Solar PV System Installation and Maintenance

Level-II

Learning Guide -48

Unit of Competence	Inspecting PV Components/ Materials Compliance
Module Title	Inspecting PV Components/ Materials Compliance
LG Code	EIS PIM2 09 LOT 1 LG-48
TTLM Code	EIS PIM2 TTLM 0819V1

LO1. Identify components/ materials and specifications for inspection/ testing

Instruction sheet	Learning Guide: - 39

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

- Listing System components
- System components specifications
- Identifying System components
- Inspecting system components
- Recording and Reporting damaged System components

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:-**

- List System components
- Identify System components specifications
- Identifying System components
- Inspect system components
- Record and Report damaged System components

Learning Instructions:-

1. Read the specific objectives of this Learning Guide.
2. Follow the instructions described below 3 to 4.
3. Read the information written in the information Sheet 1, Sheet 2, Sheet 3, Sheet 4, Sheet 5 in pages 3, 6, 14, 17 and 22 respectively.
4. Accomplish the Self-check 1, Self-check 2, Self-check 3, Self-check 4, Self-check 5 in pages 5, 13, 16, 21 ,26 respectively

Information Sheet-1	Listing system components

1.1. Introduction

The objective of solar PV system inspection is to support sustainable access to modern energy services for rural communities in Ethiopia.

Solar PV system inspection requires having a team of skilled personnel, comprising one (1) experienced technician and one (1) assistant, to conduct at least 2-day site visits, complete prepared checklists and questionnaires and train the beneficiary communities on system operation, maintenance and administration. Findings of these inspections should be submitted to the owner for subsequent follow-up with contractors. In addition, a baseline data with key Performance Indicator/KPI survey methodology need to be captured in advance and have a comprehensive database for continuous inspection and maintenance activities.

1.2. Listing system components

Just before staring any inspection and test ,list all the components of V systems intended to be inspected and test some of the components could be as follows:-

- Solar PV modules
- Inverter
- Solar charge controller
- Battery system
- Remote monitoring system
- Power cable and grounding
- Distribution panel
- PV array support
- Power house
- Distribution, streetlights and household connection and installation
- Lightning protection

The inspection visits would require meticulous logistical planning and preparation. Table 1 example of list of equipment below presents the equipment to be brought by the inspection team to each site, in order to fulfill the tasks at hand. Purpose of such inspection guide is to record the process and make templates available for future inspections by any interested third parties.

Table 1: Sample list of equipemts for inspection

General equipment	Measuring equipment	Survey forms and training tools
Introductory mandate letter	Clamp meter (AC and DC)	Inspection guide for PV system
GSM cell phone + charger	Digital multi-meter	Technical checklist- Component compliance
Handheld GPS device + charger/spare batteries	Digital thermometer	Technical checklist – Performance verification
Laptop (with MS office)	Measuring tape (for distance)	Technical checklist – Workmanship quality
Calculator		KPI, PV systems questioner
Camera (with memory card, charger, spare battery, USB cable)		PV system troubleshooting poster
Spare memory sticks (flash – discs)		
Pens and pencils		
Sturdy backpack		

Self-Check -1	Written test

Short Answer Type Questions

Say true and false for the following question below

1. Purpose of such inspection guide is to record the process and make templates available for future inspections by any interested third parties.
2. Solar PV system inspection requires to have a team of skilled personnel
3. before staring any inspection and test ,list all the components of PV systems
4. The inspection visits would require meticulous logistical planning and preparation
5. Solar PV system inspection is to support sustainable access to modern energy services for rural communities in Ethiopia.

Note: **Satisfactory rating 4 and above points, Unsatisfactory - below 3 points**

Score = ___________

Rating: ____________

Information Sheet-2	System component specification

2.1 Component Compliance

There should be a technical component compliance check list comprising a number of main components of the PV system. This checklist is used to verify actually installed components at site against the contractual obligations as specified in the contract. This checklist thus requires a pre-review of the tender/contract document and adding the relevant technical specifications into the checklist template. A sample of template for technical checklist and specifications is shown on table 1.In this sample template the component compliance covered the technical specifications for:

- Solar PV modules
- Inverter
- Solar charge controller
- Battery system
- Remote monitoring system
- Power cable and grounding
- Distribution panel
- PV array support
- Power house
- Distribution, streetlights and household connection and installation
- Lightning protection

Table 2: sample template for technical checklist and specifications

Site code:		Date:	
Village/site name:		Name of Inspector:	
Contractor name:		Signature:	

S/N	Component	Specification from contract (Example)	Contractor specific				Quantity	Remark	
			Type	Brand	Country	Capacity		Yes	No
1	**SOLAR MODULE**								
1.1	Type of solar module	Mono/Poly/Amor							
1.2	Output per unit	Minimum 100Wp							
1.3	Total capacity solar array	Minimum 15kwp							
1.4	Connection among solar panel	Plug-in socket							
	NOTES:								
2	**INVERTER**								
2.1	Type of inverter	Minimum 5kw each (3 units)							
2.2	Output voltage	220-230VAC							
2.3	Frequency/phase	50Hz/1 phase							
2.4	Input voltage	48V DC							
2.5	Indicator (LCD display)	Inverter voltage & current?							
		Inverter frequency?							
		Battery voltage & current?							
		Load voltage & current							
2.6	Inverter grounded?								
	NOTES:								

3	**SOLAR CHARGE CONTROLLER (SCR)**								
3.1	Type of solar charge controller	Minimum 3 units, 5kwp each							
3.2	Charge controller grounded?								
	NOTES:								
4	**BATTERY SYSTEM**								
4.1	Type of battery	VRLA Gel, OPZv stationary							
4.2	Battery capacity	Minimum 144kwh							
4.3	Nominal capacity	Minimum 2V/Cell							
4.4	Battery capacity/cell	Minimum 800Ah							
4.5	Battery bank output	Nominal minimum 48V DC							
4.6	Battery connector	Made of copper covered with isolator							
4.7	Battery protection	Minimum, 144kwh							
4.8	Battery rack/holder	Resistant to corrosion							
4.9	End terminals of battery blocks protected with non-conductive material								
4.10	Battery protection box grounded?								
	NOTE:								
5	**REMOTE MONITORING SYSTEM**								
5.1	Data connection	Modem GPRS/GSM							

5.2	Hardware and software	Monitoring and data logging							
5.3	Alarm	Faults alarm							
5.4	Display	User-interface							
	NOTES:								
6	**POWER CABLE AND GROUNDING**								
6.1	Power cable from battery to inverter and/or battery to solar charge controller	NYF 1X70mm2 (SPLN/SNI)							
6.2	Power cable from inverter to distribution panel	5KVA, type NYY 4 x 50mm2 (SPLN/SNI)							
6.3	Cable connector	Equipped with suitable connector?							
6.4	Installation materials and component grounding	Adjusted with generator capacity?							
6.5	Common grounding busbar existing (check also cable trench in power house)								
	NOTES:								
7	**DISTRIBUTION PANEL**								
7.1	Power cable	Minimum 5kva each							
7.2	Number of feeder	3 feeder sets							
7.3	System voltage	220/2030VAC, single phase							
7.4	Monitoring	Voltage							
		current							
		Frequency?							

		Kwh-meter?							
7.5	Positioning	As per safety standard and easy to monitor by the operator?							
7.6	Distribution panel grounded?								
	NOTES:								
8	**PV ARRAY SUPPORT**								
8.1	Material	Galvanized iron/metal through hot deep galvanized treatment							
8.2	Module support	Free standing above foundation							
8.3	Frame	Solid and easy to be assembled on to module support							
8.4	Angle	Between 10-15 degrees							
8.5	Height between module and ground surface	Minimum 70cm							
8.6	Distance between PV array	Properly designed so that no shades will fall on the other PV array surface in the system							
8.7	PV array support grounded?								
9	**POWER HOUSE**								
9.1	Room size	Minimum 36 m2							
9.2	Type	Permanent house/shelter							
9.3	Shelter material	Polyurethane and mild steel							

9.4	Electricity installation	5 points (3 lamps, 2 socket), MCB 2A							
9.5	Equipped surrounding with lightening rod system								
9.6	**Permanent house specs:**								
9.7	Walls	Bricks or equal, neatly plastered and painted							
9.8	Door	Board/aluminium and equipped with lock							
9.9	Battery and control room floor	ceramics							
9.10	Ventilation	Sufficient for air circulation							
9.11	Footpath	Made from concrete or using con-block with 1 meter minimum width							
9.12	Fenced in Periphery	BRC type with 120 cm minimum height and equipment with gate							
	NOTES:								
10	**STREET LIGHTS**								
10.1	Number of street lights	75 street lights							
10.2	LED lamp+ cup	Maximum 11 watt							
10.3	Lighting setting	Maximum 5 hours/day							
10.4	Control cabinet in power house grounded?								
	NOTES:								

11	**LIGHTNING PROTECTION**								
11.1	Tower and wire	Tri-angle, guyed wire							
11.2	Type	Passive system, connection slave							
11.3	Ground system	available							
11.4	System monitoring	Equipped with system monitoring							
	NOTES:								

Self-Check -2	Written test

Choose the best answer

1. From the following Component compliance covered the technical specifications are

A. Solar PV modules

B. Inverter

C. Solar charge controller

D. Battery system

E. All

2. Which one is the following Component correcte technical specifications

A. Arry

B. DC voltage

C. AC voltage

D. Battery system

Note: **Satisfactory rating 2 and above points, Unsatisfactory – below 1 points**

Score = ___________

Rating: ____________

3.1. Define system component

Solar PV systems are electrical generators that produce energy for electrical loads and may interface with other electrical systems.

