Solar PV System Installation and Maintenance

NTQF Level IV

Learning Guide -25

Unit of Competence	Supervising and coordinating solar PV system installation Activities
Module Title	Supervising and coordinating solar PV system installation Activities
LG Code	EIS PIM3 M07 LO1-LG25
TTLM Code	EIS PIM3 TTLM 0920 v1

LO1: Prepare to supervise and coordinate work activities

ADRA ETHIOPIA

Instruction Sheet	Learning Guide:-25

This learning guide is developed to provide you with the necessary information, knowledge, skills and attitude regarding the following content coverage and topics:

- Identifying, obtaining and understanding OHS processes.
- Obtaining and understanding Job specification and requirements.
- Establishing plant, materials and skills needed for the work.
- Accessing plant, materials and others needed for the work.

This guide will also assist you to attain the learning outcome stated in the cover page. Specifically, upon completion of this Learning Guide, you will be able to:-

- Identify, obtain and understand OHS processes.
- Obtain and understand job specification and requirements.
- Establish plant, materials and skills needed for the work.
- Access plant, materials and others needed for the work.

Learning Instructions:

1. Read the specific objectives of this Learning Guide.
2. Follow the instructions described below.
3. Read the information written in the information Sheets
4. Accomplish the Self-checks
5. Perform Operation Sheets
6. Do the “LAP test”

Information Sheet 1	Identifying, obtaining and understanding OHS processes

1.1 Introduction

This part gives a general view on the understanding of OHS processes.

1.2 Definition of Occupational Health and Safety (OHS)

The following paragraph is taken from (Alli, 2008)Occupational health and safety (OSH) is defined as the science of the anticipation, recognition, evaluation and control of hazards arising in or from the workplace that could impair the health and well-being of workers, taking into account the possible impact on the surrounding communities and the general environment.

1.3 Examples of variations in performance

The following paragraph is adapted from (Alli, 2008) the incidence of workplace fatalities varies enormously between countries. There appears to be a significant difference between developed and developing countries:

- A factory worker in Pakistan is eight times more likely to be killed at work than a factory worker in France.
- Fatalities among transport workers in Kenya are ten times those in Denmark.
- Construction workers in Guatemala are six times more likely to die at work than their counterparts in Switzerland.

1.4 Hierarchy of preventive and protective measures

The following paragraph is adapted from (Alli, 2008)In taking preventive and protective measures on a PV system installation site, the supervisor, together with the workers, should assess the risk and deal with it in the following order of priority:

- Eliminate the risk.
- Control the risk at source.
- Minimize the risk by means that include the design of safe work systems.
- In so far as the risk remains, provide for the use of personal protective equipment.

These four points are representative of the occupational health and safety process needed at a PV system installation site. It is therefore the joint responsibility of the supervisor, the employer and all the workers to apply those steps reliably.

1.5 Employers responsibilities

The following paragraph is adapted from (Alli, 2008) every employer of workers should comply with the following.

- Provide and maintain workplaces, machinery and equipment, and use work methods, which are as safe and without risk to health as is reasonably practicable.
- Give the necessary instructions and training to managers and staff, taking account of the functions and capacities of different categories of workers.
- Provide adequate supervision of work, of work practices, and of the application and use of occupational health and safety measures.
- Provide adequate personal protective clothing and equipment without cost to the worker, when hazards cannot be otherwise prevented or controlled.
- Ensure that work organization, particularly with respect to hours of work and rest breaks, does not adversely affect the safety and health of workers.
- Take all reasonable and practicable measures to eliminate excessive physical and mental fatigue.
- Provide, where necessary, for measures to deal with emergencies and accidents, including adequate first-aid arrangements.
- Undertake studies and research or otherwise keep abreast of the scientific and technical knowledge necessary to comply with the obligations listed above.
- Cooperate with other employers in improving occupational health and safety.

1.6 Workers duties and rights

The following paragraph is adapted from (Alli, 2008) The supervisor must ensure that the workers are practicing in respect of the rules, in line with health and safety purposes and principles. For instance, every worker should comply with the following.

- Know about workplace hazards that may affect their health or safety.
- Take reasonable care for their own safety and that of other persons who may be affected by their acts or omissions.
- Comply with instructions given for their own health and safety, and those of others, and with health and safety procedures.
- Use safety devices and protective equipment correctly (and not render them inoperative).
- Report promptly to their immediate supervisor any situation which they have reason to believe could present a hazard and which they cannot themselves correct.
- Report any accident or injury to health which arises in the course of or in connection with work.

Self-Check – 1	Written Test

Instruction: Follow the below selected instruction

The following are true or false statements, write true if the statement is true and write false if the statement is false.

N°	Questions and answers
1	OHS is not in any way related to anticipation, recognition, evaluation and control of hazards arising in or from the workplace.
	True or false:
2	Reporting any accident or injury which arises in the course of or in connection with PV installation is of no importance.
	True or false:

Satisfactory	2 points
Unsatisfactory	Below 2 points

Information Sheet 2	Obtaining and understanding Job specification and requirements

2.1 Introduction

It is important to understand job specification and requirements regarding the process of supervising and coordinating solar PV system installation activities. It means one should know in advance the tasks ahead before putting things to be done into action on the installation site. This part provides a clear description on the job specification and requirements.

2.2 Obtaining and understanding job specification

Before coming to fulfilling solar PV installation, the following in-depth works should have been properly conducted:

- Site visit for data collecting in order to better assess the need of the clients
- Design of the PV system according to the need assessment analysis, and also taking into account local PV system installation standards.
- Therefore, the job specification should account for the following:
- Knowledge of the site location and the existing conditions.
- Have access to the relevant documentation/report about the site visit.
- Understand the detailed electrical drawing of the system to be installed (the cabling structure should be as meticulous as possible).
- Sort out all the components and materials to be used according to the scope of work (assure that the quantities of the components and their power ratings and brand names comply with the scope of work). The specified voltages, currents and powers levels must be complied with as planned.
- Carry out a step by step checking of all the activities involved.
- State clearly a planning of who will do what and when, based on a well-established schedule. The way to perform the job could be specified in some situations based on predefined standards and codes to be referred to.
- Understand the specific job requirement in all possible ramifications.

2.3 Obtaining and understanding job requirements

2.3.1 Complying with the deadlines

Someone who is in charge of supervising such operations should make sure to always remember the deadlines for finishing the respective steps of the work and also for submitting the work evolution reports within the specified context.

2.3.2 Security side of the installations

The following paragraphs are adapted from (GIZ, 2016)The following basic Personal Protection Equipment (PPE) (Table 1) are required to ensure the safety of installers while at work.

Table 1: PPE and their evaluated importance

PPE	Importance
Hard hat	Essential
Goggles	Essential
Earmuffs	Desirable
Gloves	Essential
Safety boots	Essential
Body harness	Essential
Emergency first aid kit	Essential
Fire extinguisher	Essential

The corresponding PPE which the site supervisor and coordinator must make sure the workers have and use on site is depicted below (to **Error! Reference source not found.**). This is to avoid hazardous events that might lead to workers losing their lives, usually through electric shocks or falling from heights.

Figure 1: gloves and safety helmet (GIZ, 2016)

Helmet/hard hat is for protection against falling objects. Gloves are for protecting the hands from cuts and act as insulation.

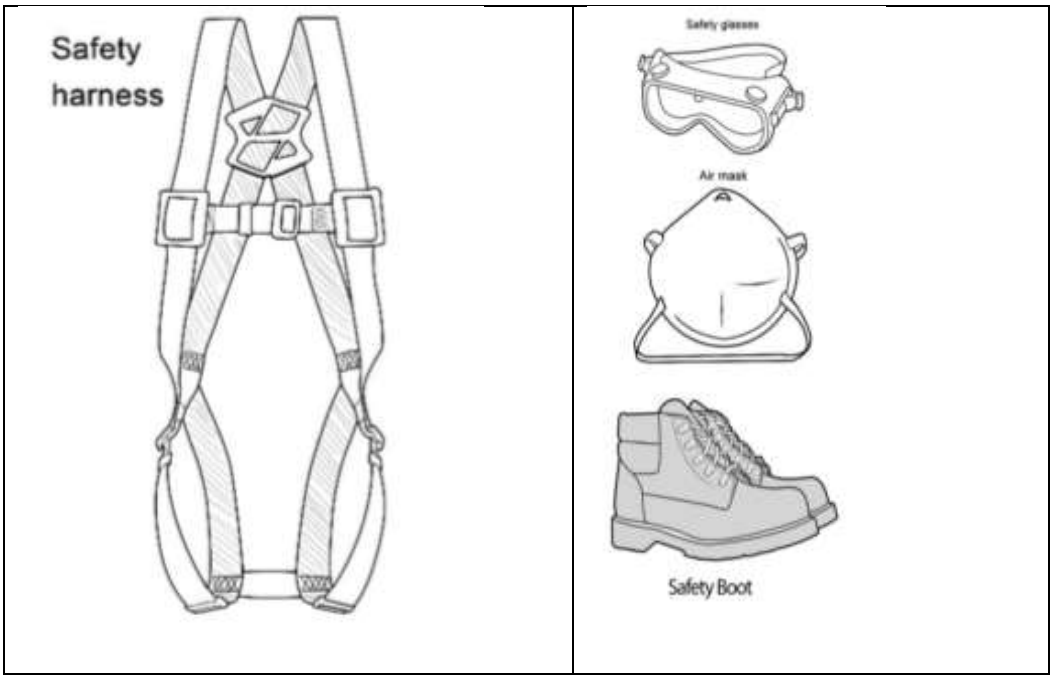


Figure 2: Safety harness, air mask, safety boot (GIZ, 2016)

Figure 3: Ear muffs, fire extinguisher, emergency first aid kit (GIZ, 2016)

Body harnesses protect workers against falls when working at heights. Safety goggles are used for protecting the eyes against sparks and flints. Air mask is to protect from fumes and dust. Safety boots (to be always worn when working on site) are for protecting the feet from impacts and for insulation. Earmuffs are for protecting the ears against loud sounds. Class E fires involving live electrical apparatus (electrical) and class C fire extinguishers are used to extinguish fires. Finally, the emergency first aid kit is for treating injuries that may occur while at work.

Securing the site before starting each activity is paramount, therefore the use of equipment such as scaffolding, guardrail and ladders are important depending on the case at hand. In fact, the installation should comply with provision of all mandatory equipment and materials. That is the responsibility of the site supervisor.

Figure 4: Scaffolding and guardrail, ladder (GIZ, 2016)

The security of the installation site is a continuous determinant part of the whole process. Thorough care should be taken in that regard to use the applicable tools and secure the site accordingly.

Make sure the workers are aware of the followings:

- They are responsible for their own safety and for the safety of others.
- All accidents are preventable.
- They should not take short cuts, therefore, always follow the rules.
- If they are not trained, they should not do a particular work.
- They should use the right tools and equipment and use them in the right way.
- They must assess the risks before approaching any work.
- Always wear proper protective gear.

2.3.3 Examples of what to do and what to avoid

Ensure that the solar panels always face south. When working in the Northern hemispheric area (if working in southern hemisphere, the solar panels should face north). The inclination of the solar panels (the tilt angle) will depend on the latitude of the area. In any case follow the defined scope of work for solar panels orientation.

