Solar PV System Installation and Maintenance

Level IV

Learning Guide -22

Unit of Competence	**Solve Problems in Stand-Alone Renewable energy Systems**
Module Title	**Solving Problems in Stand-Alone Renewable energy Systems**
LG Code	**EIS PIM4 M06 LO1-LG22**
TTLM Code	**EIS PIM4 TTLM 0920v1**

LO1: Prepare to work on stand-alone renewable energy system

ADRA Ethiopia

Instruction Sheet	Learning Guide:-22

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

- Obtaining understanding OHS procedures
- Following OHS risk control work preparation measures and procedures
- Obtaining the nature of the apparatus problem from documentation
- Seeking advice from the work supervisor
- Identifying and accessing sources of materials
- Obtaining and checking tools, equipment and testing devices

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
- Follow OHS risk control work preparation measures and procedures
- Obtain the nature of the apparatus problem from documentation
- Seek advice from the work supervisor
- Identify and access sources of materials
- Obtain and check tools, equipment and testing devices

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 understanding OHS procedures

1.1 Introduction

This chapter provides the basics on understanding OHS procedures for working on stand-alone renewable energy systems.

1.2 Definition of OHS

The occupational health and safety (OHS) 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. Occupational health and safety is one of the most important aspects of human concern. It aims an adaptation of working environment to workers for the promotion and maintenance of the highest degree of physical, mental and social wellbeing of workers in all occupations.

The purpose of the Health and Safety policies and procedures is to guide and direct all employees to work safely and prevent injury, to themselves and others. All employees are encouraged to participate in developing, implementing, and enforcing Health and Safety policies and procedures.

- **occupational safety and health can be defined as a multidisciplinary activity aiming at:**
  - ✓ Protection and promotion of the health of workers by eliminating occupational factors and conditions hazardous to health and safety at work
  - ✓ Enhancement of physical, mental and social well-being of workers and support for the development and maintenance of their working capacity, as well as professional and social development at work
  - ✓ Development and promotion of sustainable work environments and work organization

1.3 Preventive and protective measures

Here we indicate the hierarchy of preventive and protective measures regarding the preparation for work on stand-alone renewable systems.

Preventative measure includes the measures or steps taken for prevention of disease as opposed to disease treatment. Preventive Health Measures encompass a variety of interventions that can be undertaken to prevent or delay the occurrence of disease or reduce further transmission or exposure to disease. Common sense and legislation dictate that employers assess the risks for their staff and implement related preventive or control measures. Preventive measures aim at avoiding risks whereas control measures are put in place in order to reduce and manage risks

- **Some tips to help make your workplace safe.**
  - ✓ Understand the risks
  - ✓ Reduce workplace stress
  - ✓ Take regular breaks
  - ✓ Avoid stooping or twisting
  - ✓ Use mechanical aids whenever possible
  - ✓ Protect your back
  - ✓ Wear protective equipment to suit the task
  - ✓ Stay sober

Preventive measures are the actions taken to avoid a detrimental event. Example : cutting bushes and deeds before the fires arise therefore preventing the fires to start and spread.

Protective measures are those actions taken to minimize the effects of detrimental events. Example: covering doors and windows of the houses with plates and getting shelter in the underground of the house before the hurricane arrives. It does not prevent the hurricane but protect people against its effects.

Preventative measures are put in place to keep certain, typically unpleasant, accidents or events from happening. Protective measure are put in place to protect people when accidents or disasters occur or protect from exposure to dangerous materials or situations.

In the preparation of work on a stand-alone renewable system, the supervisor, together with the workers, should assess the risks and deal with them in the following order of priority:

- ✓ Identify all the possible risks on the site;
- ✓ Eliminate all the 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 availability of personal protective equipment.

These points are broadly representative of the occupational health and safety procedure needed at a stand-alone renewable energy 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.

1.4 Employers responsibility

Every employer of workers should comply with the following responsibilities to:

- protect your own Health and Safety and that of your co-workers;
- not initiate or participate in the harassment of another worker; and
- Co-operate with your supervisor and anyone else with duties under the legislation.
- Make sure to 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;
- Make sure to give the necessary instructions and training to managers and staff, taking account of the functions and capacities of different categories of workers;
- Make sure to provide adequate supervision of work, of work practices, and of the application and use of occupational health and safety measures;
- Make sure to provide adequate personal protective clothing and equipment to the workers;
- Always ensure that work organization, particularly with respect to hours of work and rest breaks, does not adversely affect the safety and health of workers;

1.5 Workers responsibilities and rights

The workers should comply with the following principles. They:

- Should know about the site hazards that may affect their health or safety;
- Should take reasonable care for their own safety and that of other persons who may be affected by their acts or omissions on the site;
- Should comply with instructions given for their own health and safety, and those of others, and with the site defined health and safety procedures;
- Should use safety devices and protective equipment correctly (and not render them inoperative);
- Should report promptly to their immediate supervisor any situation which they have reason to believe could present a hazard/risk and which they cannot themselves solve efficiently;
- Should report any accident or injury to health which arises in the course of or in connection with the installation of stand-alone renewable energy systems.

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	It is not the responsibility of the workers to know about the site hazards that may affect their health or safety
	True or false:
2	It is only in autumn that the employer should make sure to provide adequate supervision of work, of work practices, and of the application and use of occupational health and safety measures
	True or false:
3	Preventive measures are the actions taken to avoid a detrimental event.
	True or false:

Information Sheet 2	Following OHS risk control work preparation measures and procedures.

2.1 Introduction

This chapter presents tips on how to follow OHS risk control measures and procedures regarding the preparation for working on a stand-alone renewable energy system.

- **The meaning of key terms**
  - ✓ **Hazard**: means a situation or thing that has the potential to harm a person. Hazards at work may include: noisy machinery, a moving forklift, chemicals, electricity, working at heights, a repetitive job, bullying and violence at the workplace.
  - ✓ **Risk:** is the possibility that harm (death, injury or illness) might occur when exposed to a hazard.
  - ✓ **Risk control:** means taking action to eliminate health and safety risks so far as is reasonably practicable, and if that is not possible, minimizing the risks so far as is reasonably practicable. Eliminating a hazard will also eliminate any risks associated with that hazard

2.2 Tips to follow OHS risk control measures and procedures

The health and security officer can follow the below few tips to feasibly address health and safety risks control measures and procedures:

- under take 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;
- Should thoroughly examine the solutions case after case to retain the best options that could be established or implemented;
- Make sure that the proposed risks control measures and procedures are documented for reference when the need arises; the risks control measures and procedures are to be revealed to the workers and followed accordingly in the preparation of the installation of any stand-alone renewable energy system;

- Should 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;
- Should 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;
- Should 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;
- Should set the conditions governing the design, construction and layout of undertakings with a view to avoiding or minimizing hazards;
- Put into practice the proposed risks control measures and procedures need to be stated and documented qualitatively for further use;

2.3 best risk assessment control measures

- Elimination. We have already discussed this earlier on in this post, and elimination should always be the first control measure you consider
- Substitution. Substitution is the second best control measure you could use
- Engineering controls
- Administrative controls
- Personal protective clothes and equipment

The risk assessment process is based on the following steps:

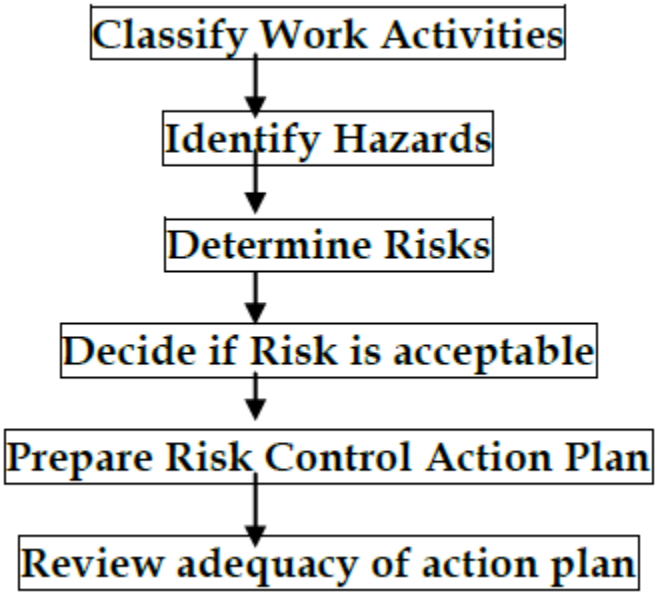

Figure 1: risk assessment process

Examples include immunization and taking regular exercise to prevent health problems developing in the future. Secondary prevention includes those preventive measures that lead to early diagnosis and prompt treatment of a disease, illness or injury.

- **Tips for work safety**

Staying healthy and safe at work is important. No matter what your job, it is important to reduce your risks of injury and illness at work. **Here are some tips to help make your workplace safe.**

- ✓ **Understand the risks.** Once you know the particular hazards of your job or workplace, you can take steps to reduce your risk of work-related injury or illness.
- ✓ **Reduce workplace stress.** Common causes include long hours, heavy workload, job insecurity and conflicts with co-workers or bosses. Stress can lead to depression, sleeping difficulties and problems with concentration.
- ✓ **Take regular breaks.** Staying fresh and alert will help you avoid injury or burnout. Schedule the most difficult tasks of each day for times when your concentration is best, such as first thing in the morning.

- ✓ **Avoid stooping or twisting.** Use ergonomically designed furniture and equipment, and rearrange your work area so that everything you need is within easy reach.
- ✓ **Use mechanical aids whenever possible.** Instead of trying to lift or carry a heavy object, use a wheelbarrow, conveyor belt, crane or forklift.
- ✓ **Protect your back.** If you do need to pick up and carry heavy loads, keep the load close to your body and lift with your thigh muscles.
- ✓ **Wear protective equipment to suit the task.** If worn correctly, gear such as earplugs, earmuffs, hard hat, safety goggles, gloves or full-face mask can dramatically reduce your risk of injury.
- ✓ **Stay sober.** Alcohol and drugs are a contributing factor in around three per cent of workplace fatalities.
- ✓ **Talk over any concerns.** Your employer or human resources manager need to be informed about hazards and risks. Your employer is legally obliged to ensure a safe working environment.
- ✓ **Know your rights.** Organisations such as Work Safe Victoria or unions can offer information and advice on workplace safety issues.

- **Risk management is a four-step process for controlling exposure to health and safety risks associated with hazards in the workplace.**
  - ✓ Step 1: Identify hazards.
  - ✓ Step 2: Assess the risk
  - ✓ Step 3: Control the risk
  - ✓ Step 4: Review risk control

- **The risk management process:**

Figure 2: risk management process

These four steps are:

- ✓ Identify hazards what could cause harm?
- ✓ Assess risks if necessary how serious could the harm be and how likely?
- ✓ Control risks what are the most effective control measures that are reasonably acticable in the circumstances?
- ✓ Review control measures Are controls working as planned?