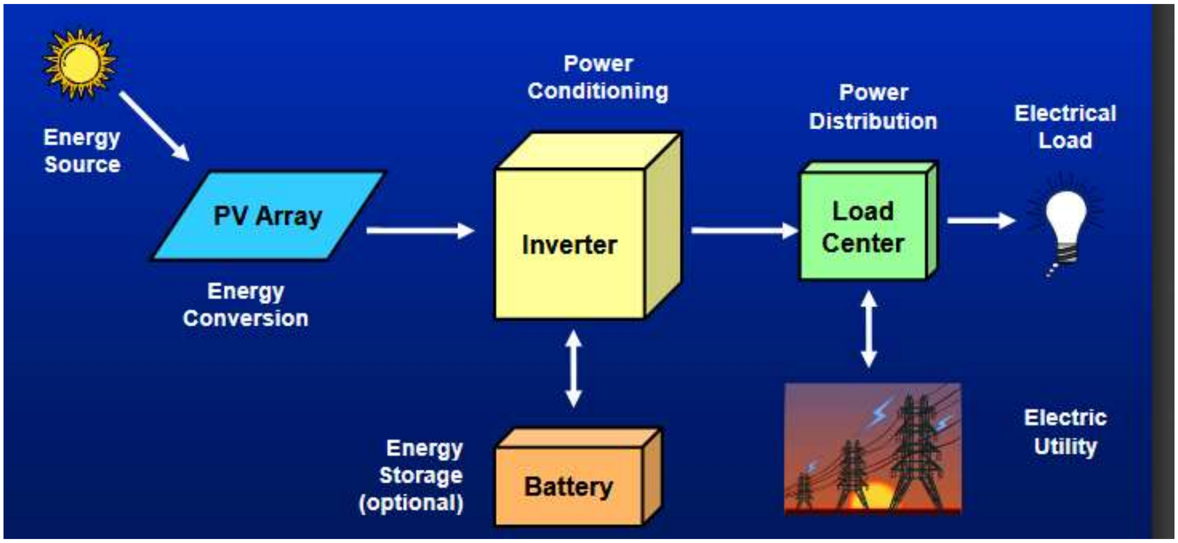


Figure 1: PV Component

3.2. What is PV system design?

Solar photovoltaic system or solar power system is one of renewable energy system which uses PV modules to convert sunlight into electricity Solar PV system is very reliable and clean source of electricity that can suit a wide range of applications such as residence, industry, agriculture, livestock, e.t.c…

3.3. Component compliance – to be conducted on site by inspector Spread sheet-based checklist comparing all components (type, specifications, quantity, etc.) installed on site between tender specifications and contractor contract. Assessment is done on the basis of “Fulfilled” or “Not Fulfilled”. Purpose is to determine whether contractors neglected to provide any components as legally required under the contract.

3.4. PV System Components

Figure 2: PV System

Table 3: Sample template checklist is shown on table

S/N	System component to be identified	Check if it is fulfilled or not fulfilled
1	Solar PV Modules	
	Installed module type:	
	Installed capacity:	
2	Inverter	
	Installed Inverter type:	
	Installed capacity:	
3	Charge controller	
	Installed charge controller type:	
	Installed capacity:	
4	Battery system	
	Installed battery type:	
	Installed capacity:	
5	Balance of system	
	Electric wiring as specified:	
	Grounding as specified:	
	Array mounting as specified:	
	Combiner boxes as specified:	
	Lightening protection as specified:	
	Distribution panel as specified:	
	Street light installed and operating:	
	Appliances are functional as specified:	

Self-Check -3	Written test

I. Say true and false

1. Component compliance are to be conducted on site by inspector Spread sheet-based checklist comparing all components (type, specifications, quantity, etc.) installed on site between tender specifications and contractor contract.
2. Solar photovoltaic system or solar power system is one of renewable energy system which uses PV modules to convert sunlight into electricity

Note: **Satisfactory rating 1 and above points, Unsatisfactory - below 1 points**

Score = ___________

Rating: ____________

Information Sheet-4	Inspecting system components

4.1. Inspection Process

The inspection process follows the flow as shown in Figure 3 Inspection flow diagram. In some instances, depending on the situation on site, the order of activities might be certainly modified.

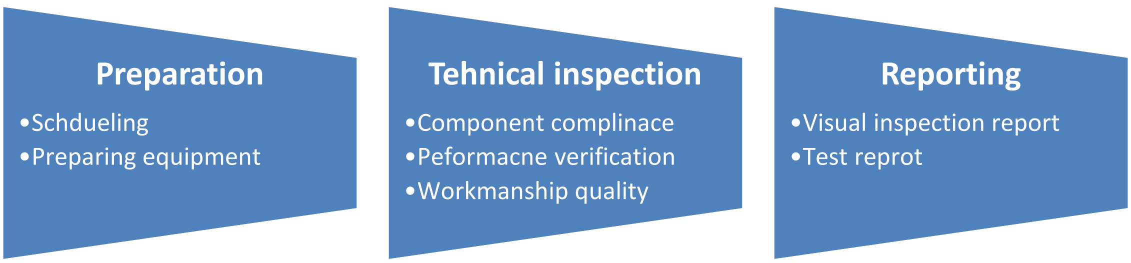


Figure 3: Inspection flow diagram

Visual inspection of system components and collecting photographic evidence of the inspection on site is vital. Photographs confirm the observations of the inspector and can also reveal issues that are not recorded in the checklists, table 1 shows sample templet for visual inspection of system components: -

Table 1: visual inspection checklist template

1	Outside power house	• Highlight the distance to the solar array • Foundation and apron condition • General workmanship (i.e. plastering, painting)
2	Inside power house	• Overview of power house (with battery, inverter, and monitoring system visible) • Overview of general condition (cleanliness, tidiness) • Overview of ventilation • Detail of windows and ventilation (glass and

3	Battery	• Plate showing brand and type • Arrangement of batteries • Battery terminal connection • Measurement of battery room temperature 
4	Charge controllers	• Plate showing brand and type • General workmanship • Controller interior 
5	Inverter	• Plate showing brand and type • General workmanship • Measurements as shown on LCD 

6	Details of cabling	It comprises both external and internal cabling, to highlight if the correct cables (in terms of type and size) are used as well as the quality of installation
7	Solar array	• Overview of solar array (TIP: take a higher land or climb the lightning rod to get the overall picture of the site, if possible) • Foundation and struts • Grounding • Mounting (nuts and bolts) 
8	Solar module	• Plate showing brand and type • Junction box • Randomly on some spots, be alert for damage/breakage! 
9	Remote monitoring system (RMS)	• Location of computer set in the power house • Display of monitoring software on screen

10	Connection and distribution box in the power house or in the panel box	• Ampere and Voltage measurement • kWh-meter and hour-meter records
11	Streetlights	• Type of lamp and fixture (close-up) • Installation and location 
12	Appliances connection	• Close-up of socket/plug and switch • Close-up of lamps • Cabling workmanship • Overview of connection workmanship
13	People in actions	For example: • Operator cleaning the PV module • Inspector checking the installation • Inspector training the operator

Self-Check -4	Written test

Short Answer Type Questions

1. Inspection flow diagram. In some instances, depending on the situation on site, the order of activities might be certainly modified.
2. Electrical System are randomly on some spots be alert for damage/breakage

Note: **Satisfactory rating 2 and above points, Unsatisfactory - below 1 points**

Score = ___________

Rating: ____________

Information Sheet-5	Recording and reporting damaged system components

5.1. Guiding information

Verify and record all system parts arrived undamaged and installed properly at site. After visually inspecting the system components for damage or obvious safety issues report accordingly using damaged system component reporting format shown on Table1

Note in the test report any damage or safety issues. It is up to the Tester, in consultation with the requestor, to determine if any damage or safety issues are sufficient to discontinue testing, although the tester may discontinue the tests if the system is considered unsafe.