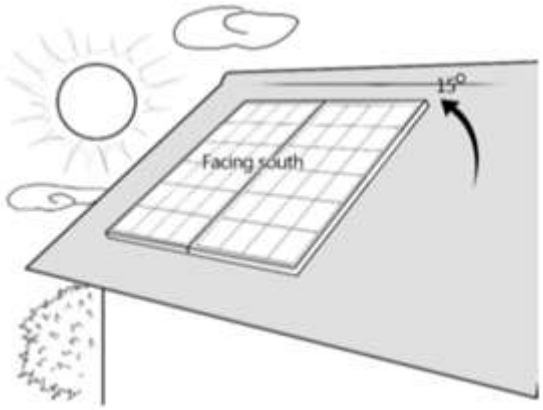


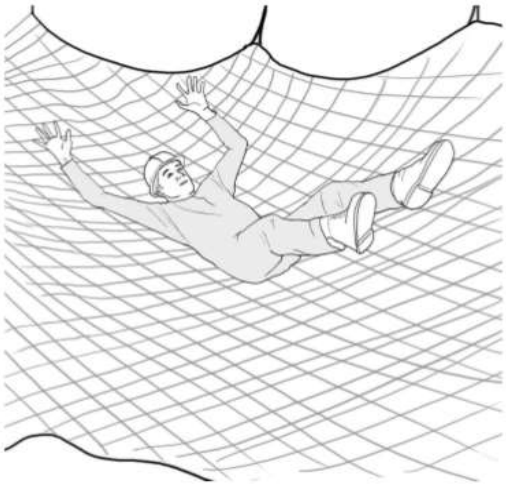
Figure 5: Solar panels facing south at 15° (GIZ, 2016)

Sufficient back ventilation of the panel is needed (**Error! Reference source not found.**6). during operation, solar panels get very hot, so it is important that you provide space for air to circulate below the panels. The minimum space required is specified in the panel installation manual.

Figure 6: Sufficient back ventilation of the panel (GIZ, 2016)

The use of lifelines should be in accordance with the recommended length (Figure 7). Safety nets should be installed when needed (Figure 8); the use of ladders must be done in a secured manner with workers always working in couples at least (Figure 9).

Figure 7: The required length of the lifeline (GIZ, 2016)



Safety net

Figure 8: Installed safety net when applicable (GIZ, 2016)

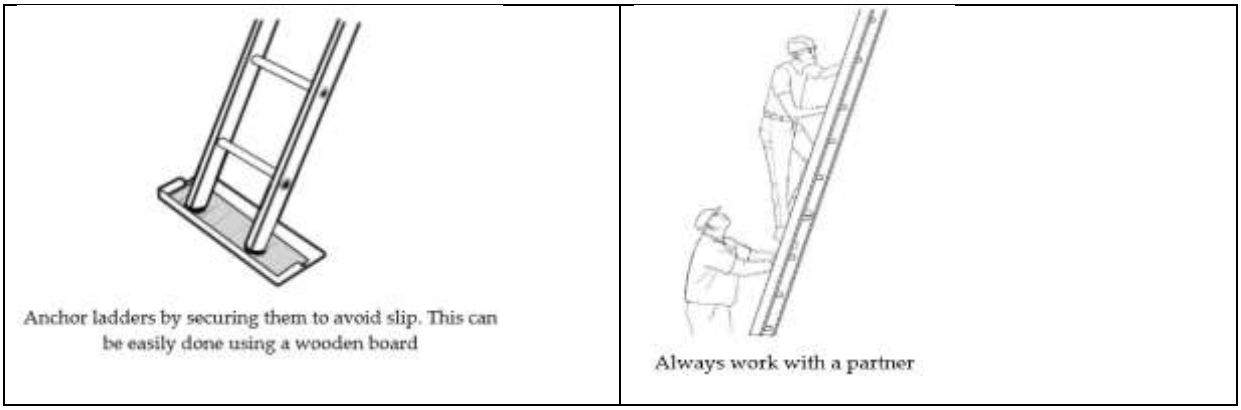


Figure 9: Secured ladders, workers always working in couple (GIZ, 2016)

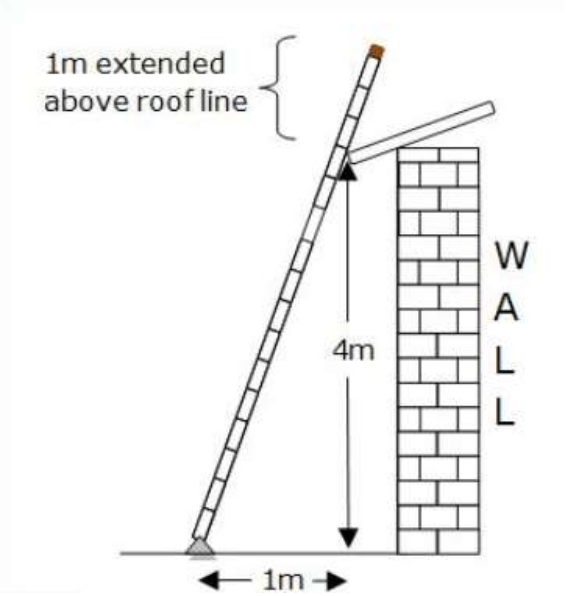
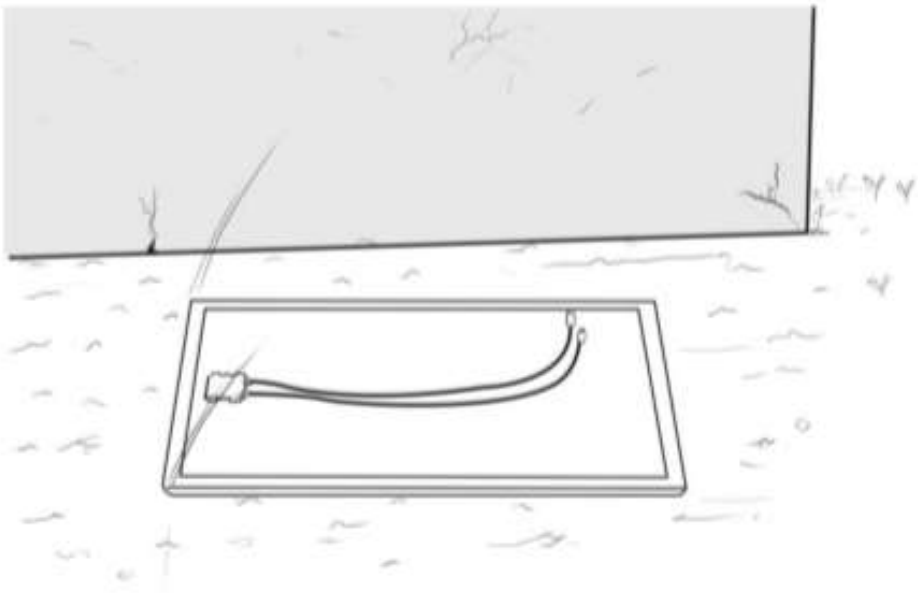


Figure 10: Ladder 4:1 ratio (Source: https://www.ozladders.com.au)

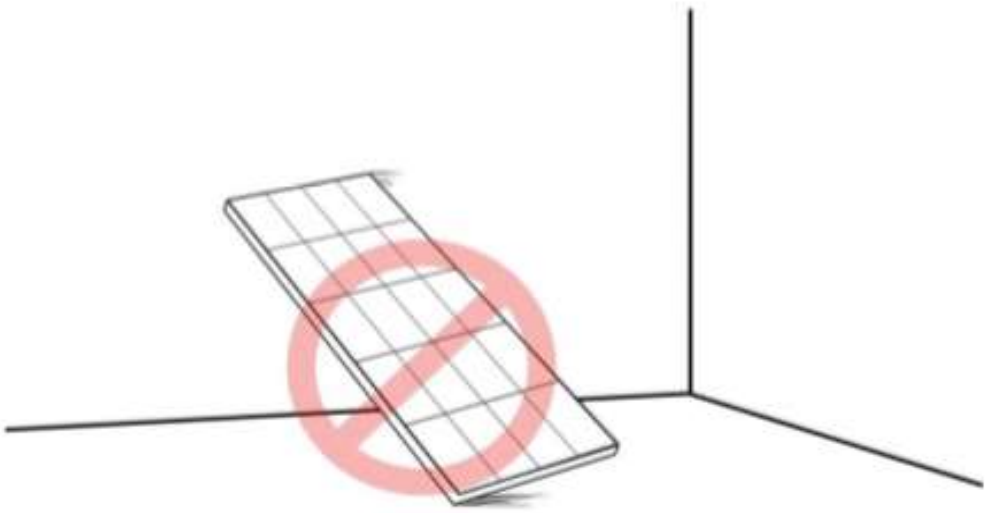
The following drawings and photos (Figure 11 to Figure 12) show what to do and what not to do on the site.