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	One should thoroughly examine the solutions case after case to retain the best options that could be established or implemented
	True or false:
2	There is no need documenting the strategies applied for putting into practice the proposed risks control measures and procedures
	True or false:
3	Risk is the possibility that harm (death, injury or illness) might occur when exposed to a hazard.
	True or false:
4	Hazard means a situation or thing that has the potential to harm a person.
	True or false:

Information Sheet 3	Obtaining the nature of the apparatus problem from documentation

3.1 Introduction

This chapter provides some tips for obtaining the nature of the apparatus problem from documentation.

3.2 Tips to obtain the nature of the apparatus problem

The following are some tips to be considered.

- Check every apparatus documentation to identify the problems which could occur;
- Check all the possible reasons behind the different problems; clearly understand the reasons;
- Check the proposed solutions from the manufacturer per case;
- If applicable check the maintenance reports to get updated information about the apparatus maintenance; the maintenance reports should indicate the evolution of the actions being conducted on the apparatus;
- If applicable check any other reliable documentation in search of technics to solve problems;
- Discuss with the work supervisor who could know more of the apparatus problem; therefore qualitatively establish the scope of work to be undertaken;

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	It is advised to check all the possible reasons behind the different problems, therefore clearly understand the reasons before actions
	True or false:
2	The proposed solutions from the manufacturer is the first thing to search while facing a situation
	True or false:

Information Sheet 4	Seeking advice from the work supervisor

4.1 Introduction

This chapter gives recommendations on how to seek advice from the work supervisor.

4.2 Recommendations to seek advice from the supervisor

Seeking advice from the supervisor is aimed to ensure the work is coordinated effectively with others. The following are some tips to effectively seek advice from the work supervisor regarding the work on a stand-alone renewable energy system, especially while aiming to solve specific situations/problems. They:

- Should inform the work supervisor of any work to be performed; therefore the work supervisor should have clear knowledge of what is being conducted;
- Should mention to the work supervisor the difficulties encountered in the preparation of the activity;
- Should mention to the work supervisor the difficulties encountered during the activity;
- Should diagnose the problems and think of the candidates applicable solutions;
- Should refer to the work supervisor and make the proposed solutions known to him;
- Should seek the work supervisor opinion on the proposed solutions;
- Should take note of the suggestions from the work supervisor;
- Should make sure that the work supervisor validates the definite solution to implement; should coordinate with the other workers towards finding the definite solution; this will allow for an effective coordination of the on-going and upcoming activities;

How do you approach a supervisor with a problem?

- Think about solutions before you approach the boss. Remember that your boss already has a lot on his or her plate
- Calculate the risks
- Know your timing
- Ask for help
- Take the boss out to lunch
- Be prepared

- Be professional
- Make sure your side of the street is clean

4.3 **Tips** to turn conflict into consensus

- Understand the nature of the conflict
- Encourage employees to work it out themselves
- Nip it in the bud quickly
- Listen to both sides
- Determine the real issue, together
- Consult your employee handbook
- Find a solution
- Write it up

4.4 Seven things you should tell your boss at review time:

- **What you love about your job, and what you wish you could be doing more of.**
  Start off by talking about what you love about your job, and you'll set a positive and productive context for your performance review, Grainger-Marsh says. "When you talk about what you wish you did more of, you should make sure you keep it contextual – both to your own needs and wishes as well as the company's needs."

- **Other skills you have that you believe would benefit your workplace.**
  "We all tend to think our manifest talents are clearly visible to everyone around us. However, there's a good chance your boss doesn't know every skill you have," Grainger-Marsh says.

- **The achievements you're most proud of, and why.**
  Don't be a wallflower when it comes to talking about your accomplishments and what motivates you at work. "That side of you is what your manager needs to see and understand, so they have the best chance to provide you with the type of role and environment where you will thrive and add the most value," says Grainger-Marsh.

- **What you need in order to do your best work.**

  “We are all affected both positively and negatively by external factors like environment or management,” says Grainger-Marsh. “However, before you raise any requests for change, make sure you’ve looked at both sides.” Think about the difference between ‘must-haves’ and ‘nice-to-haves’.

- **The skills you want to gain and why.**

  It’s important to continue up skilling, and raising your desire to gain new skills with your manager shows you care about your work. However, you need to make sure the skills you want to develop are related to your role, and that they will benefit your workplace.

- **Which processes you think could improve, and how.**

  Performance reviews are great opportunities to provide feedback on processes that you feel could be refined, and doing so will show your manager that you’re proactive. Keep in mind, though, that not all things can be changed.

- **What you would like to achieve in the next 12 months.**

  As with the skills you want to gain, this is your chance to demonstrate your alignment to the business, says Grainger-Marsh. Try to find some common ground between what you want to do, and what the business is focusing on.

- **Conflict Resolution Strategies**
  - ✓ **Avoiding**

Someone who uses a strategy of "avoiding" mostly tries to ignore or sidestep the conflict, hoping it will resolve itself or dissipate.

- ✓ **Accommodating**

Using the strategy of "accommodating" to resolve conflict essentially involves taking steps to satisfy the other party's concerns or demands at the expense of your own needs or desires.

- ✓ **Compromising**

The strategy of "compromising" involves finding an acceptable resolution that will partly, but not entirely, satisfy the concerns of all parties involved.

- ✓ **Competing**

Someone who uses the conflict resolution strategy of "competing" tries to satisfy their own desires at the expense of the other parties involved.

- ✓ **Collaborating**

Using "collaborating" involves finding a solution that entirely satisfies the concerns of all involved parties.

- **What advisers can do?**

Depending on what needed advisers might

Serve as a sounding board	Test a tentative path	Expand the frame of reference	Provide process guidance	Generate substantive ideas
Restate and play back arguments to sharpen the seeker's understanding of the situation and the conclusions she has drawn	Scrutinize the reasoning behind the selection of an option and elaborate on the potential consequences	Provide greater breadth and depth of understanding about the nature of the problem the seeker faces—and the implications for action	Suggest how to approach and manage a complicated, delicate, or high-stakes situation	Increase the number and range of options being considered
KEY PRACTICES				
Asking a few well-chosen questions that probe the seeker's underlying rationale and motivation—and listening attentively	Assessing the seeker's thinking, often using hypotheticals and critical questions to achieve a deeper understanding	Sharing key details and tendencies from prior experiences in similar situations to flesh out the larger context	Examining the interests involved, the possibilities for action, and alternative steps the seeker might take	Brainstorming with the seeker

Figure 3: Tasks of advisers

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	Should mention to the work supervisor the difficulties encountered during the activity
	True or false:
2	Should not wait for the work supervisor validation of the definite solution to implement
	True or false:
3	Someone who uses a strategy of "**avoiding"** mostly tries to ignore or sidestep the conflict, hoping it will resolve itself or dissipate.
	True or false:

Information Sheet 5	Identifying and Accessing sources of materials

5.1 Introduction

This chapter gives advices on the identification and accessibility of the sources of materials.

5.2 Advices on identifying and accessing sources of materials

The following are advices for identifying and accessing sources of materials.

- Get informed on the established procedures if available;
- Make observation on the material to identify readable information;
- Read in a precise manner the information written on the nameplate if applicable; get to know of the manufacturer, the technical specifications etc.
- Refer to datasheets to locate all valuable information to comfort identifying and accessing sources of materials;
- Go to manufacturers websites and perform necessary research; download any feasible documentation;

5.3 The main sources are: producers and distributors.

- **Bibliographic sources include:**
  - ✓ resource lists and bibliographies.
  - ✓ bibliographic databases.
  - ✓ acquisitions bulletins.
  - ✓ book reviews and summaries.
  - ✓ sources of information for articles.
  - ✓ Blue Trunk Library lists.

- **Local sources of information include:**
  - ✓ colleagues in the same organization
  - ✓ resource center users
  - ✓ other organizations
  - ✓ research and development projects
  - ✓ training programmes
  - ✓ Book fairs, exhibitions and conferences.

- **Documentary information sources:**

PRIMARY		SECONDARY		TERTIARY
➢ Periodical ➢ Research Report ➢ Conference Proceedings ➢ Patents ➢ Standards ➢ Trade Literature ➢ Thesis	Condensation & Repackaging	➢ Indexing Services ➢ Abstracting Services ➢ Review of Progress ➢ Reference Works ➢ Treatises ➢ Monographs ➢ Text Books	Keys and aids to search	➢ Yearbooks and Directories ➢ Bibliographies ➢ Location list of periodicals ➢ List of Indexing and abstracting services ➢ Guides ➢ List of Research in progress ➢ Guide to professional organizations

Figure 4: sources of information

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	Making observation on the material to identify readable information is only useful in winter season
	True or false:
2	The solar module nameplate does not indicate the technical specifications
	True or false:

Information Sheet 6	Obtaining and checking tools, equipment and testing devices

6.1 Obtaining tools, equipment and testing devices

Obtaining the tools, equipment and testing devices is about having access to them. Table 1 contains a listing of the minimum tools and equipment and protective equipment which could be needed while working on a stand-alone renewable energy system. Generally, for an installation work or maintenance work the need arises to buy tools, main equipment and protective equipment.

Table 1: Main equipment, protective equipment and tools

Main equipment	Protective equipment	Tools (part 1)	Tools (part 2)
• Solar modules • Solar modules mounting structure • Inverters • Regulators • Batteries • Batteries supports • Cables • Junction boxes • Protection units	• Hard hat • Goggles • Ear muffs • Gloves • Safety boots • Body harness • Air mask • Emergency first aid kit • Fire extinguisher • Scaffolding • Guardrail • Other fall protection equipment	• Ladder • Cordless drill • Extension cord • Socket drivers • Drill • Philips driver bits • Chisel • Crimping • Line man's plier • Needle nose plier • Wire cutter • Screw driver set • Protractors • Watt and Watt-hour meters • Solar shading calculator • Graph paper	• Rope • Ratchet wrench • Electricians chalk line • Tool belt • Tape measure • Hammer • Cable knife • Clamp meter • Spirit level • Calculator • Compass • Digital multimeter • Power quality equalizer • Flashlights • Mirrors

For trouble shooting, the most useful tool is a multimeter that among other features can measure voltage and amperage. A lot of meters can handle AC without any issue but are limited when it comes to measuring DC. So when shopping for a meter for PV applications, look for one that, at a minimum, can measure both AC and DC voltage and current values. Also, make sure the meter has the ability to read DC levels that are high enough for the work you plan to do. It is recommended to choose a meter that can read at least 100 amps direct current (ADC). Many meters are limited to 10 ADC, which hinders the ability to measure many arrays.

6.2 Checking tools, equipment and testing devices

The following tables contain suggestions on the checking of the main equipment, PPE and tools and testing devices.

Table 2: Checking of the main equipment

Main equipment	Suggestions for the checking
Solar modules, solar modules mounting structure, inverters, regulators, batteries, batteries supports, cables, junction boxes protection units	Read the solar modules nameplates to ensure the maximum power; measure open circuit voltage and short-circuit current; check the conformity of the solar modules mounting; check and verify the specifications of the inverter, regulator, batteries, protection units etc.