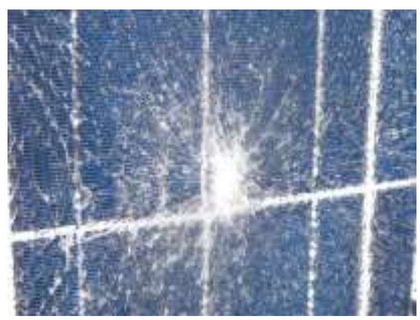
Verify that all parts listed on the parts list are present. Note any missing system parts that should have been included. Any parts that are required but are not included with the system should be also reported.

Site code:	
Village/site: name:	
Inspector name:	

Table 4: Damaged system components report template

1	Battery	• Arrangement of batteries • Battery terminal connection ***Example picture of damaged battery*** 
2	Charge controllers	• General workmanship • Controller interior ***Example picture of damaged charge controller*** 

3	Inverter	• General workmanship • Measurements as shown on LCD ***Example picture of damaged inverter*** 
4	Details of cabling	It comprises both external and internal cabling, to highlight if the correct cables (in terms of type and size) are used as well as the quality of installation ***Example solar cables*** 

5	Solar array	• Overview of solar array (TIP: take a higher land or climb the lightning rod to get the overall picture of the site, if possible) • Grounding ***Example of damaged solar array*** 
6	Solar module	• Junction box • Randomly on some spots, be alert for damage/breakage! ***Example of damaged solar module*** 

Self-Check -5	Written test

Say True and False for the following question below

1. Verify and record all system parts arrived undamaged and installed properly at site.
2. After visually inspecting the system components for damage or obvious safety issues report accordingly using damaged system.
3. Solar array Overview of solar array takes a higher land or climbs the lightning rod to get the overall picture of the site.

Note: **Satisfactory rating2 and above points, Unsatisfactory – below 1.5 points**

Score = ___________

Rating: ____________

List of Reference Materials

1. Robert W Schultz and Amalia Suryani, *Inspection Guide for Photovoltaic Village Power (PV-VP) Systems*, October 2013

2. Seaward Group USA, *Photovoltaic System Commissioning and Testing, A Guide for PV System Technicians and Engineers*,6304 Benjamin Road, Suite 506, Tampa, Florida, 33634

Solar PV System Installation and Maintenance

Level-II

Learning Guide -49

Unit of Competence	Inspecting PV Components/ Materials Compliance
Module Title	Inspecting PV Components/ Materials Compliance
LG Code	EIS PIM2 09 LOT 2 LG-49
TTLM Code	EIS PIM2 TTLM 0819V1

LO2. Interpret Manuals

Instruction sheet	Learning Guide: - 40

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

- Locating relevant sections and chapters of specifications/manuals
- Interpreting Information and procedure in the manual
- Testing procedure
- Interpreting manuals of system components and accessories

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:-**

- Locate relevant sections and chapters of specifications/manuals
- Interpret Information and procedure in the manual
- Identifying System components
- Identify testing procedures
- Interpret manuals of system components and accessories

Learning Instructions:-

1. Read the specific objectives of this Learning Guide.
2. Follow the instructions described below 3 to 4.
3. Read the information written in the information Sheet 1, Sheet 2, Sheet 3, Sheet 4, in pages 30, 36, 39 and 44 respectively.
4. Accomplish the Self-check 1, Self-check 2, Self-check 3, Self-check 4 in pages 35, 38, 43, and 47 respectively

Information Sheet-1	Locating relevant section and chapters of specifications/manuals

1.1. System documentation

All PV installations should have adequate documentation providing details of the system design and all components and materials used in its construction. The documentation should also include safety information, and procedures for operating and maintaining the system. Proper system documentation helps ensure safe and reliable system operations, and is generally required for the following purposes:

- Plan review and permitting process with local building officials
- Interconnection approval from the local utility
- Installation and maintenance contractors
- Owners and caretakers
- Informing emergency services

System documentation is a vital and important part of successful software development and software engineering. Generally speaking, it is comprised of detailed language, illustrations and photos that help different people understand the software, and it is essential reference material. Many developers face challenges in creating software documentation that is both comprehensively helpful and easy to read.

1.2. Different Types of Documentation

Computer software documentation is broadly defined. It can be a **user manual** that consumers read to understand the requirements and operations of a software system so they can then download it, install it and use it. It can also be more technical, describing the capabilities and characteristics of the system for a technical user, such as someone in IT or a systems administrator. Technical documentation can include coding for the software and a record of how it was designed, such as the architecture of the creation and the goals of designing the software and each of its aspects.

Generally, documentation is designed to inform the reader about the software and describe how it was created, what it is intended to do and how it works. It should also be easy to find or access and it should have the ability to be updated as changes are made to the software over the course of time. While details have to be included for documentation to be properly comprehensive and effective, the goal is for all computer software documentation to be written in language that's fairly easily understood. This can be a challenge when using technical language.

Categories of Documentation

Overall, documentation can be divided into a couple of different categories: **process documentation and product documentation.** Process documentation is designed for those working in the internet technology field, and it uses industry-specific jargon about the process of engineering and developing the software. Product documentation describes the product and how it is to be used.

However, these categories are further divided. Product documentation includes both **system documentation,** which is technical, and **user documentation,** which should not be too technical. This is because it's designed for the everyday average computer user, not someone in the software engineering or IT field.

- **System Documentation and User Documentation**

  There is a difference between system documentation and user documentation. In the information systems world, system documentation is much more technical. It is geared toward an advanced or specialized reader, such as a systems administrator or IT professional. System documentation includes things like **source code, testing documentation and API documentation** (programmers' documentation or instructions). It describes the requirements and capabilities of the software and informs the reader about what the software can and can't do – in other words, its functionality.

This is important for IT people to understand when they are, for example, evaluating whether or not a software program is good for their entire company to purchase and put on everyone's computers for broad usage. They need to understand the space and computing requirements and the product's intended use so they can gauge whether or not it is something the department can install and something that everyone will ultimately be able to use. On the other hand, user documentation is designed for the average user, also called an "end user."

1.3. What Is User Documentation?

User documentation is descriptive language designed to speak to the average user of the software or system as opposed to an IT professional or other technical professional. It is designed to explain to the average person how to properly install and use the software or service.

User documentation may also include best practices for optimal results, describe features and the benefits of those features and can include a description of different tips and tricks for maximizing software performance as well as how to customize the software so it works best for each user and the intended task.

Software documentation can include an explanation of the purpose of different settings and how to manipulate them, menus and other customization options within the software once it has been installed. User documentation has to be written in language the average person can understand, whereas system documentation is written from a much more technical standpoint. This can be a challenge for a technical professional. Understanding the difference between writing for an end user and writing for another IT professional can be difficult.

1.4. Components of User Documentation

User documentation can include everything from how to download and install software to how to use each aspect of the software or system. This includes user manuals and frequently asked questions sections, which are designed for everyday consumers to read, use and understand.

It can include instructions such as video tutorials, flash cards, and web pages to visit for help or on-screen help text along with step-by-step illustrations or screenshots on how to perform all the different functions of the software.

Finally, it should also include instructions for troubleshooting problems that crop up when using the software, such as how to deal with different errors and how to obtain help if there is an undocumented problem or an issue they are unable to solve.

1.5. Types of Documentation

Types of system documentation include a requirements document, source code document, quality assurance documentation, software architecture documentation, solution instructions and a help guide for advanced users.

Types of user documentation include training manuals, user manuals, release notes and installation guides. User documentation can also include system requirements so that the users understand whether or not their system will be able to handle the software.

- **Documentation and Software Development**

Reliable, understandable documentation is an important part of software engineering. Even on small projects, documentation should not be overlooked, as it helps with maintenance and upgrades over time. Small projects can become big before you know it, and documentation helps ensure everyone is on the same page. Documentation improves quality and records requirements and key decisions that went into the creation of the product.

This documentation is used to inform, describe and record knowledge about the software that can be communicated to others, whether they are in a technical job such as a systems administrator or are simply consumers wanting to install software on their computer or mobile device. As an engineer or developer, you may be working on multiple applications at once, so documenting everything for each specific application becomes even more important.