Always transport modules in their original packaging

Inappropriate transport and installation may break the module



Do not forcibly set down the face of the solar panels on any surface



Do not rest a solar panel unprotected on its edge

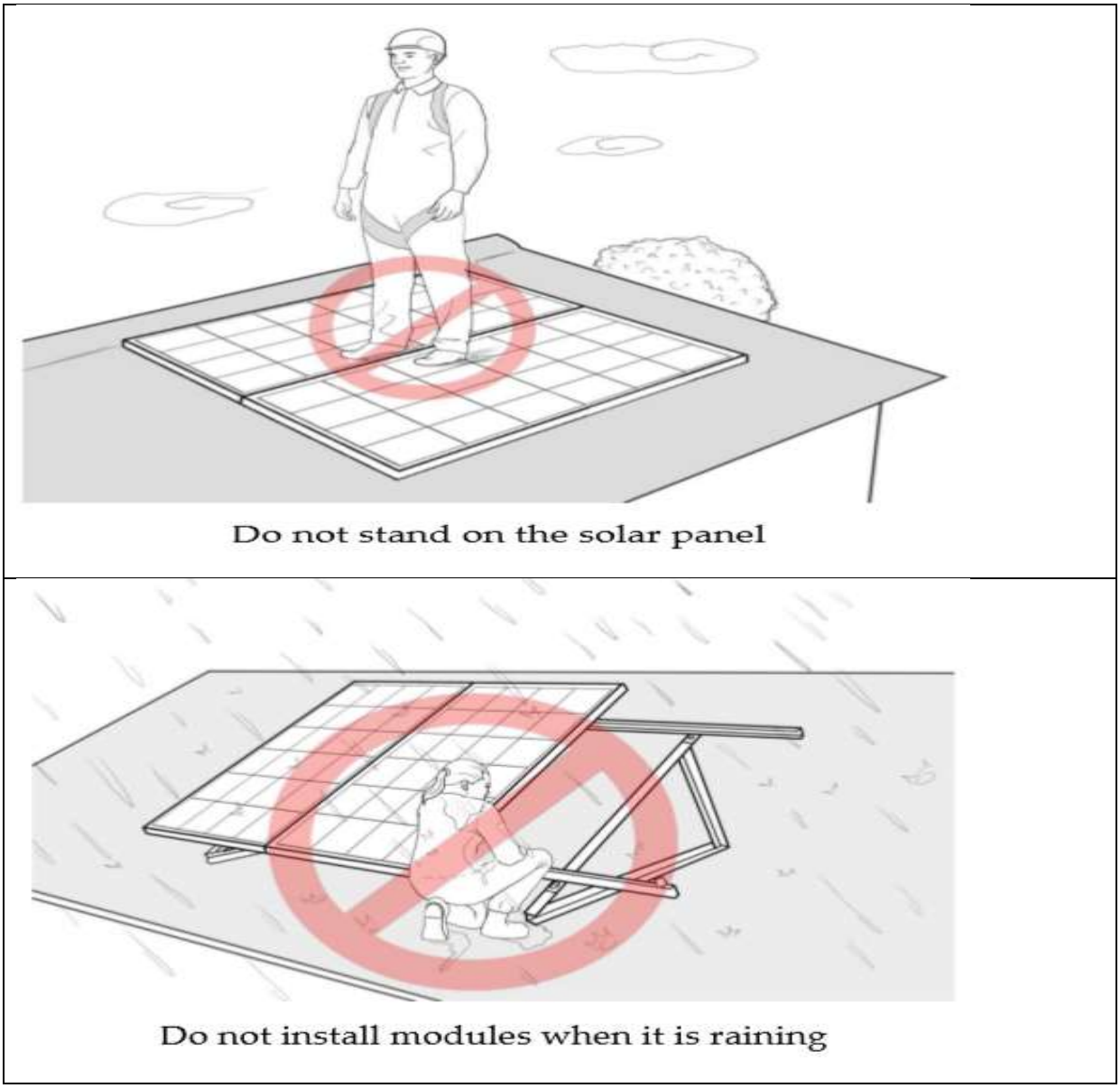


Figure 11: Examples of what to do and what to avoid on the site (GIZ, 2016)

Figure 12: Proper PPE wiring while working on rooftop PV systems (GIZ, 2016)

2.4 Complying with the job specification

The above cited job specifications should be complied with as planned. That is, the quality, quantity and other important characteristics of the equipment and materials should be provided as requested. The position of the cabling, inverters, controllers, batteries, protective devices, earthling protection etc. should be respected while referring to the corresponding documentation throughout the installation. The workers must comply with all of the drawings as designed and validated by the planning engineers. Briefly, the person in charge of supervising and coordinating the solar PV system installation activities must make sure the finalised work on site complies with all the requirement and specification.

The following paragraph is taken from (Hankins, 2010)In all cases, a competent person should supervise work to ensure that the system is installed according to the local electric safety codes and so that no person is injured or equipment damaged during installation.

Self-Check - 2	Written Test

The following are true or false statements, write true if the statement is true and write false if the statement is false.

N°	Questions and answers
1	There is no need installing a solar PV system according to the local electric safety codes.
	True or false:
2	The supervisor of the solar PV installation should assure the workers use the correct security equipment for the work.
	True or false:

Satisfactory	2 points
Unsatisfactory	Below 2 points

Information Sheet 3	Establishing plant, materials and skills needed for the work

3.1 Introduction

This part covers the preparation of the site to be ready for the work to commence. Here we give details on how to establish the plant, the materials and tools needed for the work, and finally on the skills needed for the work.

3.2 Establishing plant

The plant or site should be delimited by constructing fences and providing temporary electricity on site for possible late work at night. Water should be accessible on site for the duties it applies for. The plant must allow for ease of circulating, therefore all obstacles such as trees, herbs, wild animals should be managed and dealt with properly. If applicable, stores could be needed for storing the materials and equipment.

3.3 Establishing materials and tools needed for the work

The following paragraphs are adapted from [(GIZ, 2016)]Depending on the system sizing the materials/equipment used for the mounting of the installation are:

- The solar modules
- The solar modules mounting system
- The inverter (s)
- The battery bank regulator (charge controller)
- The batteries and their supports
- The cables per sections (both DC and AC sides)
- The protection units and the corresponding boxes

The safety precautions concerning the materials/equipment should be followed accordingly while working with the required tools. The tools needed for such installation are non-exhaustively named and depicted below (Figure 13 to Figure 17) followed with a table summarizing (Table 2) the basics tools with their corresponding purposes.

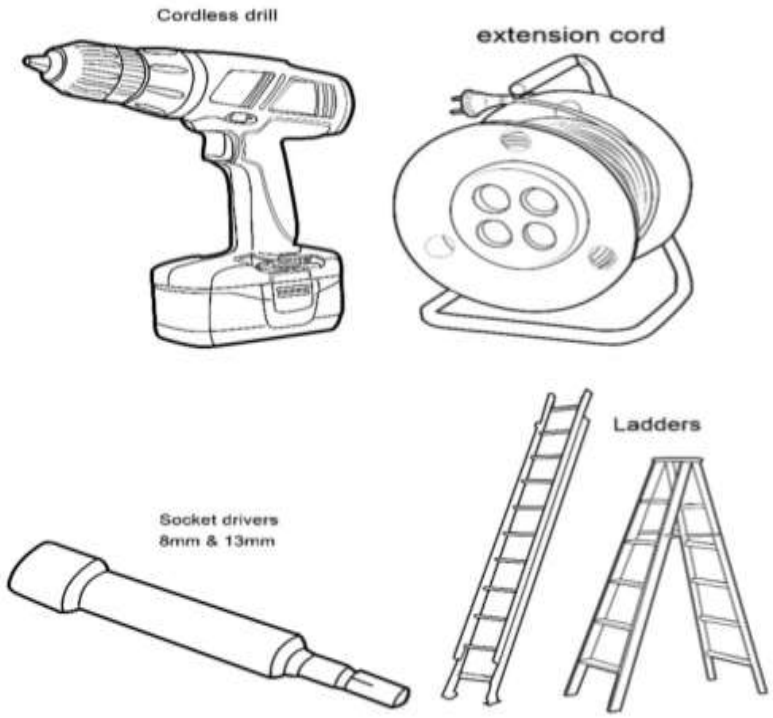


Figure 13: Cordless drill, extension cord, socket drivers, ladders (GIZ, 2016)

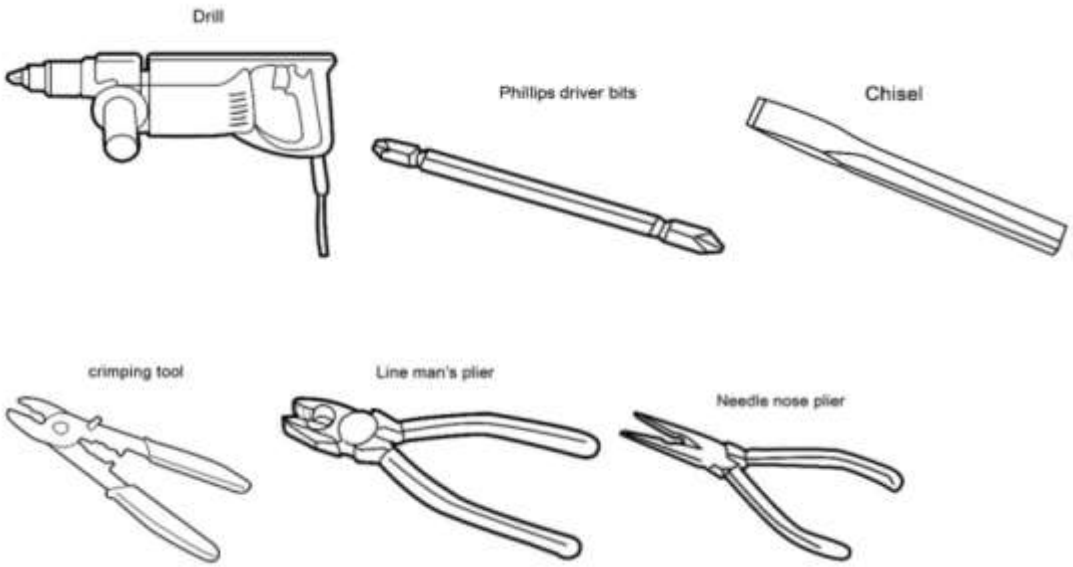


Figure 14: Drill, Philips driver bits, chisel, crimping, line man's plier, needle nose plier (GIZ, 2016)