Table 3: Checking of the protective equipment

Protective equipment	Suggestions for the checking
Hard hat, goggles, ear muffs, gloves, safety boots, body harness, air mask, emergency first aid kit, fire extinguisher , scaffolding, guardrail, other fall protection equipment	Check the technical specifications of the equipment and confirm if they are in line with the applicable health and safety measures and procedures; check if each equipment is well assembled with no missing or unstable part

Table 4: Checking of the tools and testing devices

Tools and testing devices	Suggestions for the checking
Ladder, cordless drill, extension cord, socket drivers, drill, driver bits, chisel, crimping, line man's plier, needle nose plier, wire cutter, screw driver set, protractors, W and Wh meters, solar shading calculator, graph paper, rope, ratchet wrench, electricians chalk line, tool belt, tape measure, hammer, cable knife, clamp meter, spirit level, calculator, compass, digital multimeter, power quality equalizer, flashlights	Check the technical specifications of the equipment and confirm if they are in line with the work and the applicable health and safety measures and procedures; check if each equipment is well assembled with no unstable part; make sure that the testing devices are recommended for the testing ahead

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	Checking the technical specifications of the equipment, tools and testing devices cannot impact work quality
	True or false:
2	The protective equipment are only requested while performing the installation of a stand-alone renewable energy system
	True or false:

LAP Test	Practical Demonstration

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

Task 1: You are taking part in the maintenance of a stand-alone PV system.

- Your first task is to investigate the potential risks and propose the risks control measures and procedures.
- Secondly, identify the nature of the apparatus problem from the available documentation. Lastly, you are requested to check and confirm the conformity of the used tools and testing devices.

Solar PV System Installation and Maintenance

Level IV

Learning Guide -23

Unit of Competence	**Solve Problems in Stand-Alone Renewable energy Systems**
Module Title	**Solving Problems in Stand-Alone Renewable energy Systems**
LG Code	**EIS PIM4 M06 LO2-LG23**
TTLM Code	**EIS PIM4 TTLM 0920v1**

LO2: Solve problem in stand-alone renewable energy systems

Instruction Sheet	Learning Guide-23

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 work measures and procedures
- Determining the need to test or measure live
- Checking circuits as being isolated
- Using established routines to solve stand-alone PV systems problems
- Solving problem without damage to apparatus, circuits

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 work measures and procedures
- Determine the need to test or measure live
- Check circuits as being isolated
- Use established routines to solve stand-alone PV systems problems
- Solve problem without damage to apparatus, circuits

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1. Read the specific objectives of this Learning Guide.
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Information Sheet 1	Following OHS risk control work measures and procedures

1.1 Introduction

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

1.2 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 followed and implemented in each and every aspects of stand-alone PV system installation or maintenance. 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.

1.3 Following 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 and followed in time. The objective is to minimize the risk and there isn't two ways about it than concretising the control measures according to the needful.

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 and answers
1	Noting and identifying risk control measures is not relevant in the context of small stand-alone PV system installation
	True or false:
2	Following noted and identified risk control measures is relevant in the context of large scale stand-alone PV system maintenance
	True or false:

Information Sheet 2	Determining the need to test or measure live

2.1 Introduction

This chapter gives details on the need of testing or measuring live solar panels and strings while exposed to sunlight, within established safety procedures.

2.2 Requirement of live measuring

It might be required to test a live solar panel or a string of solar panels in the situation where one would like to know the real time produced current and voltage, therefore the produced power. It can be other equipment such as charge controller, inverter, battery etc. Considering the case of a single solar panel, it is usually the need to measure its open circuit voltage and short-circuit current in order to compare the corresponding values to those provided by the manufacturer. This enables the installer to evaluate or confirm the quality of the product in terms of technical characteristics/specifications. Some of the parts which can be tested or measured live are:

- the positive and negative connections of a solar cell/solar panel;
- the resulting positive and negative connections of a group of series/parallels connected solar cells/solar panels;
- the positive and negative connections of a battery or group of batteries;
- the arriving/departing cables at a DC combiner box;
- the arriving/departing cables at an AC combiner Box etc.

2.3 Live measuring procedures

For most measuring procedures a multimeter or a clamp meter is used. Figure 1 depicts the basic anatomy of a multimeter.

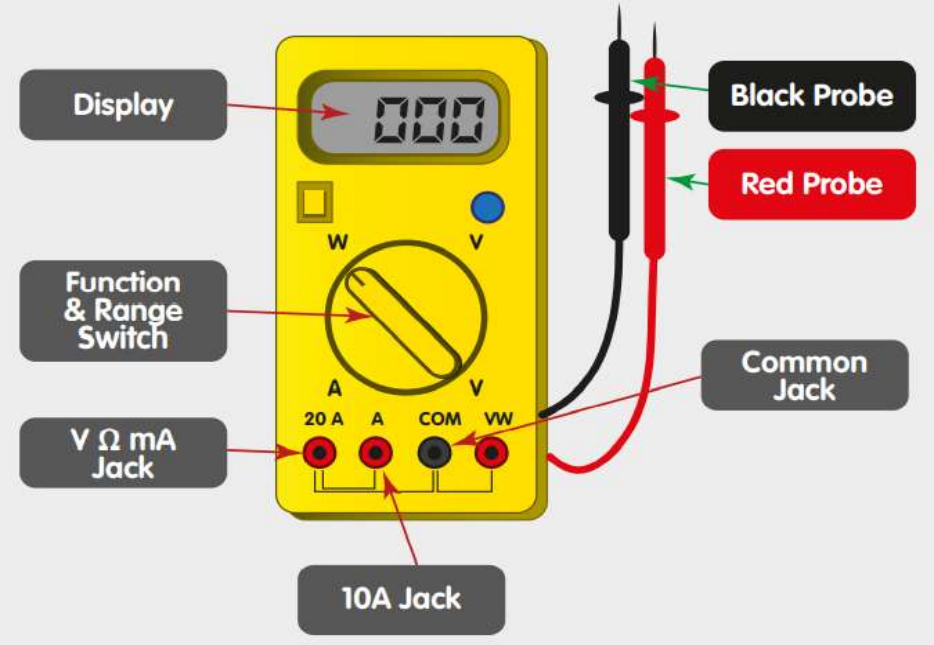


Figure 5: Basic anatomy of a multimeter (SNV, 2015)

When a solar panel is manufactured, it is tested to ensure it meets the required standards. There are two important parameters to be considered during testing. Among the parameters is the short-circuit current, which is the current measured when the solar panel terminals (positive and negative) are connected together and there is no load, while the solar panel is exposed to the sunlight. Figure 2 shows an example of such measurement.

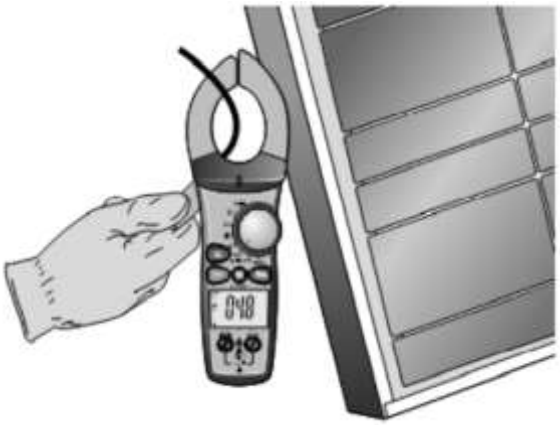


Figure 6: Solar panel measurement: short-circuit current

The open-circuit voltage is the voltage across the negative and positive terminals of the solar panel when it is not connected to any load. Figure 3 shows a descriptive demonstration on how to proceed. The figure shows how to hold the multimeter.

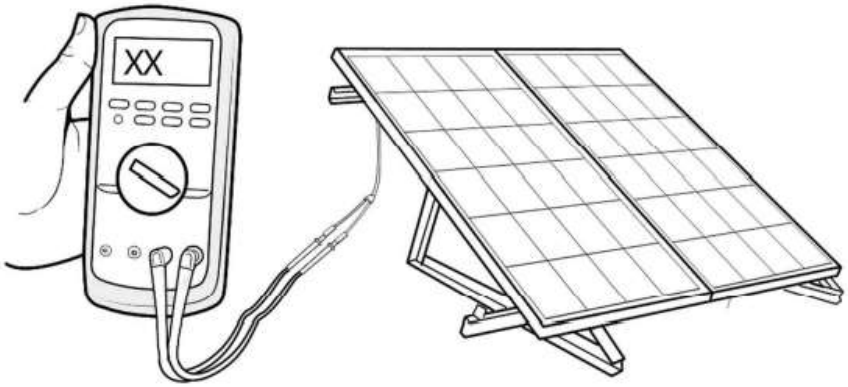


Figure 7: Solar-panel measurement: open-circuit voltage

The similar principle can be applied on a battery for measuring its charge level as depicted in Figure 4. Different voltage levels will refer to different battery state of charges (SOC), therefore, one should refer to the manufacturer datasheet to better understand the battery SOC.

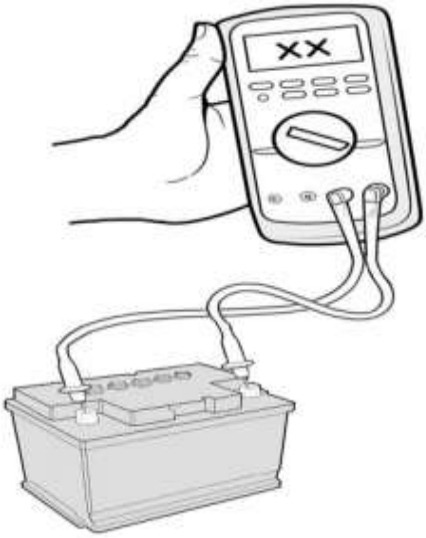


Figure 8: Measuring battery charge level

For the live electrical testing of a solar module, one should expose the module to the good intensity sun light before measuring the DC voltage for example. For this, the selector knob of the multimeter should be adjusted to the position indicating an appropriate measuring range. For a single solar panel this would be typically a range of more than 20V DC for example. Orient the module to the clear sky sun light and connect the positive (+) terminal of the module to the positive terminal of the multimeter and negative (-) terminal to the respective negative terminal. Make the necessary measurement, knowing that if the solar module is damaged, it will not indicate the appropriate voltage and in such case the module needs to be changed. Figure 5 shows a typical example of a solar module voltage measurement at the solar panel junction box.

Figure 9: Measurement of solar module voltage

Figure 6 shows the back of module showing leads from junction box, where the mutlimeter is usually connected to conduct measurements. But: if the junction box of a solar panel is sealed, which is usually the case for new solar panels, do not open it. The junction box will not be waterproof anymore and warranty claims will be lost. All measurements can be done at the cable ends or plugs instead.

