# Solar PV System Installation and Maintenance

## Level IV

# Learning Guide -15

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|---|---|
| Unit of Competence | Install configuring and commissioning mini grid connected PV systems |
| Module Title | Installing, configuring and commissioning mini grid connected PV systems |
| LG Code | EIS PIM4 M04 LO1-LG15 |
| TTLM Code | EIS PIM4 TTLM 0920v1 |

## LO1-Prepare to install photovoltaic power system

ADRA ETHIOPIA

| Instruction Sheet | Learning Guide:-15 |
|---|---|

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

- Obtaining and understanding OHS procedures for a given work area
- Selecting Tools and equipment in line with job order requirements
- Identifying and selecting Personal protective equipment
- Identifying and establishing health and safety risks control measures and procedures
- Implementing noted and identified risk control measures
- Preparing system Installation sequentially in consultation with others
- Determining the nature and location of the work from documentation
- Planning system components location
- Seeking advice from appropriate persons
- Obtaining needed materials for the installation work
- Obtaining tools, equipment and testing devices for installation work
- Checking preparatory work to ensure there is no damage

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:-

- Obtain and understand OHS procedures for a given work area
- Select tools and equipment in line with job order requirements
- Identify and select personal protective equipment
- Identify and establish health and safety risks control measures and procedures
- Implement noted and identified risk control measures
- Repair system installation sequentially in consultation with others
- Determine the nature and location of the work from documentation
- Plan system components location
- Seek advice from appropriate persons
- Obtain needed materials for the installation work
- Obtain tools, equipment and testing devices for installation work
- Check preparatory work to ensure there is no damage

**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 | Obtaining and understanding OHS procedures for a given work area |
|---|---|

**Introduction**

This chapter provides the basics on understanding OHS procedures for a given work area. The working area can vary, depending on the type of installation, but here we tackle the case of mini grid connected PV system site, to reveal the aspects that should be considered to reinforce workers health and safety while working.

**Short definition of OHS**

OHS means occupational health and safety. It is 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.

**Site hierarchy of preventive and protective measures**

Here we indicate the hierarchy of preventive and protective measures regarding the installation of a mini grid connected PV system. In taking preventive and protective measures on a mini grid connected 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 all the possible risks on the site;
- Control all the risks at their sources;
- Minimize all the risks by means that include the design of healthy and safe work systems;
- Ensure the constant availability of personal protective equipment no matter the nature of the risks at hand; knowing that even minor risks need serious attention.

These four points are broadly representative of the occupational health and safety procedure needed at a mini grid connected PV system installation site. Thus, it is the joint responsibility of the site supervisor, the employer and all the workers to abide by the rules and therefore apply those steps reliably.

**Examples of employer's responsibility**

The different skills needed for an installation call for workers that are hired by employers who also have their role to play in ensuring the workers safety and health.

Every employer of workers should comply with the following.

- Provide and maintain workplace, machinery and equipment, and use work methods which are without risk to health as it is reasonably practicable; provide the needed/recommended tools for the work;
- 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 to the workers;
- 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;

**Examples of workers duties and rights**

Every worker should comply with the following principles.

- Know about the site 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 on the site;
- Comply with instructions given for their own health and safety, and those of others, and with the site defined 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/risk and which they cannot correct themselves efficiently;
- Report any accident or injury to health which arises in the course of or in connection with the installation of the mini grid connected PV system;

| Self-Check - 1 | Written Test |
|---|---|

**Instruction: Follow the below selected instruction**

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

| N° | Questions and answers |
|---|---|
| **1** | Ensuring that OHS procedures for a given work area are obtained and understood by the workers is of no use |
| 2 | Comply with instructions given for their own health and safety, and those of others, and with the site defined health and safety procedures |
| **3** | Workers should avoid reporting to their immediate supervisor any situation which they have reason to believe could present a hazard/risk |
| 4 | WHO means occupational health and safety. It is the science of the anticipation, recognition, evaluation and control of hazards |

**Note: the satisfactory rating is as followed**

| | |
|---|---|
| Satisfactory | 2 points |
| Unsatisfactory | Below 2 points |

**Answer Sheet**

Score = _____

Rating: _____

Name

Date

_____

| Information Sheet 2 | Selecting Tools and equipment in line with job order requirements |
|---|---|

## 2.1. Introduction

This chapter gives advice on how to select tools and equipment in line with job order requirements.

## 2.2. Listing of tools and equipment

Table 1 contains a listing of the minimum tools and equipment and protective equipment which could enter into the process of constructing a mini grid connected PV system.

**Table 1 : Equipment and tools listing**

| Equipment | Protective equipment | Tools | Tools |
|---|---|---|---|
| • Solar modules<br>• Solar modules mounting structure<br>• Inverters<br>• Regulators<br>• Batteries<br>• Batteries supports<br>• Cables (PV side and grid side cables)<br>• Junction boxes<br>• Protection units<br>• Utility meter | • Hard hat<br>• Goggles<br>• Earmuffs<br>• Gloves<br>• Safety boots<br>• Body harness<br>• Air mask<br>• Emergency first aid kit<br>• Fire extinguisher<br>• Scaffolding<br>• Guardrail<br>• Other fall protection equipment | • Ladder<br>• Cordless drill<br>• Extension cord<br>• Socket drivers<br>• Drill<br>• Philips driver bits<br>• Chisel<br>• Crimping<br>• Line man's plier<br>• Needle nose plier<br>• Wire cutter<br>• Screwdriver set<br>• Protractors<br>• Watt and Watt-hour meters<br>• Solar shading calculator<br>• Graph paper | • Rope<br>• Ratchet wrench<br>• Electricians chalk line<br>• Tool belt<br>• Tape measure<br>• Hammer<br>• Cable knife<br>• Clamp meter<br>• Spirit level<br>• Calculator<br>• Compass<br>• Digital multimeter<br>• Power quality equalizer<br>• Flashlights<br>• Mirrors |

## 2.3. Selection of the tools and equipment

The strategy for selecting the appropriate tools and equipment is dependent of the task to be accomplished based on the established job order requirement. Following the job order requirement, each worker, before performing a specific task, should think well on the equipment and tools to consider. Therefore, the time to use every equipment and tools should be correctly identified, because any unintentional mistake could lead to huge damage including workers losing their lives.

- The installation planning should tell when and where and even how to perform the installation of modules, cables, inverters, regulators, batteries, junction boxes etc. based on a designed procedure to be followed.
- The correct use of the protective equipment is a must, and therefore, workers should clearly understand the role of each of the protective equipment and know when to wear or use them as well.
- The workers should know the role of the tools and the corresponding time to use them for a particular work. Table 2 summarizes the purpose of some of the above cited tools.

**Table 2: Tools and their purpose of use**

| Tool | Purpose of use |
|---|---|
| Digital multimeter | Testing connections, measuring voltage, needs to be able to measure DC current up to 10 A at least, and be properly fused |
| Screw drivers | Tightening screws and terminals |
| Hydrometer | Measuring battery state of charge |
| 12 V drill and drill bits (if not available use, use a hand drill) | Drilling holes for various purposes |
| Tape measure | Measuring distances and marking wire clip placement |
| Hack saw | Cutting metal frames |
| Wire cutter and stripper | Preparing cables |
| Inclinometer and compass | Fixing the angle of solar modules |

| | |
|---|---|
| Extension cord | Running power from inverters to tools |
| Hammer | Various construction tasks |
| Pliers | Holding bolts and nuts during tightening |

The person in charge of the security and protection of the workers has to recall the role of the protective equipment. In fact, the person should ensure that the correct protective equipment is applied accordingly after investigating the risks before every activity, whereby the workers contribute to balance the work feasibility and efficiency. It must be regarded as a team work, not a sort of individual assignment.

| Self-Check - 2 | Written Test |
|---|---|

**Choose the best option & circle the letter of your choice.**

| N° | Questions and answers |
|---|---|
| **1** | Testing connections, measuring voltage, needs to be able to measure DC current up to 10 A at least, and be properly fused.<br>A. Screw drivers<br>B. Digital multimeter<br>C. Hydrometer<br>D. Tape measure |
| **2** | Measuring distances and marking wire clip placement<br>A. Screw drivers<br>B. Digital multimeter<br>C. Hydrometer<br>D. Tape measure |
| **3** | Measuring battery state of charge<br>A. Screw drivers<br>B. Digital multimeter<br>C. Hydrometer<br>D. Tape measure |
| 4 | Holding bolts and nuts during tightening<br>A. Extension cord<br>B. Pliers<br>C. Hydrometer<br>D. Hammer |

| | |
|---|---|
| Satisfactory | 3 points |
| Unsatisfactory | Below 3 points |

| Information Sheet 3 | Identifying and selecting Personal protective equipment |
|---|---|

### 3.1. Introduction

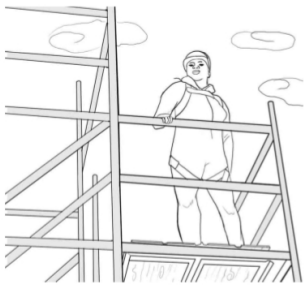
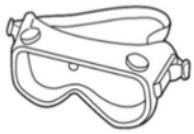
PPE should be primarily selected based on the hazards identified during the assessment. However, employers should also take the fit and comfort of PPE into consideration when selecting appropriate items for each employee. PPE that fits well and is comfortable to wear will encourage employee use of PPE.

### 3.2. Identifying and selecting personal protective equipment

Table3 shows some named personal protective equipment with their corresponding figures plus precision on the time to select and use them.

**Table 3: identifying and selecting personal protective equipment**

| Protective equipment | Example of figure | Selection and usage |
|---|---|---|
| Gloves and safety helmet |  | When working on electrical wires, cables, corrosive structure, wet structure, under the sun, exposed conditions such as load carrying around workers, working at height, low voltage and high voltage conditions etc. |
| Safety harness |  | When working on height (roof, electric poles etc.) |

| | | |
|---|---|---|
| Safety boot |  Safety Boot | All the time on the site |
| Ladder |  | When the need arises to access a rooftop or another heighted location |
| Scaffolding and guardrail |  Scaffolding and guardrail | When performing work on height |
| Safety glasses and air mask | Safety glasses  Air mask  | When the need arises to protect eyes and nose to avoid getting infected. |

### 3.3. Tips on identifying and selecting personal equipment

The following are some guiding tips toward quality identification and selection of personal equipment.

- Precisely identify the work to be done;
- Precisely identify the existing risks;
- Figure out the best solutions to minimize/eliminate the risks, but with the compatible and appropriate protective equipment;
- In case of any doubt ask other workers to confirm the chosen protective equipment before beginning the work; you could as well refer to the site supervisor for confirmation;
- The sequence of the selection of the protective equipment should follow the sequence of the work order requirement;

| Self-Check - 3 | Written Test |
|---|---|

**Choose the best option & circle the letter of your choice.**

| N° | Questions |
|---|---|
| **1** | One of the following is need arises to access a rooftop or another heighted location<br>A. Safety harness<br>B. Safety boot<br>C. Ladder<br>D. safety helmet |
| 2 | When performing work on height<br>A. Safety harness<br>B. Safety boot<br>C. Scaffolding<br>D. safety helmet |
| **3** | In all the cases, safety harness cannot be needed during work at height<br>A. True<br>B. False |
| 4 | When the need arises to protect eyes and nose to avoid getting infected<br>A. Safety glasses<br>B. Air mask<br>C. A and B<br>D. All |

| | |
|---|---|
| Satisfactory | 4 points |
| Unsatisfactory | Below 4 points |

| Information Sheet 4 | Identifying and establishing Health and safety risks control measures and procedures |
|---|---|

## 4.1. Introduction

This chapter presents the tips on how to identify and establish health and safety risks control measures and procedures.

## 4.2. Tips to identify and establish health and safety risks control measures and procedures

The following are some tips to feasibly identify and establish health and safety risks control measures and procedures

- Undertake research and analysis on the site to identify all hazards and risks and find means of overcoming them;
- Undertake analysis on the site to find all the means of overcoming the existing hazards and risks;
- Examine the solutions case after case to retain the best options that could be established or implemented;
- 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;
- 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;
- The proposed risks control measures and procedures should be documented for reference when the need arises;

- The strategies for putting into practice the proposed risks control measures and procedures need to be stated and documented qualitatively for further use;

| Self-Check - 4 | Written Test |
|---|---|

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

| N° | Questions |
|---|---|
| **1** | The workers cannot participate in the identification and establishment of the risks control measures and procedures |
| **2** | The proposed risks control measures and procedures should be undocumented for reference when the need arises. |
| **3** | The planned risks control measures and procedures for a specific work must be implemented as such |
| 4 | Examine the solutions case after case to retain the best options that could be established or implemented |

| | |
|---|---|
| Satisfactory | 4 points |
| Unsatisfactory | Below 4 points |

| Information Sheet 5 | Implementing noted and identified risk control measures |
|---|---|

## 5.1. Introduction

This chapter describes the implementation of noted and identified risk control measures.

## 5.2. Identify control options

A wealth of information exists to help employers investigate options for controlling identified hazards. Before selecting any control options, it is essential to solicit workers' input on their feasibility and effectiveness.

- **How to accomplish it**

Collect, organize, and review information with workers to determine what types of hazards may be present and which workers may be exposed or potentially exposed. Information available in the workplace may include

- ✓ Review sources such as OSHA standards and guidance, industry consensus standards, National Institute for Occupational Safety and Health (NIOSH) publications, manufacturers' literature, and engineering reports to identify potential control measures. Keep current on relevant information from trade or professional associations.
- ✓ Investigate control measures used in other workplaces and determine whether they would be effective at your workplace.
- ✓ Get input from workers who may be able to suggest and evaluate solutions based on their knowledge of the facility, equipment, and work processes.
- ✓ For complex hazards, consult with safety and health experts, including OSHA's On-site Consultation Program

## 5.3. Select controls

Employers should select the controls that are the most feasible, effective, and permanent.

- **How to accomplish it**
  - ✓ Eliminate or control all serious hazards (hazards that are causing or are likely to

cause death or serious physical harm) immediately.

- ✓ Use interim controls while you develop and implement longer-term solutions.
- ✓ Select controls according to a hierarchy that emphasizes engineering solutions (including elimination or substitution) first, followed by safe work practices, administrative controls, and finally personal protective equipment.

### 5.4. Noting and identifying risk control measures

It is the first responsibility of the person in charge of the site security and safety to always report his noted and identified risk control measures per activity. Once the risk control measures are clearly known they should be implemented in each and every aspect. The strategy to identify the risk control measures is to assess all the risks and then carry out an evaluation of their gravity to further propose the suitable corrective control measures best known to the security and safety specialist. The solutions will variably depend on the site realities and protective equipment availability and accessibility.

### 5.5. Implementing noted and identified control measures

Here it is about putting the written measures into concrete actions. The implementation procedures are to be clearly identified and completely applied. The objective is to minimize the risk and create useful and practical control measures.

| Self-Check - 5 | Written Test |
|---|---|

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

| N° | Questions and answers |
|---|---|
| **1** | The noted and identified risk control measures can be easily implemented if the site has less constraints |
| 2 | For complex hazards, consult with safety and health experts, including OSHA's On-site Consultation Program |
| **3** | There is no need for the supervisor to verify the efficiency of the taken risk control measures before implementing them |
| 4 | Use interim controls while you develop and implement shorter-term solutions. |

| | |
|---|---|
| Satisfactory | 4 points |
| Unsatisfactory | Below 4 points |

**Answer Sheet**

Score = _____

Rating: _____

Name

Date

_____

| Information Sheet 6 | Preparing system Installation sequentially in consultation with others |
|---|---|

## 6.1. Introduction

This chapter provides ideas on the sequential preparation of a mini grid connected PV system in consultation with others.

## 6.2. Sequential mini grid connected PV system installation preparation

The sequential preparation of a mini grid connected PV system installation means to identify and order the steps that are involved towards completion of the installation. Before beginning the installation, the following is recommended:

- Ensure that the safety measures are taken on the site
- Assemble the toolkit for the work, especially the protective equipment
- Proceed to the site preparation
- Test all the solar panels if possible
- Test the batteries efficiency
- Verify the conformity of the control equipment (inverters, charge controller)
- Proceed to the installation of the mini grid connected PV system

## 6.3. Preparing system Installation in consultation with others

Other parties involved in an installation can e.g. be electricity providers. Before starting to install a mini grid connected PV system, it is recommended to make arrangements with the electricity provider for them to set you up as a renewable energy generator. Therefore, consultation from the electricity provider is important to make the installation project legal and justified. Regulations and agreements vary from country to country and from electricity provider to electricity provider, but at the very least the electricity provider will need to install an export meter to your building or site in order to accurately meter how much energy you are providing. They will later also ask for an inspection certificate from a qualified electrician, to confirm that the work has been done to an acceptable standard. Physically, installing a mini grid connected PV system is very similar to installing any other solar energy system, except, of course, you do not have any batteries to work with most of the time and there is a connection to the public

electricity grid.

| Self-Check - 6 | Written Test |
|---|---|

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

| N° | Questions and answers |
|---|---|
| **1** | There is need to assemble the toolkit for the work, especially the protective equipment. |
| 2 | Physically, installing a mini grid connected PV system is very similar to installing any other solar energy system |
| **3** | Before starting to install a mini grid connected PV system, it is recommended to make arrangements with the electricity provider |
| 4 | |

| | |
|---|---|
| Satisfactory | 4 points |
| Unsatisfactory | Below 4 points |

| Information Sheet 7 | Determining the nature and location of the work from documentation |
|---|---|

## 7.1. Introduction

Here we enumerate why it is important to determine the nature and location of the work from documentation. The place of work is the location in which a currently employed person performs his or her job, and where a usually employed person performs the primary job used to determine his/her other economic characteristics such as occupation, industry, and status in employment.

## 7.2. Nature of a Job

The nature of an employee's work is best defined as the type of work that he does. This can refer to the basic daily tasks carried out as part of a job and can refer to other non-routine tasks that may be required. Added together, the characteristics of these tasks comprise the nature of an employee's work. The nature of this work may be summed up in the employee's title. For example, a human resources manager is someone who manages a human resources department and performs all of the tasks required of such a position.

## 7.3. Level of Performance

The level of an employee's work refers to the quality of her performance, relative to others with jobs of a similar nature. The level of work is related to the nature of an employee's work because it provides an indication of how well the employee is performing the tasks required for the position. The level of an employee's work may be graded objectively, or perceived in a more subjective manner by your managers.

## 7.4. Complexity of the Job

The complexity of the job performed by employees and the nature of the job are also directly related. Organizations are all structured in different ways, but in nearly all organizations, the more complex work is performed by those at the high end of the food chain. These are the managers and executives responsible for running your organization. The nature of these roles and their work is typically more complex than the work performed by those in entry-level positions.

### 7.5. Performance of the Work

An employee's work can be evaluated in the same way, regardless of the nature of the work performed. Evaluating an employee is done relative to his position within the company. Although you may not necessarily grade an entry-level employee in the same way that you would a manager, in terms of specific tasks, most companies have some type of established rubric by which they grade employee performance.

### 7.6. Tips to determine the nature and location of the work

Documenting found and calculated valuable information is important while preparing the installation of a mini grid connected PV system. Throughout the site visit, system sizing and design, documents are normally produced for reference, in the normal procedure. These documents summarize all the considerations needing to be taken for the work to go on smoothly. They contains details information on the site location, nature of electrical and mechanical diagrams, the total PV system power, components technical specifications, components position and orientation, components distancing, the way to achieve the cabling, the precise work sequencing etc. Therefore, the best way to finding suitable answers for the mini grid connected PV system installation is taking them from the documentation. Obviously, if the previous preparatory work has been completed and well documented then the documentation will exactly tell the workers the nature and the location of the work.

| Self-Check - 7 | Written Test |
|---|---|

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

| N° | Questions and answers |
|---|---|
| **1** | The prepared documentation should only tell the nature of the work, not the location of the job |
| 2 | Level of Performance performed by employees and the nature of the job are also directly related. |
| **3** | The prepared documentation should not tell the nature of the work, but should state the site location |
| 4 | A human resources manager is someone who manages a human resources department and performs all of the tasks required of such a position. |

| | |
|---|---|
| Satisfactory | 4 points |
| Unsatisfactory | Below 4 points |

| Information Sheet 8 | Planning system components location |
|---|---|

## 8.1. Introduction

This chapter gives some tips on how to plan a mini grid connected PV system components location.

