** Potential safety risk.
- **Who may be affected by the risk:** Employees and materials.
- **Probability:** Level of probability.
- **Severity:** Degree of severity.
- **Risk score:** Calculated risk score.
- **Risk definition:** Risk level classification.
- **Measures to be taken:** Actions to mitigate the risk.
- **Contact person:** Responsible person.
- **Deadline:** Timeframe for action.
- **Explanation, situation:** Further details or context related to the risk.
| No. | Department | Action | Hazard | Risk | Unauthorized persons entering and leaving the transformer station\nInjury, loss of limb, death | ALL EMPLOYEES, THIRD PARTIES, CONTRACTOR COMPANIES |
|-----|------------|--------|--------|------|-----------------------------------------------------------------|
| 1   | WORKING AREA (GENERAL) | Panel Cleaning | Not using pure water | Electric shock, fire | Exposure to accidents of third parties and employees, injury, loss of limb, death | ALL EMPLOYEES, MATERIAL LOSSES IN THE BUSINESS |
| 2   | WORKING AREA (GENERAL) | Entering the facility | Not determining the operating area, Invasion of third parties | Injuries, loss of limb, death | High-level risk | ALL EMPLOYEES, MATERIAL LOSSES IN THE BUSINESS |
| 3   | TRANSFORMER SECTION | Battery Room | Fire, explosion, deflagration | Injuries, loss of limb, death | High-level risk | ALL EMPLOYEES, THIRD PARTIES, CONTRACTOR COMPANIES |
| 4   | TRANSFORMER SECTION | Transformer section | Unauthorized persons entering and leaving the transformer station | Injury, loss of limb, death | High-level risk | ALL EMPLOYEES, THIRD PARTIES, CONTRACTOR COMPANIES |

**Risk Assessment**

| No. | Department | Action | Hazard | Risk | Who may be affected by the risk | Probability | Severity | Risk score | Risk definition |
|-----|------------|--------|--------|------|--------------------------------|-------------|----------|------------|----------------|
| 1   | WORKING AREA (GENERAL) | Panel Cleaning | Not using pure water | Electric shock, fire | ALL EMPLOYEES, MATERIAL LOSSES IN THE BUSINESS | Medium-level risk | Medium-level risk | Low risk | Measures to be taken: It is recommended to use pure water for cleaning the panels. |
| 2   | WORKING AREA (GENERAL) | Entering the facility | Not determining the operating area, Invasion of third parties | Injuries, loss of limb, death | High-level risk | High-level risk | High-level risk | Measures to be taken: The Visitor Security instruction must be applied. The purpose of this instruction should be to determine the Occupational Health and Safety issues to be applied in the parts where dangerous works are performed in the workplace and to ensure that the works are done according to these provisions. In order to prevent intrusions into the business, the business is surrounded by a wire fence and its door is kept locked. It is also monitored by business security cameras. |
| 3   | TRANSFORMER SECTION | Battery Room | Fire, explosion, deflagration | Injuries, loss of limb, death | High-level risk | High-level risk | High-level risk | Measures to be taken: Use of ex-proof (flame-proof) installation material. Having outward-opening doors and windows, switches, sockets and fuses are outside. Providing suitable ventilation. Not using a discharge panel in the battery room. Fixing the battery groups against earthquakes and shakes. Ensuring the use of appropriate PPE. |
| 4   | TRANSFORMER SECTION | Transformer section | Unauthorized persons entering and leaving the transformer station | Injury, loss of limb, death | High-level risk | High-level risk | High-level risk | Measures to be taken: People who do not have the qualifications specified in Article 60 of the EKAT regulation will not be allowed into the transformer section. Visitors can enter after getting permission from the authorities and signing the relevant forms and in accordance with the regulations. |

**Explanation / Situation**

- Panels get dirty over time and their efficiency decreases. Therefore, they must be cleaned at regular intervals. In the case of using conductive mains water during cleaning, being cracks in the panels or cables, a chassis may cause fire and / or electric shock. It is recommended to use insulating pure water during cleaning.

- At the entrance of the business, there is a sign that "no one can enter but the authority". The business is surrounded by a wire fence. It is monitored by security cameras. Safety instructions should be created for visitors.