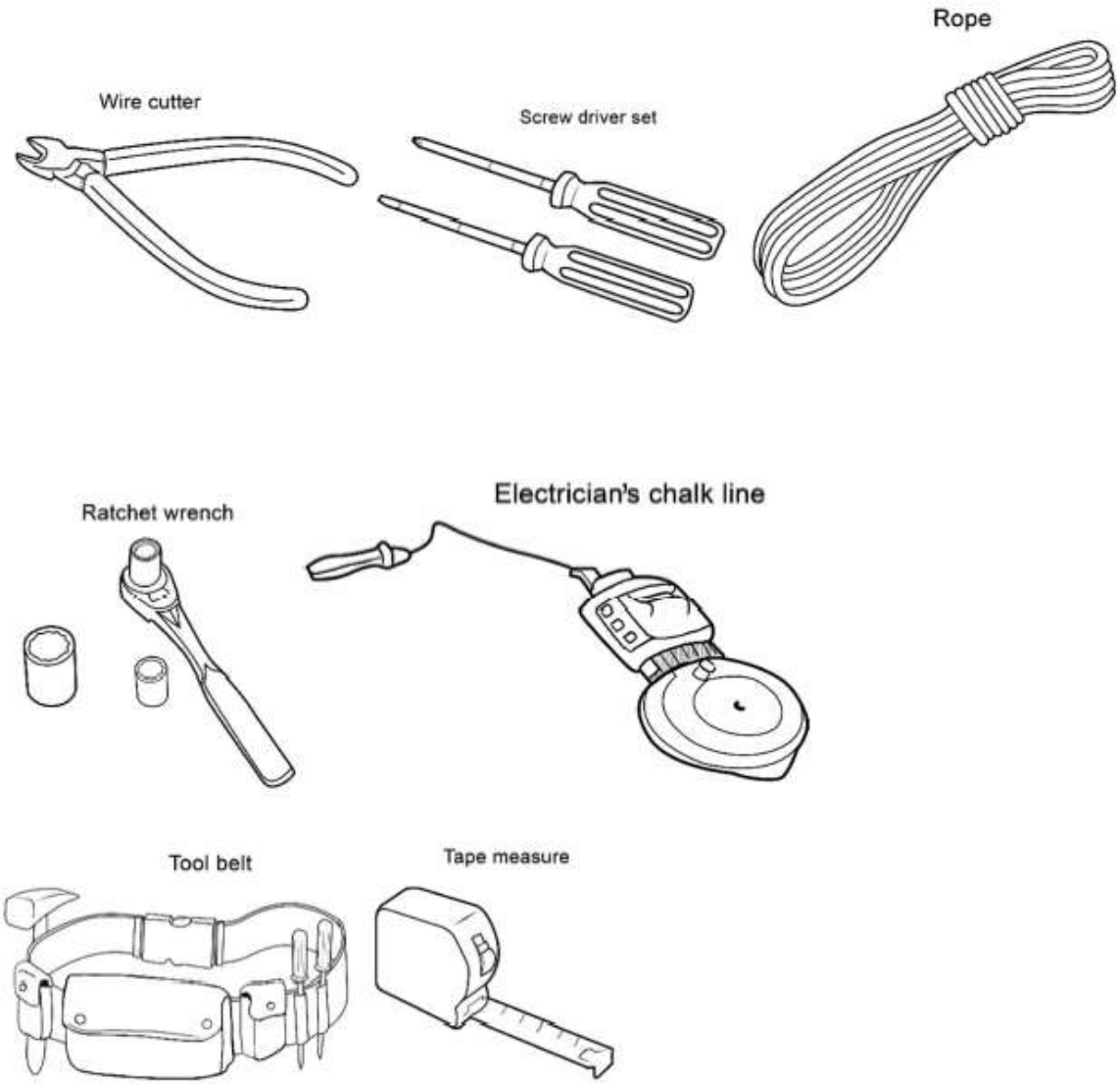
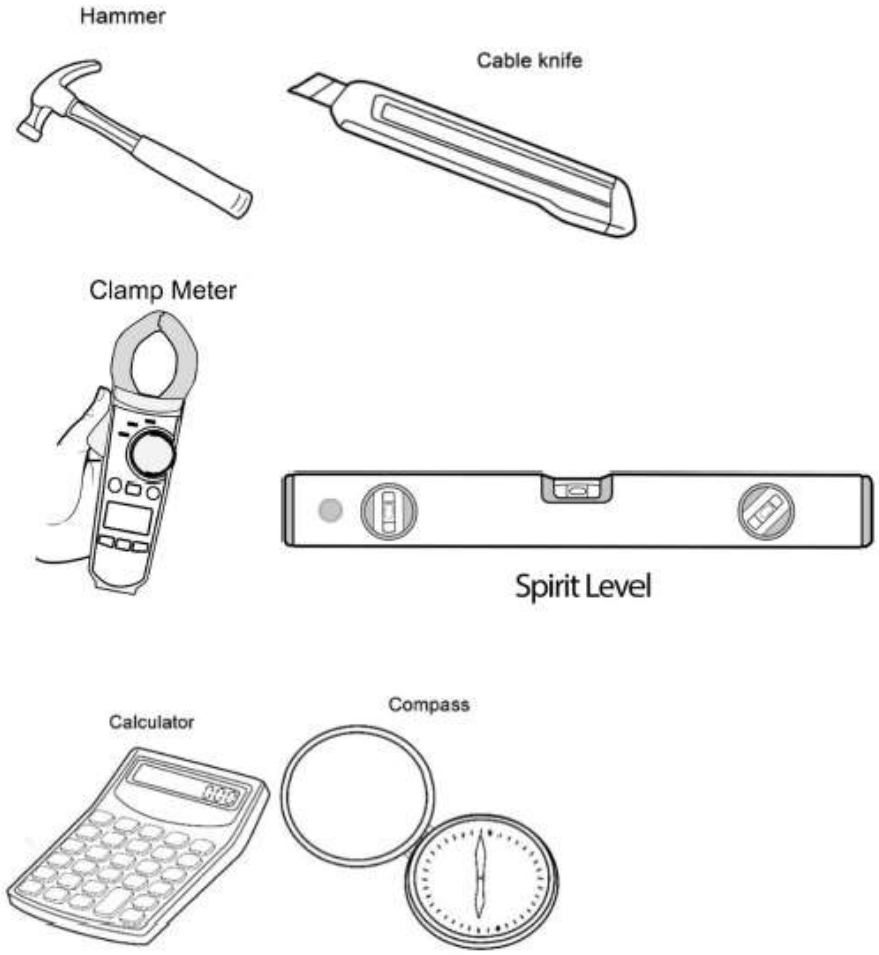


Figure 15: Wire cutter, screw driver set, rope, ratchet wrench, electricians chalk line, tool belt, tape measure (GIZ, 2016)



Fine, Figure 16: Hammer, cable knife, clamp meter, spirit level, calculator, compass (GIZ, 2016)

Figure 17: Digital multimeter (Hankins, 2010)

Table 2: Basics tools used for PV systems installation (Hankins, 2010)

Tool	Purpose of tool
Crimping tool (see page 149)	Attaching bootlace, ring and spade terminals to wires
12V DC Soldering iron	Connecting wires to terminals, fixing electrical parts
Digital multimeter	Testing connections, measuring voltage, needs to be able to measure DC current up to 10A at least, and be properly fused
Screw drivers (star- and flat-bladed, insulated)	Tightening screws and terminals
Hydrometer	Measuring battery state of charge
12V drill and drill bits (if not available, use a hand drill)	Drilling holes for various purposes
Tape measure	Measuring distances and marking wire clip placement
Pencil and paper	Taking notes on measurements
Hack saw	Cutting metal frames
Utility knife	Various cutting jobs
Wire cutter and stripper	Preparing cables
Torch	Laying wires in dark places (ceiling), working after dark
Pliers	Holding bolts and nuts during tightening
Adjustable spanner	Tightening battery terminals
Hammer	Various construction tasks
Shovel	Digging trenches, foundations
Level	Checking grade of mount, laid wire and foundations
File	Smoothing rough surfaces after cutting
Extension cord	Running power from inverters to tools
Inclinometer and compass	Fixing the angle of solar modules
Product literature for system components	Source of reference information

3.4 Establishing the skills needed for the work

The requirement on the skills usually depends on the site realities, as every site installation comes with its challenges asking for various skills. However, broadly, the following skills could be requested.

- Skilled solar energy engineer
- Skilled electrical engineer or technician
- Skilled mechanical technician
- Skilled civil technician
- Skilled security and safety technician

The following paragraph is adapted from (Hankins, 2010)

The different skills personnel ought to collaborate throughout these installation tasks:

- The preparation of the tools and materials necessary to complete the installation.
  - ✓ The positioning, mounting and wiring of the solar modules.
  - ✓ The wiring of the control and batteries.
  - ✓ The laying of the cables.
  - ✓ The making and inspecting of the final connections.
  - ✓ The commissioning of the system and the training of the system managers.

These tasks need not necessarily to be carried out in this order – it depends on the installation. The most important is to plan the work logically.

Self-Check - 3	Written Test

The following are true or false statements, write true if the statement is true and write false if the statement is false.

N°	Questions and answers
1	There is a universal manner of planning solar PV system installation before the work commences.
	True or false:
2	Only solar modules, a digital multimeter, a cordless drill, and a ladder are enough equipment and tools to install an off-grid home solar PV system.
	True or false:

Satisfactory	2 points
Unsatisfactory	Below 2 points

Information Sheet 4	Accessing plant, materials and others needed for the work

4.1 Introduction

This chapter describes how to access plant, materials and others needed for the work.

4.2 Accessing plant

After establishing the plant/site, it is time to take measures to ease access to the plant/site. The measures will vary depending on the specificities at the location. Allowing the workers, materials and related needs to be brought to site call for enabling quality roads to and from the plant/site. For instance, there is a need for visual inspection of vegetation, weed growth and pest control. There is also a need for performing approved waste disposal, weed abatement and vegetation control services to limit vegetation height and avoid shading and encroachment. Additionally, a complete visual inspection of the direct and surrounding roads to the project site is of utmost importance towards performing corrective actions as required in some situations.

4.3 Accessing materials and others needed for the work

The access to the bought materials and others needed for work is essential for not only using them for the task ahead but to allow checking and making sure of their quality, through observation and measurement. On one hand, if applicable, once the access to the plant/site is made quite easy, the stores incorporating the materials and other needful things could be also accessed with no difficulty. On a well-established plant/site, having well-organised stores the materials can be kept in such a way to ease their access for specific work. On the other hand, it may be difficult to obtain tools, extra parts and equipment while on-site. For this reason – before departing for the installation site – it is advised to make check lists of all the materials and tools needed. This list should be carefully crosschecked during trip preparations.

Self-Check - 4	Written Test

The following are true or false statements, write true if the statement is true and write false if the statement is false.

N°	Questions and answers
1	**Accessing the plant for solar PV system installation is not important.**
	True or false:
2	**It is the responsibility of the client to provide the workers working tools on site.**
	True or false:

Satisfactory	2 points
Unsatisfactory	Below 2 points

LAP Test	Practical Demonstration

Instructions: Given necessary materials, tools and measuring instruments you are required to perform the following tasks within 2 hours.

Task 1:

Your instructor will give you an already prepared/completed site survey for a building he will show you. You will also be provided with an electrical drawing of the PV system to install at the building. Your task is to use the available information to clearly write on the provided sheet the way you understand the job specification and requirement, and how you plan to establish and access the plant, the needed materials and other things for the work.

Solar PV System Installation and Maintenance

NTQF Level IV

Learning Guide-26

Unit of Competence	**Supervising and coordinating solar PV system installation Activities**
Module Title	**Supervising and coordinating solar PV system installation Activities**
LG Code	**EIS PIM3 M07 LO2-LG26**
TTLM Code	**EIS PIM3 TTLM 0920 v1**

LO2: Supervise and coordinate work activities

Instruction Sheet	Learning Guide-26

This learning guide is developed to provide you with the necessary information, knowledge, skills and attitude regarding the following content coverage and topics:

- Implementing and monitoring OHS procedures and programs.
- Sequencing and completing work instructions.
- Seeking cooperation from others.
- Monitored /Supervising and coordinating work progress.
- Dealing with conflict issues at the work site.
- Dealing with requested variations to job specification.
- Selecting methods for dealing with unexpected situations.
- Selecting methods for dealing with unexpected situations

This guide will also assist you to attain the learning outcome stated in the cover page. Specifically, upon completion of this Learning Guide, you will be able to:-

- Implement and monitor OHS procedures and programs.
- Sequence and complete work instructions.
- Seek cooperation from others.
- Monitor/Supervise and coordinate work progress.
- Deal with conflict issues at the work site.
- Deal with requested variations to job specification.
- Select the methods for dealing with unexpected situations.

Learning Instructions:

1. Read the specific objectives of this Learning Guide.
2. Follow the instructions described below.
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6. Do the “LAP test”

Information Sheet 1	Implementing and monitoring OHS procedures and programs

1.1 Introduction

This part discusses the implementing and monitoring OHS procedures and programs.

1.2 Implementing OHS procedures and programs

The following paragraph is adapted from (Alli, 2008)

In order to implement OHS procedures and programs, and taking account of the available technical means of action, the competent authority or authorities will need to:

- Issue or approve regulations, codes of practice or other suitable provisions on occupational safety and health, taking account of the links existing between safety and health on the one hand, and hours of work and rest breaks, on the other.
- Undertake or promote studies and research to identify hazards and find means of overcoming them.
- Provide specific measures to prevent catastrophes, ensuring that action is coordinated and coherent at all levels, with particular attention to areas of potentially high risk for workers and the population at large.
- Provide information and advice, in an appropriate manner, to employers and workers, and promote or facilitate cooperation between them and their organizations, with a view to eliminating hazards or reducing them as far as practicable.
- Set the conditions governing the design, construction and layout of undertakings with a view to avoiding or minimizing hazards.
- Ensure that hazards are avoided or controlled when operations begin, or when major alterations or changes are made.
- Verify the safety of technical equipment used at work.
- Identify work processes, substances and agents which are to be prohibited, limited or made subject to authorization or control, taking into consideration the possibility of simultaneous exposure to several substances or agents.
- Establish and apply procedures for the notification of occupational accidents and diseases by workers and, when appropriate, insurance institutions and others directly concerned, and produce annual statistics on occupational accidents and diseases.