## 8.2. Tips on planning system components location

Table 4 contains some equipment that enter into the construction of a mini grid connected PV system alongside some tips to plan the components location.

**Table 4: Components and tips on planning their location**

| Component | Tips on planning the location |
|---|---|
| Solar modules | Chose the location depending on the results of the simulated system performance which should have revealed the suited geographical location of the solar modules. It should be done scientifically, not based on mere assumptions. |
| Solar modules mounting structure | To be placed at the same position as the solar modules, but the best orientation and slope angle should be respected |
| Inverters | Follow the manufacturer datasheet and the required distancing (recommended); |
| Regulators | Follow the manufacturer datasheet and the required distancing (recommended); should be mounted close to the solar array and batteries |
| Batteries | Follow the manufacturer manualand the required distancing and safety measurements (recommended); |
| Batteries supports | Follow the battery manufacturer datasheet if the supports are provided by the manufacturer; mounted with batteries |
| Cables (PV side and grid side cables) | According to main components manufacturers datasheets, choose shortest way for shorter cable length; run along walls or edges to keep them |

| | |
|---|---|
| | safe for accidental damage through the user |
| Junction boxes | According to manufacturer datasheet |
| Protection units | According to manufacturer datasheet and experience |
| Utility meter | According to the recommendation of the electricity provider |

| Self-Check - 8 | Written Test |
|---|---|

**Match the components in column A to their respective power plants in column B**

| Questions | |
|---|---|
| **A** | **B** |
| 1. Follow the manufacturer manual and the required distancing and safety measurements | A. Utility meter |
| 2. According to manufacturer datasheet | B. Inverters |
| 3. According to the recommendation of the electricity provider | C. Regulators |
| 4. Follow the manufacturer datasheet and the required distancing | D. Batteries |
| 5. required distancing should be mounted close to the solar array and batteries | E. Junction boxes |

| | |
|---|---|
| Satisfactory | 4 points |
| Unsatisfactory | Below 4 points |

| Information Sheet 9 | Seeking advice from appropriate persons |
|---|---|

## 9.1. Introduction

This chapter shortly provides tips on how to seek advice from appropriate persons.

## 9.2. Eight reasons people seek advice

The financial advisors at Rued Wealth are experts in retirement planning, and people seek our advice for many reasons. In fact, I have actually seen people seek and benefit from expert advice for all the reasons

### a. To Reduce Complexity

It is human nature to procrastinate on tasks that make us uncomfortable. Everyone has their thing that, “they’ll get around to eventually” and for some that’s planning for retirement

### b. To Save Time

Do you want to spend your time in retirement learning everything there is to know about retirement planning or do you want to focus on the things you love and retired for? Whether that’s extra time with friends and family, picking up old hobbies, or volunteering at your favourite charity, time saved managing your finances is time spent on things you enjoy.

### c. To Offload Unpleasantness

Dealing with personal finance issues can be unpleasant for people. It can be stressful, overwhelming, time consuming, and hard to talk about with your significant other. Sometimes it’s easier to have someone else work through difficult financial issues and complete the follow-up tasks related to the retirement planning process

### d. To Increase Their Confidence

I may be capable of changing my own oil or doing my own taxes, but I feel more comfortable and confident that a place that specializes in that service will do it right. Retirement is supposed to be enjoyable and if you are constantly worrying about your retirement plans, then it may be time to let someone step in and give you that extra

confidence you need to have a stress-free retirement

**e. To Help Make Better Trade-Offs**

Sometimes people are too wrapped up in their own situation to realize all the options they have. An expert advisor can not only provide you with additional trade-offs you may not have considered, they will help you balance those trade-offs to make the right decisions. Having a clear understanding of how decisions will impact their future makes investors more confident in their choices.

**f. To Receive Encouragement**

Sometimes people need words of encouragement to stay on track. This is especially true when life throws you financial curveballs, like an unfavourable stock market. The worst thing a person can do is abandon their plan, because they'll most likely do it at the worst time imaginable. An advisor help you through those tough times. Sometimes all people need is a little perspective on the situation and a little history lesson on what to expect.

**g. To Feel Safer**

As an advisor, I see first-hand the sense of safety people experience by having someone taking care of them and always watching over their plan. They worry considerably less about every little bounce in their investment portfolio and whether their financial goals will be impacted.

**h. Choosing Your Advisor**

I personally seek advice from a professional unless I feel 100% percent certain I know what I'm doing. Though I may think I am capable of doing certain things myself, my experience in financial planning has taught me it's very hard for people to spot issues if they don't know they exist in the first place!

### 9.3. Tips on seeking advice from appropriate persons

One thing is to seek advice, another thing is to seek advice from the right or appropriate persons. The appropriate person means the eligible personwhom you can refer to in case of doubt or in need for clarifications.

Regarding the installation of any mini grid connected PV system it is essential to ask

advice from the following appropriate persons:

- An expert in grid connected PV system installation who has conducted such installations in the past;
- A qualified engineer with years of experience with both standalone and grid connected PV systems;
- A qualified technician with years of experience with standalone and grid connected PV systems;

Moreover, the site supervisor could as well seek advice from his direct superiors; the workers are also recommended to seek advice from the supervisor. Above all, requests should be formulated as clear as possible to enable the expert to understand and address it concisely.

| Self-Check - 9 | Written Test |
|---|---|

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

| N° | Questions |
|---|---|
| **1** | An expert in grid connected PV system installation can be consulted for advice regarding issues on the installation of a mini grid connected system, but only in summer |
| 2 | Reduce Complexity is extra time with friends and family, picking up old hobbies, or volunteering at your favourite charity |
| **3** | A qualified engineer of years of experience in the field is eligible to providing advice for correct installation of a mini grid connected PV system |
| 4 | The financial advisors at Rued Wealth are experts in retirement planning, and people seek our advice for many reasons. |

| | |
|---|---|
| Satisfactory | 3 points |
| Unsatisfactory | Below 3 points |

| Information Sheet 10 | Obtaining needed materials for the installation work |
|---|---|

## 10.1. Introduction

The goal of this chapter is to explain the process of obtaining needed materials for the installation of a mini grid connected PV system. The materials that are required for solar panel installation are: roof anchors that are made up of aluminium or steel; a unique key lock system between the roof anchors and the mounting frame; mounting frame; bolts are used to screw it tightly; you will also need a clamp to fix the solar panels to the mounting frame.

## 10.2. What are the materials needed for solar panel installation?

Energy resources are depleting at a very fast pace, and so we should make use of alternative sources of energy to prevent the exhaustion of energy resources. Solar energy can be converted to electrical energy through photovoltaic cells. Solar panels can be installed in different ways depending upon the needs of the users

**Figure 1: Solar panels can be installed**

Solar panels are installed on roofs. Solar panels can be installed easily by the home owner or one can also call a professional to install the solar panels. The materials that are required for solar panel installation are: roof anchors that are made up of aluminium or steel; a unique key lock system between the roof anchors and the mounting frame; mounting frame; bolts are used to screw it tightly; you will also need a clamp to fix the solar panels to the mounting frame; solar panels.

### 10.3. Obtaining needed materials for the installation work

Once the needed materials (tools, equipment etc.) are known it is time to get them from the local or international market. Obtaining the materials means contacting the sellers or directly the manufacturers. Here we provide some reputable brand names; therefore the list is non-exhaustive.

### 10.4. Reputable brand names

Most solar manufacturers are not household names, and as such it is difficult for someone outside the industry to know which brands have the best reputation. Of course, here is provided a subjective list of brand names, simply because if a manufacturer does not appear on this list, it does not mean the brand or the product is not good.

- **Solar panel manufacturers and brands**

Poly-Crystalline Silicon Solar Panel 72CELL 310~330W

**Features:**

- ✓ Excellent module efficiency up to 17%
- ✓ Positive power tolerance of 0-3% improve system performance
- ✓ Salt mist and ammonia resistance, for seaside and farm environments
- ✓ Excellent performance under weak light condition
- ✓ Up to 10% lower logistic costs due to higher module capacity per container

**Poly-Crystalline**

Atlantis Energy, BP Solar, Canadian Solar, Clear Skies, EPV , Evergreen, Conergy, G.E. Electric, Hanwha Q Cells, Hitachi, ICP, Jinko Solar, Kaneka, Kyocera, LG Solar, Mitsubishi, Power Up, REC Solar, Sanyo, Sharp, Solar World, Spectrolab, Suntech, Trina Solar, Uni-solar.

- **Mono-Crystalline Silicon Solar Panel**

**Features:**

- ✓ Mono high efficiency solar cells made
- ✓ Tighter product performance distribution and current sorting reduces the mismatch power loss in system operation
- ✓ Positive tolerance off
- ✓ Good temperature coefficient enables higher output in high temperature regions
- ✓ Excellent performance under low light conditions

**Mono-Crystalline**

- **Solar controller and inverter manufacturers and brands**

Apollo Solar, Blue Sky, Enphase, Ever Solar, Exeltech, Fronius, Kaco, Magnum, Mastervolt, Morningstar, Outback, Phocos, Power Film, PV Powered, Schneider Electric, SMA, Solectria, Sterling, Steca-Katek, Studer, Victron, Xantrex.

- **Battery manufacturers and brands**

Lead battery manufacturers: BAE Batteries, East Penn, Chloride, Crown, EnerSys,

Exide, Giant, Green Power, Hawker, Hoppecke, Man Batt, New max, Narada, North star, Odyssey, Optima, Panasonic, Power King, Tanya, Trojan, US Battery, Yuasa.

Lithium battery manufacturers: Alpha ESS, Bluenova, BYD, Freedom Won, LG Chem, Pylontech, Samsung SDI, Tesla, Tesvolt

| Self-Check - 10 | Written Test |
|---|---|

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

| N° | Questions and answers |
|---|---|
| **1** | It is recommended to buy all the materials directly from the manufacturers |
| 2 | Solar panels can be installed easily by the home owner or one can also call a professional to install the solar panels. |
| **3** | The brand names listed in this chapter are the only ones to use for the installation of a mini grid connected PV system. |
| 4 | Poly-Crystalline Silicon Solar Panel excellent module efficiency up to 99% |

| | |
|---|---|
| Satisfactory | 4 points |
| Unsatisfactory | Below 4 points |

| Information Sheet 11 | Obtaining tools, equipment and testing devices needed for the installation work |
|---|---|

## 11.1. Introduction

This chapter provides tips on how to obtain tools, equipment and testing devices needed for the installation of a mini grid connected system.

## 11.2. Electrical Power Testers

Electrical Power Testers must be able to withstand both the expected steady-state voltage of the system you are measuring and any transient overvoltage (short duration surges or spikes for instance, those caused by a lightning strike or electrical motor starts and stops).

- **Handheld Meters**

The most widely used instruments are the handheld type, which normally includes clamp-on meters and multimeters. Clampon meters are widely used because of the ease of operation. Multimeters are also extremely popular because they are easy to carry and are capable of performing a wide variety and range of measurements. A large

number of attachments for these units are available, so that they can be used for measuring light levels, temperature, and other variables to further expand their usefulness to electrical personnel.

### 11.3. Tips on obtaining tools, equipment and testing devices

The workers should refer to the site supervisor to have access to the main equipment such as solar modules, solar modules mounting structure, inverters, charge regulators, batteries etc. Usually, the workers, belonging to a specific entity, are supposed to come with their working tools, except some specific tools and testing devices which should be available on site.

**Table 5:The list of some tools, equipment and testing devices is reachable from the precisely.**

| Equipment | Protective equipment | Tools | Tools |
|---|---|---|---|
| • Solar modules<br>• Solar modules mounting structure<br>• Inverters<br>• Regulators<br>• Batteries<br>• Batteries supports<br>• Cables (PV side and grid side cables)<br>• Junction boxes<br>• Protection units | • Hard hat<br>• Goggles<br>• Earmuffs<br>• Gloves<br>• Safety boots<br>• Body harness<br>• Air mask<br>• Emergency first aid kit<br>• Fire extinguisher<br>• Scaffolding<br>• Guardrail<br>• Other fall protection equipment | • Ladder<br>• Cordless drill<br>• Extension cord<br>• Socket drivers<br>• Drill<br>• Philips driver bits<br>• Chisel<br>• Crimping<br>• Line man's plier<br>• Needle nose plier<br>• Wire cutter<br>• Screwdriver set<br>• Protractors<br>• Watt and Watt-hour meters<br>• Solar shading calculator<br>• Graph paper | • Rope<br>• Ratchet wrench<br>• Electricians chalk line<br>• Tool belt<br>• Tape measure<br>• Hammer<br>• Cable knife<br>• Clamp meter<br>• Spirit level<br>• Calculator<br>• Compass<br>• Digital multimeter<br>• Power quality equalizer<br>• Flashlights |

| | | | |
|---|---|---|---|
| • Utility meter | | | • Mirrors |

| **Self-Check - 11** | **Written Test** |
|---|---|

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

| **N°** | **Questions and answers** |
|---|---|
| **1** | It is paramount to obtain the correct tools, equipment and testing devices needed for the installation work |
| 2 | The most widely used instruments are the handheld type, which normally includes clamp-on meters and multimeters. |
| **3** | Before leaving for the work site the workers must make sure they have all the necessary tools and testing devices |
| 4 | Clampon meters are small size used because of the ease of operation. |

| | |
|---|---|
| Satisfactory | 3 points |
| Unsatisfactory | Below 3 points |

| Information Sheet 12 | Checking preparatory work to ensure there is no damage |
|---|---|

## 12.1. Introduction

This chapter provides advice on how to check preparatory work to ensure there is no damage.

## 12.2. Advice on checking preparatory work

In order to limit the extent of damage the following is recommended:

- Make sure to understand OHS procedures for the installation of mini grid connected PV systems;
- Make sure to check if the selected tools and equipment are in line with job order requirements;
- Make sure to check the compatibility of the identified and selected personal protective equipment;
- Make sure to check the correctness of the identified and established health and safety risks control measures and procedures;
- Make sure to check the correctness of the implemented noted and identified risk control measures;
- Make sure to check the prepared system installation sequence in consultation with others;
- Make sure to check that the prepared nature and location of the work is according to documentation;
- Make sure to check that the planned system components location is correct;
- Make sure to check if the appropriate persons were contacted for advice;
- Make sure to check if all the needed materials are correct and accessible for the installation work;
- Make sure to check that the tools, equipment and testing devices are obtained for the installation work;

| Self-Check - 12 | Written Test |
|---|---|

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

| N° | Questions and answers |
|---|---|
| **1** | It is relevant making sure that the needed materials are correct and accessible for the installation work |
| 2 | Make sure to understand WHO procedures for the installation of mini grid connected PV systems; |
| **3** | It is irrelevant making sure of the correctness of the identified and established health and safety risks control measures and procedures |
| 4 | |

| | |
|---|---|
| Satisfactory | 2 points |
| Unsatisfactory | Below 2 points |

| Operation sheet 1 | Practical Demonstration |
|---|---|

**Instructions: Given necessary materials, tools and measuring instruments you are required to perform the following tasks within 3 hours.**

You are taken to a site on which to install a mini grid connected PV system. You are the manager of the installation; therefore in charge of evaluating the site and the specifications of the system to be installed.

**Step-1.** Your first task is to put into writing the potential health and safety risks, followed with the applicable risks control measures and procedures.

**Step-2** Describe how you intend to implement the risks control measures and procedures.

**Step-3** Explain the planning of the preparatory work, taking into account of the workers security and protection, the nature of the work from the available documentation, the materials needed for the work and the planning of components locations.

# Solar PV System Installation and Maintenance
# NTQF Level IV
# Learning Guide -16

| | |
|---|---|
| **Unit of Competence** | **Installing, configuring and commissioning mini grid connected PV systems** |
| **Module Title** | **Installing, configuring and commissioning mini grid connected PV systems** |
| **LG Code** | **EIS PIM4 M04 LO2-LG16** |
| **TTLM Code** | **EIS PIM4 TTLM 0920v1** |

# LO2-Install photovoltaic power systems

| **Instruction Sheet** | **Learning Guide-16** |
|---|---|

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

- Following OHS risk control measures and procedures
- Determining the need to test or measure live within established safety procedures
- Checking circuits/machines/plant in isolation where necessary

- Installing system components to comply with technical standards
- Terminating wiring at components and associated requirements
- Discussing and documenting established methods for dealing with unexpected situations
- Dealing unexpected situations
- Undertaking on-going checks of the quality of installed apparatus
- Carrying out system installation efficiently

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:-

- Follow OHS risk control measures and procedures
- Determine the need to test or measure live within established safety procedures
- Check circuits/machines/plant in isolation where necessary
- Install system components to comply with technical standards
- Terminate wiring at components and associated requirements
- Discuss and document established methods for dealing with unexpected situations
- Deal with unexpected situations
- Undertake on-going checks of the quality of installed apparatus
- Carry out system installation efficiently

**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 | Follow OHS risk control measures and procedures |
|---|---|

## 1.1. Introduction

This chapter describes how to follow OHS risk control measures and procedures.

## 1.2. The mains aspects to consider

The following are the main aspects that need serious attention on a mini grid connected PV system installation site. The control measures and procedures guiding these points should be followed and controlled accordingly to eliminate OHS risks.

- Take measures for electrical safety on the site (risk of electric shock)
- Take measures for falling protection on the site (risk for fall from heights)
- Take measures for stairways and ladders on the site
- Take measures for security in using hand and power tools on the site
- Take measures for providing necessary personal protective equipment (PPE)
- Take measures for providing conducive working space for electrical systems
- Take all necessary measures for successful installation of the photovoltaic modules
- Take measures to ensure the batteries are well taken care of and installed as per manufacturer requirement and applicable standards (risk of stored energy)
- Take measures to eliminate heat-related illness

## 1.3. Preventive measures

The correct surveillance of OHS risk control measures and procedure calls for taking appropriate preventive measures to that effect.

- Ensure that only workers who are specifically trained on electrical risks, the characteristics of solar energy system and on how to perform the work actually conduct the work
- Evaluate the hazards of the connection to the power supply system and have the contact details of the power company; contact the power company to turn off the power, if required
- Ensure that the workers do not work alone but at least in pairs. In general, ensure that the number of workers doing a certain task is enough to perform the

task safely

- Instruct workers to avoid broken shingles and to take the necessary measures to dispose of them safely
- Take control measures to avoid the presence of airborne substances
- Provide appropriate lavatories, washing equipment, and eating areas separated from the working areas for all workers
- Provide PPE to protect workers from released chemicals, aerosols and dust (respiratory protection), flying debris (safety helmet) and noise (ear protection)
- Try to organize the work so as to minimize the need for manual handling, such as lifting and carrying operations, in particular of heavy items, or repetitive handling of even lighter items
- When lifting operation are necessary, use vacuum lifting devices, and powered trucks, conveyors, roller balls, etc. for carrying operations.
- Try to re-organize the work process and organization to minimize manual handling.
- Make sure that the emergency intervention team is informed about the risks of flashovers and their control as far as possible
- Make sure to provide detailed information on local solar systems, including their resistance and fire properties to the emergency services in advance
- Do not step on solar modules and assume all surfaces to be potentially slippery
- Put technical measures in place to noise-isolate devices through encapsulation etc. or use noise-dampening materials to ensure to reduce noise
- Ensure that workers who conduct the work are specifically trained on electrical risks and on the specific characteristics of solar energy systems
- Keep the power inverter dry and isolate suitably
- Perform a risk assessment of the work area, including electrical hazards from high voltage power lines. Make sure all workers are aware of the importance to strictly respect the safety distances to high power lines and check that they comply strictly with this.
- Make sure that workers are aware of electric risks of PV systems and that detailed information on these are available. In particular, make sure that workers are informed about the risks of low voltages causing surprise shocks and consequently possible falls.