Comprehensive and instructive documentation is almost as important as creating the software itself. Yes, it can be tedious or complicated. Software requirements explanations can become several pages long and extremely technical and text heavy, making them cumbersome to read through and difficult to use rather than being helpful and explanatory.

- **Balancing Documentation Types**

Finding the balance between conveying the necessary information for both system documentation and user documentation without it being longer and more technical than necessary for the reader to understand can be a challenge for any software engineer. Indeed, it is part of the skill of designing and engineering software to be able to create proper, helpful process and product documentation.

Users must be able to understand how the product was designed, what the environment was like where it was created, what it is intended to do, what it can and cannot be reasonably expected to perform, how to troubleshoot and fix errors that may arise through normal use and how to get help if nothing else is working.

Self-Check -1	Written test

Say True and False for the following question below

1. System documentation is a vital and important part of successful software development and software engineering.
2. System documentation includes things like source code, testing documentation and API documentation (programmers' documentation or instructions).
3. Finding the balance between conveying the necessary information for both system documentation and user documentation
4. Types of user documentation include training manuals, user manuals, release notes and installation guides
5. User documentation can include everything from how to download and install software to how to use each aspect of the software or system.

Note: **Satisfactory rating 0.8 and above points, Unsatisfactory – below 0.8 points**

Score = ___________

Rating: ____________

Information Sheet-2	Interpreting information and procedures in the manual

2.1. Definition PV system documentation is a permanent record associated with a PV installation, including maintenance and testing records. This information is critical for the effective maintenance and evaluation of the system over time. Key components of a PV system documentation package should include the following:

- The system DC and AC power ratings; the manufacturer, model and quantity of PV modules, inverters, batteries, controllers and all other major components, as applicable. The dates of the system installation, commissioning and inspection should also be noted.
- The names, postal addresses, phone numbers and email addresses for the customer/owner, system designer, installation contractor and any other responsible parties or subcontractors.
- A site layout identifying equipment locations on buildings or relative to property lines or easements. In some cases, a shading analysis and performance estimates may be provided with project proposals, and should also be including with the final system documents.
- A single line diagram depicting the overall system design, including the types of modules, total number of modules, modules per string and total number of strings; the types and number of inverters; and any other major components. For larger projects, complete as-built electrical and mechanical drawings are usually required at project close out.
- The types, sizes and ratings for all balance of- system components annotated on the single line diagram, or noted and provided in a separate table, including specifications for all conductors, raceways, junction boxes, source circuit combiner boxes, disconnects, overcurrent protection devices, and grounding equipment, as applicable.
- Data sheets and specifications for PV modules, inverters and other major components, including module mounting systems. For most inverters, installation

and user/operator manuals are available and provide important information regarding the safe operation and maintenance of the equipment.

- Operation and maintenance information including procedures for verifying proper system operation and performance, and how to determine if there is a problem and what to do. Procedures for isolating/disconnecting
- Equipment and emergency shutdown procedures should also be provided. A maintenance plan and intervals should be provided for all routine (scheduled) system maintenance, such as array cleaning as required. Operating and maintenance guidelines should differentiate what tasks can be performed by the owner or caretakers, from those that require professional service due to the complexity of the tasks, special equipment needs, or safety concerns. Maintenance agreements, plans and recordkeeping forms or sheets should also be provided to document maintenance activities over time.
- Warranty details on major components indicating the terms and conditions, and how the warranty process is handled and by whom. System warranties should also be addressed, including quality of workmanship, roof weather sealing or performance warranties as applicable.
- Copies of all commissioning test reports and verification data.
- Contracting and financial details are also an important part of system documentation, and may be included with the technical items discussed above or under a separate file. These documents would include construction contracts, invoices and payments for materials and labor, building permits, inspection certificates, interconnection agreements, and applications and approvals from incentive programs, such as rebates and tax forms.

Self-Check -2	Written test

Say True and False for the following question below

1. PV system documentation is a permanent record associated with a PV installation, including maintenance and testing records.
2. Operation and maintenance information including procedures for verifying proper system operation and performance
3. Contracting and financial details are also an important part of system Installation.

Note: **Satisfactory rating 2 and above points, Unsatisfactory - below 1.5 points**

Score = ___________

Rating: ____________

Information Sheet-3	Preparing Testing procedure

3.1. Inspection Guide Overview

Inspection preparation - conducted by inspector and evaluator prior to site visit

Preparatory work to be done in order to conduct site survey effectively and efficiently.

3.2. Performance verification - *conducted on site by inspector*

Spread sheet-based measurement sheets for spot-check measurements on the performance of key components (solar PV generation capacity, battery charging status, inverter output, and distribution network losses). Evaluation is based on quantitative data collected. Purpose is to determine whether the PV-VP system as a whole operates close to it's optimal.

3.3. Workmanship checklist – *to be conducted on site by inspector*

Spread sheet-based checklist should be prepared with a number workmanship indicators, clustered into different categories. Evaluation could be done according to a scoring system using a rating of 1 to 5 (worst to best). Purpose is to assess whether quality of installation adheres to best practices, safety requirements and overall installation sustainability.

3.4. Test Procedures

Insulation resistance testing is conducted by applying high voltages to conductors and equipment, and determining the resistance by measuring the leakage current. All circuits must be isolated from others for testing and discharged before and after testing. Grounding or bonding connections are left connected. Any surge suppression equipment must be removed from the circuits. The test leads must make a reliable connection with the circuit under test, and may require filing or grinding some coated metal components

The test voltage depends on the circuits or equipment tested. It is usually higher than the operating voltages for the circuits or equipment under test, but not higher than the voltage ratings of the equipment or conductor. Higher test voltages may be used for proof testing of equipment by manufacturers than for field tests.

For example: the maximum system voltage rating for most PV modules in the U.S market is 600 V. The IEC 62446 standard recommends a test voltage of 250 V for PV arrays with maximum voltage less than 120 V, a test voltage of 500V for PV arrays 120 V to 500 V, and a test voltage of 1000 V for arrays greater than 500 V (ensure that modules are rated for 1000 V for this test).

Insulation resistance and other electrical tests on PV arrays are generally measured at source circuit combiner boxes, where the individual array circuits can be accessed as shown on figure 4.

Figure 4: PV combiner box

The tests can be conducted dry, or a wetting agent can be sprayed on portions of an array to better pinpoint fault locations. Insulation tests may be performed using either of the following two methods:

1. between the positive dc conductor and ground, and between the negative dc conductor and ground.

2. between the shorted positive and negative dc conductors and ground. Requires an appropriate shorting device rated for circuit current and voltage. The grounding

connection is made to metallic module frames or support structures, the building grounding electrode systems, or directly to earth. Some modules and supports structure may not have a metallic support structure or frames.

For systems not bonded to ground, the tests should be carried out between array cables and ground, and also between array cables and frame.

The IEC 62446 standard recommends 0.5 MΩ as an acceptable minimum insulation resistance value for PV arrays operating at less than 120 V.

For system voltages higher than 120 V, 1 MΩ or higher is considered acceptable. Tests conducted during system commissioning may be used as a baseline for which later measurements can be compared to evaluate wiring condition and degradation.

ASTM E2047, Standard Test Method for Wet Insulation Integrity Testing of Photovoltaic Arrays provides guidelines on test procedures and interpretation of results for wet insulation resistance testing of PV arrays. This standard can be used in conjunction with the IEC 62446 standard for conducting insulation resistance testing on PV arrays.

3.5. System Functional Testing

System functional testing verifies proper system operation, including start-up, shut-down and nominal operating conditions. These tests confirm that system operating parameters are within expected and nominal limits, but are not intended to verify system ratings in accordance with specifications or warranty provisions.

Additional detailed testing, using additional measurements and normalizing data are required to verify performance with system ratings.

Knowledge of the specific equipment used and the product installation and operation instructions are crucial to verifying their safe and proper operation during functional tests. Most inverters and charge controllers provide some indication of performance and operating status, such as power output or energy production, as well as fault or error indications such as out of limit parameters or array ground faults. This information is extremely helpful in verifying proper system operation, and may reduce the need to make hand measurements on energized circuits.