- Hold inquiries in cases of accidents, diseases or any other injuries which arise in the course of or in connection with work and appear to reflect a serious situation.
- Publish information on measures taken in pursuance of the national OHS policy, and on accidents, diseases and injuries which arise in the course of or in connection with work.
- Introduce or extend systems to examine chemical, physical and biological agents, and ergonomics and psycho-social factors, with a view to assessing the risk to the health of workers, in so far as is practicable in current national conditions.

1.3 Monitoring of exposure

The following paragraph is adapted from (Alli, 2008) the main objectives of such monitoring are to:

- Identify real hazards.
- Determine the level of workers' exposure to harmful agents.
- Prove compliance with regulatory requirements.
- Assess the need for control measures.
- Ensure the efficiency of control measures in use.

1.4 Management responsibilities in OHS training

The following paragraph is adapted from (Alli, 2008) It is the responsibility of the management to:

- Give each worker practical and appropriate instruction, taking account of his or her skills and professional experience, in each case defining the objective to be achieved in terms of ability to perform a specific function.
- Provide training involving the acquisition of knowledge and know-how to be applied in a specific job and corresponding to the qualifications required; this may consist of initial training for entry to a particular trade or profession, or adaptive training associated with a modification of the workstation, the introduction of new methods or a transfer to another job.
- Give refresher courses to update the knowledge acquired through training.
- Provide further training, thus enabling workers to acquire new knowledge, supplement existing knowledge, or specialize in a particular area by acquiring more detailed knowledge.

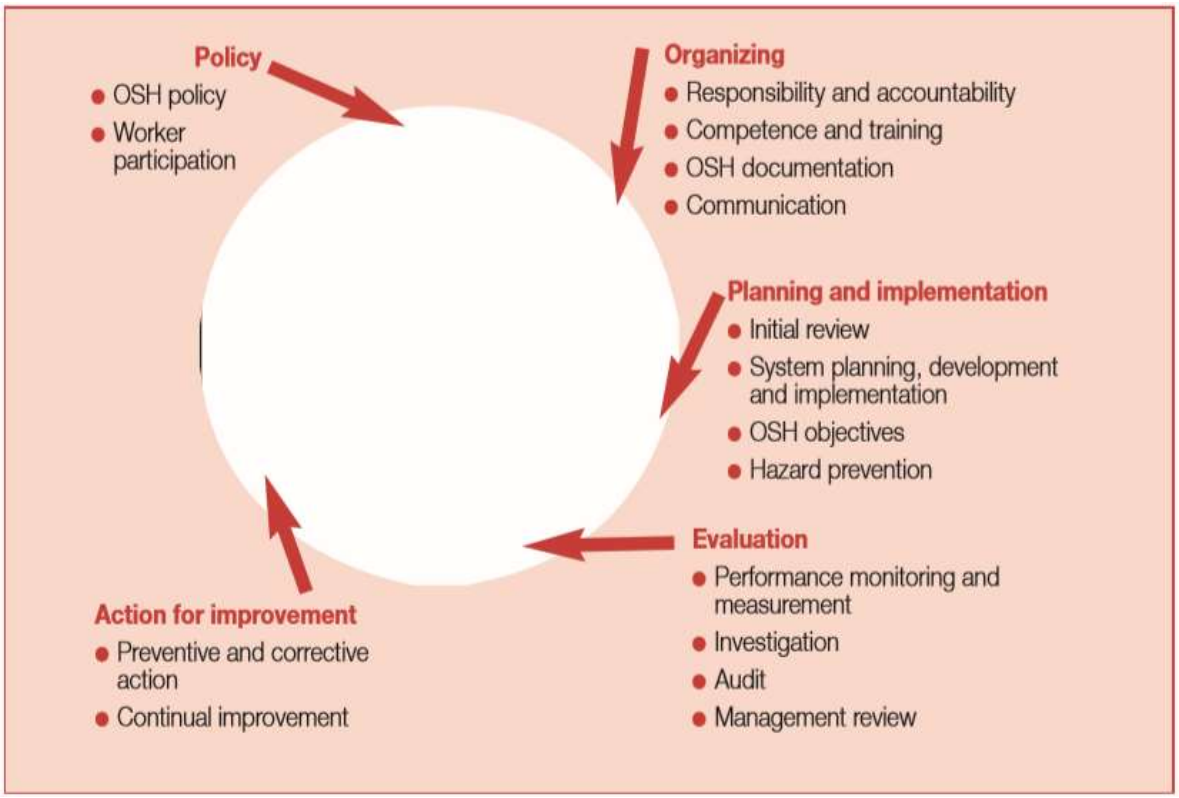

Figure 18: The OHS (OSH) management cycle (Alli, 2008)

1.5 Responsibilities of the workers in the surveillance of the working site

The following paragraph is taken from (Alli, 2008)

Staff involved in the surveillance of the working environment can be responsible for:

- Conducting surveys of the working environment;
- Interpreting the data gathered during the survey.
- Keeping records.
- Preparing appropriate control measures.
- Preparing adequate warnings.
- Suggesting precautions where dangers exist.
- Advising management on industrial hygiene.
- Educating workers and the community at large on basic occupational safety and health.
- Conducting epidemiological studies to uncover the presence of occupation-related illness and injury.

1.6 Safety and health committee

The following paragraph is adapted from (Alli, 2008) Workers health and safety committee should be:

- Given adequate information on safety and health matters.
- Enabled to examine factors affecting safety and health.
- Encouraged to propose safety and health measures.
- Consulted when major new safety and health measures are envisaged and before they are carried out.
- Ready to seek the support of workers for safety and health measures.
- Consulted in planning alterations of work processes, work content or organization of work which may have safety or health implications for workers.
- Able to communicate with workers on safety and health matters during working hours at the workplace.

Self-Check – 1	Written Test

The following are true or false statements, write true if the statement is true and write false if the statement is false.

N°	Questions and answers
1	Implementing OHS procedures and programs includes undertaking studies and research to identify hazards and find means of overcoming them.
	True or false:
2	Implementing OHS procedures and programs is only the responsibility of the work supervisor and coordinator.
	True or false:

Satisfactory	2 points
Unsatisfactory	Below 2 points

2.1 Introduction

Once the supervisor has the installation planning in hand the next step is to sequence and coordinate the work activities through given instructions to the workers.

2.2 General overview on a project

The following paragraphs we will use a practical example of a 5kW system designed for the Poly Technique College at Adama, Ethiopia. This example is also used to explain system design in module 1, how to prepare a quote in module 2 and how to prepare system documentation in module 8. The picture and drawings are taken from the real system design document. For instance, regarding the installation of a 5kWp it is relevant to understand and possess the complete overview of the project. The geographical location of the system to be installed should be identified. Figure 19 shows an overview of the location of the candidate system and Figure 20 the site layout.

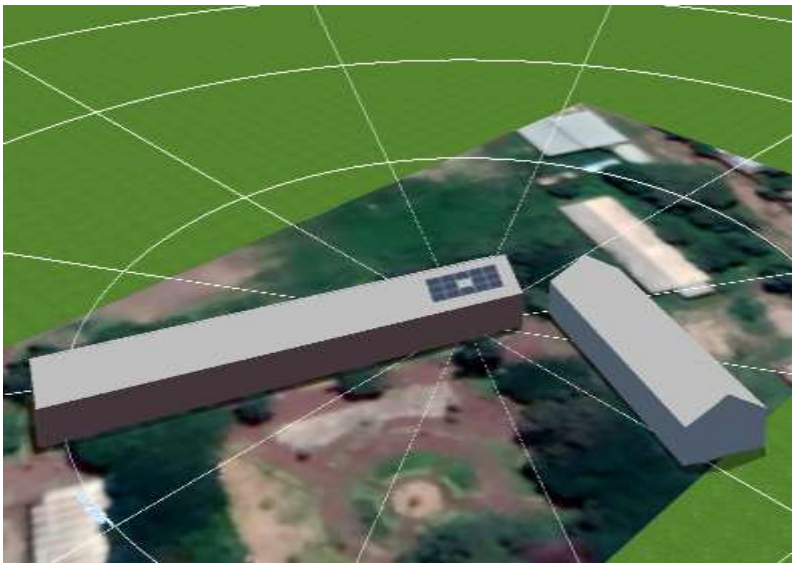

Figure 19 : 3D design of the location

Figure 20: Adama Site Layout

The supervisor should:

- Identify the components of the system. Table 3 shows the details of the different components needed for the installation.

Table 3: Parts list of the system to install

Parts list

#	Type	Item number	Manufacturer	Name	Quantity	Unit
1	PV Module		Phaesun	Phaesun PN6M72-350 E	14	Piece
2	Inverter		Phocos	Phocos Anygrid 5kW 1MPPT	1	Piece
3	Battery System		Phocos	Phocos Anygrid + Hoppecke	1	Piece
4	Meter			Bidirectional Meter	1	Piece
5	Components			Circuit Breaker B 32A	1	Piece

Have a clear understanding of the schematic diagram or circuit diagram of the system. Figure 21 shows the Single Line Diagram (SLD) of the system and Figure 22the wiring diagram.