- Prevent potential hazardous currents by using Ground Fault Circuit Interrupters
- Supply appropriate PPE (eye protectors/face shields, footwear, gloves) and ensure that it is properly maintained and that workers are trained in its use.
- Provide training for workers on how to carry out safe manual handling, including safe techniques for lifting, pushing and pulling
- Ask the building/installation owners to provide the necessary information for the workers operating on the solar system to enable them to perform their work safely.
- Make sure that workers have received proper training and record. In case of missing or unclear information on the system or working procedure, instruct workers to inform their line manager/employer before performing the work, so that these can contact the relevant persons and experts for assistance and provision of the missing information.
- Ensure good communication and teamwork exists among building owner, all workers and site managers.
- Consult and involve workers in the workplace risk assessment as well as in the choice of prevention measures
- Assess workers' workload and the feasibility of the deadlines to be met, and check that the work can be done without generating overtime. In case of too high workloads and too tight deadlines, try to re-plan and re-organize the work in consultation with workers so that workloads and deadlines are acceptable.
- Make sure to take into account the characteristics of all workers' group and adapt working conditions to their specific needs, taking into account gender, age, (migrant) worker's needs for information in their native language, etc.
- Supply all safety information in the different languages of the workers on site as necessary.
- Ensure that the ladder is fixed safely and positioned on a stable, flat surface.

| Self-Check - 1 | Written Test |
|---|---|

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

| N° | Questions |
|---|---|
| **1** | Ensuring good communication and teamwork among all the workers and site supervisor/manager is not important for achieving a successful mini grid PV connected system installation |
| 2 | Ensure that the workers do not work alone but at least in pairs. In general, ensure that the number of workers doing a certain task is enough to perform the task safely. |
| **3** | It is not essential trying to organize the work so as to minimize the need for manual handling, such as lifting and carrying operations, in particular of heavy items, or repetitive handling of even lighter items |
| 4 | Ensure that the ladder is fixed safely and positioned on a not stable, up down surface |

| | |
|---|---|
| Satisfactory | 3 points |
| Unsatisfactory | Below 3 points |

| Information Sheet 2 | Determining the need to test or measure live within established safety procedures |
|---|---|

## 2.1 Introduction

This chapter provides justifications on the need to test or measure live within established safety procedures.

## 2.2 Guide to controlling risks hazards

Here we give some guiding on the control of risks/hazards; the risks/hazards can be harmful to the workers to even take their lives. We report on hazard, pathway of harm, impact and the control recommendation needed to either smooth or correct the situation. The Table 5 concerns the cases of working at heights and working in ceiling spaces.

## 2.3 What areControlMeasures?

- Eliminate the hazard
- Substitute the hazard with a lesser risk
- Isolate the hazard
- Use engineering controls
- Use administrative controls
- Use personal protective equipment

**Table 6: Controlling the hazards linked to working at heights and in ceiling spaces**

| Hazard | Pathway of harm | Impact | Control recommendations |
|---|---|---|---|
| **Working at heights** | • Falling from roof top<br>• Falling from ladder<br>• Falling through ceiling space | • Trauma<br>• Broken bones<br>• Death | **Eliminate:** Install ground mounted solar systems |
| | | | **Engineer:** Install scaffolding around roof top with stair access. Roofer's kit, guard rails. |
| | | | **PPE:** Use fall restraint techniques |
| **Working in ceiling spaces** | • Contact with energised conductors<br>• Exposure to poor air quality such as fiberglass, coal dust, lead dust and other harmful substances<br>• Exposure to loose-fill asbestos<br>• Exposure to extreme heat<br>• Falling, trips<br>• Vermin, snakes, spiders and insects | • Electric shocks, electrocution<br>• Respiratory disease<br>• Cancer<br>• Mesothelioma, asbestosis<br>• Exhaustion, fatigue, heat stress<br>• Trauma, broken bones<br>• Stings, bites and disease<br>• Death<br>• Skin irritation, rash, increased mucus production and watery eyes | **Eliminate:** Install ground mounted solar systems avoiding the need to work in a ceiling space |
| | | | **Isolate:** Turn off all electricity to the property at the main switchboard and take steps to prevent the electricity from being turned back on while work is in progress* |
| | | | **PPE:** Wearing appropriate, well maintained and correctly-fitted personal protective equipment when working in dusty ceiling spaces, including:<br>• a respirator<br>• a head covering and goggles, to avoid eye irritation<br>• long-sleeved, loose-fitting clothing and gloves |

Table 6 concerns the cases of working with and installing electrical equipment, working outdoors, and performing work that involves or likely to involve disturbing asbestos.

**Table 7: Controlling the hazards linked to working with and installing electrical equipment, working outdoors, performing work involving or likely to involve disturbing asbestos**

| Hazard | Pathway of harm | Impact | Control recommendations |
|---|---|---|---|
| **Working with and installing electrical equipment** | • Contact with energised conductors<br>• Accidental short circuit | • Electric Shocks, electrocution<br>• Arc flash, burns<br>• Death | **Isolate:** Lockout Tagout. Test for de-energised (DEAD)<br>Do not work energised |
| | | | **Admin:** Current LVR/CPR training<br>**PPE:** Wear arc rated neck to wrist to ankle clothing with a minimum ATPV of 4cal$^{m2}$.<br>Wear protective glasses and gloves |
| **Working outdoors** | • Exposure to the sun | • Sun burn, skin cancer<br>• Exhaustion, fatigue, heat stress | **Eliminate:** Reorganising work schedules where possible so that outdoor tasks are done before 10 am and after 3 pm |
| | | | **Substitute:** Rotating tasks that involve direct sun exposure<br>Increasing amount of shade available – use gazebos |
| | | | **PPE:** Slip on clothing, slop on SPF 30+ sunscreen, slap on a hat, slide on sunglasses.<br>Drink plenty of water |
| **Work involves, or is likely to involve, disturbing asbestos** | • Inhalation of asbestos fibres | • Mesothelioma, asbestosis or cancer | **Eliminate:** Do not proceed with job until asbestos-containing material removed by licence contractors |
| | | | **Substitute:** Replace asbestos switchboard with new upgraded switchboard. Follow safe working procedures |

The different specifications of Table 5 and Table 6fully justify the need to test or measure live within established safety procedures for a mini grid connected PV system

installation.

## 2.4 Some tips to limit the hazards

- Ensure only fully licensed electricians who have been inducted into an installer's safety program will be undertaking licensed work;
- Participate in the risk assessment of possible hazards at the start of each installation especially when working at heights, working in ceiling spaces and installing and commissioning energy storage (battery) systems;
- For any high-risk activities (e.g. working on or near exposed live parts) use a safe work method statement that has been developed in consultation with the workers and is easily understood and followed.

| **Self-Check - 2** | **Written Test** |
|---|---|

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

| **N°** | **Questions** |
|---|---|
| **1** | Working at heights can only provoke trauma, broken bones and even death during winter |
| 2 | hazard turn off all electricity to the property at the main switch board and take step to prevent the electricity from being turned back on while work is in progress |
| **3** | Working with and installing electrical equipment cannot lead to death |
| | |

| | |
|---|---|
| Satisfactory | 4 points |
| Unsatisfactory | Below 4 points |

| Information Sheet 3 | Checking circuits/machines/plant in isolation where necessary |
|---|---|

### 3.1. Introduction

This chapter gives tips on how to check circuits/machines/plant in isolation where necessary. This section covers the different safety aspects of using machinery and maintaining plant and equipment in the workplace. Employers should consider how their workers use machinery, and have adequate maintenance arrangements in place to ensure it remains safe to use.

### 3.2. Why is machinery safety important?

Moving machinery can cause injuries in many ways:

- People can be struck and injured by moving parts of machinery or ejected material. Parts of the body can also be drawn in or trapped between rollers, belts and pulley drives.
- Sharp edges can cause cuts and severing injuries, sharp-pointed parts can cause stabbing or puncture the skin, and rough surface parts can cause friction or abrasion.
- People can be crushed; both between parts moving together or towards a fixed part of the machine, wall or other object, and two parts moving past one another can cause shearing.
- Parts of the machine, materials and emissions (such as steam or water) can be hot or cold enough to cause burns or scalds, and electricity can cause electrical shock and burns.
- Injuries can also occur due to machinery becoming unreliable and developing faults or when machines are used improperly through inexperience or lack of training.

### 3.3. The basic principle of isolation

- Isolate all forms of potentially hazardous energy to ensure that an accidental release of hazardous energy does not occur;
- Control all other hazards to those doing the work

- Ensure that entry to a restricted area is tightly controlled.

The basic principle is comprised of three separate steps:

a. Lock;
b. Tag; and
c. Try.

The success of the basic principle depends on two key factors:

- thorough training of all workers in isolation procedures;
- The disciplined exercise of individual responsibility in always following the procedures.

### 3.4. Basic isolation procedure

a. Identify the plant involved and the corresponding energy sources.
b. Identify all other hazards.
c. Shut the plant down.
d. De-energise all stored energy sources.
e. Isolate and lock out all energy sources.
f. Tag plant controls, energy sources and other potential hazards.
g. Control other potential hazards.
h. Test by 'trying' to re-activate the plant, without exposing the tester or others to risk, to ensure isolation procedures have been effective, before commencing any maintenance, cleaning, inspection or repairs on the plant.
i. Carry out the work on the plant.
j. Once remedial work is complete, the people who tagged the controls are to remove the tags before the plant is returned to operational status

### 3.5. Tips for necessary checks

The following tips are helpful in comforting the checking of circuits/machines/plant in isolation where necessary.

- The workers should organize themselves in few groups to completely inspect the plant ;
- Make time to inspect the plant to note all the isolated parts;
- Make the necessary adjustment regarding the isolation recommendations;

- Check and re-check each and every circuits to confirm if it should be isolated or not according to design and planning ;
- Take all the necessary measures to correct circuits structures as planned ;
- Conduct a control on all the machines used for the work to see if they are isolated or not, therefore take corrective and appropriate measures;
- The checking must be done while constantly referring to the mini grid connected PV system last updated electrical diagram ;
- Wear the applicable protective equipment during the checking, and ensure of taken the required security measures ;

| Self-Check - 3 | Written Test |
|---|---|

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

| N° | Questions and answers |
|---|---|
| **1** | One of the following isthe basic principle of comprised<br>A. Lock C. Try<br>B. Tag D. All |
| 2 | Which One of the following is not basic isolation procedure?<br>A. Control all other hazards to those doing the work<br>B. Identify the plant involved and the corresponding energy sources<br>C. Identify all other hazards<br>D. Isolate and lock out all energy sources |
| **3** | Isolate all forms of potentially hazardous energy to ensure that an accidental release of hazardous energy it is occur;<br>A. True<br>B. False |
| 4 | The checking of circuits/machines/plant must be done while constantly referring to the mini grid connected PV system last updated electrical and mechanical diagrams.<br>C. True<br>D. False |

| | |
|---|---|
| Satisfactory | 3 points |
| Unsatisfactory | Below 3 points |

| Information Sheet 4 | Installing system components to comply with technical standards |
|---|---|

## 4.1. Introduction

This chapter describes how to install system components to comply with technical standards.

## 4.2. Types of mini grid connected PV systems

Figure 1 shows a typical grid-direct PV system where the following components can be seen: solar modules forming the solar array, the junction box, DC disconnect, inverter, AC disconnect, main load centre (MDP), and the utility meter.

- **Solar cell array**: Consists of two or more solar cell modules formed by encapsulating solar cells. At present, single crystalline or polycrystalline silicon solar cells are used, which are made of waterproof glass on the front contact and soft material on the back contact
- An electrical **junction box** is an enclosure housing electrical connections, to protect the connections and provide a safety barrier.
- **DC disconnects** are switches that complete or interrupt a flow of DC electricity. In a solar PV system, the DC disconnect is placed between the solar panel array and the power inverter so it can easily be thrown if you (or the fire department) need to shut off solar power to the house.
- An **AC disconnect** is also known as an air conditioner switch box or fuse box. It contains the controls for the main energy supplier of the air conditioner, like the breakers and fuses. It also protects the wires of the air conditioner from weather and other outdoor elements
- **Inverter** is a power electronic device or circuitry that changes direct current(DC) to alternating current(AC).
  - ✓ The input voltage, output voltage and frequency, and overall power handling depend on the design of the specific device or circuitry. The inverter does not produce any power; the power is provided by the DC source.

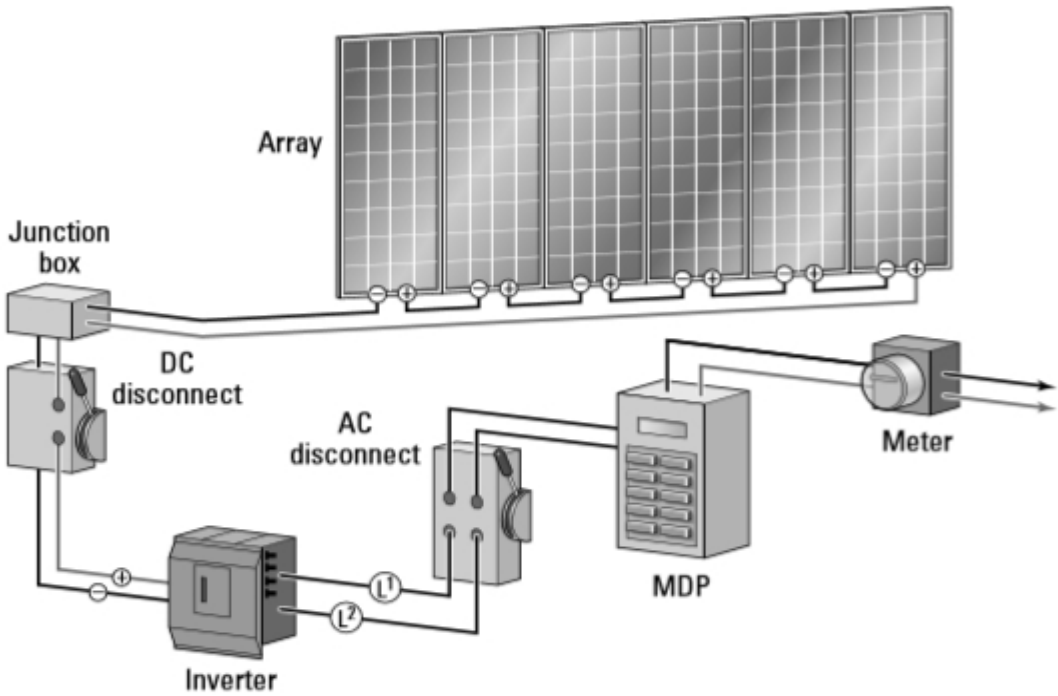



**Figure 2: Typical grid-direct PV system**

Figure 2 shows a utility interactive battery-based PV system where the following components can be seen: solar modules forming the solar array, the charge controller, the battery bank, inverter, an isolated subpanel, main load centre (MDP), and the utility meter; with the presence of the grid.

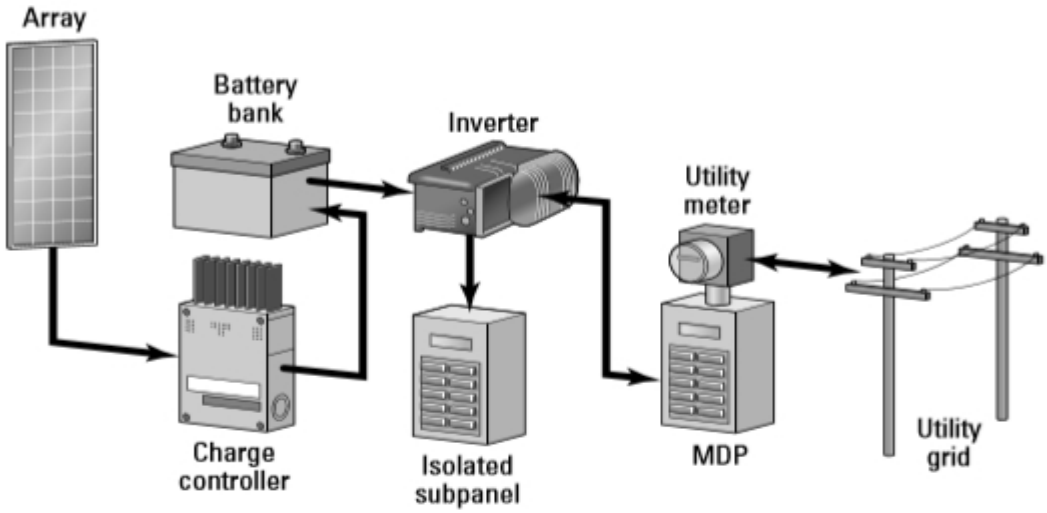



**Figure 3: Utility interactive battery-based PV system**

Depending on the type of mini grid to install other equipment could be requested, but basically the above figures show the two systems that exist, with and without battery-backup.

### 4.3. Cabling solar modules according to standards

Here we depict the recommended manners to cable solar modules. Figure 3 shows the wiring of five PV modules in series. Solar panels in series connection are called a string. This is the most common and most efficient way for smaller PV systems. The pre-assembled cables and plugs are used to interconnect the modules. The voltage range of the inverter determines how many modules can be connected in series.

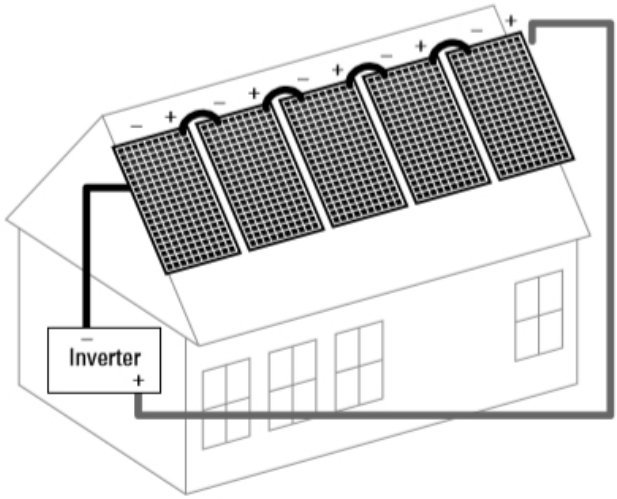



**Figure 4: Five modules wired in series**

Figure 4 shows the case of five PV modules wired in parallel. This way of wiring requires the use of Y-plugs to connect the PV modules which makes it slightly more expensive than wiring in series. Nevertheless, especially in off-grid systems it is sometimes necessary to choose parallel wiring because of a limited voltage range of the inverter or charge controller.

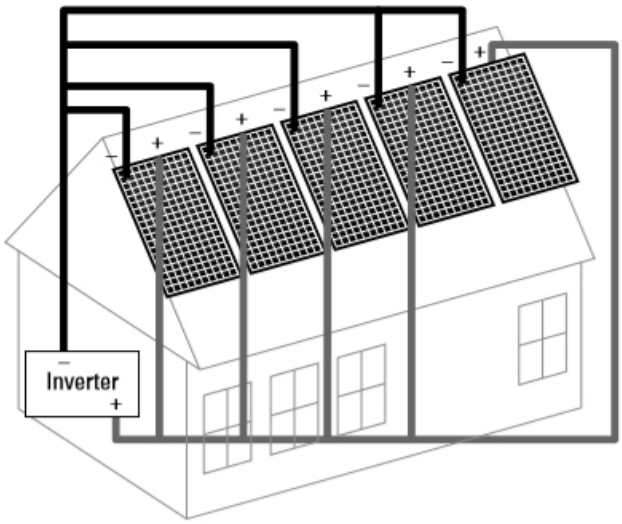



**Figure 5: Five PV modules wired in parallel**

Figure 5 shows the last case of PV modules wired in a series-parallel configuration. This is the most flexible way of wiring. Usually, the number of modules in a string (in series connection) is selected first based on the charge controller or inverter capacity and then more strings are connected in parallel until the required number of modules is reached. It is recommended to always use the same number of modules in parallel strings.

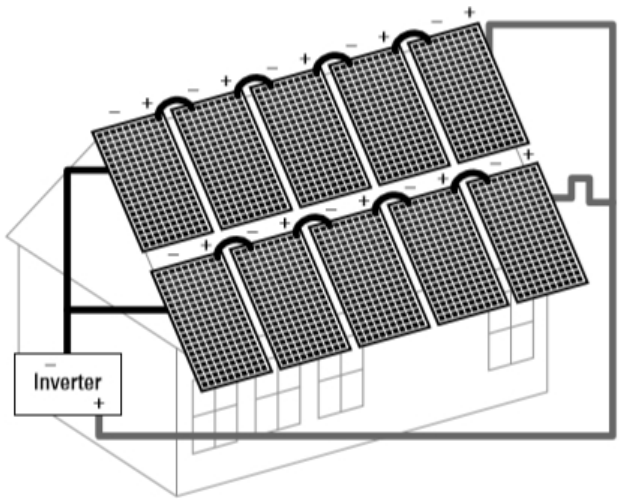



**Figure 6: PV modules wired in a series-parallel configuration**

Engaging the stage of the installation means that all the preparation work is done accordingly (obtaining the permit, correct sizing of conductors and equipment, correct safety measures, correct design). Therefore, the system should be installed considering all the electrical and mechanical specifications.