- It is made in accordance with the standards. Doors open to outside. There is a ventilation. There is also a ventilation fan that works when the temperature rises above 23 degrees.

**Contact person**

- Employer / Representative of the Employer
- Employer / Representative of the Employer
- Employer / Representative of the Employer
- Employer / Representative of the Employer

**Deadline**

- It must be kept under control continuously.
- It must be kept under control continuously.
- It must be kept under control continuously.
- It must be kept under control continuously.
### WORKING AREA (GENERAL)

#### Panel and Transformers

**Intra-business divisions are not specified, and no authorization is given for entrances to departments.**

**Work accident**

**ALL EMPLOYEES**

| No | Department | Action | Hazard | Risk | Value may be affected by the risk | Probability | Severity | Risk score | Risk definition | Measures to be taken | Risk assessment after measures |
|----|------------|--------|--------|------|----------------------------------|-------------|----------|------------|----------------|----------------------|-------------------------------|
| 12 | Electric transmission cables and connection points | Loose connections and sockets | Shock, fire | Medium | Low | 2 | 4 | 8 | Low Risk | MUST BE KEPT UNDER CONTROL CONTINUOUSLY | LOW RISK |
| 13 | Electric transmission cables and connection points | Loose connections and sockets | Shock, fire | Medium | Low | 2 | 4 | 8 | Low Risk | MUST BE KEPT UNDER CONTROL CONTINUOUSLY | LOW RISK |
| 14 | Electric transmission cables and connection points | Loose connections and sockets | Shock, fire | Medium | Low | 2 | 4 | 8 | Low Risk | MUST BE KEPT UNDER CONTROL CONTINUOUSLY | LOW RISK |
| 15 | Electric transmission cables and connection points | Loose connections and sockets | Shock, fire | Medium | Low | 2 | 4 | 8 | Low Risk | MUST BE KEPT UNDER CONTROL CONTINUOUSLY | LOW RISK |

### Routine Work

**Personnel getting higher in the work area**

| No | Department | Action | Hazard | Risk | Value may be affected by the risk | Probability | Severity | Risk score | Risk definition | Measures to be taken | Risk assessment after measures |
|----|------------|--------|--------|------|----------------------------------|-------------|----------|------------|----------------|----------------------|-------------------------------|
| 16 | Routine Work | Falling, injury | All employees | Medium | Low | 2 | 4 | 8 | Low Risk | MUST BE KEPT UNDER CONTROL CONTINUOUSLY | LOW RISK |

### Low Risk

**No Department**

- **Risk assessment after measures**
  - **Explanation / situation**
  - **Probability**
  - **Severity**
  - **Risk score**
  - **Risk definition**

### MEDIUM LEVEL RISK

**No Department**

- **Risk assessment after measures**
  - **Explanation / situation**
  - **Probability**
  - **Severity**
  - **Risk score**
  - **Risk definition**

### LOW RISK

**No Department**

- **Risk assessment after measures**
  - **Explanation / situation**
  - **Probability**
  - **Severity**
  - **Risk score**
  - **Risk definition**
### WORKING AREA (GENERAL)