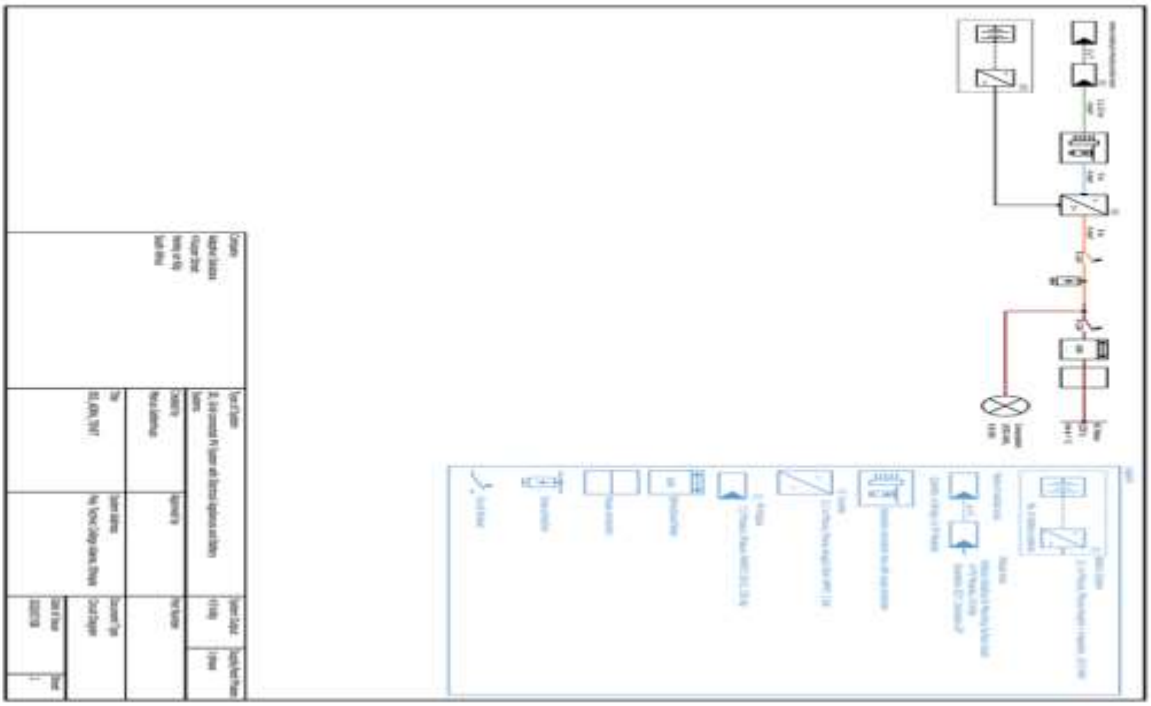

Figure 21: Schematic diagram of the Adama 5 kWp system

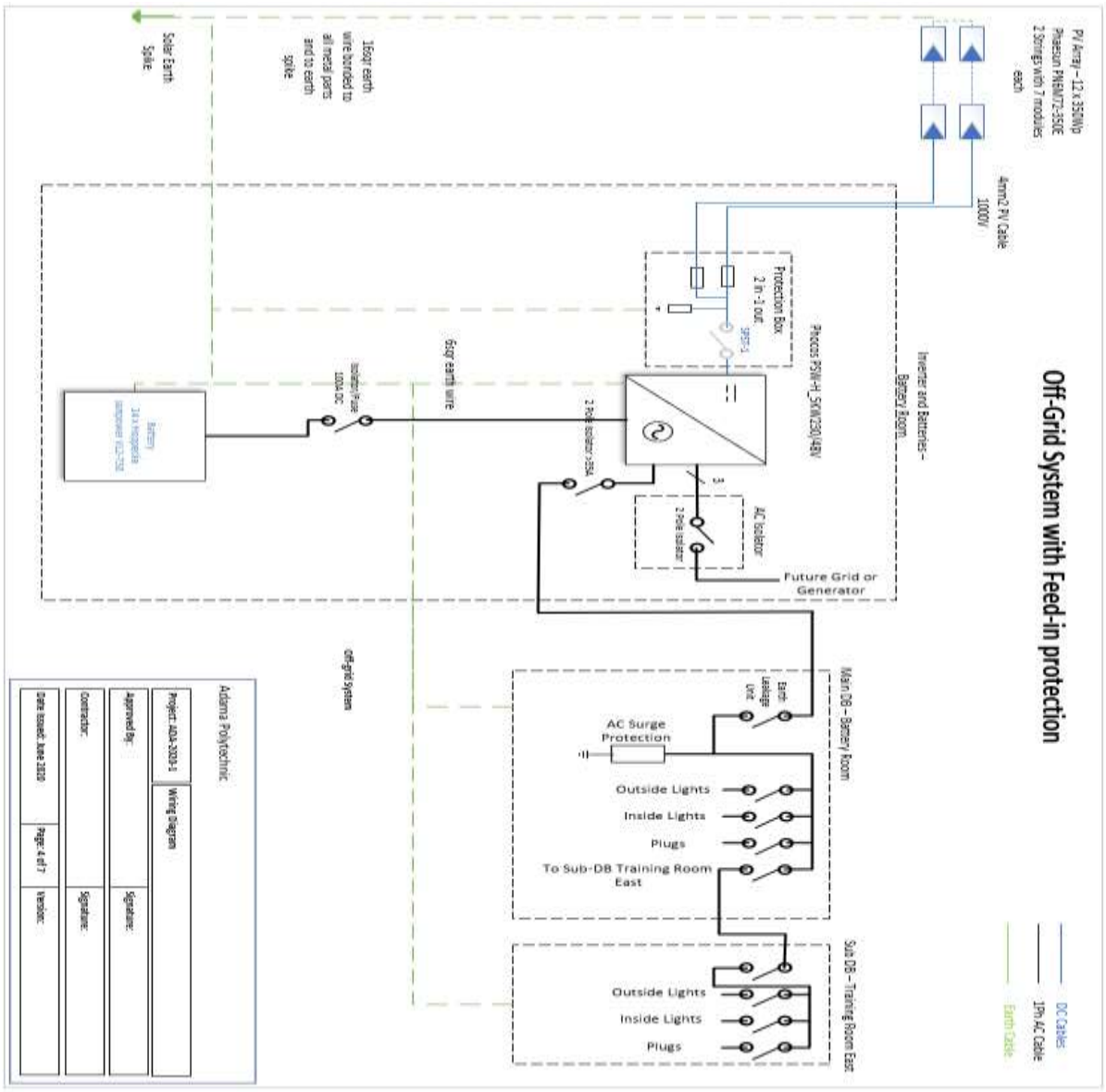

Figure 22: Adama 5 kWp wiring diagram

- Understand the expected yield of the system while under function
- Have a view on the system consumption and climate data
- Have precise knowledge of the solar field.

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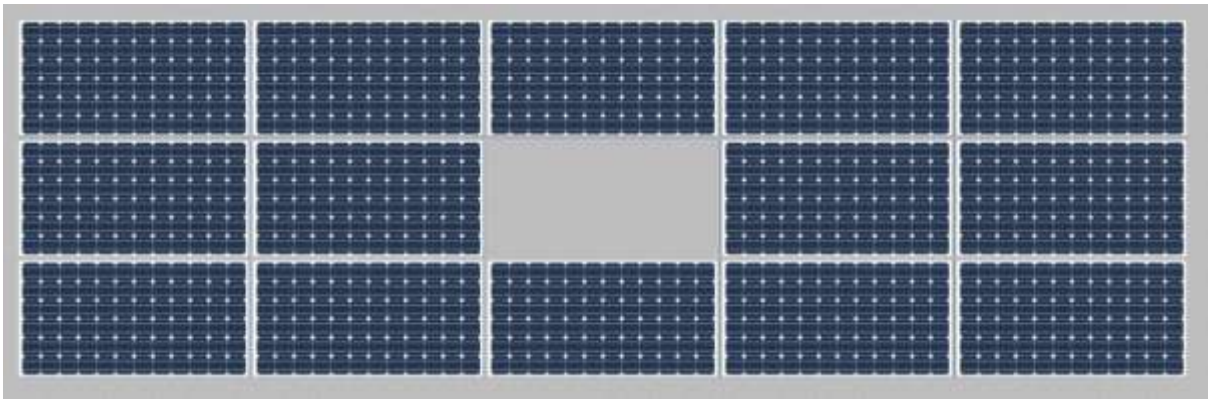

Figure 23: Modules area of the 5 kWp PV system

Figure 24 shows the string connections for the 5 kWp rooftop PV system installation project.

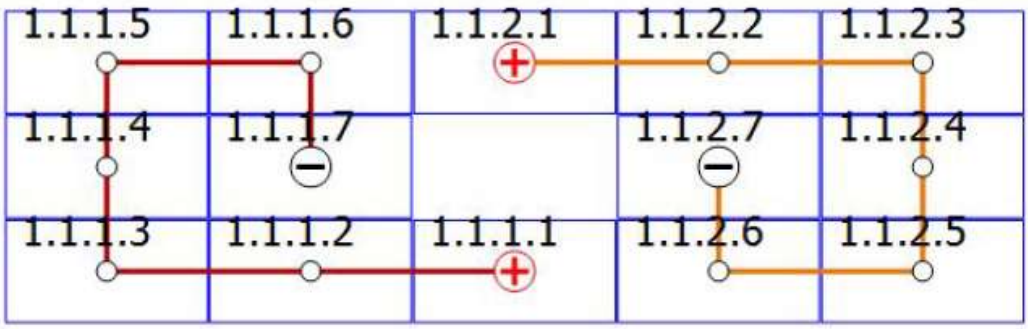

Figure 24 : String connections of the 5 kWp PV system

- Understand the detailed characteristics and configurations of the inverter and battery systems
- Have an idea of the simulated results of the system power production and energy consumption

2.3 Recommendations on sequencing and completing work instruction

It is important that the supervisor does a detailed review of the planning and explain to the team what to do step by step for a successful installation of the corresponding 5kWp system represented in Figure 25.

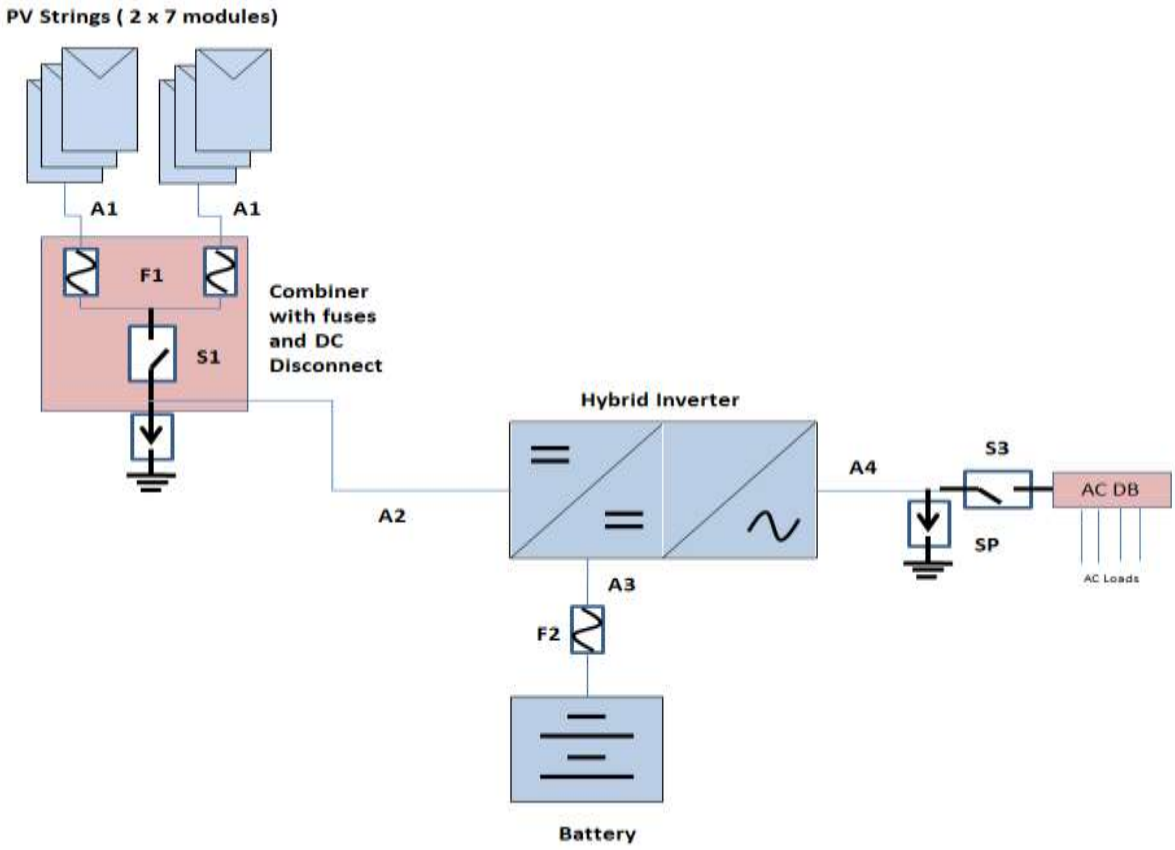

Figure 25: More elaborate design of the

The supervisor should instruct the workers to perform the following steps:

- The solar field location, positioning and orientation should be completed according to the planning.
- Cable all the modules progressively while applying the applicable security measures.
- The cabling from the solar field to the rest of the system must be identified and available physically. The cabling must comply with the project cables sections.
- Start positioning the inverter, batteries, and DC and AC junction boxes at their locations and position the boxes by respecting the recommended distancing between them.
- Install the protective equipment at their requested places.
- Proceed to the cabling of the main components based on a define sequencing having in mind that one could need electricity during the installation for supplying specifics working tools; there is no universal rule to that effect.