## 4.4. Tips to install the system components to comply with technical standards

After installing the mechanical structure, it is time to begin the installation of the electrical elements. Installing the electrical elements is about:

- Placing electrical equipment in the right spots according the plan
- Wiring the equipment together at the requested sequence
- Examining the grounding structure for security purpose (based on the best grounding options)
- Connecting the PV system to the near grid (comply with the utility technical standards; ensure that electricity meter is working properly)
- Performing the commissioning and required registrations
- After the installation the inspection and maintenance will follow

Figure 6 shows an example of system-grounding options for utility-interactive PV systems.

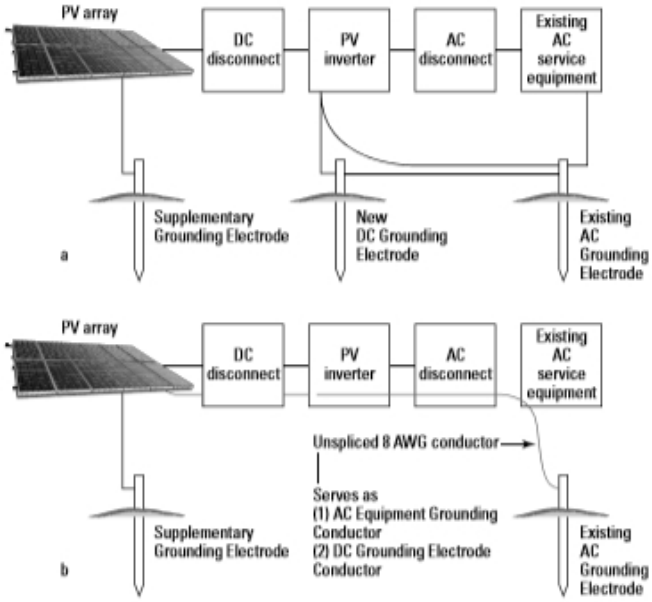



**Figure 7: System-grounding options for utility-interactive PV systems**

The DC and AC disconnects locations should be well implemented to allow for disconnecting either the PV array or the utility power. Figure 7 depicts an example of a grid connected PV system configuration including DC and AC disconnects.

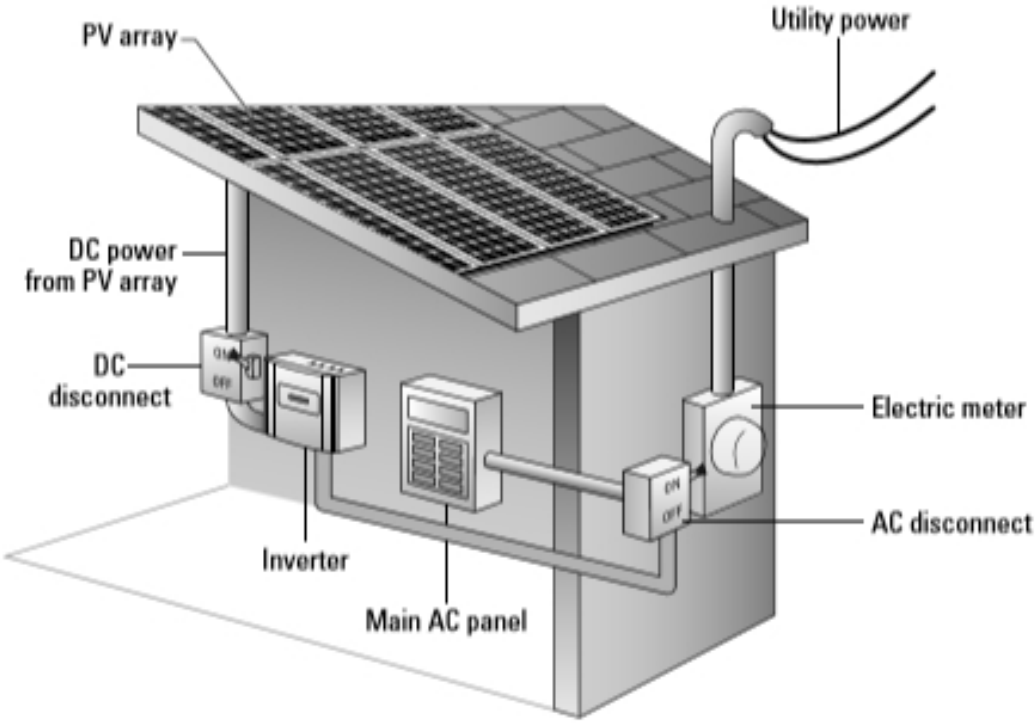



**Figure 8: Typical utility-required disconnect location**

A sample of system commissioning form is shown in Figure 8.

**General Information**

Site address _____
Your name _____
Date _____
Time _____
Currently producing (Watts) _____ (total from all inverters)
System peak Watts _____ (STC rating)
Inverter manufacturer _____
Inverter model number _____
Inverter serial number _____
Currently producing (Watts) _____
Utility meter number _____
Module manufacturer _____
Module model number _____
Actual grid voltage (Measured at point of interconnection) L1-L2: _____ L1-N: _____ L2-N: _____

**Array Information**

| | Array A | Array B | Total |
|---|---|---|---|
| Array true bearing/azimuth (degrees) | | | — |
| Array tilt (degrees) | | | — |
| Inverter quantity | | | |
| Module quantity | | | |

**Component Numbers and Inverter Production**

Performance Verification — Back of module temp: _____ Solar irradiance: _____ (in module plane)
Measure temp & irradiance at the same time as reading inverter outputs

| | Location and quantity | Model number |
|---|---|---|
| AC disconnect | | |
| DC disconnect | | |

**Inverter 1 PV String Measurements**

| | Number of modules | $V_{oc}$ | $I_{mp}$ |
|---|---|---|---|
| String 1 | | | |
| String 2 | | | |
| String 3 | | | |
| Continue on additional sheet if necessary | | | |

**Inverter 2 PV String Measurements**

| | Number of modules | $V_{oc}$ | $I_{mp}$ |
|---|---|---|---|
| String 1 | | | |
| String 2 | | | |
| String 3 | | | |
| Continue on additional sheet if necessary | | | |

Notes:

**Figure 9: Sample of system commissioning form**

## 4.5. Conclusion

The workers should have clear knowledge and understanding of the technical standards and abide by them while following the planned installation scenarios.

| Self-Check - 4 | Written Test |
|---|---|

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

| N° | Questions | |
|---|---|---|
| | A | B |
| | 1. At present, single crystalline or polycrystalline silicon solar cells are used | A. AC disconnect |
| | 2. protect the connections and provide a safety barrier | B. Inverter |
| | 3. power electronic device or circuitry that changes direct current to AC | C. junction box |
| | 4. It contains the controls for the main energy supplier of the air conditioner. | D. DC disconnects |
| | 5. placed between the solar panel array and the power inverter | E. Solar cell array |

| | |
|---|---|
| Satisfactory | 4 points |
| Unsatisfactory | Below 4 points |

| Information Sheet 5 | Terminating wiring at components and associated requirements |
|---|---|

## 5.1 Introduction

This chapter provides tips on how to terminate wiring at components and the associated requirements.

## 5.2 Safety Considerations

Terminated, capped electrical wires should never be buried behind drywall, whether loose or in an electrical box. The leading edge of the electrical box must be flush with the drywall

**Safety martial**

**Table: 8 Equipment / Tools Materials**

| Equipment / Tools | Materials |
|---|---|
| Wire stripper<br>Non-contact voltage tester<br>Flat-head screwdriver<br>Utility knife | Electrical box<br>Electrical tape<br>Wire nuts (wire caps)<br>Blank wall plate for the box |

## 5.3 Instructions

- **Shut off the power:** to the electrical circuit by switching off the appropriate circuit breaker in your home's electric service panel or circuit breaker box. For added safely, run a strip of electrical tape across each circuit breaker switch involved with this project to prevent anyone, even you, from accidentally flipping on the circuit breaker.

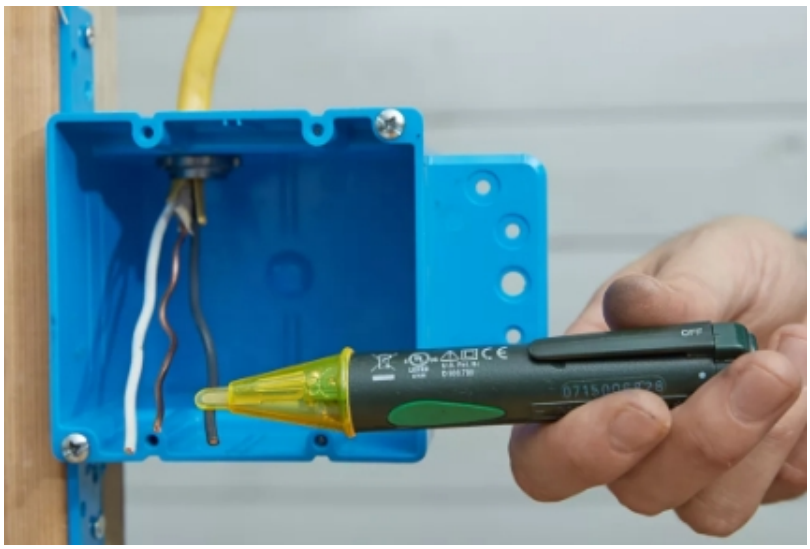


**Figure 10: Shut off the power**

- Prepare the Bare Ends of the Wires: with the electrical wire stripper, cut off any bare ends of wire down to the wire coating to tidy them up. Strip the plastic coating off the ends of the wires. Make sure that you have about 1/2-inch of clean, straight wire at the end.

**Figure 11: Prepare the Bare Ends of the Wires**

- Place Wire Nuts on the Wires: turn the plastic wire nuts (also called wire caps) onto the ends of the wires. Use the appropriate size of wire nut for the wire. Wire nuts

that are too big will not sufficiently grip the wire and will fall off. Wire nuts that are too small may initially feel like they are on the wire, but they, too, may fall off. Turn the wire nut clockwise.

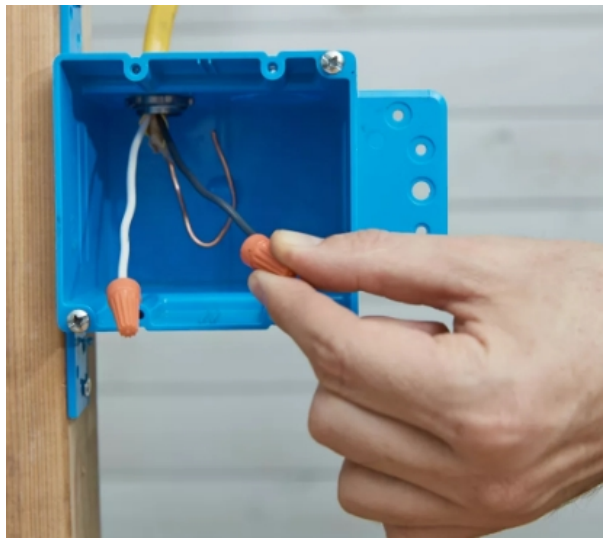


**Figure 12: Place Wire Nuts on the Wires**

- Push the Wires into the Box: Push the wires back into the box. Check to make sure that your assembly has not come apart before proceeding to the next step. Any exposed copper wire may cause an electrical short or fire

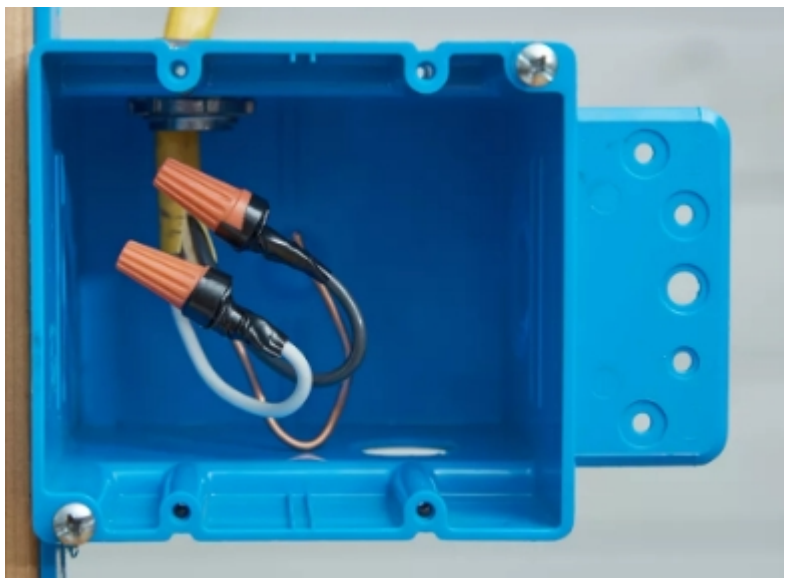


**Figure 13: Push the Wires into the Box**

## 5.4 Tips to terminate wiring at components

The following are recommendations on how to proceed for terminating wiring at components.

- The components inputs and outputs should be clearly identified with wires having specific colours for conformity purpose;
- Make sure to use uniform colours for the wires of the same category to ease the installation procedure and further identification during the occasional maintenance;
- Make sure wires phases and neutrals are not misplaced;
- Make sure to correctly plug the wires at the requested corresponding inputs and outputs;
- Proceed continuity tests to ensure that the wires are responding and conducting efficiently;
- While connecting the grid make sure to take all the necessary protective measures to avoid electrocution; the utility distribution line could be cut off for the time to implement the connection;
- After the wiring is finished take time to re-check the whole wiring structure to enable finding mistakes that could have been made;

### 5.5 Associated requirements

The associated requirements are mainly the application of the health and safety measures. It concerns the wearing of personal protective equipment and the use of appropriate working tools to perform the work. The rule is to not take any risk, therefore addressing the installation in respect of the prescribed procedures. The prescribed procedures include the respect of the local codes and standards conditioned by the utility provider.

| Self-Check - 5 | Written Test |
|---|---|

**Choose the best option & circle the letter of your choice.**

| N° | Questions and answers |
|---|---|
| 1 | Strip the plastic coating off the ends of the wires. Make sure that you have about 1/2-inch of clean, straight wire at the end.<br>A. Push the Wires into the Box<br>B. Place Wire Nuts on the Wires<br>C. Prepare the Bare Ends of the Wires<br>D. Shut off the power |
| 2 | Check to make sure that your assembly has not come apart before proceeding to the next step.<br>A. Push the Wires into the Box<br>B. Place Wire Nuts on the Wires<br>C. Prepare the Bare Ends of the Wires<br>D. Shut off the power |
| 3 | For added safely, run a strip of electrical tape across each circuit breaker switch involved with this project to prevent anyone, even you, from accidentally flipping on the circuit breaker<br>A. Push the Wires into the Box<br>B. Place Wire Nuts on the Wires<br>C. Prepare the Bare Ends of the Wires<br>D. Shut off the power |
| 4 | After the wiring is finished there is no need taking time to re-check the whole wiring configuration for enabling finding mistakes that could have been made<br>A. True<br>B. False |

| | |
|---|---|
| Satisfactory | 3 points |
| Unsatisfactory | Below 3 points |

| Information Sheet 6 | Discussing and documenting established methods for dealing with unexpected situations |
|---|---|

## 6.1. Introduction

This chapter is about discussing and documenting established methods for dealing with unexpected situations. Documentation is any communicable material that is used to describe, explain or instruct regarding some attributes of an object, system or procedure, such as its parts, assembly, installation, maintenance and use. Documentation can be provided on paper, online, or on digital or analogue media, such as audio tape or CDs. Examples are user guides, white papers, online help, and quick-reference guides. Paper or hard-copy documentation has become less common. Documentation is often distributed via websites, software products, and other online applications.

## 6.2. Tips to identify methods for dealing with unexpected situations

The unexpected situations on a mini grid connected PV system installation site usually depend on many elements that are difficult to predict. Thus, the random nature of unexpected situations on such 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. In other words, it is not advisable to rely on mere methods that are made for situations that could be far in context from the case at hand. The following are tips to rely on to find methods 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;

### 6.3. Discussing and documenting the established methods

Based on experience the different methods used to solve the unexpected situations should be documented each time possible. It means the supervisor and the workers should always cooperate so that the used methods are discussed and documented. Therefore, the noted methods could be used while facing similar scenarios in the future.

| Self-Check - 6 | Written Test |
|---|---|

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

| N° | Questions and answers |
|---|---|
| **1** | Every situation should be thoroughly examined before applying the most suitable solution |
| 2 | In fact, stating some to be selected methods to deal with unexpected scenarios seems inaccurate and incorrect. |
| **3** | It is a bad idea to solve the situations/problems with the help and cooperation from the workers |
| 4 | Discussing is any communicable material that is used to describe. |

| | |
|---|---|
| Satisfactory | 3 points |
| Unsatisfactory | Below 3 points |

| Information Sheet 7 | Dealing unexpected situations |
|---|---|

## 7.1. Introduction

This chapter recalls the tips needed for dealing with unexpected situations.

## 7.2. How to handle unexpected situations gracefully?

- Keep Calm and Patience. It is the most essential and beneficial attitude you could keep when you face any unexpected situation in life
- Develop acceptance in you. Life is full of surprises where not everything can go as you want to
- Try to make wise strategies
- Control over yourself
- Be optimistic and positive

**Tips for dealing with unexpected situations**

- One should evaluate the gravity of the unexpected situation based on experience;
- One should inform his or her immediate boss about the situation if he or she cannot face and solve it with his or her experience;
- One should solve the situations with the help and cooperation from the workers if applicable; later inform your immediate boss about that if it is relevant;
- One should take all necessary notes towards solving an issue that cannot be handled immediately (meaning issues that ask for more days);
- One should always face the situations 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;
- One should think of scientific ways of solving encountered problems;
- One should ask cooperation from others that are not immediately involve in the site ongoing activities, it could be experts in the field;

| Self-Check - 7 | Written Test |
|---|---|

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

| N° | Questions and answers |
|---|---|
| **1** | One should think of the best scientific ways of solving encountered problems on mini grid connected PV system installation site |
| 2 | One of handling unexpected situations gracefully is try to make wise strategies. |
| **3** | One should take all necessary notes towards solving an issue that cannot be handled immediately |

| | |
|---|---|
| Satisfactory | 2 points |
| Unsatisfactory | Below 2 points |

| Information Sheet 8 | Undertaking on going checks of the quality of installed apparatus |
|---|---|

## 8.1. Introduction

This chapter provides tips on checking the quality of the installed apparatus.

## 8.2. Tips to check the quality of installed apparatus

Before the beginning of the installation there is need to perform the following:

- Check the conformity of the apparatus brand names and different specifications;
- Make necessary measurements on each apparatus to appreciate the different specifications;
- In case some apparatuses do not comply with their datasheets one should request immediate replacement;

During the installation there is need to perform the following:

- Make sure the distancing among the apparatuses is respected as recommended;
- Check the behavior of the different apparatus and make all necessary observations;
- Make sure the apparatus is wired and taken care of the way the manufacturer designed and configured it;

At the end of the installation there is need to perform the following:

- Check each apparatus out of functioning to see if the wiring is done properly;
- Check each apparatus under functioning to see if it is working properly;
- Make all necessary tests regarding the configuration of the applicable apparatus;
- Make sure all the elements to be observed are within the manufacturers and local codes and standards norms;

| Self-Check - 8 | Written Test |
|---|---|

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

| N° | Questions |
|---|---|
| **1** | The checking of the conformity of apparatus brand names and different specifications is irrelevant |
| 2 | During the installation there is need make all necessary tests regarding the configuration of the applicable apparatus |
| **3** | Should make sure each apparatus is wired and taken care of the way the manufacturer designed and programmed it |

| | |
|---|---|
| Satisfactory | 2points |
| Unsatisfactory | Below 2 points |

| Information Sheet 9 | Caring out system installation efficiently |
|---|---|

## 9.1. Introduction

This chapter describes how to carry out system installation efficiently.

## 9.2. Examples of good practices

Figure 9 shows acceptable edge protection. HSE inspectors would expect to see this standard of protection during solar panel installation on the roof.