System functional tests ensure that the system starts and operates properly, and can be safely disconnected. Among the types of functional tests conducted on PV systems include:

- Verifying the proper operation of disconnecting means and component connection and disconnection sequences.
- Verify that interactive inverters and ac modules de-energize their output to utility grid upon loss of grid voltage. This is a safety requirement to prevent interactive inverters from operating as an islanded electrical system without voltage or frequency control, and preventing them back feeding de-energized electrical systems. These functions are performed internally by all utility-interactive inverters listed according to the IEEE 1547 and UL1741 standards.
- Verify that interactive inverters automatically reconnect to their output to the grid once the voltage has been restored for at least 5 minutes.
- Verify that battery-based interactive inverters disconnect ac loads from the utility source when operating in stand-alone mode.
- Verify the proper grid voltage and frequency to operate inverters, including evaluating voltage drop between the inverter ac output and point of connection to the grid.

Self-Check -3	Written test

Say True and False for the following question below

1. PV System conducted by inspector and evaluator prior to site visit Preparatory work to be done in order to conduct site survey effectively and efficiently.
2. System functional testing verifies proper system operation, including start-up, shut-down and nominal operating conditions.
3. Insulation resistance testing is conducted by applying high voltages to conductors and equipment, and determining the resistance by measuring the leakage current.
4. System functional tests ensure that the system starts and operates properly, and can be safely disconnected.

Note: **Satisfactory rating 3 and above points, Unsatisfactory - below 2 points**

Score = ___________

Rating: ____________

Information Sheet-4	Interpreting manuals of systems components and accessories

4.1. Definition of Interpreting Manual

- Interpretation and understanding of the technical details to the manufacturer's installation, operation and maintenance manuals of PV components are essential in understanding the inspection and testing procedures:-
- The terms "interpret" and "translate" have similar definitions and are often used interchangeably: „
  - ✓ Interpret to explain the meaning of; to conceive the significance of; to translate orally
  - ✓ Translate to render in another language; to put in simpler terms; to explain. The major difference between the two terms is that an interpreter relays a message orally, whereas a translator works with the written word. Consequently interpreters and translators develop different skill sets. Interpreters must have the capacity to work "on the spot" and convey spoken words from one language to another, in both directions. In contrast, translators require strong writing abilities and will typically convert written text from a second language into their native language, in one direction.

Table 5: shows the general guide what to consider in interpretation of the technical manuals.

Element	Interpretation Criteria
Identify and locate technical information	• Information needs are identified and confirmed with the appropriate persons. Eg. Team of solar PV system inspection personnel • Workplace information resources are identified and their location is determined in the information system. Eg. Solar PV system installation site detail: GPS location… • Appropriate technical information is obtained
Access Technical	• Relevant technical information such as operation

information	manuals, installation manuals, maintenance and repair manuals…are located properly • Symbols, drawings, codes, legends and abbreviations are interpreted correctly. • Technical information is accessed and relevant application is understood. • Clarification or further explanation of technical information is obtained, where required. • If applicable the revision status of the technical information is verified to ensure current status.
Interpret and analyze technical information	• Technical information such as electrical and mechanical drawings and related symbols, codes, legends and abbreviations are interpreted and analyzed for use for inspection and test procedures • Such technical information is used for inspection and test procedures
Explain and use information	• Information and analysis is explained and distributed to appropriate personnel. • Information resources are used according to work requirements • Where applicable, work is undertaken in accordance with acquired technical information. • Work is undertaken in accordance with acquired technical information.
Identify implications of change to technical information	• Change to technical information are documented, for example: if any solar component has been replaced with a new one and different from the original model. • If the manufacturer changed some technical parameters of any PV system components

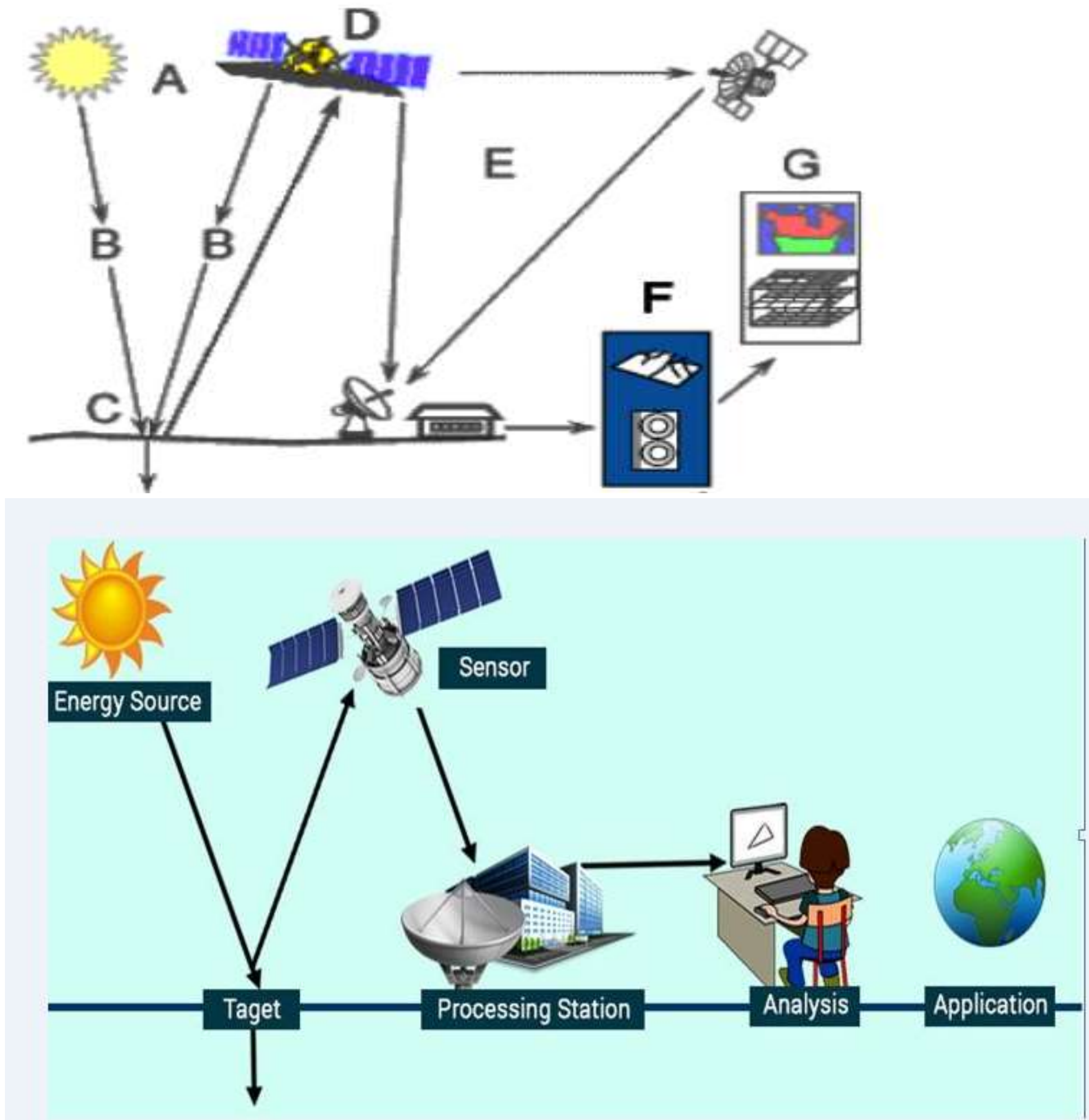


Figure 5: How to interpret the drawing

Self-Check -4	Written test

Say True and False for the following question

1. The terms “interpret” and “translate” have similar definitions and are often used interchangeably: „
   A. Interpret to explain the meaning of to conceive the significance of to translate orally
   B. Translate to render in another language
   C. A&B

2. Interpretation and understanding of the technical details to the manufacturer’s installation, operation and maintenance manuals of PV components

Note: **Satisfactory rating 0.8 and above points, Unsatisfactory - below 0.8 points**

Score = ___________

Rating: ____________

List of Reference Materials

1. Robert W Schultz and Amalia Suryani, Inspection Guide for Photovoltaic Village Power (PV-VP) Systems, October 2013

2. Seaward Group USA, Photovoltaic System Commissioning and Testing, A Guide for PV System Technicians and Engineers,6304 Benjamin Road, Suite 506, Tampa, Florida, 33634

Solar PV System Installation and Maintenance

Level-II

Learning Guide -50

Unit of Competence	Inspecting PV Components/ Materials Compliance
Module Title	Inspecting PV Components/ Materials Compliance
LG Code	EIS PIM2 09 LOT 3 LG-50
TTLM Code	EIS PIM2 TTLM 0819V1

LO3. Identify and prepare test instruments

Instruction sheet	Learning Guide: - 41

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

- Test instruments
- compiling test instrument specifications

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

- Identify test instruments
- Compiling test instrument specifications

Learning Instructions:-

1. Read the specific objectives of this Learning Guide.
2. Follow the instructions described below 3 to 4.
3. Read the information written in the information Sheet 1, Sheet 2, in pages 51 and 59 respectively.
4. Accomplish the Self-check 1, Self-check 2, in pages 58 and 61 respectively

Information Sheet-1	Test Instruments

1.1. Definition of testing Instrument

A variety of instruments are available for the PV system inspection and testing, but it is important to make sure the correct instrument is selected and avoid products which only provide one or two tests, reducing the number of instruments needed as well as calibration requirements.