- The airflow within the technical room should be good enough as equipment such as batteries and inverters loose efficiency while kept in very hot environment;

install an air-conditioning system to smooth the hot temperature by cooling down the room.

- After the entire cabling is complete the system needs a final checking to ensure that the installation was done following the rules.
- Before testing the system, the supervisor must make sure the workers perform the necessary parameters' programming on the inverter.
- Then the system should be tested entirely to confirm proper functioning for few hours or days depending on its size.
- The proper functioning should show correct system parameters such as voltages, currents, frequency, produced power, energy consumption.

2.4 Commissioning and registration of the installation

The commissioning should be done by another expert to re-confirm that the system is operating in conformity with the codes and regulations in the country. Depending on the procedure per country the installation should be registered accordingly.

2.5 Some detailed instructions on the step by step installation

2.5.1 System installation: Step by step

To assist orientation, the position of the PV modules can be drawn on the roof using chalk. Where the roof hooks are going to be fitted, the roof tiles must be removed so that the rafters of the roof structure are visible at the marked points. The roof hooks are positioned so that the leg lies over the wave through the roof tile below. And the mounting plate is located across the full width of the rafter. If the roof hook does not clear the tile surface by at least 5mm, it must be shimmed. Most manufacturers provide suitable shim plates. The roof hooks are then fixed to the rafters by using two timber screws (minimum screw diameter of 8mm, with a length of 80mm). Pre-drilling the holes in the rafters and lubricating the screws makes it easier to screw them in and helps to prevent them from shearing off. The screws should be screwed into the rafters to a depth of at least 60mm to 80mm. If insulation is located over the rafters, correspondingly longer screws must be used. The tiles that were lifted must lie flush on the roof tiles below and at the side when they are put back in their original places. The leg of the roof hook will prevent this with tiles that are grooved

at the top and bottom. The roofer or installation engineer needs to cut or abrade these tiles so that they fit together cleanly again. Depending upon the roof tile, only the top tile or possibly both tiles will need to be adapted. Then the tiles that were removed can be replaced again. Next, the roof cover is sealed again and the roof is protected against weathering.

Note that the roof hooks should not alter the position of the tiles since this could otherwise lead to roof leakages. Since transformer-less inverters are used, the metal array support frame generally needs to be equipotent ally bonded to the building. The capacitive discharge currents resulting from the system must be safely conducted to earth/ground (personal protection). Earthing/grounding and Equipotential bonding codes and regulations differ from country to country. These must be consulted and observed.

2.5.2 Mounting the modules

To prevent slippage, bolts are placed in the mounting holes on the module frame with the shaft outwards and secured in place with nuts. The threaded part of the bolt projects from the back can be used to hang the modules in the upper horizontal rail during installation. Before the individual modules are finally secured in place, they are electrically connected to each other. For modules without plugs, the module junction box has to be opened and the connections wired up inside it. The cables are placed and secured in the transverse rails (e.g. using UV-resistant cable ties). This ensures that rainwater is not prevented from running off the roof and that no snowmelt can build up in the area of the array as a result of cables lying on the roof surface. It ensures that no drip water can run into the plug connectors or module junction boxes. The cables must be laid so that no mechanical damage can occur to the insulation through sharp edges, pointed objects, etc. (short-circuit and earth/ground fault proof wiring!). Note: if metal cable ducts are used, insulating edge protection must be employed, where necessary.

The modules are attached to the ends of the module fixing channels using angle brackets screwed to them. Thin weather-proof spacers (e.g. neoprene) are inserted between the angle brackets and the module frames. The brackets enable sufficient mechanical tension to be generated in the module rows so that no rattling or vibration sounds can be created by the module frames. The string cables are run in protective conducts through the roof's inner cladding, thermal insulation and vapour-proof barrier at a centrally defined point to the

outside. The cable laying must not adversely affect the roof's vapour barrier or thermal insulation. It must also be ensured here that the cabling is short-circuit and earth/ground-fault proof.

The protective ducts are first inserted through the previously made openings and fixed to prevent them from sliding out. The cables are then drawn through them; with long distances, for example, this can be done with the help of a feed coil. It is also possible to draw the cables through the ducts in advance to enable the protective ducts and cables to be installed simultaneously. Running the cables through the protective ducts ensures a high level of operating safety and a long service life for the cables. The protective ducts should be inserted through the vapour barrier at the overlapping points of the sheeting. This ensures that it can be easily sealed again after installation. Note that protective ducts must be UV resistant and rated for use in external areas. Finally, the string cables are run through the opening of a ventilation tile onto the roof. This is inserted at an appropriate point in the roof tiling and ensures that the roof remains waterproof at the lead-through point. For aesthetic reasons, this tile should be situated beneath the modules and be invisible from outside. The string cables are attached to the mounting frame and connected to the corresponding modules (first and last modules in a string).

2.5.3 String wiring installation inside the building

The string wiring is routed inside the building along the shortest possible route to the DC main disconnect/isolator switch (or to the PV array combiner/junction box, if present). Here, strict attention should be paid to earth/ground-fault proof and short-circuit proof installation when laying the wires. Because these wires carry direct current, they should be marked as such, especially if they are routed together with other wires in the building. There are often existing wiring routes or ducts that can be used.

The string cables are connected to the terminals of the DC main disconnect/isolator switch terminals or of the PV combiner/junction box (caution is required with voltages > 120V DC). Surge voltage protectors and string fuses ensure the appropriate operational safety, while the two-pole DC main disconnect/isolator switch ensures safe system switch-off under load (e.g. for servicing and maintenance).

2.5.4 Inverter installation

Connections to the respective string inverters are made from the DC main disconnect/isolator switches (or PV combiner/junction boxes) to the respective string inverters' DC input terminals. The inverters must be installed in a place where faultless operation is guaranteed. Factors to be considered include the ambient temperature, the heat dissipation capability (e.g. for installation in a cupboard), the relative humidity and the noise emissions. For service and maintenance purposes, the inverters should be easily accessible. The manufacturer's instructions must be followed. If there is a large distance between the PV combiner/junction box and the inverter, an additional DC main disconnect/isolator switch should be installed before the inverter. This enables safe isolation of the DC main cable from the inverter, even under load.

2.5.5 Installing the mains connections

The AC inverter outputs are connected to the mains grid via protective equipment (e.g. fuses and line circuit breakers) and via the distribution network operator's feed meter, in the meter cupboard. The commissioning of the PV system starts with setting up the meters. For this, all relevant measurements are taken and entered in the commissioning log. The mains voltage is switched on, the DC voltage connected and, with this, the inverter operation is started. The display on the inverter enables the relevant operating states to be read off, allowing conclusions to be made as to whether the system is functioning properly.

2.5.6 Guarantee

The installation engineer and planner, if involved, provide a guarantee for the PV system. In addition, any warranty obligations that are still effective from previous work carried out should be taken into consideration when penetrating the roof or installing electrical equipment. For instance, the basic guarantee period in Germany is two years and some installation firms voluntarily offer longer guarantee periods. Within the guarantee period, the installer must remedy any defects in the installation or defects caused by improper installation at his own expense. In addition to electrical safety and system safety, the weather-tightness and structure of the roof and the structural integrity of the PV array are relevant with respect to liability law.

Self-Check - 2	Written Test

The following are true or false statements, write true if the statement is true and write false if the statement is false.

N°	Questions and answers
1	The step by step sequencing of a solar PV system installation is not a prerequisite to a successful completion of the installation.
	True or false:
2	The work supervisor plays a role which is not necessarily relevant in the aim of installing a solar PV system.
	True or false:

Satisfactory	2 points
Unsatisfactory	Below 2 points

Information Sheet 3	Seeking cooperation from others

3.1 Introduction

This part provides understanding of what it means to work alone, or in groups, on a PV system installation site while seeking the intervention of others with the same or other skills.

3.2 Safely working alone and with others

The following paragraphs are adapted from (Mayfield, 2010)On an installation site the supervisor should advise and coordinate the work in such a way that he and the workers cooperate to achieve it properly. Everybody can need help from anywhere and from anybody. There are tasks that even more than two persons cannot complete in a secured, safe and quality manner. That is the workers should cooperate enough so that the supervisor work is made easy for quality installation. No one is exempt from asking for help or assistance in certain conditions depending on how things evolve on the site. It is even highly advised to offer and ask cooperation to and from others. It is rather a team work than a competition. Although the following statements are also the concern of the supervisor, it is relevant that he reminds the workers about them.

- Working alone is never the first choice in solar PV system installation - too many problems can sneak up on you that require a second person in order to maintain proper safety. The helper could be or not directly available on site.
- If you are working on a PV system alone or doing a related specific task, be aware of your limits. Realize that if you try to perform a task that really needs a second set of hands and you get hurt or perform bad, you will not save any time or money; in fact, just the opposite will occur. Never underestimate an activity with low chances to be done alone, nor look at any job as more important than your personal safety; rather ask for help while you need it, but in a strategic manner. When working with others on a job site, you need to have a different level of awareness. Here are some guidelines to follow:
- Never assume where people are or what their next move will be. If you move behind someone, announce your presence.
- Use directions with clear references. This tip is handy when you are working with someone to accomplish a common task, like carrying a large, heavy object across a roof. Asking cooperation involves constant well oriented discussion to understand each other for the purpose of the same goal.

Self-Check - 3	Written Test

The following are true or false statements, write true if the statement is true and write false if the statement is false.

N°	Questions and answers
1	A single worker can achieve all sorts of tasks on a solar PV installation site.
	True or false:
2	Seeking cooperation from others on site is of no use in the context of solar PV system installation.
	True or false:

Satisfactory	2 points
Unsatisfactory	Below 2 points

Information Sheet 4	Monitored / Supervising and coordinating work progress

4.1 Introduction

This part presents the way to go about supervising and coordinating work progress.

4.2 Tips to supervise and coordinate the work progress

As the title suggests it is to give some tips on how to monitor and coordinate the installation work evolution. To follow up the work evolution means to closely monitor the activities on ground. Records of the work progress are recommended, both at specific periods and each time needed. Here some tips are suggested to enable the supervisor to deliver a proper job through ensuring correct work progress.