**Figure 14: Acceptable edge protection**

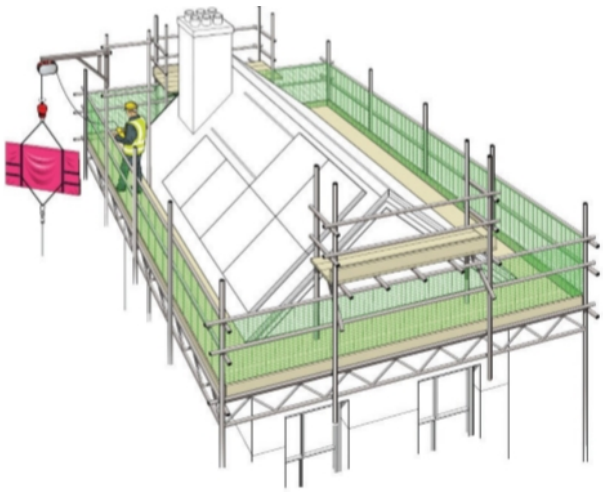


**Figure 15 : Fall protection around all edges of the roof of a domestic property during mini grid connected PV system installation**

The system in Figure 10 provides fall protection around all edges of the roof of a domestic property. It would be an appropriate solution where panels are being fitted to

both roof pitches and to within 2 m of the gable ends. A powered hoist to lift panels to roof level is shown, but a manually operated pulley would also be acceptable. (Some scaffolding components have been omitted on the figure for clarity.) The alternative system in Figure 11 provides guard-rails and toe-boards at the gable ends. This would provide sufficient fall protection around the working area when panels are being fitted to a single roof pitch. (Some scaffolding components have been omitted for clarity.)

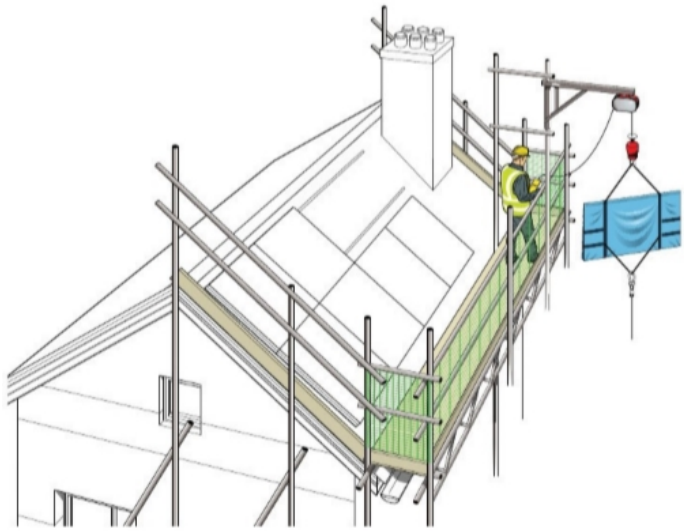


**Figure 16: alternative system with guard-rails and toe-boards**

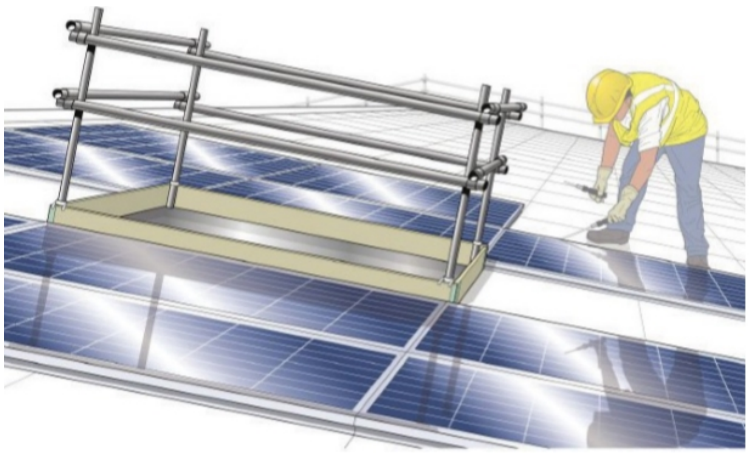


**Figure 17: PV panels being fitted to the roof of commercial premises**

The illustration in Figure 12 shows PV modules being fitted to the roof of commercial premises. The roof contains flush-fit roof lights of fragile material, while the rest of the roof surface is non-fragile and known to be capable of bearing the weight of solar panels and workers. In this example, temporary edge protection, made from scaffolding components, has been fitted around the roof lights for the duration of the work. (Some scaffolding components and roof lights have been omitted for clarity.)

### 9.3. Tips for efficient installation of mini grid connected PV systems

The following are some valuable tips for correct installation of mini grid connected PV systems.

- Take all legal measures with the utility service provider;
- Use the appropriate tools for the work; always work at least in pair;
- Employ the applicable protective and security measures;
- Make sure of the quality and quantity of the different equipment for the work;
- Perform correct equipment wiring and positioning according to the design and planning;
- Make necessary checking after wiring the equipment;
- Especially, ensure that the utility meter works correctly and the voltages currents and other specifications are within the specified ranges;
- Make the required tests to confirm proper functioning;
- Throughout the installation make noted observations;
- Proceed to quality commissioning and related registrations;

### 9.4. Overview of the installations

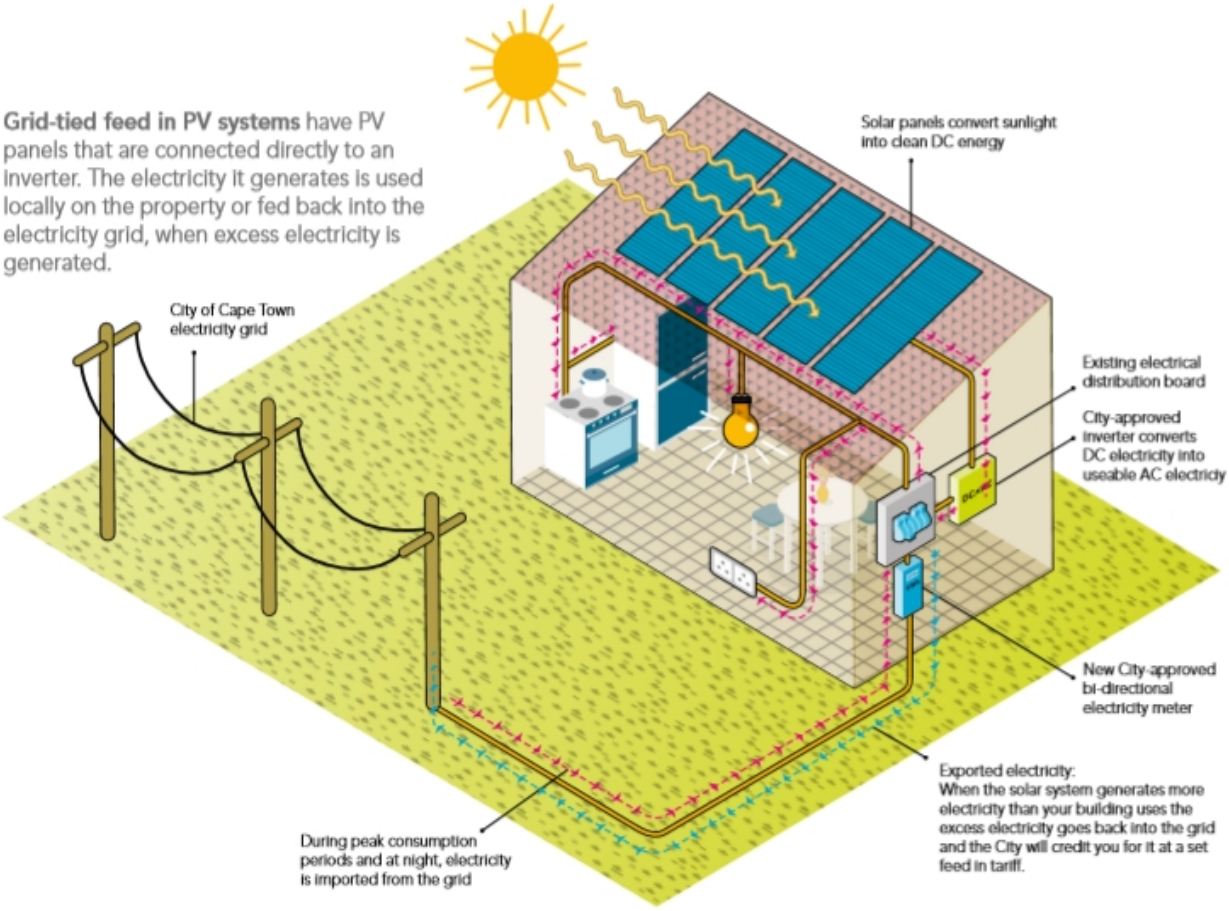



**Figure 18: Grid-tied feed in PV system(www.capetown.gov.za)**

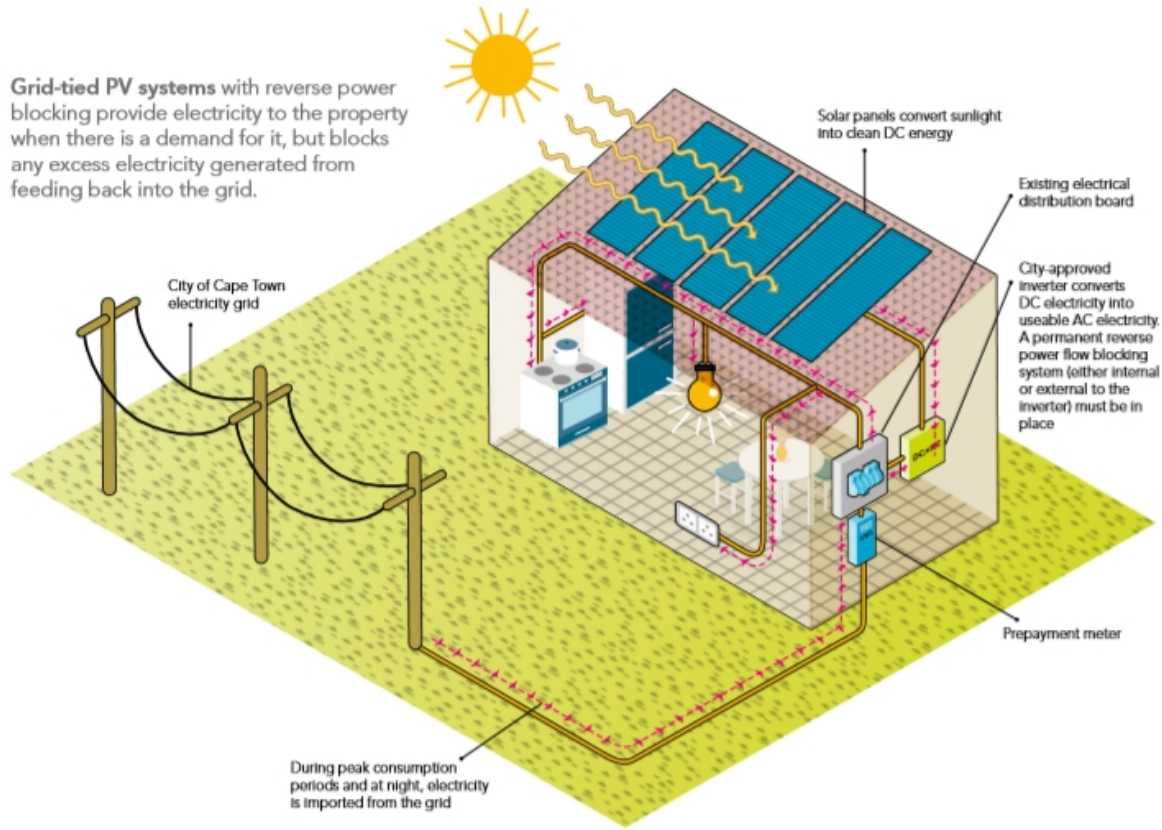


**Figure 19: Grid-tied PV system with reverse power blocking (www.capetown.gov.za)**

Figure 13 shows a grid-tied feed in PV system, whereas Figure 14 depicts a grid-tied PV system with reverse power blocking. The working principle is explained on each figure.

| Self-Check - 9 | Written Test |
|---|---|

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

| N° | Questions and answers |
|---|---|
| **1** | A mini grid connected PV system can be either grid-tied feed in or with reverse power blocking |
| 2. | The roof surface is non-fragile and known to be capable of bearing the weight of solar panels and workers. |
| **3** | Contacting the utility service provider is not a determinant step in the process of installing a mini grid connected PV system |
| 4 | For correct installation of mini grid connected PV systems aremake necessary checking after wiring the equipment. |

| | |
|---|---|
| Satisfactory | 3 points |
| Unsatisfactory | Below 3 points |

| Operation sheet -1 | Install Solar PV system configuration |
|---|---|

Laboratory equipment contains the following elements

Step -1 Four PV 05v/1.0/0.5w with 4mm bushings

Step- 2 Two measuring devices (universal measuring instrument with rechargeable 9v- battery

Step- 3 One luxmeter with a rechargeable 9 V,

Step- 4 Battery charger for charging 9 V - batteries,

Step- 5 Set of resistors on the aluminum holder (7 resistors /1 diode),

Step- 6 Halogen source of radiation 200 W (with a spare halogen bulb)

- Two measuring devices (universal measuring instrument with a rechargeable 9 V - battery),

Step- 7 Conductors for measuring:

- Set of resistors on the aluminum holder (7 resistors /1 diode),
- Halogen source of radiation 200 W (with a spare halogen bulb),
- Conductors for measuring:
  - ✓ 2 x red conductor of 100 cm length,
  - ✓ 2 x blue conductor of 100 cm length,
  - ✓ 3 x red conductor of 50 cm length,
  - ✓ 3 x blue conductor of 50 cm length,
- Measuring pole, and
- Hood to cover the PV cells


- Set of resistors on the aluminum holder (7 resistors /1 diode),
- Halogen source of radiation 200 W (with a spare halogen bulb),
- Conductors for measuring:
  - ✓ 2 x red conductor of 100 cm length,
  - ✓ 2 x blue conductor of 100 cm length,
  - ✓ 3 x red conductor of 50 cm length,
  - ✓ 3 x blue conductor of 50 cm length,
- Measuring pole, and
- Hood to cover the PV cells

- Set of resistors on the aluminum holder (7 resistors /1 diode),
- Halogen source of radiation 200 W (with a spare halogen bulb),
- Conductors for measuring:
  - ✓ 2 x red conductor of 100 cm length,
  - ✓ 2 x blue conductor of 100 cm length,
  - ✓ 3 x red conductor of 50 cm length,
  - ✓ 3 x blue conductor of 50 cm length,
- Measuring pole, and
- Hood to cover the PV cells
- Set of resistors on the aluminum holder (7 resistors /1 diode),
- Halogen source of radiation 200 W (with a spare halogen bulb),
- Conductors for measuring:
  - ✓ 2 x red conductor of 100 cm length,
  - ✓ 2 x blue conductor of 100 cm length,
  - ✓ 3 x red conductor of 50 cm length,
  - ✓ 3 x blue conductor of 50 cm length,
- Measuring pole, and
- Hood to cover the PV cells
- Set of resistors on the aluminum holder (7 resistors /1 diode),
- Halogen source of radiation 200 W (with a spare halogen bulb),
- Conductors for measuring
- Set of resistors on the aluminum holder (7 resistors /1 diode),
- Halogen source of radiation 200 W (with a spare halogen bulb),
- Conductors for measuring
- Set of resistors on the aluminum holder (7 resistors /1 diode),
- Halogen source of radiation 200 W (with a spare halogen bulb),
- Conductors for measuring
  a) 2x red conductor of100 cm length,
  b) 2 x blue conductor of 100 cm length
  c) 3x red conductor of50 cm length,
  d) 3x blue conductor of50 cm length

Step- 8 Measuring pole, and

Step- 9 Hood to cover the PV cells.

| 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 a participant to the installation of a mini grid connected PV system. Explain how the workers are being taken care of to minimize the risk of being injured. In addition, check and justify if the system components are installed in compliance with technical standards; report the existing mistakes. Report the unexpected situations and the different methods used for dealing with them during the installation. Finally, describe how the checking of the quality of the installed apparatuses is proceeded.

# Solar PV System Installation and Maintenance
# NTQF Level IV
# Learning Guide -17

| | |
|---|---|
| Unit of Competence | Install configuring and commissioning mini grid connected PV systems |
| Module Title | Installing, configuring and commissioning mini grid connected PV systems |
| LG Code | EIS PIM4 M04 LO3-LG17 |
| TTLM Code | EIS PIM4 TTLM 0920v1 |

## LO3- Install Solar PV system for 3phase configuration

| Instruction Sheet | Learning Guide:-17 |
|---|---|

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

- Following OHS risk control measures and procedures
- Inverters encompassing:
  - ✓ Typing of inverters
  - ✓ The basic function of an inverter.
  - ✓ simple block diagram of a typical inverter used in grid connected system
- Preparing sketch for three phase inverter configurations
- Wiring and interconnecting of the inverter

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:-

- Follow OHS risk control measures and procedures
- Prepare sketch for three phase inverter configurations
- Wire and interconnect the inverter

**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 | Carrying out OHS risk control measures and procedures |
|---|---|

## 1.1. Introduction

This chapter lists some of the measures that are essential for carrying out OHS risk control measures and procedures.

## 1.2. Eliminating the risk

You must always aim to eliminate the risk. For example, you can eliminate significant Electrical risks by designing-in or designing-out certain features to eliminate hazards and working de-energised rather than energised. That is why the WHS Regulation prohibits energised electrical work subject to certain exceptions. If eliminating the hazards and associated risks is not reasonably practicable, you must minimise the risk by one or more of the following:

- **Substitution**: minimize the risk by substituting or replacing a hazard or hazardous Work practice with something that gives rise to a lesser risk. For example, it may be reasonably practicable to use extra-low voltage electrical equipment such as a battery-operated tool rather than a tool that is plugged in to mains electricity.
- **Isolation**: minimize the risk by isolating or separating the hazard or hazardous work practice from any person exposed to it. For example, it may not be reasonably practicable to eliminate energized electrical work altogether; however, even if it is necessary (for one of the legally permissible reasons) to work on an energized Electrical part, it may be possible to de-energies the surrounding parts.
- **Engineering controls**: engineering controls are physical control measures to minimize risk. For example, insulation, guarding, and installing RCDs prevent electric shock.

### 1.3. Tips to carry out OHS risk control measures and procedures

Carrying out OHS risk control measures and procedures means to implement them as it should be. The implementation of OHS risk control measures and procedure calls for taking appropriate measures. Some of these measures are listed here.

- Check that the workers who are specifically trained on electrical risks, the characteristics of solar energy system and on how to perform the work actually conduct the work;
- It is recommended to evaluate the hazards of the connection to the power supply system and have the contact details of the power company; contact the power company to turn off the power, if required;
- The workers should not work alone but at least in pairs. Therefore, the number of workers doing a certain task should be made enough to perform the task safely;
- The workers are to avoid broken shingles and to take the necessary measures to dispose of them safely;
- Control measures are needed to avoid the presence of airborne substances;
- It is a must to provide appropriate lavatories, washing equipment, and eating areas separated from the working areas for all workers;
- PPE are requested to protect workers from the hazards, therefore PPE should be provided in quantity and quality;
- It is recommended to minimize the need for manual handling;
- Make sure that the emergency intervention team is informed about the risks of flashovers and their control as far as possible;
- Make sure to provide detailed information on local solar systems, including their resistance and fire properties to the emergency services in advance;
- Do not step on solar modules, therefore assume all surfaces to be potentially slippery;
- It is recommended putting technical measures in place to noise-isolate; devices through encapsulation etc. or use noise-dampening materials to ensure to reduce noise;
- Should keep the power inverter dry and isolate suitably;
- Perform a risk assessment of the work area, including electrical hazards from high voltage power lines. Make sure all workers are aware of the importance to strictly respect the safety distances to high power lines and check that they comply strictly

with this;

| Self-Check - 1 | Written Test |
|---|---|

**Choose the best option & circle the letter of your choice.**

| N° | Questions and answers |
|---|---|
| **1** | If eliminating the hazards and associated risks is not reasonably practicable, you must minimise the risk by one or more from the following:<br>A. Engineering controls B. Isolation C. Substitution D. all |
| 2 | ---------- minimise the risk by substituting or replacing a hazard or hazardous Work practice with something that gives rise to a lesser risk.<br>A. Engineering controls B. Isolation C. Substitution D. all |
| **3** | ----------minimise the risk by isolating or separating the hazard or hazardous work practice from any person exposed to it.<br>A. Engineering controls B. Isolation C. Substitution D. all |
| 4 | -------- Engineering controls are physical control measures to minimize risk.<br>A. Engineering controls B. Isolation C. Substitution D. all |

| | |
|---|---|
| Satisfactory | 2 points |
| Unsatisfactory | Below 2 points |

| Information Sheet 2 | Inverters encompassing |
|---|---|

## 2.1. Introduction

'Inverters' (also called 'power conditioning units') convert lower voltage DC electricity into a higher voltage AC. They are often convenient for PV owners who wish to run appliances that require 110 or 230V AC (e.g. for colour televisions, laptops or music systems). Changing DC power into AC power is also called inverting DC to AC, hence the name inverters. Inverters are available in sizes ranging from 50 watts to thousands of watts. Check Chapter 12 for more sources of information about inverters for solar PV systems. In the process of converting DC to AC, inverters use up energy. They are typically about 90 per cent or less efficient in converting power at full or near to full load (though there are some types that are even more efficient). At half-load or lower they will usually be less efficient. When planning large systems the energy loss in conversion must be included in calculations. Remember, inverters do not create energy – they actually use more energy and make the entire system less efficient.