| Department | Action | Hazard | Risk | Risk definition | Measures to be taken | Contact person | Deadline | Explanation/ situation |
|------------|--------|--------|------|----------------|----------------------|----------------|---------|------------------------|
| ELECTRICAL PANELS | ELECTRICAL PANELS | ELECTRICITY | ELECTRIC SHOCK, WORK ACCIDENT, INJURY | ALL EMPLOYEES | 2 5 10 | MEDIUM-LEVEL RISK | EMPLOYER / REPRESENTATIVE OF THE EMPLOYER | It must be kept under control continuously | To prevent fires that may be caused by switch burns that frequently occur in the facility, studies have been started to monitor the system with a thermal camera. |
| ELECTRICAL PANELS | ELECTRICAL PANELS | ELECTRICITY | ELECTRIC SHOCK, WORK ACCIDENT, INJURY | ALL EMPLOYEES | 2 5 10 | MEDIUM-LEVEL RISK | EMPLOYER / REPRESENTATIVE OF THE EMPLOYER | It must be kept under control continuously | The suitable warning signs are posted in the necessary places in the business. People who do not have the necessary personal protective equipment are prevented from interfering with the electricity generation equipment of the enterprise. |
| ELECTRICAL PANELS | ELECTRICAL PANELS | ELECTRICITY | ELECTRIC SHOCK, WORK ACCIDENT, INJURY | ALL EMPLOYEES | 2 5 10 | MEDIUM-LEVEL RISK | EMPLOYER / REPRESENTATIVE OF THE EMPLOYER | It must be kept under control continuously | As some points in the business, modern machines and equipment used, which have risk on them, are used. Those machines and equipment present risk in their own service. |
| ELECTRICAL PANELS | ELECTRICAL PANELS | ELECTRICITY | ELECTRIC SHOCK, WORK ACCIDENT, INJURY | ALL EMPLOYEES | 2 5 10 | MEDIUM-LEVEL RISK | EMPLOYER / REPRESENTATIVE OF THE EMPLOYER | It must be kept under control continuously | The suitable warning signs are posted in the necessary places in the business. People who do not have the necessary personal protective equipment are prevented from interfering with the electricity generation equipment of the enterprise. |
| ELECTRICAL PANELS | ELECTRICAL PANELS | ELECTRICITY | ELECTRIC SHOCK, WORK ACCIDENT, INJURY | ALL EMPLOYEES | 2 5 10 | MEDIUM-LEVEL RISK | EMPLOYER / REPRESENTATIVE OF THE EMPLOYER | It must be kept under control continuously | To prevent fires that may be caused by switch burns that frequently occur in the facility, studies have been started to monitor the system with a thermal camera. |
| ELECTRICAL PANELS | ELECTRICAL PANELS | ELECTRICITY | ELECTRIC SHOCK, WORK ACCIDENT, INJURY | ALL EMPLOYEES | 2 5 10 | MEDIUM-LEVEL RISK | EMPLOYER / REPRESENTATIVE OF THE EMPLOYER | It must be kept under control continuously | The suitable warning signs are posted in the necessary places in the business. People who do not have the necessary personal protective equipment are prevented from interfering with the electricity generation equipment of the enterprise. |
### Working Area (General)

#### Pest Control

- **Hazard:** Contagious disease, biological risk, damage by gnawing on electrical cables due to lack of hygiene
- **All Employees**

**Low Risk**

- All kinds of measures will be taken to prevent pests, insects and gnawing animals in the workplace.
- All kinds of measures will be taken to destroy, insecticides and rodenticides required for their destruction will be used, the conditions that facilitate reproduction will be destroyed.
- Since it is in the business area, it should be also disinfected against the Crimean Congo hemorrhagic fever disease caused by ticks. Ticks should be prevented from gnawing on the cables.

No precaution has been taken for ticks and rodents in the business. Nests of rodents were seen in the business. It is recommended to struggle with rodents against the risk of these rodents entering transformers, panels and cutting cables. It is recommended to pass the cables through the laryngeal tube.

#### General Work

- **Hazard:** Lack of road allocated for safe walking in the work area
- **All Employees**

**Low Risk**

- A road should be allocated for safe walking in the work area.
- EMPLOYER/REPRESENTATIVE OF EMPLOYER

The roads used to access the boards and panels within the enterprise are covered with soil and grass. Suitable walking paths are recommended for access to these points.

#### Weather Conditions

- **Hazard:** Climatic and weather conditions
- **All Employees, Material losses in the business**

**Low Risk**

- The place where the business is established should be evaluated in terms of the frequency of weather conditions such as storms, wind and hail.
- EMPLOYER/REPRESENTATIVE OF EMPLOYER

The area where the business is located has been evaluated and selected in terms of exposure to the storm. In addition, the fixings made throughout the enterprise should be constantly checked to prevent damage in case of a storm. In case of hail in the area where the business is located, the panels should be checked and they should be replaced in case of damaged.

No precaution has been taken for ticks and rodents in the business. Nests of rodents were seen in the business. It is recommended to struggle with rodents against the risk of these rodents entering transformers, panels and cutting cables. It is recommended to pass the cables through the laryngeal tube.