1.2. Examples of Testing Solutions

To understand how destructive material testing is used in solar cell and module manufacturing, examples of production control for the individual stages of production of thick-film cells testing applications are introduced. More information about key principal types of solar cells is available: Solar cells or photovoltaic cells are electrical components that convert the radiant energy contained in light directly into electrical energy. Principal Types:

- Thick-film solar cells are made from monocrystalline or polycrystalline silicon. They are widely used in Central Europe because of their high efficiency (over 20%). Additionally, they are characterized by a high degree of efficiency per surface area unit. For example, approximately 8 sq. m. of roof area is needed to produce an output of 1 Kwp. The amount of material and energy required to manufacture these modules is relatively high, therefore quality assurance is essential.
- Thin solar cells exist in a number of variations regarding substrate and vapor-deposited materials: amorphous or micro-crystalline silicon (a-Si, µ-Si), gallium arsenide (GaAs), cadmium telluride (CdTe), or copper-indium-(callium)-

sulphur-selenium compounds (CIGS). Thin-film cells differ from solar cells based on crystalline silicon wafers primarily in their production process and in the film thickness of the materials used.

- Organic solar cells (made of plastics with semiconductor properties)

Testing requirements may vary considerably according to the type of solar cell, as the various technologies in use can in some instances lead to fundamentally different designs.

1.3. TEST PLANNING

- Testing needs to be planned. The Review and Test Management Plan document describes the global approach to testing, but this section will provide detail for the tests themselves.
- In planning tests a wide range of factors have to be taken into consideration. These may include:
  - ✓ Performance requirements that emerge from the system specification, where response times or latency (delays) in the system delivering messages matter for example.
  - ✓ Investigations of the system under low-loading conditions, such as when a single user is logged onto the system and if appropriate where larger numbers of users are using it in parallel.
  - ✓ The architecture of the system and any security implications that may arise or need to be addressed. For example a two tier-thin client architecture will require a different range of testing to a fat client two-tier system or a three-tier architecture. Moreover security testing should address firewalls, operating system vulnerabilities and system administration controls.
  - ✓ The distributed nature of the system and how test data might be made available to simulate ‘live’ data being passed over the network.

Table 6: shows list of test instruments that can be used for testing of small and medium range solar PV systems.

S/N	Test instrument	Description of test instrument	Picture
1	I-V curve tracer	The tester measures ground (earth) continuity, open circuit voltage, short circuit current, maximum power point voltage, current and power (with AC/DC clamp). The instrument will also give you the fill factor of the PV module or system under test. Could be free PV Mobile App to allows you to view I-V and power curves in full colour and high definition detail in the field by touching your mobile device against the NFC(near- field communication) chip	
2	Solar PV Reporting Software	Solar PV reporting software allows you to easily download and manipulate data from the I-V curve tracer. View accurate and detailed I-V curves and compare against module manufacturers STC values. You can also view measured, STC and nominal values for each string; calculate and display the fill factor and performance ratio for each string, and create a performance report for an entire site or drill down into a single string with the click of a button.	

3	Clamp meter	The lightweight Solar AC/DC Current Clamp is a compact instrument capable of providing accurate measurements of AC or DC currents in conductors measuring up to 22mm in diameter. AC and DC currents can be measured from 0.5A to 40.0A.	
4	Solar Survey Irradiance Meter	This meter connects wirelessly to the I-V curve tracer and gives real-time irradiance, ambient temperature and PV module temperature measurement results simultaneously to electrical tests being conducted. Results can be downloaded from the I-V curve tracer into the reporting software that should be included in the kit.	
5	Other Accessories	The solar PV complete test kit should also come with 2 x MC4 test lead adaptors, 2 x combiner box test probes and detachable alligator clips (MC4), 2 x test leads with detachable alligator clips (4mm), USB download cable, rugged carry bag, quick start guide, calibration certificates and a 2 year warranty.	
6	Multi-function PV system handheld tester	Conduct many tests, including continuity and resistance, polarity, voltage and current tests, and insulation resistance tests. By combining these test functions into single instruments, testing personnel avoid having to purchase, carry and maintain multiple meters. Multi-functional PV system testers simplify and speed up	

		testing. These instruments can also store data for later retrieval and processing into commissioning test reports that become part of the system documentation record.	
	Battery Analyser	The ideal test tool for maintenance, troubleshooting and performance testing of individual stationary batteries and battery banks used in critical battery back-up applications. Covers a broad range of battery test functions ranging from DC voltage and resistance tests to full condition testing using automated string function testing and the test probe integrated infra-red temperature measurement system Designed for measurements on stationary batteries of all types.	

	Battery hydrometer	Used for wet batteries, checks the charge level of a battery by testing the specific gravity of the battery fluid, Calibrated graduations for accurate measurement, Glass tube, Simple and easy to use	

Self-Check -1	Written test

Mach the following question from B to A below

A	B
1. I-V curve tracer	A. PV reporting software
2. Solar PV Reporting Software	B. view I-V and power curves
3. Clamp meter	C. Checks the charge level of a battery
4. Solar Survey Irradiance Meter	D. accurate measurements of AC or DC
5. Battery A hydrometer	E. connects wirelessly to the I-V

Note: **Satisfactory rating 3 and above points, Unsatisfactory - below 2.5points**

Score = ___________

Rating: ____________

Information Sheet-2	Compiling test instrument specifications

2.1. SCOPE

This specification covers site electrical pre-operational tests and commissioning tests required for electrical apparatus, wire, cables and other miscellaneous equipment and material as called for in the specifications and must be read in conjunction with the other specifications.

2.2. TESTING EQUIPMENT

All testing equipment for tests which are to be performed shall be furnished by the Contractor.

2.3. **Testing equipment** required to prove guarantee values shall be calibrated immediately prior to the relevant tests to be performed. The error curves shall be submitted with the report.

2.4. TESTING RECORDS.

- Test results shall be entered in test forms provided by the Contractor or, if such forms are not available, in test forms approved by the Engineer.
- Authorized, qualified representatives of the parties interested shall be present to approve a test when made. One (1) copy of the rough draft-test report shall be given to each authorized representative at the time the test is made.
- Formal test reports approved by the Engineer shall be supplied and prepared by the party performing the test within 48 hours, signed by the authorized representatives, and furnished to the Engineer for distribution.

2.5. ROVISIONAL ACCEPTANCE

- The Engineer's Provisional Acceptance of any electrical installation shall be based upon the completion of tests and checks prescribed in clauses 8 through13, submission of test data (where required), satisfactory materials and workmanship, and demonstration of satisfactory start-up.
- view I-V and power curves

- measurements of AC or DC

The following summarizes basic specification required to be done by the test instruments:-

- **Continuity and resistance testing** verifies the integrity of grounding and bonding systems, conductors, connections and other terminations.
- **Polarity testing** verifies the correct polarity for PV dc circuits, and proper terminations for dc utilization equipment.
- **Voltage and current testing** verifies that PV array and system operating parameters are within specifications.
- **Insulation resistance testing** verifies the integrity of wiring and equipment, and used to detect degradation and faults to wiring insulation.
- **Performance testing** verifies the system power and energy output are consistent with expectations. These tests also require measurements of array temperature and solar irradiance.

For stand-alone or hybrid PV systems incorporating energy storage and additional energy sources, the following additional tests should be conducted:

- Measurements of battery voltage, capacity and specific gravity.
- Verification of charge controller set points and temperature compensation.
- Verification of charging current and load control functions.
- Verification of performance and wiring integrity for other sources, such as generators.

Self-Check -2	Written test

Say True and False for the following question below

1. Short Circuit Current – These tests simply verify correct installation, and are not intended to verify performance.
2. Insulation Resistance (Megger) Test — Insulation resistance tests are used to verify and demonstrate the integrity of electrical wiring systems
3. Open Circuit Voltage – Short circuit current tests are conducted on PV string source circuits to verify proper readings, and that the circuits are clear from major faults.
4. Polarity of DC Wiring – As for any DC circuits, the polarity of array wiring and dc equipment is a critical concern for PV Installations.
5. Ground Continuity – Continuity testing is commonly used to verify grounding and bonding connections in electrical systems.