## 2.2. The basic function of an inverter

There are two ways that inverters can be used in off-grid PV systems:

- In some systems, a small inverter is bought to power a single appliance. For example, small systems often have a 150W inverter attached to their system to power a color TV. Usually, the appliance is plugged directly into the inverter. See Figure 20.
- In other types of systems, a larger inverter is used to power entire circuits. For example, one common arrangement is to have all lights in the system powered by 12V DC power and to use an inverter to supply AC power to sockets for appliances.

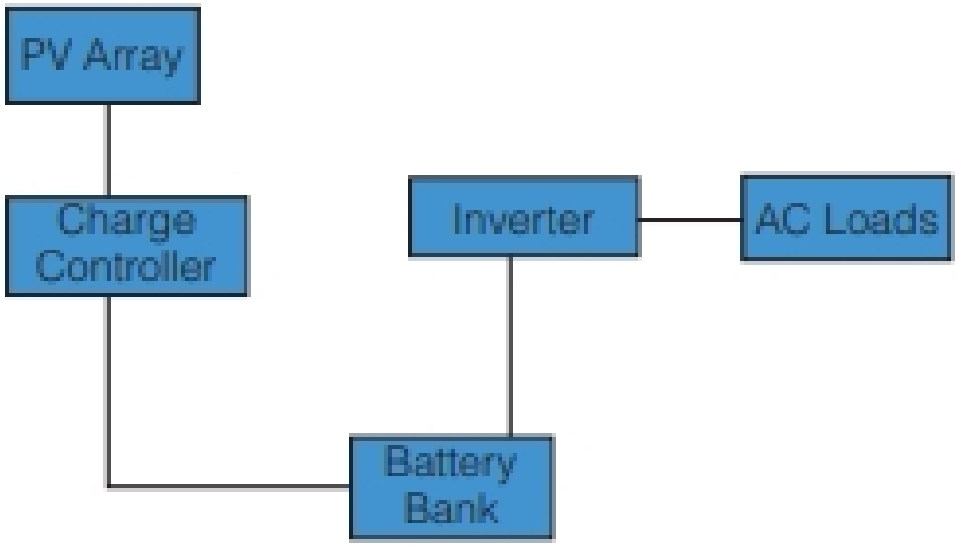



**Figure 20: common inverter configuration**

## 2.3. Choosing Inverters

Inverters should be carefully chosen to meet the needs of your solar PV system. Try to choose an efficient model made for PV systems! Remember, many inverters are not designed for solar use and perform poorly in PV systems because of poor efficiency or wave shape. Remember; never choose 'grid-tie' inverters for off-grid PV systems. Datasheets and instruction manuals should always be read carefully before buying (if the inverter you are considering does not have a datasheet with full information, this is a sign that it may be a poor quality unit). Important factors to consider when selecting inverters include the following.

- **Types**

Make sure the inverter is for off-grid systems, not a feed-in inverter for grid connects systems. Be aware of the differences between an inverter and an inverter-charger. Most inverters do not have integrated charge controllers, but some do – consider the advantages and disadvantages of using one of these. Both of these are discussed below. In any case, read the inverter manual carefully (usually available on the internet) before purchasing.

- **Size**

Inverters must be properly sized to handle the highest load that the system might require or the peak energy demand.

- **Voltage**

Make sure your inverter matches the battery/controller voltage of your system and the voltage of your loads. Inverters are commonly available to accept 12V, 24V and, for very large systems, 48V DC. Depending on the part of the world

- **Efficiency**

Usually inverters are between 60 and 95 per cent efficient. Efficiency varies greatly depending on the load and most inverters do not perform up to their efficiency rating all the time (they tend to be less efficient when loads are at less than 50 per cent of their capacity). Every inverter has an efficiency curve which will indicate its efficiency over a range of loads. Also, many poor quality low cost inverters (and appliances) on the market are not designed for solar PV and are quite inefficient. Always check manufacturer's efficiency ratings and ask an expert if in doubt.

- **Wave form**

This is a measure of how 'clean' the AC current output is. Inverters are classified into three types of output:

a. Square-wave
b. Modified sine-wave and
c. Sine-wave

a. **Square-wave inverters** cost less, but may not be able to power some appliances (such as fluorescent lamps or videos); they may damage some equipment.
b. **Modified sine-wave inverters** are better than square-wave and in general better for off-grid PV systems in terms of efficiency and overall performance.
c. **Sine wave inverters,** generally the most expensive type, have a wave shape that is very close to clean grid power. Use sine-wave inverters for appliances that

are sensitive to wave form. To avoid disappointment, always make sure beforehand that the inverter you choose can handle all of the equipment you are running! This information is usually available in the manual. Inverters can interfere with radio and telecom equipment. If this is an issue, resolve it before buying an inverter.

- **Surge capability**

This refers to inverter ability to supply sudden surges in power demand. For example, when a motor or refrigerator compressor turns on, it draws a large amount of power for a short time and the inverter must be able to deliver this surge. Surge capability of inverters should be provided in their datasheets and instruction manuals.

- **Phantom loads, stand-by mode and load detection**

Even when appliances are turned off, many inverters still consume power from the battery (this is known as a phantom load). Consult the manufacturer's data for 'self-consumption' and tell system owners to switch the inverter off when it is not being used. Some inverters for solar systems shut themselves down when no load is turned on. They automatically detect when loads are in use, and switch themselves on. Such inverters use much less power than units that continually consume power even when no AC load is connected.


**Figure 21:** Common sine wave inverters used in PV systems: Solon ASP Domino, 600W at 12V, 1000W at 24V (top left); Steca Fronius Solaris IP, 500W, version with integrated solar charge controller available (top right); Solon ASP Top Class, 1000W (middle left); Outback inverter with integrated

battery charger for charging batteries from generator, 2000W (middle right); Studer-Innotec AJ Series, 400W (bottom left); Steca Solarix Sinus 500W, version with integrated solar charge controller available (bottom right)

## 2.4. Voltage Converters

Many small DC appliances operate at a different voltage than the battery. These include radios, music systems, cell-phones or even laptop computers. For example, a radio may draw 6V DC while a PV system battery is likely to be 12V DC.

'Voltage converters' are used to step the current down to the proper voltage. This avoids damage to the appliance and improves the overall efficiency of the system. Voltage converters are available in electric appliance stores and from speciality suppliers of solar electric equipment. Low-cost simple units are available made for radios and charging cell-phones. Units for cell-phones or laptops will save quite a bit of energy, but must be specially procured for the individual power need. Make sure you get the right type of voltage converter for your appliance!


**Figure 22: Voltage converters'**

## 2.5. Simple block diagram of a typical inverter used in grid connected system

In this post we discuss the construction of a 5000 watt inverter circuit which incorporates a ferrite core transformer and therefore is hugely compact than the conventional iron core counterparts.

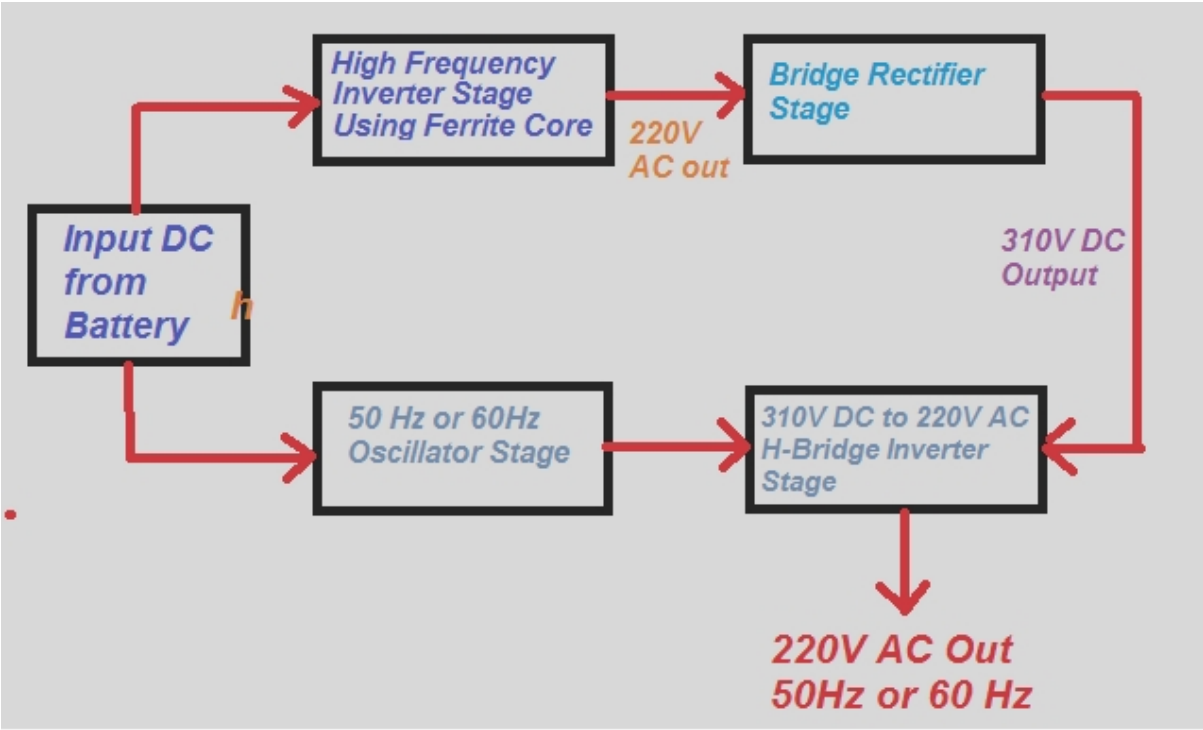



**Figure 23:5kva Ferrite Core Inverter Circuit**

**Please note you can convert this ferrite core inverter to any desired wattage, right from 100 watt to 5 kv or as per your own preference.** Understanding the above block diagram is quite simple:

The input DC which could be through a 12V, 24V or 48V battery or solar panel is applied to a ferrite based inverter, which converts it into a high frequency 220V AC output, at around 50 kHz. But since 50 kHz frequency may not be suitable for our home appliances, we need to convert this high frequency AC into the required 50 Hz / 220V, or 120V AC / 60Hz. This is implemented through an H-bridge inverter stage, which converts this high frequency into output into the desired 220V AC. However, for this the H-bridge stage would need a peak value of the 220V RMS, which is around 310V DC. This is achieved using a bridge rectifier stage, which converts the high frequency 220V into 310 V DC. Finally, this 310 V DC bus voltage is converted back into 220 V 50 Hz using the H-bridge. We can also see a 50 Hz oscillator stage powered by the same DC source. This oscillator is actually optional and may be required for H-bridge circuits which do not have its own oscillator. For example if we use a transistor based H-bridge then we may need

this oscillator stage to operate the High and low side mosfets accordingly. The DC input supply, say 12 V, is fed to a switching circuit, which makes and breaks the current path on a fixed regular interval. The switch On-Off time is controlled by the switch control circuit. The output of the switching circuit now is rather quasi AC than DC. By the term quasi, it is to be understood that the AC is not the type of AC in which the flow of current reverses periodically. In the present case, the current either flow in one direction or do not flow at all. In technical terms, this AC is shifted in voltage axis by a level equal to its negative swing. Now if this quasi AC voltage is passed through an electronic component (capacitor) that blocks the DC voltage level, AC voltage in true sense is obtained. Thus obtained AC voltage magnitude does not exceed the input DC level. Voltage boosting circuit (transformer) is further used to increase the magnitude of the AC voltage to required level.

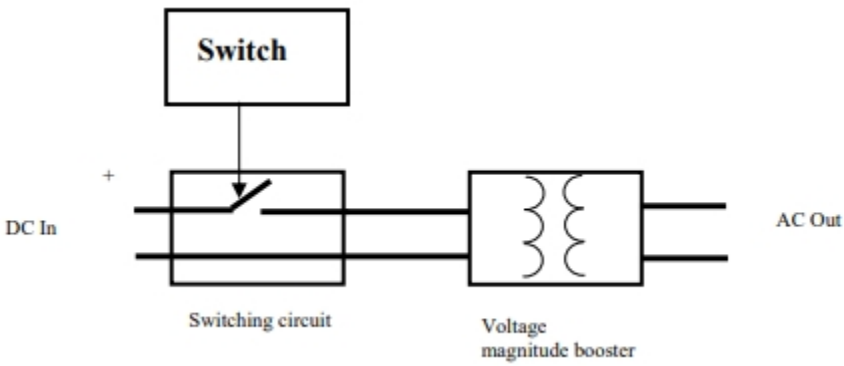



**Figure 24: Functional diagram of DC-AC conversion**

| Self-Check - 2 | Written Test |
|---|---|

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

| N° | Questions and answers |
|---|---|
| **1** | Charge controller is convert lower voltage DC electricity into a higher voltage AC. |
| 2 | Voltage converters are used to step the current down to the proper voltage. |
| **3** | Square-wave inverters are better than square-wave and in general better for off-grid PV systems in terms of efficiency and overall performance |
| 4 | Use sine-wave inverters for appliances that are sensitive to wave form. |

| | |
|---|---|
| Satisfactory | 2 points |
| Unsatisfactory | Below 2 points |

| Information Sheet 3 | Preparing sketch for three phase inverter configurations |
|---|---|

## 3.1 Introduction

This chapter provides tips on the preparation of sketch for three phase inverter configuration. In this chapter the three-phase inverter and its functional operation are discussed. In order to realize the three-phase output from a circuit employing dc as the input voltage a three-phase inverter has to be used. The inverter is built of switching devices, thus the way in which the switching takes place in the inverter gives the required output. In this chapter the concept of switching function and the associated switching matrix is explained. Lastly the alternatives as to how the inverter topologies can be formed are presented.

## 3.2 Three phase inverter

In this three phase inverter is formed by six Step Bridge by using six switches, and each phase of this inverter consists of two switches. Here for one complete cycle of $360^0$, each step is of $60^0$intervals for a six step inverter. The figure of three phase inverter using six switches is shown below

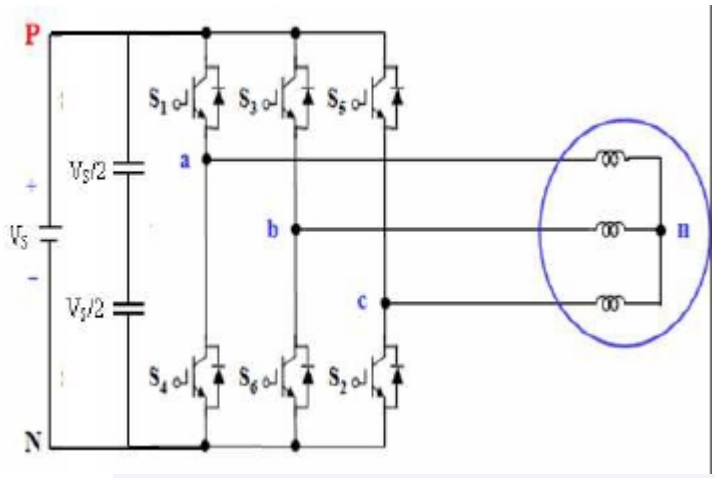



**Figure 25: Three phase inverter using six switches**

In the above fig. there are capacitors which are connected at the input terminals, these capacitors suppresses the harmonics which are fed back to the source and also keeps the DC input constant. Two different patterns can be used for gating switches.

a) $180^0$Conduction Mode

b) $120^0$Conduction Mode In

$180^0$Conduction Mode each switch conducts for $180^0$and three switches will in ON condition at any instant of time.

### 3.3 Three phase Inverter circuit 120 Degree and 180 Degree conduction

We all know about inverter - it is a device which converts DC into AC. And we previously learned about different types of inverters and built a single phase 12v to 220v inverter. A 3 Phase Inverter converts the DC voltage into 3 Phase AC supply. Here in this tutorial, we will learn about three Phase Inverter and its working, but before going any further let us have a look at the voltage waveforms of the three-phase line. In the above circuit, a three-phase line is connected to a resistive load and the load draws power from the line. If we draw the voltage waveforms for each phase then we will have a graph as shown in the figure. In the graph, we can see three voltage waveforms are out of phase with each other by 120º.

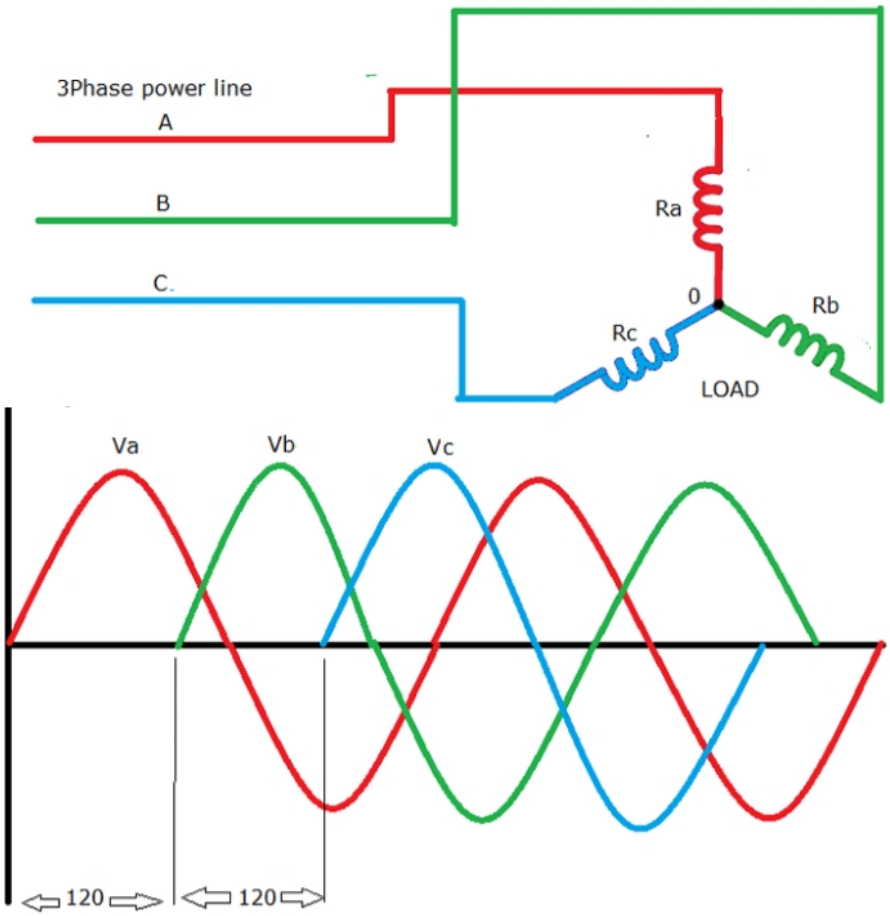



**Figure 26: Three Phase Inverter Circuit**

### 3.4 Phase Inverter Working

Now let us look into the3 Phase Inverter Circuit and its ideal simplified form. Below is a three-phase inverter circuit diagram designed using thyristors & diode(for voltage spike protection)

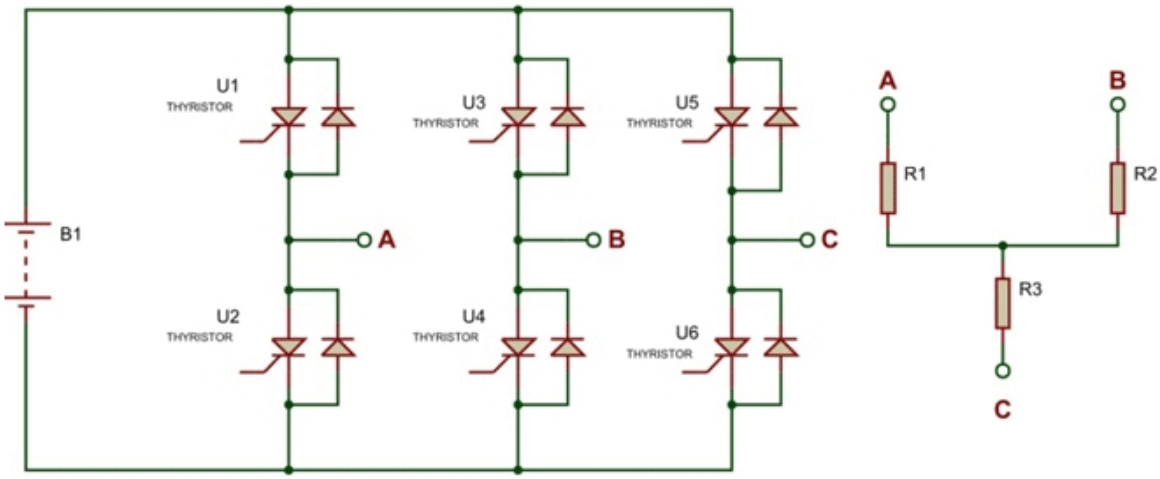



**Figure 27: 3 Phase Inverter Circuit using Thyristors and Diode**

### 3.5 Basic inverter designs for grid-tie solar system

There are three basic designs for grid-tie solar energy systems:

- Single string in-series systems;
- Multiple string in-series systems;
- Micro-inverter systems;

#### 3.5.1. Single string in-series system

Figure 15 shows the case of single string in-series system.