Figure 10: Back of module showing leads from junction box (Hankins, 2010)

Typically, you measure DC current on a single module when you suspect that the module is not working properly or on an array when you want to verify the proper power output. Wiring diagrams of the PV array help to identify the different strings, calculate the expected voltage output and narrow down the area of a potential fault. On the AC side, if you suspect that the inverter is under producing, you need to check the AC current levels. Another common scenario for checking current on the AC side is to see what an individual load is pulling; this information can be especially useful in battery-based systems where you need to know how many amps each load needs.

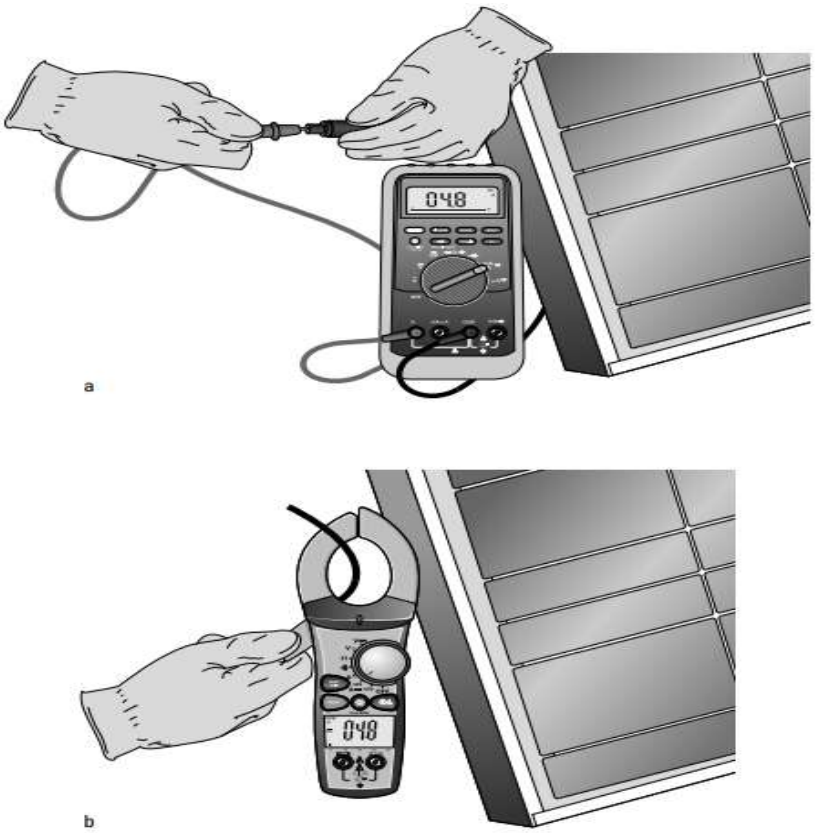


Figure 11: The use of inline and clamp meters

It is recommended using a clamp meter when measuring current. Here's how to properly use one:

- Put on personal protective equipment (PPE) such as insulating gloves and safety glasses.
- Verify that you can safely place the meter's clamp around the conductor you want to measure.
- Set the meter's dial to read the appropriate range of DC current.
- Zero the meter reading.
- Open the meter's clamp and place it around a single conductor
- Read and record the current value from the meter.

Importantly, never use an amp meter to connect the two terminals of a battery. At best, you will ruin both objects by creating a short circuit between the two terminals. At worst, you will place yourself in unnecessary danger. Figure 8 shows a typical digital multimeter that has been set up for reading DC voltages on a PV module.

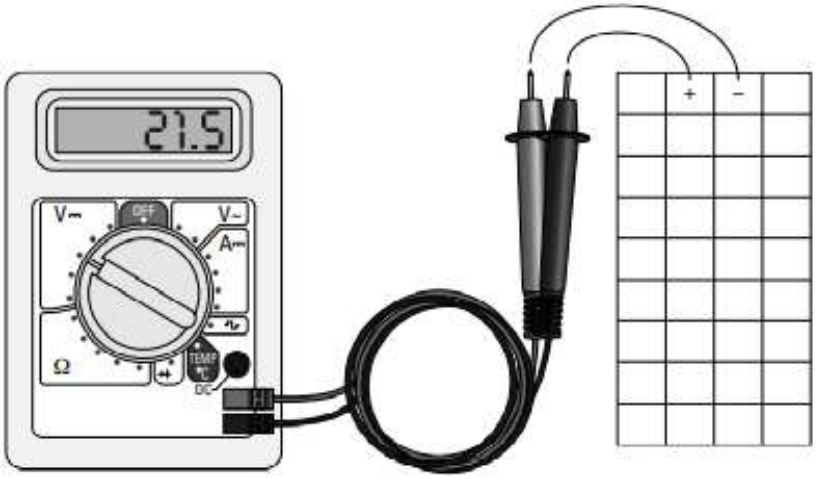


Figure 12: Measuring a PV module voltage with a digital multimeter

- **To make the voltage measurement:**
  - ✓ Put on personal protective equipment (PPE), including insulating gloves and safety glasses.
  - ✓ Make sure the disconnects are in the off position
  - ✓ Make the location where you want to take the voltage measurement accessible by removing the lids to the proper boxes, opening disconnect covers, or accessing the connectors on the backs of the modules
  - ✓ Place the black meter lead in the connection point labelled Common on the meter.
  - ✓ Place the red meter lead in the connection point labelled *V* on the meter
  - ✓ Set the meter's dial to read the appropriate range of DC voltage.
  - ✓ Place the black lead on the negative terminal for the PV module.
  - ✓ Place the red lead on the positive terminal for the PV module.
  - ✓ Read the voltage measurement on the meter's screen
  - ✓ Switch the meter leads on the PV module and note the presence of the negative symbol.
  - ✓ Remove the leads from the module and pull them from the meter.

To use a digital multimeter to measure resistance and check continuity between various components, follow these steps:

- ✓ Put on personal protective equipment (PPE) such as insulating gloves and safety glasses;
- ✓ Switch the AC and DC disconnects to the off position to remove any power sources present;
- ✓ Make the location where you want to take the continuity measurement accessible;
- ✓ Place the black meter lead in the connection point labelled Common on the meter;
- ✓ Place the red meter lead in the connection point labelled Ω;
- ✓ Set the meter's dial to read the circuit's resistance;
- ✓ Place the black lead on the first connection point;
- ✓ Place the red lead on the second connection point;
- ✓ Read the resistance measurement on the meter's screen or listen for the alarm that indicates a low-resistance connection;
- ✓ Remove the leads from the module and pull them from the meter.

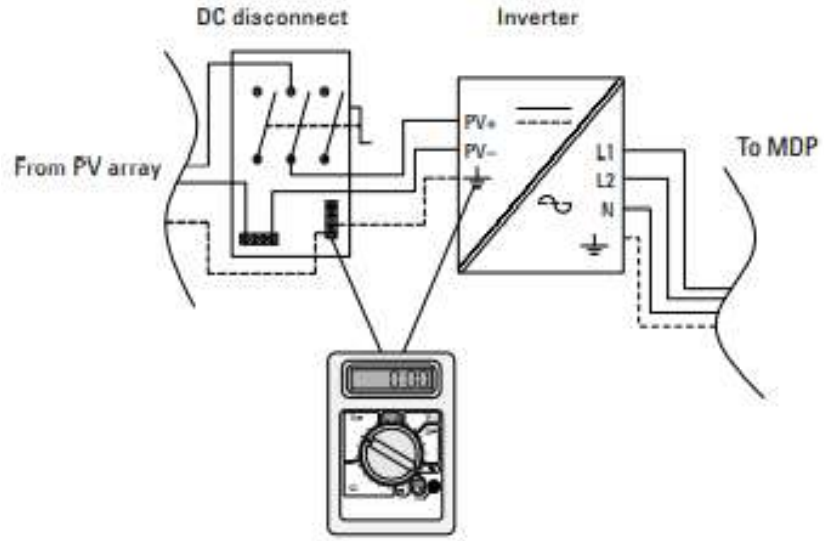


Figure 13: Measuring resistance with a digital multi meter

2.4 Limiting hazards during live measurements

Depending on different factors, e.g. the size of the PV system, solar insolation and the length of the strings in the array measuring, the live measuring of PV systems can be dangerous.

The following safety rules should be obeyed:

- It is recommended to ensure that only fully licensed electricians who have been inducted into an installer's safety program are undertaking licensed work;
- It is recommended to 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;
- It is recommended to participate in the risk assessment of possible hazards at the start of each maintenance activity;
- 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.

2.5 OHS during live measuring

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 while testing or measuring live. Tests and measurements can be done in many ways. It is therefore essential to 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.

Table 5: 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 • Falling from ladder • Falling through ceiling space	• Trauma • Broken bones • 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 • Exposure to poor air quality such as fiberglass, coal dust, lead dust and other harmful substances • Exposure to loose-fill asbestos • Exposure to extreme heat • Falling, trips • Vermin, snakes, spiders and insects	• Electric shocks, electrocution • Respiratory disease • Cancer • Mesothelioma, asbestosis • Exhaustion, fatigue, heat stress • Trauma, broken bones • Stings, bites and disease • Death • 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: • a respirator • a head covering and goggles, to avoid eye irritation • long-sleeved, loose-fitting clothing and gloves

Table 6: 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 • Accidental short circuit	• Electric Shocks, electrocution • Arc flash, burns • Death	**Isolate:** Lockout Tagout. Test for de-energised (DEAD) Do not work energised
			Admin: Current LVR/CPR training **PPE:** Wear arc rated neck to wrist to ankle clothing with a minimum ATPV of 4cal^{m2}. Wear protective glasses and gloves
Working outdoors	• Exposure to the sun	• Sun burn, skin cancer • 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 Increasing amount of shade available – use gazebos
			PPE: Slip on clothing, slop on SPF 30+ sunscreen, slap on a hat, slide on sunglasses. 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

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	It is recommended to 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;
	True or false:
2	It is not important to control the hazards linked to working with and installing and maintaining electrical equipment, working outdoors etc.
	True or false:

Information Sheet 3	Checking circuits as being isolated

3.1 Introduction

This chapter gives tips on how to check circuits as being isolated.

3.2 Isolating circuits

Depending on the task ahead many circuits can be isolated in a PV system. For instance, the following circuits can be isolated:

- The batteries circuit
- The incoming and output inverter circuits
- The DC combiner circuit
- The AC combiner circuit
- The solar panel wiring circuits

- **The strategies of isolating all of the above circuits are as follows:**
  - ✓ The batteries circuit : follow the battery manufacturer recommendations to switch off the cable(s) that are responsible of charging the batteries from either the charge controller or directly from the suitable/compatible inverter;
  - ✓ The incoming and output inverter circuits: take off the output cable(s) from the DC combiner box; the corresponding cables are the one(s) which enter the input(s) of the inverter;
  - ✓ The DC combiner circuit : switch off the DC current/voltage from the solar panel by disconnecting the dedicated cable(s);
  - ✓ The AC combiner circuit : switch off the electricity arrival from the inverter;
  - ✓ The solar panels wiring circuits: proceed with a step by step switching off of series of grouped solar panels to limit fire hazard; in case of small system it is recommended to cover up the surface(s) of the modules for ensuring a low output and then freely/strategically proceed to switching off the array.