Note: **Satisfactory rating 3 and above points, Unsatisfactory - below 2.5 points**

Score = ___________

Rating: ____________

List of Reference Materials

1. Robert W Schultz and Amalia Suryani, *Inspection Guide for Photovoltaic Village Power (PV-VP) Systems*, October 2013

2. Seaward Group USA, *Photovoltaic System Commissioning and Testing, A Guide for PV System Technicians and Engineers*,6304 Benjamin Road, Suite 506, Tampa, Florida, 33634

3. http://www.seawardsolar.com/userfiles/pv150-solar-pv-installation-tester.php

Solar PV System Installation and Maintenance

Level-II

Learning Guide -51

Unit of Competence	Inspecting PV Components/ Materials Compliance
Module Title	Inspecting PV Components/ Materials Compliance
LG Code	EIS PIM2 09 LOT 4 LG-51
TTLM Code	EIS PIM2 TTLM 0819V1

LO4. Inspect/test System components and materials

Instruction sheet	Learning Guide: - 42

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

- Identifying testing procedures
- Recording tests results
- Accomplishing Inspection/Testing

- Performing task using personal protective equipment (PPE)

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

- Identify testing procedures
- Record tests results
- Accomplish Inspection/Testing
- Performing task using personal protective equipment (PPE)

Learning Instructions:-

1. Read the specific objectives of this Learning Guide.
2. Follow the instructions described below 3 to 6.
3. Read the information written in the information Sheet 1, Sheet 2, Sheet 3, Sheet 4, in pages 65, 70, 73 and 77 respectively.
4. Accomplish the Self-check 1, Self-check 2, Self-check 3, Self-check 4 in 69, 72, 76, and 80 respectively
5. If you earned a satisfactory evaluation from the “Self-check” proceed to Operation
   Do the “LAP test” on page

Information sheet -1	Performing task using personal protective equipment(PPE)

Definition of Safety

Conducting electrical testing on any PV system should be performed by qualified individuals having knowledge and experience with electrical systems measurements, the test equipment used, the equipment or systems being tested, and an awareness of the hazards involved. Working with PV systems involves exposure to energized circuits with high voltages and potentially lethal currents, presenting electrical shock hazards.

Battery systems and higher voltage installations can also present electrical burn and arc flash hazards. When these electrical hazards are combined other hazards such as working at heights and in difficult locations exposed to the elements, it is imperative for those installing and servicing PV systems to follow all applicable safety standards and guidelines.

Best practices for preventing electrical hazards and other common safety hazards associated with PV installations include the following:

- Carry out a risk assessment before conducting any work at the site.
- Working on electrical equipment and circuits in a de-energized state using documented lockout and tag out procedures.
- Wearing the appropriate PPE, including protective clothing, nonconductive Class E Hard hat, electrical hazard (EH) rated foot protection, and safety glasses at all times.

Figure 6: PPE (clothing, eye glass, hat, safety shoe)

- ✓ Using electrically insulated hand tools and properly grounded or double-insulated power tools maintained in good condition.

Figure 7: Electrical insulated had tools

- ✓ Avoiding contact with overhead power lines and buried electrical conductors.
- ✓ Using ladders with wooden or fiberglass rails when working on or near energized conductors.

Figure 8: Fiberglass ladders for electrical work

- ✓ Mitigating fall hazards and using personal fall arrest systems (PFAS) whenever working at unprotected heights of 6 feet or more.

Figure 9: Solar roof top inspection safety

- ✓ Maintaining an orderly work site and cautious approach. In some cases, working on energized equipment is unavoidable, for example when making measurements on PV arrays that are always energized when exposed to sunlight. Certain test equipment, such as mega ohm meters and insulation testers also produce high test voltages, and appropriate safety precautions must be observed when using this equipment. Proper electrical insulating gloves and other applicable PPE should always be worn when working on or testing energized circuits. The level of PPE required depends on the voltage levels and fault currents for the circuits under test. Particular care should be exercised whenever touching a PV array or associated conductive surfaces to protect against electrical shock, especially when faults are suspected.

- General safety recommendations for using electrical test equipment include:
  - ✓ Follow manufacturer's instructions for the safe operation of any test instruments.
  - ✓ Only use test instruments for their intended purpose, within their established limits and ratings.
  - ✓ Carefully inspect test equipment and leads prior to each use.
  - ✓ Properly maintain test instruments and recommended calibrations.
  - ✓ Plan and review all testing, safety and emergency procedures in advance.
  - ✓ Use appropriate personal protective equipment, including electrical insulating gloves.
  - ✓ Work with a partner.

Figure 10: Electrical insulating gloves

Self –Check -1	Written Test

Say True false for the following question below

1. Conducting electrical testing on any PV system should be performed by qualified individuals having knowledge and experience with electrical systems
2. Carry out a risk assessment before conducting any work at the site.
3. Working on electrical equipment and circuits in a de-energized state using documented lockout and tag out procedures.
4. Wearing the appropriate PPE, including protective clothing, nonconductive Class E Hard hat, electrical hazard

Note: **Satisfactory rating 2 and above points, Unsatisfactory - below 2 points**

Score = ___________

Rating: ____________

Information Sheet-2	Identifying testing procedures

1.1. Definition of testing procedure

- A test procedure is a formal specification of test cases to be applied to one or more target program modules. Test procedures are executable. A process called the VERIFIER applies a test procedure to its target modules and produces an exception report indicating which test cases, if any, failed. Test procedures facilitate thorough software testing by allowing individual modules or arbitrary groups of modules to be thoroughly tested outside the environment in which they will eventually reside.

  Test procedures are complete, self-contained, self-validating and execute automatically. Test procedures are a deliverable product of the software development process and are used for both initial checkout and subsequent regression testing of target program modifications. Test procedures are coded in a new language called TPL (Test Procedure Language). The paper analyses current testing practices, describes the structure and design of test procedures and introduces the Fortran Test Procedure Language.

- The test procedure can be done according to the type of PV system to be tested however in general the following testing procedure should be followed:-
- **Step 1:** Insulation resistance testing is conducted by applying high voltages to conductors and equipment, and determining the resistance by measuring the leakage current
- **Step 2:** Insulation resistance and other electrical tests on PV arrays are generally measured at source circuit combiner boxes,
- **Step3:** All circuits must be isolated from others for testing and discharged before and after testing
- **Step 4:** Any surge suppression equipment must be removed from the circuits, grounding or bonding connections are left connected
- **Step 5:** The test leads must make a reliable connection with the circuit under test, and may require filing or grinding some coated metal components.
- **Step 6:** be aware that the test voltage depends on the circuits or equipment tested. It is usually higher than the operating voltages for the circuits or equipment under test

example in case of inverter test and charge controller output voltage, but not higher than the voltage ratings of the equipment or conductor. Higher test voltages may be used for proof testing of equipment by manufacturers than for field tests.

1.2. System Functional Testing

- Verifying the proper operation of disconnecting means and component connection and disconnection sequences.
- Verify that interactive inverters and ac modules de-energize their output to utility grid upon loss of grid voltage. This is a safety requirement to prevent interactive inverters from operating as an islanded electrical system without voltage or frequency control, and preventing them back feeding de-energized electrical systems. These functions are performed internally by all utility-interactive inverters listed according to international and local standards.
- Verify that interactive inverters automatically reconnect to their output to the grid once the voltage has been restored for at least 5 minutes.
- Verify that battery-based interactive inverters disconnect ac loads from the utility source when operating in stand-alone mode.
- Verify the proper grid voltage and frequency to operate inverters, including evaluating voltage drop between the inverter ac output and point of connection to the grid.