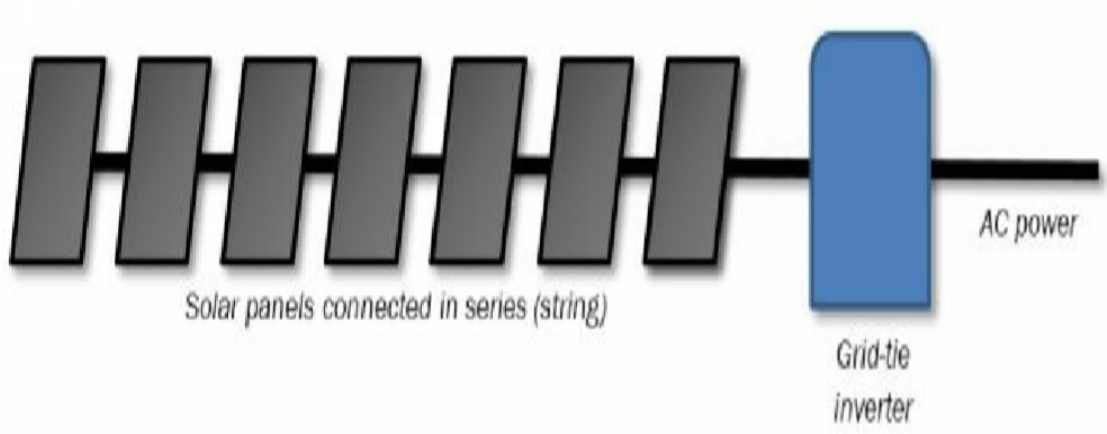



**Figure 28: Block diagram showing the basic layout of a high voltage in-series solar energy system**

### 3.5.2. Multiple string in-series systems

Figure 16 show the case of multiple string in-series systems.

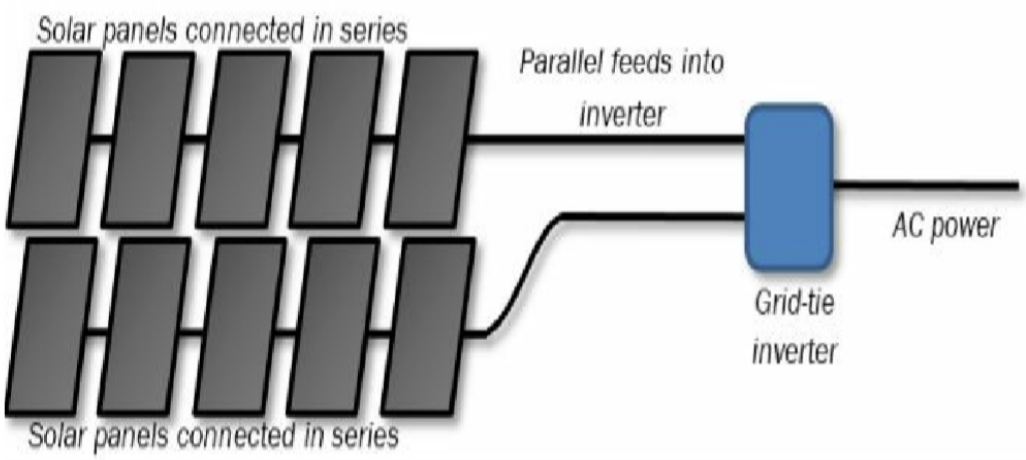



**Figure 29: block diagram showing the basic layout of a low-voltage solar energy system where multiple strings of solar panels are connected in parallel (Boxwell, 2017)**

### 3.5.3. Micro-inverter systems

Figure 17 depicts the case of micro inverter systems.

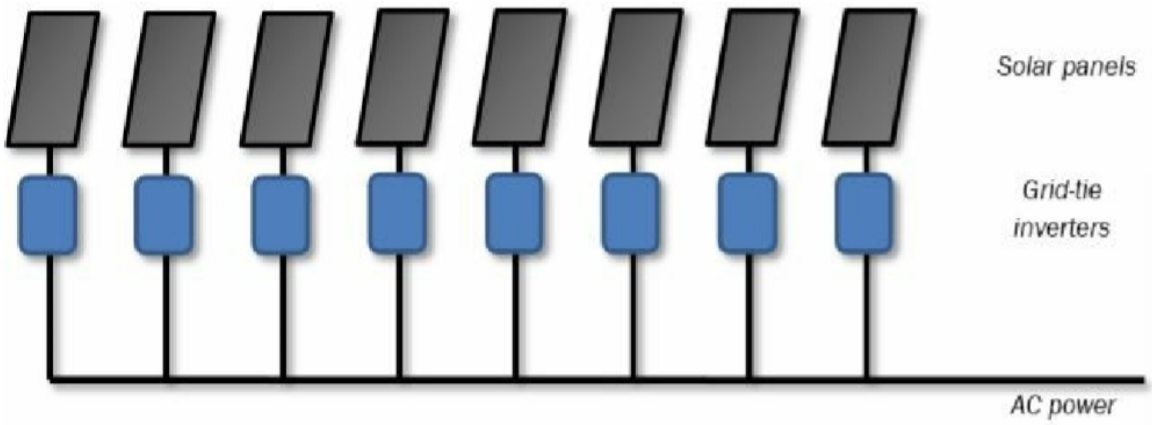



**Figure 30: Simplified block diagram showing the basic layout of a micro inverter system (Boxwell, 2017)**

## 3.6 Tips for preparing the sketch for three phase inverter configuration

- Select the basic design to implement (according to the system sizing);
- Select the three phase inverter for the installation (different from ordinary

inverters);

- Follow the inverter manufacturer datasheet to decide on how to perform the sketching of the three phase inverter configuration;
- Proceed to the sketching in respect of the inverter datasheet (the datasheet could include the single line diagram on the wiring procedure form the solar module) and the recommendations from the utility provider; shows a sample block diagram for a mini grid connected PV system.

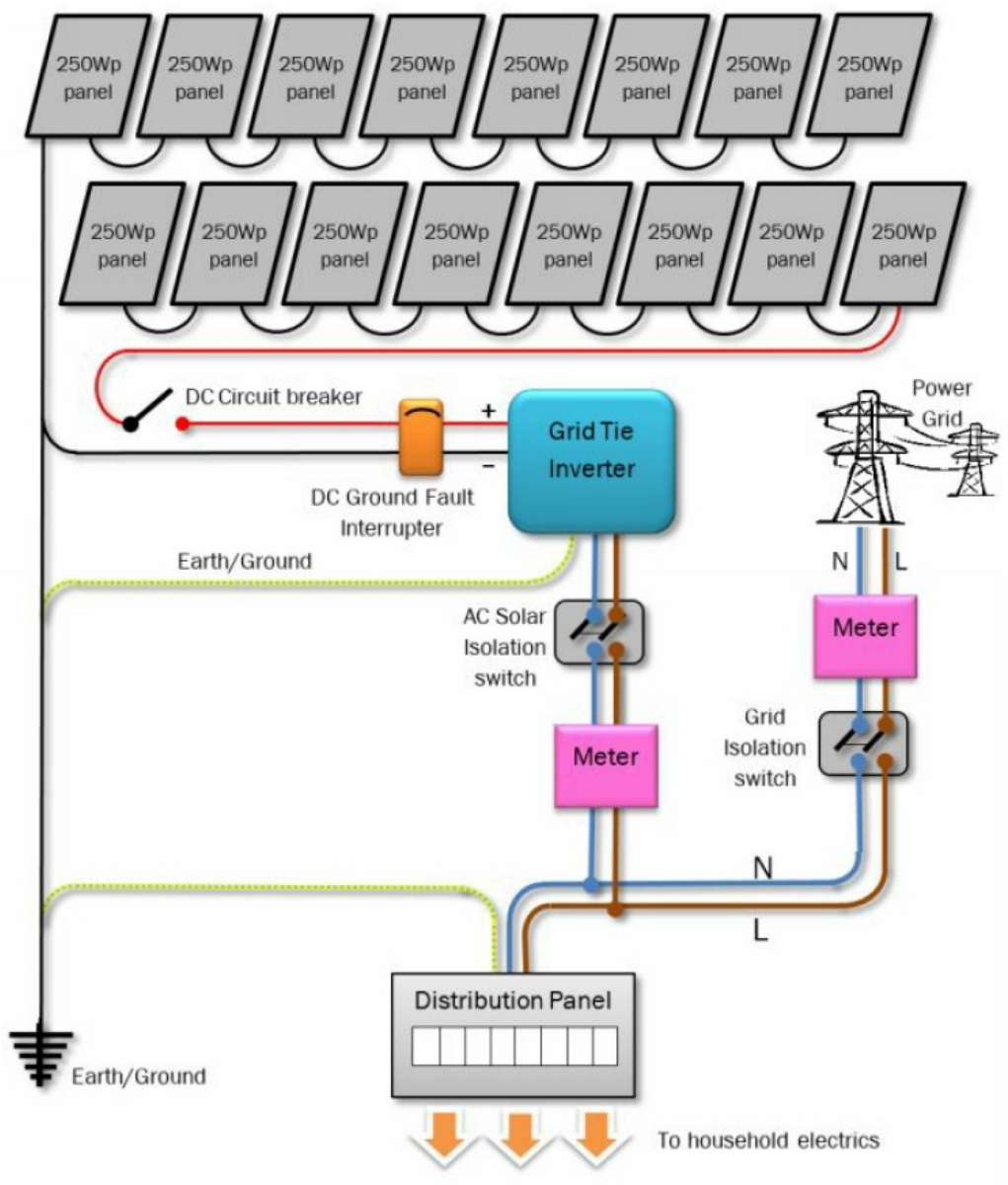



**Figure 31: A sample block diagram for a mini grid connected PV system (Boxwell, 2017)**

| Self-Check - 3 | Written Test |
|---|---|

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

| N° | Questions and answers |
|---|---|
| **1** | There are seven basic designs for grid-tie solar energy systems |
| 2 | It is recommended to proceed to the sketching of the three phase inverter configuration in respect of the inverter datasheet and the recommendations from the utility provider |
| **3** | Follow the inverter manufacturer datasheet to decide on not how to perform the sketching of the three phase inverter configuration |
| 4 | It is well-known that some switching devices exist between the source and the load, the number of which depends on the circuit or the type of the load |
| | |

| | |
|---|---|
| Satisfactory | 2 points |
| Unsatisfactory | Below 2 points |

| Information Sheet 4 | Wiring and interconnecting of the inverter |
|---|---|

## 4.1 Introduction

This chapter provides ideas on how to wire and interconnect the inverter.

## 4.2 Understanding grid connected inverters

Grid-tie inverters convert the DC power from the solar energy system into AC power, and convert the voltage to the same as the grid. This allows the connection of the system into the grid, enabling to become a mini power station and supply the electricity to the electricity companies. One cannot use an ordinary inverter for grid-tie applications. There are a number of reasons for this:

- Grid-tie inverters have to work in conjunction with the grid, in order to be able to export electricity to it. The AC pure sine waveform generated by the inverter has to be perfectly coordinated with the waveform from the grid;
- There is an additional safety feature with grid-tie inverters to cut off power from the solar array if the grid shuts down; however if the connected system has batteries they could supply priority loads until the situation is back to normal;
- Grid-tie inverters are connected directly to the solar panels. In an in-series system, this means the input voltage from the panels can fluctuate widely, often jumping or dropping by several hundred volts in an instant. Non grid-tie inverters cannot cope with such massive voltage jumps;
- In many countries, grid-tie inverters have to be certified for use with the grid;

There are a number of things to consider when purchasing a grid-tie inverter:

- Input voltage
- MPP range
- Power rating
- Power tracking
- How many strings the inverter can support
- Diagnostics and reporting information
- Inbuilt safety systems
- Installation options and operating environment

- Certification and local regulations

### 4.3 Tips for wiring and interconnecting the inverter

It is advised to follow up the recommendation of the utility provider towards wiring and interconnecting the inverter. There is no universal rule as the procedure differ from one country to another, depending on the standards.

### 4.4 Automatic UPS / Inverter Connections

In case of emergency breakdown when utility power is not available from the power house, we may use automatic inverter / UPS and batteries to connect the power without interruption. We will show two basic UPS / Inverter with batteries connection the home distribution board.

- Auto UPS / Inverter with Two Wires
- Automatic USP / Inverter Wiring with One Live Wire

Note: To be in safe mode, use 6 AWG (7/064″ or 16mm2) cable and wire size to connect the UPS to the main panel board.

- Related Post: How to Connect a Portable Generator to the Home Supply – 4 Methods
- **Automatic UPS / Inverter Wiring with two Wires.**

No rocket science here. Just connect the outgoing Neutral and Live wires to the UPS. Now connect the two outgoing Neutral and Phase wires from UPS / Inverter (As output) to the appliances as shown in fig 1.

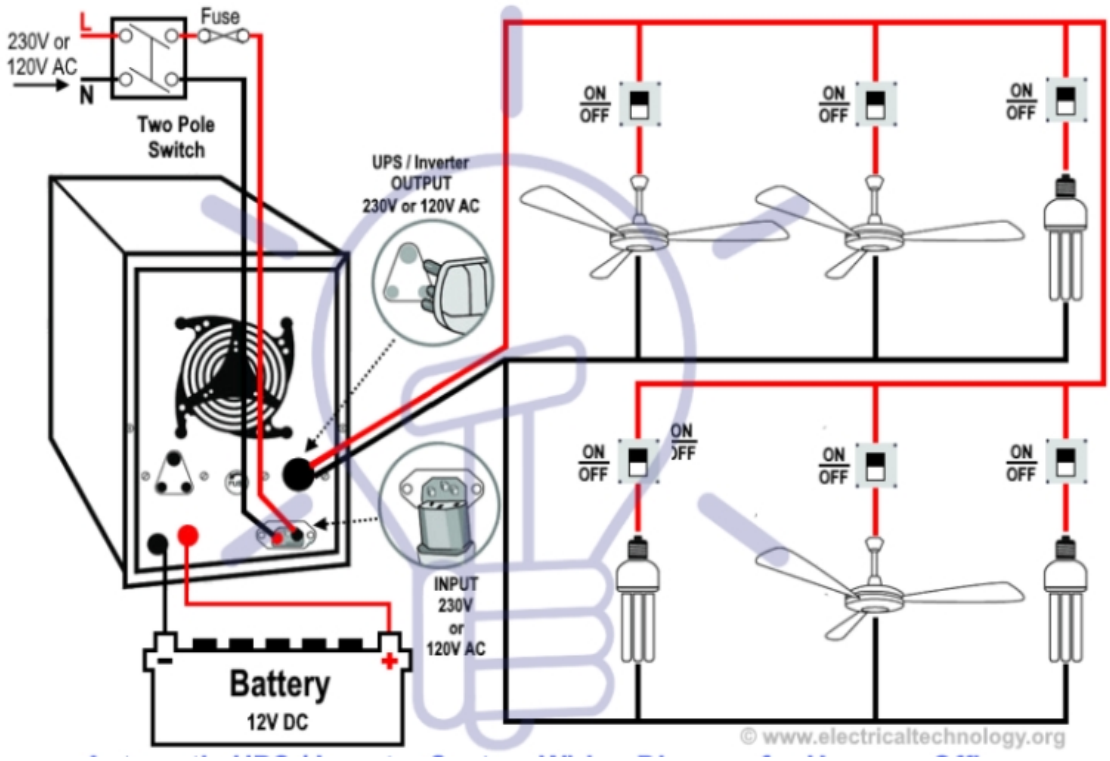



**Figure 32: Automatic UPS / Inverter Wiring with two Wires**

**How to Connect a UPS / Inverter to the Switch Board?**

The below fig 3 shows that how to connect a UPS / Inverter with batteries to the Main Distribution Unit for continues power supply in case of the utility power failure. Additional wiring connection with connected load and appliances for two rooms in home. How to Connect Automatic UPS / Inverter to the Home Supply System?

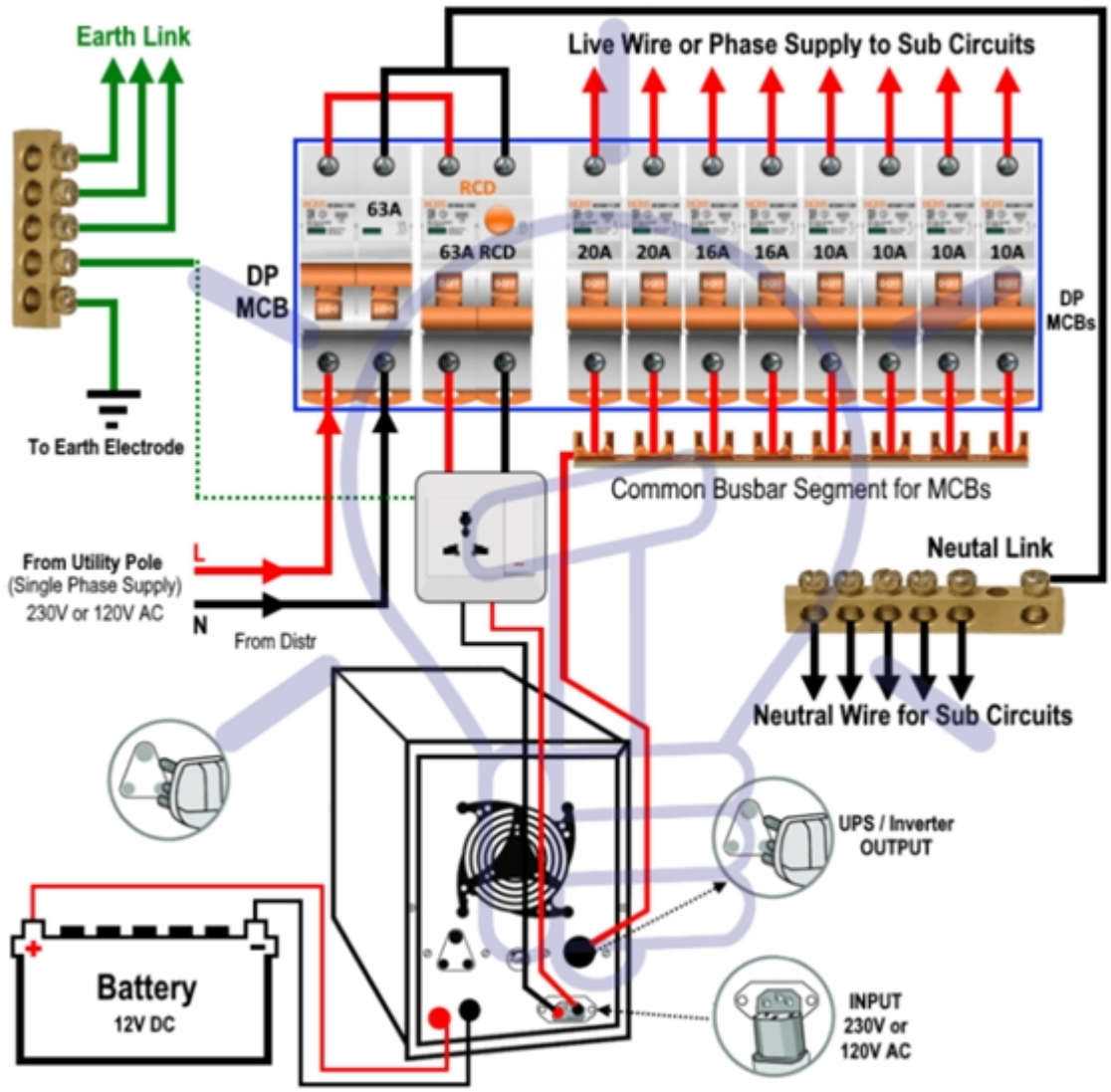



**Figure 33: wire UPS / Inverter to the Home supply**

| Self-Check - 4 | Written Test |
|---|---|

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

| N° | Questions and answers |
|---|---|
| **1** | In many countries, grid-tie inverters have to be certified for use with the grid |
| 2 | The following things are to be considered when purchasing a grid-tie inverter: input voltage, power rating, power tracking, how many strings the inverter can support, diagnostics and reporting information etc. |
| **3** | There is an additional safety feature with grid-tie inverters to not cut off power from the solar array if the grid shuts down; however if the connected system has batteries they could supply priority loads until the situation is back to normal; |
| 4 | It is advised to follow up the recommendation of the utility not provider towards wiring and interconnecting the inverter |

| | |
|---|---|
| Satisfactory | 2 points |
| Unsatisfactory | Below 2 points |

| Operation sheet | Practical Demonstration |
|---|---|

This case study features a desert settlement with 300 people, 500 cattle and 2000 goats. The water source is a shallow well.