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| No  | Department | Action | Hazard | Risk | Who may be affected by the risk | Probability | Severity | Risk definition | Risk value | Measures to be taken | Risk assessment after measures |
|-----|------------|--------|--------|------|--------------------------------|-------------|----------|----------------|------------|----------------------|-------------------------------|
| 22  | Working Area (General) | Pest Control | Pest, insect, gnawing animals, tick | Risk | All Employees | 2 | 3 | 6 | LOW RISK | | |
| 23  | Working Area (General) | General Work | Lack of road allocated for safe walking in the work area | Risk | All Employees | 2 | 3 | 6 | LOW RISK | | |
| 24  | Working Area (General) | Weather Conditions | Climatic and weather conditions | Risk | All Employees, Material losses in the business | 2 | 3 | 6 | LOW RISK | | |
3. Results And Discussion

Due to its location, Turkey has high potential in terms of solar energy. Our country has an average of 7.5 hours of sunshine per day [21]. In the works done during the conversion of solar energy into electrical energy through energy panels, fixed electrical circuits and panels are used rather than manpower. There are no insured and full time employees. However, during the control of the system, the occupational safety of the technical staff who come to the power plant during outsourcing should be ensured in order to install new technological circuits and solve various problems caused by the environment.

Various hazards and risks are at stake during the installation of panels based on energy generation in the solar power plant, doing periodic controls and the installation of new panels by technical staff. These hazards and risks can be evaluated with a 5x5 L type Matrix risk analysis and work accidents and occupational diseases can be prevented by taking the necessary measures. The aim of occupational health and safety practices is to provide employees with a healthy and safe working environment by showing the necessary proactive approaches to work accidents and occupational diseases.

As a result of the 5x5 L type Matrix risk analysis, high-level risks were shown as yellow, medium-level risks as yellow, and low-level risks as green. The probability score was calculated for the identified risks and the regulatory and preventive action was specified. Hazards such as the lack of location, number and control of fire tubes, unauthorized and uniformed persons coming to the power plant for technical support, not taking measures against the possibility of fire and explosion in the battery room, and lack of grounding installation that should be done once a year at the latest or not being checked constitute high-level risks. Regulatory measures should be taken in a short time.

Risks arising from dangerous movements and situations such as not showing the passage route of the cables in the ground inside the facility, the entrance of people from outside the power plant to the power plant, loosening, abrasion and breakage of the electrical transmission cables and connections, the transformer cabinets are not in compliance with hygiene rules, the lack of insulating mats in front of the panels, the lack of fire detection and siren system in emergency situations or not working, not using pure water during cleaning of solar panels, not taking the necessary measures when working at height in the power plant, the lack of emergency stop buttons and lightning rod are included in the medium-level risk group. Regulatory and preventive actions should be taken in the medium term to control these risks and prevent their harm.

Failure to store waste in the work area, to pest control and spraying, lack of a suitable walking corridor for employees and visitors in the work area, sunstroke in summer due to weather conditions, and lack of suitable place in case of cold and freezing in winter, damage caused by metal burrs in and around panel poles are defined as a low-level risk. Necessary measures should be taken in the long term.

Although the degree of risks identified may vary according to the prediction and interpretation of the observing occupational health and safety expert, the risk level remains the same. The necessary measures should be taken for identified risks and should be followed regularly. The risks identified in solar power plants are also close to each other in other solar and wind power plants. They are plants with low human factors. The risk analysis performed is a qualitative risk analysis. The response of the data obtained is expressed verbally as low, medium and high levels. In our country, occupational health and safety experts working actively in the field have difficulties in applying and interpreting Fine Kinney, which is not a quantitative analysis but a qualitative analysis. Therefore, 5x5 Matrix risk analysis is used to identify hazards and risks in the profession of occupational health and safety.

A study was done by Dündar and Ethem (2016) on the issues related to the measures to be taken in terms of occupational health and safety during the installation and field phase of solar power plants [22,24]. Çelik and Utku (2013) contributed to the literature on OHS in energy studies by working on the examination of possible situations to be experienced during the installation phase of the wind power plant in terms of occupational health and safety [23].

4. Acknowledge

I would like to thank Ahmet AKTAŞ, the owner of the solar power plant, and Asist.Prof.Dr. Berna GÜR and lecturer Ahmet Doğan ÇAKIR, who supported the preparation of the article.
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