3.3 Checking isolated circuits

The following are tips to check circuits as being isolated.

- Clearly identify OHS requirements and procedures for working at heights;
- Clearly identify OHS requirements and procedures for working on specific electrical equipment;
- Check the solar modules circuits to ensure conformity; when connected in string PV voltage must sum up, one should check data sheet for voltage of a single panel to see if it matches total voltage;
- Check inverter circuits to ensure conformity:
  - ✓ input voltage and output voltage alongside the corresponding currents can be measured effectively;
  - ✓ The earthing can be also measured to evaluate the system resilience to electrical hazards.
- Check the batteries circuit to make sure the wiring is correct;
  - ✓ Twelve volt batteries in 12V systems are arranged in parallel. If there are two 12V batteries in a 24V system, they should be arranged in series. If there are four 12V batteries in a 24V system, two should be in series and two should be in parallel as shown in Figure 11.
  - ✓ Make sure the connection is made according the wiring chart
- Check the charge controller to make sure its circuit is correct; for the circuit to be correct the input and output voltages should be within the manufacturer specifications, therefore the necessary measurements will help to conclude in this regards.
- Check the protection units and junction boxes for conformity purpose; normally, the protection units ought to respond to fault if and only if there is a presence of fault urging the corresponding protection units to trigger and isolate the faulty area/portion.
- Check all the cabling routing to make sure everything is of quality, i.e. verify if the insulation, labelling, cable channels are well done add to the fact that there should be no loose ends.

Figure 14: Battery terminal connections

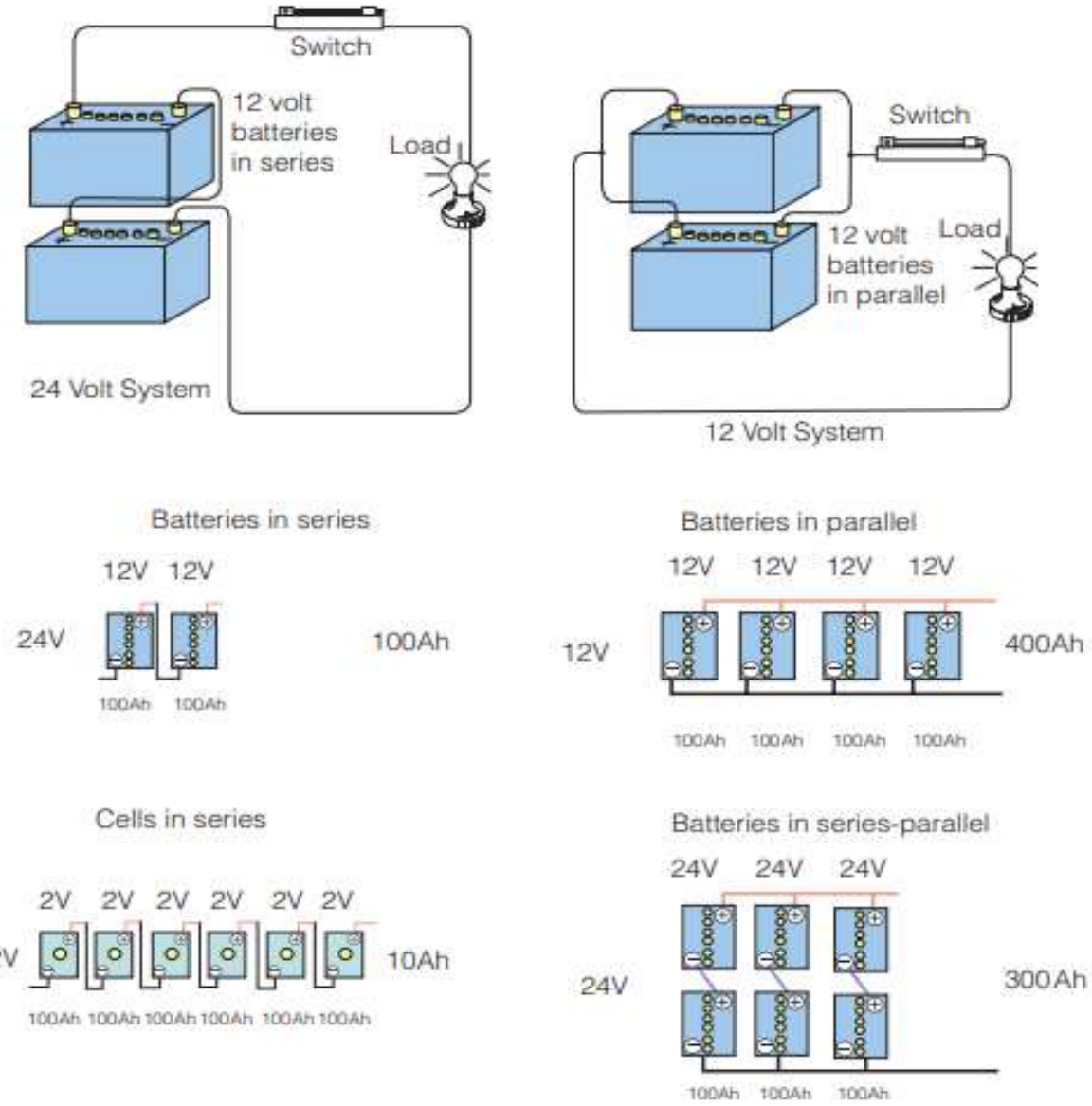


Figure 15: Parallel and series battery configurations (12 V, 24 V)

Figure 16: A 48 V battery bank for a mini-grid in Kenya consisting of a string of eight, six-volt batteries arranged in series

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	Should check the solar modules circuits to ensure conformity only when it is raining
	True or false:
2	Should check the protection units and junction boxes for conformity purpose only for small stand-alone PV system
	True or false:

Information Sheet 4	Using established routines to solve stand-alone PV systems problems

4.1 Introduction

This chapter states some established routines to solve stand-alone PV systems problems. Once the solar electric system is in place, it should give you many years of untroubled Service. If it does not, one needs to troubleshoot the system to find out what is going wrong and why. The problems should be solved without damaging the circuits and apparatus.

4.2 Keeping safe

All the safety warnings that go with installation also relate to troubleshooting. Solar arrays will generate electricity almost all the time (except in complete darkness), however batteries do not have an ‘off’ switch. That means an installer has to be careful and keep in mind OHS whenever dealing with solar systems or components, even though they appear to be not working anymore.

4.3 Common faults

There are different types of faults that can occur in solar PV systems. Some result from the way of installation, others from usage or from other influences over time. The main categories for causes for faults or problems in the system are the following:

- Component failure
- Installation faults
- Ageing/failures over time
- Too much power usage
- Insufficient generation
- Permanent external factors: rodents, weather damage (storms, hail)
- Temporary external factors: weather conditions, shade

- **Faults that are typically found are the following:**
  - ✓ Excessive power usage – i.e. you are using more power than you anticipated
  - ✓ Insufficient power generation – i.e. you are not generating as much power as you expected
  - ✓ Damaged wiring/ poor connections
  - ✓ Weak batteries
  - ✓ Obstructions (shading)
  - ✓ Faulty earth (ground)
  - ✓ Inverter faults.

4.4 Excessive power usage

This is the most common reason for solar electric systems failing, where the original investigations underestimated the amount of power that was required. Almost all solar controllers provide basic information on an LCD screen that allows you to see how much power you have generated compared to how much energy you are using, and shows the amount of charge currently stored in the battery bank. Some solar controllers include more detailed information that allows you to check on a daily basis how your power generation and power usage compares.

Using this information, you can check your power drain to see if it is higher than originally expected. If you have an inverter in your system, you will also need to measure this information from your inverter. Especially in off-grid PV system, the failure comes from users who do not understand PV system principle and functioning. Therefore, it is important for the PV installers to brief the users at the end of the installation. The functioning of the system should be properly explained to the clients for them to understand the essential things to care about and apply the suited action when it is required.

Basically, the clients or users should understand that they need to observe the health of their PV system and what actions to take when they observe the battery SOC going below the critical value. This also requires understanding of the basic working principle of the system, where the energy comes from and why it is not good to use more devices than initially agreed

before system sizing. It should be explained to the client that the battery makes it possible to store the solar energy to use it also at night. But the battery is quite sensitive so there are some rules to follow to keep the battery working and prevent from losing capacity. What is most important is the fact, that the battery always needs a certain amount of energy in it to stay alive.

As soon as the battery is completely empty it is not possible to charge it again, the battery is destroyed forever. In general, the deeper the battery is discharged the shorter the lifetime and the lower the capacity gets. So for a lifetime of about 5 years it is minimum necessary not to discharge the battery more than 50 % ever. A minimum State of Charge (SOC) of 50% is the most economic option.

There are three choices:

- Reduce the power load
- Increase the size of your solar array
- Add another power source (such as a fuel cell, wind turbine or generator) to top up your solar electric system when necessary.

4.5 Insufficient power generation

For a newly installed stand-alone PV system you should not have a problem with insufficient power generation. However, over a period of a few years, the solar panels and batteries will degrade in their performance (batteries more so than the solar panels), whilst new obstructions that cut out sunlight may now be causing problems.

You may also be suffering with excessive dirt on the solar panels themselves, which can significantly reduce the amount of energy the solar array can generate. Pigeons and cats are the worst culprits for this. Your site may have a new obstruction that is blocking sunlight at a certain time of day. For example, a tree that has grown substantially since you carried out the original site survey. Alternatively, you may have made a mistake with the original site survey and not identified an obstruction. Unfortunately, this is the most common mistake made by inexperienced solar installers. It is also the most expensive problem to fix, especially when the system consists of more than one PV module. This is why carrying out the site survey is so

important. To identify if your system is not generating as much power as originally expected, check the input readings on your solar controller to see how much power has been generated by your solar panels on a daily basis. If your solar controller cannot provide this information, use a multi-meter with data logger to record the amount of energy captured by the solar panels over a three-to-five day period.