- Should have clear knowledge of the design to install on ground in all the available details.
- Make sure the retained cabling structure is recommendable and complies with the project objectives.
- Make sure all of the materials/equipment are brought to site according to sizing and quality.
- Make sure the workers are qualified enough for the tasks ahead.
- Make sure the workers understand all the activities to be implemented and the way to perform them.
- Make sure the workers always work with the appropriate tools while wearing appropriate protective equipment.
- Make sure all the security measures are taken before the beginning of all the activities.
- Make sure the modules are mounted as planned in the correct position and orientation; the cabling of and from the modules should be of quality and the cables should be as short as possible to avoid power loss.
- Make sure the inverter, DC and AC junction boxes, batteries, charge controller, are well positioned and cabled towards the modules. The sequence of cabling them is to be defined accordingly.
- Make sure the cabling is achieved in time and that nothing is missing.
- Make sure the necessary tests are conducted to ensure the system works adequately, and proceed to the commissioning, training of the managers and final reception of the installation.

Self-Check - 4	Written Test

The following are true or false statements, write true if the statement is true and write false if the statement is false.

N°	Questions and answers
1	The supervisor should avoid taken security measures are taken before the beginning of all the activities.
	True or false:
2	The commissioning and training of the client/manager is the first step to fulfil in the aim of installing any off-grid home solar system.
	True or false:

Satisfactory	2 points
Unsatisfactory	Below 2 points

Information Sheet 5	Dealing with conflict issues at the work site

5.1 Introduction

Here we teach some methods to handle conflict issues at the work site.

5.2 The strategy to deal with conflict issues at the work site

Conflict management are undoubtedly unwanted scenarios pleasant to no one. Therefore they should be minimized through the respect of the established working plan before installation begins. The nature of the conflict is dependent on random situations that are difficult to predict. However, usually, among the possible reasons, the following are the cause of conflicts at work site:

- Supervisor running from his or her duties.
- Hiding or unrevealing relevant information.
- Lack of explanation on what to do.
- Workers willing to do things their ways.
- Stealing materials and tools from the site.
- Previous existing problems among the workers.
- The absence of cooperation from others.

The Table 3 suggests some actions to take per above mentioned cause of conflicts irrespective of the nature of the conflict.

Table 4 : Corrective measures to the causes of the conflicts

Cause of conflicts	Level of gravity	The action to take
Supervisor running from his or her duties.	High	The supervisor must be put to order.
Hiding or unrevealing relevant information.	Average	All the information's should be documented and made available to every eligible worker or coordinator.
Lack of explanation on what to do.	High	Work should be made clear by the supervisor as he knows best the goal.

Cause of conflicts	Level of gravity	The action to take
Workers willing to do things their ways.	High	Punishment is needed; it could be certain amount deduction from their salaries.
Stealing materials and tools from the site.	Average	Investigation will clarify the responsibilities and the guilty should be punished according to the law.
Previous existing problems among the workers.	Low	Workers must put their differences aside; the supervisor is to talk to them and advise them.
Work variations	Average	The supervisor must make sure all the workers understand the changes to apply.
The absence of cooperation from others.	Average	The supervisor is responsible for installing a good cooperation spirit among the workers.

When the cited causes are properly fixed, the probability of the re-occurrence of conflicts which will constitute major hindrance to the work will be quite low.

Self-Check - 5	Written Test

The following are true or false statements, write true if the statement is true and write false if the statement is false.

N°	Questions and answers
1	Workers stealing materials and tools on the site cannot be source of conflicts to deal with.
	True or false:
2	The best way to deal with conflicts on the site is doing nothing and expect the situation to pass.
	True or false:

Satisfactory	2 points
Unsatisfactory	Below 2 points

Information Sheet 6	Dealing with requested variations to job specification

6.1 Introduction

Here we clearly state the way to deal with requested variations to job specification.

6.2 Dealing with requested variations to job specification

The variations could be of various directions, maybe on the electrical side (brands, characteristics, technologies of materials/equipment needing changes), or on the mechanical side (mounting system to change, maybe the addition of a tracker etc.), or the civil engineering side (specific materials to change for quality reasons etc.), or the activities allocation to the workers, which can experience some arrangement due to lack of personnel or competency reasons etc. How to deal with these situations call for a clear report containing the changes to make each time they occur. The report should be made available, for the workers to know exactly the new structure to be considered for the installation, and the updated responsibility of each and every one. Briefly, there is no magic formula than meticulously revealing the changes to be put into action for better results. In case those changes request for new system sizing and design they should be complied with accordingly, in respect of the concerned codes and standards, by also making sure that the new considerations are well known to the client and therefore accepted by him. It is of no doubt that dealing with those technical changes is also dealing with them financially in case economical adjustments arise.

Figure 26: Change Management Process (dreamstime.com)

Self-Check - 6	Written Test

The following are true or false statements, write true if the statement is true and write false if the statement is false.

N°	Questions and answers
1	The respect of local codes and standards is important in dealing with requested variations to job specification.
	True or false:
2	There is no universal formula to deal with requested variations to job specification.
	True or false:

Satisfactory	2 points
Unsatisfactory	Below 2 points

Information Sheet 7	Selecting methods for dealing with unexpected situations

7.1 Introduction

This part presents some tips for selecting the suitable methods while dealing with unexpected situations on the working site.

7.2 Tips to select the suitable methods

Likewise the case of dealing with the requested variations to job specification there is no magic formula in dealing with unexpected situations on site. Therefore, the randomness nature of the unexpected situations on site call more for experience than applicable methods which might lack consistency of the real situation on ground. In fact, stating some to be selected methods to deal with unexpected scenarios seems inaccurate and incorrect. The reason is that generally the unexpected situations come with bags of inconvenience and things to be accounted for, making it challenging to rely on mere methods made with considerations that could be far from the real case at hand.

The following are tips to rely on for dealing with unexpected situations.

- Evaluate the gravity of the unexpected situation based on experience.
- Inform your immediate boss about the situation if you cannot face and solve it with your experience.
- Solve the situations/problems with the help and cooperation from the workers if applicable; later inform your immediate boss about that if it is relevant.
- Take all necessary notes towards solving an issue that cannot be handled immediately (meaning issues that ask for more days).
- Always face the problems and solve them completely, and avoid procrastinating for later actions, because leaving unsolved problems can only slowdown and delay the work progress, therefore bringing more unexpected situations.

Self-Check - 7	Written Test

The following are true or false statements, write true if the statement is true and write false if the statement is false.

N°	Questions and answers
1	There is no need evaluating the gravity of the unexpected situations based on experience.
	True or false:
2	It is irrelevant taking notes towards solving an issue that cannot be handled immediately.
	True or false:

Satisfactory	4 points
Unsatisfactory	Below 4 points

LAP Test	Practical Demonstration

Instructions: Given necessary materials, tools and measuring instruments you are required to perform the following tasks within 4 hours.

Task 1: You are in charge of supervising and coordinating a rooftop small solar system installation. Propose the sequence of the activities to complete work instructions. Follow up workers to monitor the work progress; include reporting on the intentional work variations and different conflicts you were confronted to. Relate the methods you applied to solve the so-called unexpected situations.

Solar PV System Installation and Maintenance

NTQF Level IV

Learning Guide -27

Unit of Competence	**Supervising and coordinating solar PV system installation Activities**
Module Title	**Supervising and coordinating solar PV system installation Activities**
LG Code	**EIS PIM3 M07 LO3-LG27**
TTLM Code	**EIS PIM3 TTLM 0920 v1**

LO-3:-Document supervision and coordination activities

Instruction Sheet	Learning Guide:-27

This learning guide is developed to provide you with the necessary information, knowledge, skills and attitude regarding the following content coverage and topics:

- Maintaining job records.
- Following processes to ensure activities.

This guide will also assist you to attain the learning outcome stated in the cover page. Specifically, upon completion of this Learning Guide, you will be able to:-

- Maintain job records.
- Follow processes to ensure activities.

Learning Instructions:

1. Read the specific objectives of this Learning Guide.
2. Follow the instructions described below.
3. Read the information written in the information Sheets
4. Accomplish the Self-checks
5. Perform Operation Sheets
6. Do the “LAP test”

Information Sheet 1	Maintaining job records

1.1 Introduction

How to maintain the job record is that which is covered in this information sheet.

1.2 The way to maintain job records

The following paragraphs are adapted from (Hankins, 2010)The idea behind maintaining job records is to be able to later go back and check if things are being or have been done properly. The progress of all the installation on site must be documented and signed off through multiple reports. System records help those who are installing and managing the solar PV systems installation to follow up the ongoing activities. For instance, electricians may need to see the electrical drawings and its related records to confirm the installation is done properly. Records of daily remarks on modules, batteries, mounting structure, controllers, cabling routes can further help analyse problems when they turn up and can help avoid more serious situations.

Keep all written information about the PV system installation progress in a safe place. The information could be classified in terms of most important information and less relevant ones. Templates should be designed accordingly, to report the information considering the possible scenarios that could occur. Especially, large PV systems installations works perform better when someone (the supervisor for example) is given the job of coordinating the work and keeping valuable records up-to-date. Important PV system information includes what was initially planned and when applicable details on the following changes:

- The changes on the modules positioning and location.
- The changes on the battery's location and configuration.
- The changes on circuit diagrams and maps.
- The changes on runs, junction boxes and cabling structure.
- The changes on the type of materials/components being used.
- The changes about the distancing between the equipment.

Above all, maintaining the job records it to help the supervisor and coordinator to producing a complete and reliable final report of the whole installation activities. The corresponding times and dates of the reported information are to be considered as well.

Self-Check - 1	Written Test

The following are true or false statements, write true if the statement is true and write false if the statement is false.

N°	Questions and answers
1	The job records should only contain the details of what was initially planned, no need to notify the progressive changes made.
	True or false:
2	Only the changes concerning the batteries and the inverter must be reported in the job records, no other changes are relevant.
	True or false:

Satisfactory	2 points
Unsatisfactory	Below 2 points

Information Sheet 2	Following processes to ensure activities

2.1 Introduction

This information sheet describes how to follow the processes to ensure activities.

2.2 How to follow processes to ensure activities

The best way of following the processes towards ensuring the activities is to first better identify them. The processes have been clearly identified in the information sheet 1 of LO1, and even frequently referred throughout this training course. Therefore, all the processes namely, the site visit, the system sizing and design, proper installation, programming, commissioning and training must be constantly stuck to until completion of the work.

Self-Check - 2	Written Test

The following are true or false statements, write true if the statement is true and write false if the statement is false.

N°	Questions and answers
1	The system commissioning is not a valuable process to account for while installing solar PV systems.
	True or false:
2	The supervisor must ensure the system sizing and design is of quality.
	True or false:

Satisfactory	2 points
Unsatisfactory	Below 2 points

LAP Test	Practical Demonstration

Instructions: Given necessary materials, tools and measuring instruments you are required to perform the following tasks within 4 hour.

Task 1: As a supervisor of a solar PV system construction, you are provided with a team of two workers to install a small PV system to power few lamps and a fan. Your duty is to keep the work records and ensure effective activities' processes. Therefore, you are advised building handy templates on the available computer and report the necessary information on them throughout the installation.

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