**Step 1:** consider all pumping alternatives and estimate their costs. Wind resources at the site are poor. Because of its isolation and the costs, a diesel pump is not desired. Solar resources are high (5–6kWh/m2/day).

**Step 2:** calculate water requirements. About 40m3 of water per day is required. People: 300 × 40 litres/person/day = 12$m^3$

Cattle: 500 × 40 litres/cow/day = 20$m^3$

Goats: 2000 × 7.5 litres/goat/day = 15$m^3$

Total requirements: 47 m3/day (with 3$m^3$ added for growing needs this equals 50$m^3$)

**Step 3:** calculate the vertical pumping distance (the head). This is 15m.

**Step 4**: calculate the hydraulic lift and decide on the type of pump. The settlement would require a total hydraulic lift of 750m4 per day (15m × 50m3). A submersible pump could be used.

**Step 5:** size the solar array. The radiation at the site is 5kWh/m2/day; approximately a 1.2kWp array would be required (calculated using the solar pump supplier's method in catalogue). With the above information it is possible to speak to suppliers about possible options and to investigate what is generally on the market to suit the systems needs.

| 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:** You are taken to a site where the installation of a mini grid connected PV system is being conducted. Firstly, according to the available documentation and the ongoing work, you are requested to explain and comment the followed sketch for the three phase inverter configuration. Secondly, concisely explain the wiring of the inverter and the interconnection of the inverter to the grid.

# Solar PV System Installation and Maintenance
# NTQF Level IV
# Learning Guide -18

| | |
|---|---|
| **Unit of Competence** | **Install configuring and commissioning mini grid connected PV systems** |
| **Module Title** | **Installing, configuring and commissioning mini grid connected PV systems** |
| **LG Code** | **EIS PIM4 M04 LO4-LG18** |
| **TTLM Code** | **EIS PIM4 TTLM 0920v1** |

# LO4 Completion and report installation activities

| | |
|---|---|
| **Instruction Sheet** | **Learning Guide:-18** |

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

- Following OHS risk control measures and procedures
- Cleaning and Making work site safe
- Making final checks
- Documenting ‘As-installed’ apparatus and associated equipment and notifying

appropriate person(s)

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:-

- Follow OHS risk control measures and procedures
- Clean and Make work site safe
- Make final checks
- Document 'As-installed' apparatus and associated equipment and notify the appropriate person(s)

**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

| Information Sheet 1 | Follow OHS risk control measures and procedures |
|---|---|

## 1.1. Introduction

This chapter provides tips on how to follow OHS risk control measures and procedures. OHS means occupational health and safety. It is 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.

## 1.2. Tips on how to follow OHS risk control measures and procedures

The corresponding tips for following OHS risk control measures and procedures have been thoroughly discussed in LO2, precisely in the information sheet 1. However, here we re-call the mains aspects that need serious attention on a mini grid connected PV system installation site. The control measures and procedures guiding the below points should be followed and controlled accordingly for eliminating OHS risks.

- Take measures for electrical safety on the site (risk of electric shock);
- Take measures for falling protection on the site (risk for fall from heights);
- Take measures for stairways and ladders on the site;
- Take measures for security in using hand and power tools on the site;
- Take measures for providing necessary personal protective equipment (PPE);
- Take measures for providing conducive working space for electrical equipment and systems;
- Take all necessary measures for successful installation of the photovoltaic modules;
- Take measures to ensure the batteries are well taken care of and installed as per manufacturer requirement and applicable standards (risk of stored energy)
- Take measures to eliminate heat-related illness

## 1.3. Site Risk & Hazard Assessment

What risks are there in on-site work?

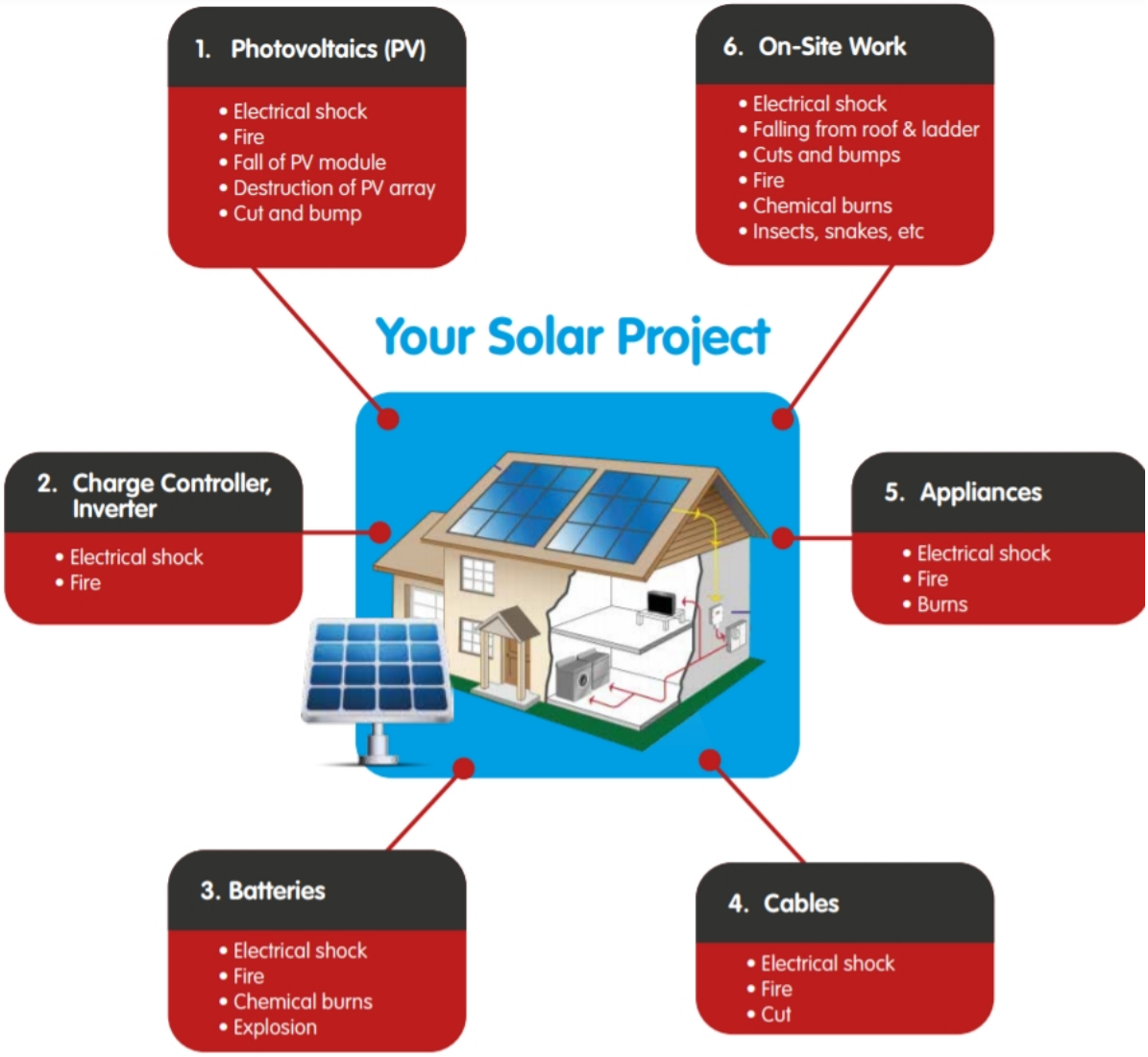



**Figure 34: Site Risk & Hazard Assessment**

Residual Current Device (RCD): a device, often referred to as a 'safety switch', intended to isolate supply to protected circuits, Socket Outlets or electrical equipment in the event of a current flow to earth that exceeds a predetermined value. The RCD may be fixed or portable.

| Self-Check - 1 | Written Test |
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The following are true or false items, write true if the statement is true and write false if the statement is false.

| N° | Questions and answers |
|---|---|
| **1** | It is not paramount to take measures to ensure the batteries are well taken care of and installed as per manufacturer requirement and applicable standards. |
| 2 | Most of the measures for falling protection on an off-grid PV system installation site can be applied to a mini grid connected PV system installation site |
| **3** | control measures and procedures OHS risk take measures to eliminate heat-related illness |

| | |
|---|---|
| Satisfactory | 2 points |
| Unsatisfactory | Below 2 points |

| Information Sheet 2 | Making and cleaning work site safe |
|---|---|

## 2.1. Introduction

This chapter provides tips on how to make and clean work site safe.

## 2.2. Decide on control measures

There are a range of strategies that have been proven to control the risk of slips, trips and falls, while also leaving floors and other surfaces clean and free from contaminants. The best cleaning requires a combination of important elements, as listed below.

## 2.3. Cleaning methods:

- Leave a clean and dry surface, free from moisture or dry waste e.g. 'clean-to-dry'
- Do not leave a build-up of cleaning products
- Maintain the slip resistant properties of the floor/surface (if non-slip flooring)
- Are based on advice from the flooring supplier
- Are tailored to the specific flooring and contaminants – i.e. type and concentration of chemicals etc. For example, the time detergent is on the floor has been shown to have a significant effect on cleanliness. It is also noted that flooring that is slip resistant can be cleaned to be as hygienic as other flooring.

## 2.4. Cleaning schedules:

- are systematic and well planned
- have routine daily cleaning conducted during quiet/slow periods
- include periodic deep/comprehensive cleaning
- provide a rapid/urgent response to spills
- include indoor and outdoor areas
- include customer/visitor areas
- Accommodate for periods of bad weather.

## 2.5. Cleaning equipment/products

- suited to the task, environment and the users

- Don’t spread the problem (e.g. paper-towel instead of wet mop for small spill, or 'spill-kit' materials for oil leaks, spill stations where resources are kept etc.)
- includes barriers and signs to keep people off any wet areas if 'clean-to-dry' is not possible

## 2.6. Site preparation

Prepare site before installation

- Site fencing and office construction
- Provision of water and power for use
- Preparing necessary access ways (e.g. roads)
- Civil works to prepare the land for construction
- Establishing security systems – CCTV cameras, security guards etc.
- Installation logistics planning for the duration of the installation
- Kick-off meeting with all stakeholders on site
- Preparation of necessary installation tools and equipment

**Figure 35: Solar panel installation.**

## 2.7. Personnel responsible for cleaning:

The cleaning method you use will depend on a number of factors. This is best decided in consultation with the flooring and cleaning equipment suppliers based on the workplace's requirements. A combination of methods may be used across the workplace. The following table is from a review of cleaning options for health settings,

and may be relevant to other similar settings.

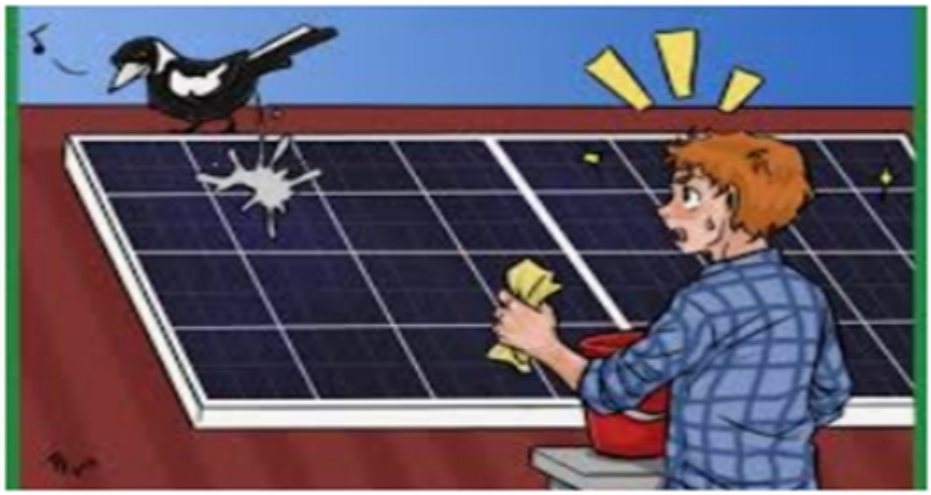

**Figure 36: Solar cleaning**

### 2.8. Cleaning solar panels

Keep solar panels clean so they operate efficiently and safely. Always follow the manufacturer's recommendations. A competent person should

- Use water, not cleaning products
- Not use scorers or other abrasive cleaners
- Avoid using high pressure water cleaners

  Not rest buckets or lean on the panels.

### 2.9. Making work site safe

This section concerns the safety at the work site; it is about taking all the measures for ensuring complete safety after leaving the site.

- Inform building manager or client about safety measurements and procedures, provide instructions on emergency shut-down, cleaning of solar array and other maintenance measurements;
- Indicate with corresponding symbols and warning signs the not to be done actions and the related gravity in and of each zone, e.g. risk of fire in the battery room, so no smoking and open flames;
- Put up warning signs on battery and components room and label all load carrying cables, especially DC cables to prevent accidental touching or damaging
- Check work area for unfinished tasks and remove risks, e.g. open cable ends,

exposed cables; unlabelled load carrying cables

- Remove risk of tripping or falling by removing all loose cables or cables hanging from ceilings etc.
- Only qualified workers should be allowed for entering the protected zones;

## 2.10.Preventing electrical risks

You may be able to remove some electrical risks by using tools powered by air, hand or hydraulics. However, be aware that these tools could introduce other hazards for the user. Lower voltages can reduce or remove the risks of shocks and burns. Battery powered tools are safest. Use lower voltage portable tools at 110 volts. Temporary lighting can also run at lower voltages. You should use a residual current device or lower voltage tools in harsh environments.

## 2.11.Cleaning work site safely

The following are some tips for the efficient cleaning of the work site.

- The location of the solar modules should be cleared off with the appropriate cleaning materials, see module installation manuals for instructions;
- Clean the work area and dispose of all rubbish appropriately, e.g. cable ends, insulation parts, ends of cable ties, packaging
- The circulation area needs cleaning to eliminate elements that could provoke contamination and fatal accidents; the place needs to be exempt from factors that are likely to induce workers injuries and illness;
- The technical room for the inverters, regulators, junction boxes, batteries etc. need proper cleaning to avoid unpredictable electrical hazards such as electrocution ;

| Self-Check - 1 | Written Test |
|---|---|

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

| N° | Questions |
|---|---|
| **1** | The health and security supervisor must analyse the risks in relation with all the working zones and apply preventive measures |
| 2 | The circulation area at the site is not exempt from cleaning to eliminate elements that could provoke contamination and fatal accidents |
| **3** | Only qualified workers should be allowed for entering the protected zones; |
| 4 | Remove risk of tripping or falling by removing all loose cables or cables hanging from ceilings etc. |

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| Satisfactory | 2 points |
| Unsatisfactory | Below 2 points |

| Information Sheet 3 | Make final checks |
|---|---|

### 3.1. Introduction

This chapter gives tips on how to make final checks on a mini grid connected PV system.

### 3.2. Same final checks

- Check the condition of any fuses that might be in the power path.
- Verify the system wiring is correct and intact.
- Check all the connections and terminals for good electrical contact.
- Should your system for whatever reason not be giving the results you expect, please contact us for further advice.

### 3.3. Tips for making final checking

The following are tips for making final checking of the installation:

- Check the presence of all the equipment according to design and planning;
- Check that the position of each equipment is in compliance with the technical documentation;
- Check the wiring route to ensure it is in conformity with planned route, if there are deviations, make sure they are documented;
- Check that the fragile equipment is well protected through the protective electrical equipment such as relays;
- Check to make sure the whole system functions properly through necessary tests; evaluate voltages, currents and other characteristics levels at the inputs and outputs of all the equipment;
- Check if the grounding/ear thing structure is strong enough;
- Make the necessary measurements;
- Check the quality of the monitoring system if applicable;
- Take photos of the finalised system and the system parts and serial numbers to document the handover and save the photos with the system documentation, they might be useful for remote error diagnosis later.

| Self-Check - 3 | Written Test |
|---|---|

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

| N° | Questions and answers |
|---|---|
| **1** | The supervisor should check the effective presence of all the equipment according to design and planning; |
| 2 | The whole mini grid connected system should be checked to ensure it functions properly through necessary tests |
| **3** | Check the presence of all the equipment not according to design and planning |
| 4 | Final Check not the condition of any fuses that might be in the power path. |

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| Satisfactory | 3 points |
| Unsatisfactory | Below 3 points |

| Information Sheet 4 | Documenting 'As-installed' apparatus and associated equipment and notifying appropriate person(s) |
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## 4.1. Introduction

This chapter gives ideas on the procedure to document 'As-installed' apparatus and associated equipment and notify the appropriate persons.

## 4.2. How to Use This Document

This document is best viewed on a computer or tablet in order to take full advantage of the embedded, clickable hyperlinks that lead to further information and additional resources. Each hyperlink is fully cited in the References and Resources section beginning on page 23. Relevant definitions used in this document are attached as Appendix A.

## 4.3. Ideas on the documenting procedure

After a successful installation of a mini grid connected PV system there is need to document 'As-installed' apparatus. The corresponding document will reveal how the work has been done, precisely in terms of what have been installed, where and how. It should also include the important details on the system installation such as what has changed compared to the initial design; therefore the made significant modifications should be mentioned. The 'As-installed' apparatus and associated equipment are to be cited, located, wired and structured as clearly as possible. More precisely, such a technical report should faithfully relate to the installed system, exactly as it is on the site.

Concisely, the technical report should account for:

- Explanatory schematic diagrams;
- Explanatory statements for clarification purpose;

## 4.4. Notifying the appropriate person (s)

Not everyone should be informed about the documenting of the 'As-installed' apparatus and associated equipment. It is recommended to have knowledge of the appropriate person(s) to inform, because the responsibilities can vary from one site to the other;

therefore the context is not the same.

| Self-Check - 4 | Written Test |
|---|---|

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

| N° | Questions and answers |
|---|---|
| 1 | Documenting ‘As-installed’ apparatus and associated equipment call for having a precise view on the whole installed system |
| 2 | The technical document of ‘As-installed’ apparatus and associated equipment cannot contain explanatory diagrams, but only mere explanatory statements |
| 3 | This Installation not the Best Practices Guide is designed to improve solar asset transparency for investors and rating agencies. |
| 4 | After a successful installation of a mini grid connected PV system there is need to document ‘As-installed’ apparatus. |

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| Satisfactory | 3 points |
| Unsatisfactory | Below 3points |

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