Figure 17: Dusty solar panels being washed

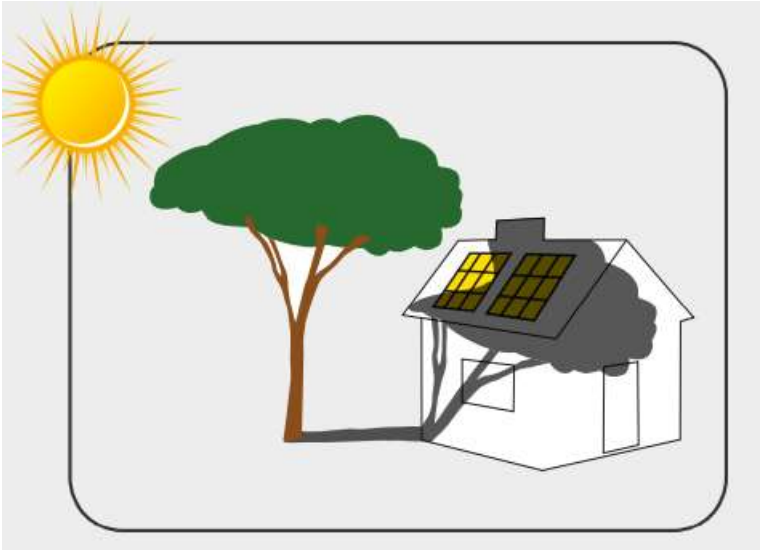


Figure 18: Growing tree shading on PV array

4.5.1 Solutions to solve insufficient power generation

If you have identified that you are not generating as much power as you should be, start by checking your solar array. Check for visible damage on the solar array. Look for cracked panels or burnt cells or any other unusual condition. The next step is to check if the PV modules are dirty. If there is dirt, bird droppings or dust, give the array a good wash with warm water, a soft cloth and a squeegee to remove excess water. The washing should only be done early in the morning when the modules are still cool. Washing them in the heat of the day might cause the panels to crack because of the temperature difference of the water. Important: do not lean or kneel on the panels during washing. That causes micro-cracks in the module which make the performance even worse.

Before starting the cleaning, read the module manual. Every manufacturer has his own requirements. Not following the instructions in the manual might break the module or reduce the efficiency and the warranty will be lost. Check all the wiring. Make sure that there is no unexplained high resistance in any of the solar panels or on any run of wiring. It could be a faulty connection or a damaged cable that is causing the problems. Carry out another site survey and ensure there are no obstructions between the solar array and the sun. Double-check that the array itself is in the right position to capture the sun at solar noon. Finally, check that the array is at the optimum angle to collect sunlight.

If you are experiencing these problems only at a certain time of the year, it is worth adjusting the angle of the solar panel to provide the maximum potential power generation during this time, even if this means compromising power output at other times of year. Check the voltage at the solar array using a multi-meter. Then check again at the solar controller. If there is a significant voltage drop between the two, the resistance in your cable is too high and you are losing significant efficiency as a result. This could be due to an inadequate cable installed in the first place, or damage in the cable. If possible, reduce the length of the cable and test again. Alternatively, replace the cable with a larger and better quality cable. If your solar panels are working as they should (verify with data sheet and design) but there is still not enough power, you have three choices:

- Reduce your power load ;

- Increase the size of your solar array ;
- Add another power source (such as a fuel cell, wind turbine or generator) to top up your solar electric system when necessary.

If the solar array is underperforming but you cannot identify the fault, it might be degradation of the panels. Solar modules lose efficiency over time that means they produce less power. In cheaper quality modules this process usually happens faster than in good quality panels. If more power is needed the options are to expand the system or to replace the modules.

4.6 Damaged wiring/poor connections and solutions

If you have damaged wiring or a poor connection, this can have some very strange effects on your system. If you have odd symptoms that do not seem to add up to anything in particular, then wiring problems or poor connections are your most likely culprit.

Examples of some of the symptoms of a loose connection or damaged wiring are:

- A sudden drop in solar energy in very warm or very cold weather. This is often due to a loose connection or damaged wiring in the solar array or between the solar array and the solar controller;
- Sudden or intermittent loss of power when you are running high loads. This suggests a loose connection between batteries, or between the batteries and solar controller or inverter;
- Sudden or intermittent loss of power on particularly warm days after the solar array has been in the sun for a period of time. This suggests a loose connection somewhere in the array, a damaged panel or high resistance in a cable;
- Significantly lower levels of power generation from the solar array suggest a loose wire connection or a short circuit between solar panels within the array
- A significant voltage drop on the cable between the solar array and the solar controller suggests either an inadequate cable or damage to the cable itself;
- Likewise, a significant voltage drop on the cable between the solar controller and your low-voltage devices suggests an inadequate cable or damage to the cable itself;
- If you find a cable that is very warm to the touch, it suggests the internal resistance in that cable is high. The cable should be replaced immediately;

Unfortunately, diagnosing exactly where the fault is can be time-consuming. You will require a multi-meter, a test light and plenty of time. Your first task is to identify which part of the system is failing. A solar controller that can tell you inputs and outputs is useful here. The information from this will tell you whether your solar array is underperforming or the devices are just not getting the power they need.

Once you know which part of the system to concentrate on, measure the resistance of each cable using the ohm setting on your multi-meter. If the internal resistance is higher than you would expect, replace it. If any cable is excessively hot, replace it. The problem could be caused either by having an inadequate cable in the first place (i.e. too small) or by internal damage to the cable. Next, check all the connections in the part of the system you are looking at. Make sure the quality of the connections is good. Make sure that all cables are terminated with proper terminators or soldered. Make sure there is no water ingress.

4.7 Weak battery and solutions

The symptoms of a weak battery are that either the system does not give you as much power as you need, or you get intermittent power failures when you switch on a device. In extreme cases, a faulty battery can actually reverse its polarity and pull down the efficiency of the entire bank. Weak battery problems first show themselves in cold weather and when the batteries are discharged to below 50–60% capacity. In warm weather, or when the batteries are charged up, weak batteries can quite often continue to give good service for many months or years. If your solar controller shows that you are getting enough power in from your solar array to cope with your loads, then your most likely suspect is a weak battery within your battery bank, or a bad connection between two batteries. Start with the cheap and easy stuff. Clean all your battery terminals check your battery interconnection cables, make sure the cable terminators are fitting tightly on the batteries and coat each terminal with a layer of petroleum jelly in order to ensure good connectivity and protection from water ingress. Poor battery connections cause voltage drop, heat and sparking. Sparking will quickly destroy the battery connector. A case of poor battery connection is depicted on the left in Figure 13 compared to battery good connection on the right.

Figure 19: Poor connection (left), good connection (right)

Then check the water levels in your batteries (if they are 'wet' batteries). Top up as necessary. If, however, you are seeing a disparity on one battery of 2 volts or over, it is likely that you have a failed cell within that battery. You will probably find that this battery is also abnormally hot. Replace that battery immediately. If your solar controller has the facility to balance batteries, then use this. If not, top up the charge on the weaker batteries, using an appropriate battery charger, until all batteries are reading a similar voltage.

If you are still experiencing problems after carrying out these tests, you will need to run a load test on all your batteries in turn. To do this, make sure all your batteries are fully charged up, disconnect the batteries from each other and use a battery load tester (you can hire these cheaply from tool hire companies). This load tester will identify any weak batteries within your bank. For instance, a visual inspection should be done to assess the general condition of the system's batteries. Check for any electrolyte leak, cracks in the batteries, or corrosion at the terminals or connectors. Batteries should be clean, dry and free of electrolyte and corrosion residue. Corrosion at battery terminals is seen as a white coating around the battery terminals. Cleaning should be done at least once monthly. Batteries should be located in a cool, vented room. Figure 18 shows a recommendable situation of battery location.

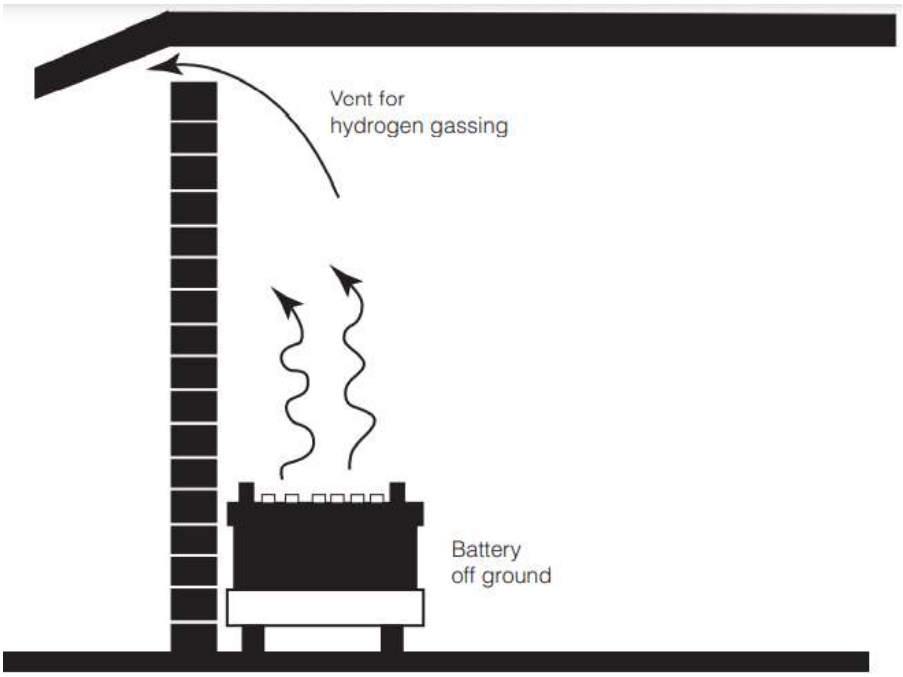


Figure 20: The battery should be located in a place that is well ventilated – including roof spaces – to make sure that hydrogen gas cannot build up between ceilings and roofs

Here are some general guidelines for locating and installing the batteries, but for large battery banks (two or more units) the battery installation manual should be referred to.

- Nearness to array: batteries should be located as close as possible to the array to reduce voltage drop. The cable is generally sized large enough to carry the charge current from the module with 2 per cent or less voltage drop;
- Ventilation: the battery room must have some sort of opening for air to enter and leave. Batteries emit explosive gases when charging and this must be allowed to escape. Place a 'No Smoking or Naked Flames' sign in the room where the batteries are located;
- Accessibility: batteries should be accessible for easy state-of-charge measurement and cleaning, but only to authorized persons;
- Temperature: batteries should be located in a cool place. If battery temperature gets above 40°C (104°F), its lifetime and performance will be reduced. Never place a battery where it will be exposed to the sun;

- Battery boxes: batteries should not be placed directly on the floor as moisture or accidental puddles can increase their self-discharge rates. They should be kept in a vented box to prevent children and animals from injuring themselves and to prevent accidental short circuits;
- Security and safety: locate batteries where they are secure and not likely to be stolen. A closet or room where children and animals cannot tamper with it might be suitable for a battery box containing two batteries. Battery boxes or rooms should be locked, but always ensuring that the key is nearby for quick access;

4.8 Changing batteries

If all your batteries are several years old and you believe they are getting to the end of their useful lives, it is probably worth replacing the whole battery bank in one go. Badly worn batteries and new batteries do not necessarily mix well, because of the voltage difference. If you mix new and used, you can easily end up with a bank where some of the batteries never fully charge up. If you have a bank of part-worn batteries and one battery has failed prematurely, it may be worth finding a second-hand battery of the same make and model as yours. Many battery suppliers can supply you with second-hand batteries. Not only are they much cheaper than new, but because the second-hand battery will also be worn, it will have similar charging and discharging characteristics to your existing bank, which can help it bed down into your system. If you cannot find a part-worn battery, you can use a new one, but make sure you use the same make and model as the other batteries in your bank. Never mix and match different models of batteries, as they all have slightly different characteristics.

If you add a new battery to a part-worn bank, you may find the life of the new battery is less than you would expect if you replaced all them. Over a few months of use, the performance of the new battery is likely to degrade to similar levels to the other batteries in the bank. Before changing your battery, make sure that all of your batteries (both new and old) are fully charged. Put a label on the new battery, noting the date it was changed. This will come in useful in future years when testing and replacing batteries. Once you have replaced your battery, take your old one to your local scrap merchants. Lead acid batteries have a good scrap value and they can be 100% recycled to make new batteries.

4.9 Inverter issues

The symptoms of inverter issues can include:

- Buzzing or humming sounds from some electronic equipment when powered from the inverter;
- Failure of some equipment to run from the inverter;
- Regular tripping of circuits;
- Sudden loss of power;

If you are experiencing buzzing or humming sounds from electronic equipment when powered from the inverter, or if some equipment is not running at all, it suggests that the inverter is not producing a pure AC sine wave. If you have a stand-alone system and have purchased a modified sine wave inverter (or quasi-sine wave), it may be that you cannot resolve these issues without replacing the inverter. Some electronic equipment, such as laptop computers and portable televisions, may not work at all using a modified sine wave inverter, whilst other equipment will emit a buzz when run from these inverters. If you have sudden and unexplained tripping of circuits when running from an inverter, or experience sudden loss of power, there are a number of things to check:

- Does the tripping occur when a heavy-load appliance such as a fridge switches itself on or off?
- Does the tripping occur when the inverter cuts in at the start of the day or when it cuts out at the end of the day?
- Does the tripping occur more often on very warm days or after heavy rain?

Unfortunately, circuit tripping and sudden power loss often only occurs when a combination of events occur, which can make diagnosis time-consuming and difficult to get right. The most common reasons for circuit tripping or sudden power loss are temperature related issues. Inverters can generate a huge amount of heat. The hotter they get, the less power they produce. If the inverter is running too hot, a sudden peak demand can be enough to shut the inverter down momentarily. If the inverter runs too hot for too long, it will shut down for a longer period of time in order to cool. If this is the case, you are going to have to provide your inverter with more ventilation.

If you cannot keep it cool, it may also mean that you require a more powerful inverter in order to cope with the load. If the issue occurs during sudden rain or on very hot days, you may also have a grounding problem. Check the inverter with a PAT tester to ensure that you are not getting a ground leakage from the inverter itself. If you are, check all the connections from the DC input of your inverter.

4.10 Involving the client in the problem solving process

The client can contribute a lot to solving power usage problems when he or she is suitably trained for specific situations. When handing over the PV system, the client should be briefed on how to treat the system during operation and how to deal with problems. The advantage is that he will have to call the installer only when it is necessary, e.g. when the generation goes down despite of good maintenance through the client.

A basic task that the client must perform, especially in smaller solar home systems is to observe the battery levels. The charge controller usually shows how much energy is in the battery. In Figure 14 is an overview of what to do in different situations, it is taken from a handbook that was provided to a client. The LCD display shown is from a Steca PR3030 charge controller but other models use a similar principle to display the state of charge. Generally, the client should switch off the system when below 30% battery. If the problems occur more often, it will be helpful if the client keeps a diary of the daily battery status in the morning and evening, observe the batteries to notice any visible unusual situations.

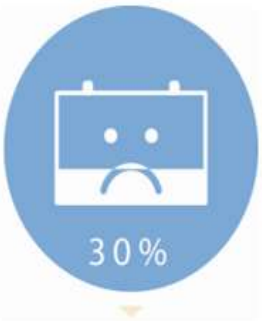
What the display of the Charge Controller shows	How the State of Charge of the battery is	What to do
		Fully loaded! You can connect your consumers, and take out energy.
		At 50 % State of Charge (SOC) you should stop consuming energy in order not to let the amount get even lower. If it is day, make sure that the module is in the sun and sun is shining. When the battery is charging by strong sunshine and the amount is not decreasing you can keep on consuming.
		Critical point. Disconnect all devices and switch off the inverter! If you keep on taking out energy the battery will be seriously destroyed. For the future the capacity will be much lower than before. Put the module in the sun and save your battery by charging it immediately.

Figure 21: Checking charge controller screen

To reduce shading on PV modules the client should frequently cut grass and/or trees. Also, the client should clean the panels on a regular basis. The cleaning procedure is described in the previous chapter 4.5. At least once a week the client should check if there is the need for cleaning. The frequency of cleaning depends on the location of the system and if there is a lot of dust, rain, or anything nearby that causes pollution in the air. The client can also clean the batteries from dust, disconnect the loads to prevent fire hazards. However, a training is needed for telling the clients when and how to act.

The more clients and installer has, the higher the volume of problem reports. It can become very difficult to deal with all the requests especially when the systems are installed in remote areas and when the people do not have the money to pay a technician to drive to them and check the system. It is recommendable to provide the clients with a handbook with instructions how to deal with problems so that they can prevent or solve as many as possible by themselves. In case the system is not working anymore there are many possible reasons. What you should do is:

- Keep calm and try to identify the problem. Which component is not working?
- If it is the inverter, what is the problem?
- If the red light is on or if it makes sounds there could be connected consumers with a total power over 600W or it could be overheated. Switch the inverter off, disconnect all consumers, wait 15 minutes until it cools down. Then try again if it works.
- If it does not work again, if neither the red nor the red light on the inverter is on despite it is switched on or if there is a problem with any other component call the installer for assistance.

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	The following are common faults in stand-alone PV system: faulty earth, excessive power usage, insufficient power generation, damaged wiring, poor connections, weak batteries etc.
	True or false:
2	Reducing power load and increasing the size of the solar array cannot solve insufficient power generation
	True or false:
3	The client can contribute a lot to solving power usage problems when he or she is suitably trained for specific situations.
	True or false:

Information Sheet 5	Solving problem without damage to apparatus

5.1 Recommendations

In order to solve problems without damage to apparatus one should consider the following recommendations:

- Clearly identify the problem to be solved;
- Clearly define the step by step procedure towards solving the problem;
- Request help from others when there is need to carry loads and wiring apparatus;
- Read the datasheet of the apparatus to know the manufacturer technical specifications to consider while performing installation or maintenance actions;
- Take safety measures around each element/equipment to avoid damaging them by falling work tools;
- Avoid making use of water or any other liquid substance around electrical apparatus;
- For delicate maintenance always take advice from the workers who conducted the installation in case no maintenance reporting document is available for reference.

5.2 Problems with solar modules

Table 7 reports some problems related to solar modules in a stand-alone PV system with justification of applicable solutions.

Table 7: Problems with solar modules and solutions

Problem	Causes of the problem (justification of the solution)	The solutions
Low output current	Presence of dust	Cleaning the modules
	Shading	Remove the cause of the shading
	Poorly oriented or tilted modules	Change orientation / tilt
	Some connections broken or corroded	Repairing connections
	Bypass diodes failure	Change of faulty bypass diodes
	Some damaged or faulty modules	Replacement of faulty modules
	Insufficient lighting	Wait for the sun to appear

No output current	Faulty connections The bypass diodes are short-circuited	Resume connections Change the bypass diodes or remove them (in the case of 12 or 24 V systems)
Low open circuit voltage	A bypass diode is short-circuited	Replace or remove the bypass diode (12 V or 24 V systems)
Broken glass	Vandalism or shock	Modules still functional but risk of power loss due to corrosion Change the module to an equivalent model

5.3 Problems with charge controller and battery and solutions

Table 8 reports some problems related to charge controller and battery in stand-alone PV system with justification of applicable solutions.

Table 8: Problems with charge controller and battery and solutions

Problem	**Causes of the problem (justification of the solution)**	**The solutions**
The charge controller does not work	Reverse PV field connection No fuse	Reverse connection Insert a correctly sized fuse
Internal fuse defective	Reverse battery connection	Reverse the connection and replace the fuse
The battery is not fully charged	Faulty battery connection Voltage drop too high on the battery cable Significant temperature difference between regulator and battery	Check the battery connection Increase the section of the battery cables and /or reduce their length Ensure that the temperature conditions are identical for the regulator and the battery

	Wrong choice of battery voltage	Check the compatibility of the battery voltage with that of the regulator
The battery is overcharged	Defective battery cell Significant temperature difference between regulator and battery	Replace the battery Ensure that the temperature conditions are identical for the regulator and the battery
No voltage on the "use" terminals	Maximum current limit exceeded Capacitive load of DC loads Short circuit	Disconnect too powerful loads Connect the loads to the battery via a protection and a relay controlled by the regulator Check the discharge circuit and remove the short circuit
Low battery voltage	Load fault (regulator failure, PV generator, protections or wiring) Temporary overconsumption Incorrect regulation of threshold settings Defective battery	Check the charging circuit (regulator, PV generator, protection or wiring) Reduce consumption and eliminate standby times Adjust the regulation thresholds or control the temperature probe Replace the battery
Too low electrolyte level	Lack of maintenance	Readjust the level with distilled or demineralized water
Corroded battery terminal	Electrolyte overflowing out of cells	Clean the battery with a dry cloth and put paraffin on the terminals
Strong smell	Insufficient ventilation	Create high and low ventilation
Low temperature electrolyte crystals	Electrolyte gel	Replace the batteries

5.4 Problems with the inverter

Table 9 reports some problems related to the inverter in stand-alone PV system with justification of applicable solutions.

Table 9: Problems with the inverter and solutions

Problem	Causes of the problem (justification of the solution)	The solutions
The inverter does not work	Work/Stop switch in "off" position Poor contact between battery cables and inverter cables Defective external fuse Battery in very bad condition Inverter in stand-by with no load	Activate the switch to put in the "on" position Clean the battery terminals and/or the contacts Tighten the screws well Replace the fuse with an equivalent model and rating Change the battery Connect a load at power output greater than the stand-by threshold
Low battery voltage alarm	Bad battery Poor contact or voltage drop in the wiring	Recharge or replace the battery Check the connections, the section and the length of the cable
Overload or short circuit alarm	The inverter is overloaded The inverter protects itself against excessive current calls The connected load has the wrong power factor The connected load causes a short circuit at the output of the inverter	Check whether the total power connected does not exceed the nominal power of the inverter Review the sizing of the inverter if it is not possible to put loads without current draw Reduce the load by putting compensation capacities Replace the loads in question with loads with better power factor

		Replace the inverter with a more powerful one Check that the connected load is not defective, including the wiring between the load and the inverter
Temperature alarm	Lack of ventilation around the inverter Ambient temperature too high	Make sure to leave a space of at least 10 cm around the inverter Keep away from all sources of heat Move the inverter to a cooler location or provide additional cooling using an external fan

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	Requesting help from others when there is need to carry loads and wiring apparatus is the only way of solving problems without damage to apparatus;
	True or false:
2	During a particular maintenance it is allowed making use of water or any other liquid substance around electrical apparatus;
	True or false:

LAP Test	Practical Demonstration

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

Task 1: You are involved in the installation or maintenance of a stand-alone PV system.

- Your first task is to state clearly the applicable risks control measures and procedures.
- Secondly, define a procedure to check circuits as being isolated.
- Thirdly, reveal the methods used to solve the encountered problems, without damage to apparatus and circuits.

Solar PV System Installation and Maintenance

Level IV

Learning Guide -24

Unit of Competence	**Solve Problems in Stand-Alone Renewable energy Systems**
Module Title	**Solving Problems in Stand-Alone Renewable energy Systems**
LG Code	**EIS PIM4 M06 LO3-LG24**
TTLM Code	**EIS PIM4 TTLM 0920v1**

LO3 Complete work and document problem solving activities

Instruction Sheet	Learning Guide:-24

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

- Following OHS work completion risk control measures and procedures
- Cleaning and making work site safe
- Documenting justification for solutions used to solve stand-alone renewable energy systems
- Documenting work completion with notification

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 work completion risk control measures and procedures
- Clean and make work site safe
- Document justification for solutions used to solve stand-alone renewable energy systems
- Document work completion with notification

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	Following OHS work completion risk control measures and procedures

1.1 Introduction

This chapter provides tips on how to follow OHS work completion risk control measures and procedures.

1.2 The corresponding tips

The control measures and procedures guiding the below points should be followed and controlled accordingly for eliminating OHS work completion risks.

- Refer to the existing documented work completion risk control measures and procedures; follow and implement the risk control measures and procedures per situation.
- Take measures to ensure the batteries and other equipment are well taken care of and installed and maintained per manufacturer requirement and applicable codes and standards (risk of stored energy and electric shock).
- Take measures for electrical safety on the site throughout the work completion (risk of electric shock);
- Take measures for falling protection on the site throughout the work completion (risk for fall from heights);
- Take measures for stairways and ladders on the site throughout the work completion.
- Take measures for security in using hand and power tools on the site throughout the work completion.
- Take measures for providing necessary personal protective equipment (PPE) throughout the work completion.
- Take measures for providing conducive working space for electrical equipment and systems throughout the work completion.
- Take all necessary measures for successful checking of all the parts of the stand-alone system throughout the work completion.

1.3 Hazard Identification and Control

The following table provides examples of control measures for a range of generic hazards. These examples are provided as a guide only and important site specific factors must also be considered. Note also that this table of examples does not include all possible hazards.

Hazard	Possible Cause	Control Measure (in combination where appropriate)
1. Traffic Hazards	1.1 Trucks entering, exiting a work site	• Use of traffic controllers • Installation of temporary traffic signals • Use of Safety Signs • Speed restriction signs displayed and enforced
	1.2 Working in close proximity to roads	• Develop traffic management plan • Use of witches hats or temporary barriers • Closure of road • Use of Safety Signs • Speed restriction signs displayed and enforced
2. Manual Handling (refer SOP 105)	2.1 Handling of equipment	• Use of lifting aids • Imposed restrictions on certain activities • Requirements for two person lifts • Training of employees
	2.2 Use of heavy hand held tools eg grass slasher	• Use of support harness • Limits on duration of use
	2.3 Handling of heavy objects	• Provide mechanical aids • Redesign object or task
	2.4 Sustained repetitive movements or fixed awkward postures for more than 30 minutes at a time or 2 hours in a day.	• Redesign object or task • Limits on duration of task

3. Contact with Heat	3.1 Hot Materials	• Isolation of hot materials • Provide appropriate protective clothing and training
	3.2 Exposure to sun	• (see exposure to radiation 8.5)

Hazard	Possible Cause	Control Measure (in combination where appropriate)
3. Contact with Heat continued	3.3 Fire in the Workplace	• Keep workplace clear of waste materials • Eliminate ignition sources from flammable atmospheres • Remove flammable materials or store correctly • Issue of hot work permit • Provide adequate fire fighting equipment • Employee fire fighting training
4 Contact with Electricity	4.1 Faulty electric leads and tools	• Tools and leads inspected and tagged • Examine tools before each use
	4.2 No earth leakage detectors	• Residual current devices in all circuits • Residual current devices tested regularly
	4.3 Electric leads on ground	• Electrical leads kept elevated and clear of work areas
	4.4 Electrical leads in damp areas	• All electric leads kept dry
	4.5 Electric leads tied to metal rails	• All electric leads are kept insulated
	4.6 Plant not isolated	• Ensure permit to work system followed • Lock-out and equipment tag procedure
	4.7 Contact with underground or overhead cables	• Location of services to be established • Services to be isolated when working in proximity (if possible) • Establish safe clearance distances • Use Spotter • Use alternative plant (less reach)

Figure 22: Hazard Identification and Control

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 and answers
1	Should follow the measures for falling protection on the site throughout the work completion
	True or false:
2	Should not follow measures for security in using hand and power tools on the site throughout the work completion
	True or false:

Information Sheet 2	Cleaning and making work site safe

2.1 Making work site safe

This section concerns the safety at the work place. It is about taking all the measures for ensuring complete safety during stand-alone renewable energy system installation and maintenance. The health and safety supervisor should:

- Analyse the risks in relation with all the working zones and apply preventive measures;
- Indicate with corresponding symbols the not to be done actions and the related gravity in and of each zone;
- Provide the needed height work materials to avoid irreversible consequences on the workers;
- Put limits at all the zones where the activities are to be done or being conducted;
- Only qualified workers should be allowed for entering the protected zones;

2.2 Cleaning work site

The following list includes examples for cleaning tasks that should be carried out after completing work on a site of a stand-alone renewable energy system.

- The location of the solar modules should be cleared off with the appropriate cleaning materials.
- Use a broom to sweep dust and dirt, especially when installing in a person's house
- Collect and dispose of all rubbish like cable ends, cut end of cable ties, parts of cable insulation etc.
- Make sure there is no risk of tripping trough low hanging cables or obstacles on the floor
- 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. needs proper cleaning to avoid unpredictable electrical hazards such as electrocution ;
- A quality cleaning of the technical room as part of the maintenance will help drive away insects, lizards and snakes.

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	A quality cleaning of the technical room will help drive away insects, lizards and snakes
	True or false:
2	The location of the solar modules should be cleared off with the appropriate cleaning materials
	True or false:

Information Sheet 3	Documenting justification for solutions used to solve stand-alone renewable energy systems

3.1 Introduction

This chapter describes the process of documenting justification for solutions used to solve stand-alone renewable energy systems.

3.2 Documenting justification for the solutions

Whenever a problem in a PV system is solved, the measurements that were carried out should be documented. If next time another installer works on the system, he or she needs to know what was done. It is also useful to note down any observations, e.g. when the measuring showed that one battery was performing a bit worse than the others, it should be noted in the protocol. Then next time the installer doing the maintenance can check the battery again and early prevent the battery to cause system failure. For every system there should be a documentation, see details in Module 8 “Compiling and Producing Solar PV Installation Reports” LG 28-30. After every repair, the system report should be updated. Insert a chapter for maintenance and repairs in the documentation, digitally or as hard copy whatever the company prefers and document all information.

If a component is replaced with another model or a newer version of the same type, make sure that the correct data sheet and manual for the component is saved with the documentation and that plans and wiring charts are updated. This can even happen by hand, by just noting down the new model on the plan as long as other persons are still able to ready the information clearly.

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 inverter might not work due to poor contact between battery cables and inverter cables
	True or false:
2	The lack of maintenance justifies the battery too low electrolyte level
	True or false:

Information Sheet 4	Documenting work completion with notification

4.1 Introduction

This chapter provides tips on how to document work completion with notification.

4.2 Documenting “As installed” or “As maintained” apparatus

Maintenance or repair measurements should be noted down on a log sheet. The installation company can create its own template for the installers to take on site. During every visit the information can be taken and noted down. If a component is changed it should be noted in the comments. Figure 19 and 20 show exampled how a log sheet for single components can look like. Otherwise a general maintenance sheet for reporting repairs that have been done can be used.

Inverter log sheet

Date	Name	Cleaned inverter	No insects	Cable connections OK	Inverter operating correctly	Comments
		☐	☐	☐	☐	
		☐	☐	☐	☐	
		☐	☐	☐	☐	
		☐	☐	☐	☐	
		☐	☐	☐	☐	
		☐	☐	☐	☐	
		☐	☐	☐	☐	
		☐	☐	☐	☐	
		☐	☐	☐	☐	
		☐	☐	☐	☐	

Figure 23: Example for inverter log sheet

Balance of systems log sheet

	Date	Date	Date
Name			
Battery voltage			
Regulator			
Item clean			
Insects removed			
Cables connections OK			
Functioning OK			
Inverter			
Item clean			
Insects removed			
Cables connections OK			
Functioning OK			
Battery Charger			
Item clean			
Insects removed			
Cable connections OK			
Functioning OK			
Control Board			
Item clean			
Insects removed			
Cable connections OK			
All switches/circuit breakers operate correctly OK?			
Cables/conduits mechanically OK?			
Electrical connections OK?			
Comments			

Figure 24: Example for BOS log sheet

Equipment Maintenance Log

Equipment description: _____

Serial Number: _____ Model Number: _____

Date:	Action Taken/Comments:	Initials

Figure 25: Example of blank template for reporting information regarding the maintained apparatus

After a successful installation of a stand-alone 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. 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.
- Similarly, all kind of maintenance should be done in such a way that any repair is reported in a specific document to be saved in a safe place.

Table 10: One page of the reporting book for maintenance

Person in charge of the maintenance		Date of the intervention	
Starting time		Ending time	
Concerned equipment			
Maintenance number	Problem description	Solution provided (corrections made)	Next step (remaining corrections to undertake, or suggestions)
1			
2			
3			
4			
5			

4.3 Notifying the appropriate person

Not everyone should be informed about the documenting of the 'As-installed' and "As-maintained" apparatus. 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. Specific questions ought to be asked before deciding whether a person needs to be notified or not. Such questions can be the followings: Does the person have to do with the project? Who will work with the project in the future? Do the persons know where to find

information? On the other hand, some persons such as the immediate client and manager should be notified the relevant information about the project. The logistics stock manager should be notified about the used spare parts for him or her to conduct final adjustment through updating the previous statistics.

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	The ‘As-installed’ and ‘As-maintained’ apparatus should be reported in the corresponding document to ease later work
	True or false:
2	Everyone should be informed about the documenting of the ‘As-installed’ and “As-maintained” apparatus
	True or false:

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 among the staff in charge of the maintenance of a stand-alone PV system. You are requested to focus on the work completion and document the problem solving activities. Precisely, you should explain how the cleaning and the safety of the work place have been implemented, and document justification for solutions used to solve encountered problems

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