Self-Check -2	Written test

Say True and False for the following question below

1. Test procedures facilitate thorough software testing by allowing individual modules or arbitrary groups of modules
2. Electrical Procedure are complete, self-contained, self-validating and execute automatically.
3. System Functional Testing Verifying the proper operation of disconnecting means and component connection and disconnection sequences.
4. PV is Insulation resistance testing is conducted by applying high voltages to conductors and equipment, and determining the resistance by measuring the leakage current

Note: **Satisfactory rating 3 and above points, Unsatisfactory - below 2 points**

Score = ___________

Rating: ____________

Information Sheet-3	Accomplishing inspection/Testing

Inspection/Testing	
General	• Fill in the site code, village name, name of contractor, date, name of inspector and sign. • Measurements (and opening of cabinets) shall ideally be carried out by the local operator, with guidance and supervision by the inspector. • "Handheld measuring devices" refers to clamp meters, multi-meters and thermometers that the inspector carries along to site. • "RMS/LCD" refers to monitoring displays installed at site. These could include the liquid crystal display (LCD) on inverters and charge controllers and/or the monitoring interface on a computer display for a remote monitoring system (RMS). • Make comments on any faults or irregularities noticed. • Ask operator to provide name, contact number and signature after measurement.
Completing the checklist **"Time and weather conditions"**	• Time and weather conditions" are recorded at time of measurement as these parameters influence subsequent measurements. • Time is filled in using hh:mm format, while the weather condition is ticked ✓ in the appropriate cell. • Better to record in the morning times, since evening measurements are not generally affected by weather conditions.
Completing the checklist **"PV performance"**	• "PV performance" is measured using a handheld measuring device in order to detect any deviations in electricity generation from the different solar PV module strings. • The points of measurement are the different "Combiner Boxes", using handheld measuring device. • Wait for stable light conditions until you take measurements per box. • Do measurements in the morning (around 10:00 to 12:00) in order to have good light conditions, and to avoid a situation where the charge controller is switching off or regulating down the power of the panels because of full batteries. • Note: Each solar panel has two Voltage values (Vmp/Voltage at Maximum Power and Voc/Voltage at Open Circuit), while each solar charge controller has a voltage limit (eg. typically 150-250VDC). Panels connected together in strings should not exceed Vmp and Voc limits of the solar charge controllers (e.g. if a panel produces 36VDC for Voc and the solar charge controller has a limit of 150VDC for Voc input, then only 4 panels can be strung together, producing 144VDC max). • Measure the Voltage (V) between the positive and negative busbar in the combiner boxes

	• Measure the Eg. 2.3 Current (Amp) with 3 or 4 strings together in order to see if the current of all strings are similar and note the values (number of strings measured and the Ampere). • In case of different string currents, try to identify reasons (shading of modules, loose cables) and make comment. Be aware that when the light is changing rapidly due to clouds, the current will also change rapidly. • If one or more strings have no current please check for broken, burnt or loose cables, broken panels or other irregularities and make comments.
Completing the checklist "**Charge controller recording**	• "Charge controller recording" records the accumulated solar energy production (kWh) since RMS start of operation and the current charging voltage (VDC) from the solar PV array. • Points of reading are all charge controllers, through LCD on charge controller (or inverter or RMS if charge controller does not incorporate LCD). • Recording time is during peak electricity generation (at 10:00 to 12:00 in the case of solar PV). • "Energy generated", when compared with date of commissioning (from KPI survey) and hence the theoretically maximum available sunshine hours, allows an assessment of the availability factor of the installation. • Energy generated", when compared with "total consumed energy" recording, allows an assessment of the balance between electricity generation and demand. • "Solar PV voltage" (input to charge controller), when compared to "Measured Voltage on busbar" (output from PV) values, allows an assessment of losses between solar PV array and charge controllers. This might be indicative of the wiring quality.
Completing the checklist **"Battery status"**	• Battery status" measures the current state-of-charge of the battery as a means to gauge RMS battery "health" and balance between electricity generation and demand. • The point of measurement for voltage (VDC) and discharge current (Amp) is the main battery Measure terminal, using a handheld measuring device and the reading on the Charge Controller LCD or RMS. Both values are recorded in the checklist. • Evening measurement: first battery measurement is done after sunset, or when no electricity is generated, and during time of peak load. Around 19:00 for a PV-VP installation is likely optimal. This ensures values are not corrupted, caused by simultaneous charging of batteries

	• Morning measurement: second battery measurement is done the following morning, while sun intensity is still low. Around 07:00 for a PV system installation is likely optimal. This value, compared with the evening record, allows for an assessment of the night time load. • The point of measurement for battery room temperature (°C) is a thermometer or sensor placed between batteries in the battery bank during hot time of day (11:00 to 14:00). This allows an assessment whether high temperatures prevail in the battery room, which will reduce battery life expectancy. • To check whether any batteries emit more heat than others, simply touch all batteries briefly. If any hot battery cells are detected, tick ✓ the cell. This is indicative that some batteries might have a high internal resistance.
Completing the checklist **“Inverter performance”**	• “Inverter performance” measures and records the AC voltage (compared to nominal RM 220V or 230V), the current (Amp) being drawn at time of LCD measurement (i.e. the load) and the total supplied energy (kWh) since installation. • Point of measurement is the AC Distribution Board busbar using handheld measurement device. • Point of recording is the LCD on each inverter using the menu or navigation feature. • Time of measurement and reading is evening (about 19:00 to 20:00) during peak demand and morning (about 07:00 to 08:00) during off-peak demand. • Note: AC Distribution busbar Voltage and current measurement will likely be same for all inverters (regardless of whether all inverters is working or not). Only comparing the busbar Voltage and current with the recorded Voltage and Current from LCD or RMS will show inverter faults. • Record total supplied energy (kWh) at the kWh-meter(s) and/or LCD and/or RMS in the evening and the following morning. This shows approximate night-time load

Self-Check -3	Written test

Say True false for the following question below

1. General Inspecting are Fill in the site code, village name, name of contractor, date, name of inspector and sign.
2. Time and weather conditions" are recorded at time of measurement as these parameters influence subsequent measurements.
3. PV performance" is measured using a handheld measuring device in order to detect any deviations in electricity generation from the different solar PV module strings.
4. Charge controller recording" records the accumulated solar energy production (kWh) since RMS start of operation and the current charging voltage (VDC) from the solar PV array.
5. Battery status" measures the current state-of-charge of the battery as a means to gauge RMS battery "health" and balance between electricity generation and demand.

Note: **Satisfactory rating 3 and above points, Unsatisfactory - below 2.5 points**

Score = ____________

Rating: _____________

Information Sheet -4	Recording test results

2.1. Recording Test Results

Use the QCS Test Record transaction to generate quality tests and to record test results.

The warehouse mobility icon based menu and list based menu comprises of the Get It . QCS Test Record is listed as a transaction under the Get It module.

2.2. On the Get It module:

- Select **QCS Test Record**.
- Optionally, in the **Receiver** field, specify a receiver. You can use a customer, supplier, or WIP tag as a receiver. Leave blank to select from a list of receivers.
- Select **Next**. If you did not specify a receiver, a list of receivers is displayed. Select a receiver from the list.
- Select an operation.
- Specify this information:

  - ✓ **Minimum**
    Specify the minimum test result value.
  - ✓ **Maximum**
    Specify the maximum test result value.
  - ✓ **Nominal**
    Specify the nominal test result value.
  - ✓ **Qty Tested**
    Specify the quantity that was tested.
  - ✓ **Qty Failed**
    Specify the quantity that failed.
  - ✓ **Pass**
    Specify whether the test was passed.
  - ✓ **Gage Expire**
    Specify whether the gage is expired.
  - ✓ **Gage**
    Select a gage.
  - ✓ **Test Comp**
    Specify whether the test is completed.

Use the following template to record test results

Site code:		Date:	
Village/site name:		Name of Inspector:	
Contractor name:		Signature:	

1	**Time and weather condition (during measurement):**						
1.1	PV performance measurement - Morning	Time:		Sunny	Cloudy	Rain	
1.2	Battery status measurement - Morning	Time:		Sunny	Cloudy	Rain	
1.3	Inverter performance - Morning	Time:		Sunny	Cloudy	Rain	

2	**PV performance**	At 10:30 - 11:00 Voltage and Current for PV string to check consistency - measure on the each combiner box - if feasible. In case of different string currents, try to identify reasons (shading modules, cables) and make comment Take photos of display readings					
		Combiner Box 1		**Combiner Box 2**		**Combiner Box 3**	
2.1	Number of strings:		Nr		Nr		Nr
2.2	Measure voltage on busbars:		Volt		Volt		Volt
2.3	Measure current with 3 or 4 strings together:		Amp		Amp		Amp
	Comments:						

3	**Solar energy**	Record accumulated solar energy production since start of operation (via display of charge controller if available)				
3.1	Charge Controller 1 (kWh):		Charge Controller 2 (kWh):		Charge Controller 3 (kWh):	
	Comments:					

4	**Battery status**	Battery measurements at evening (19.00-20:00) and morning (07:00-08:00) Only over all measurement - not each individual batteries Take photos of display readings (handheld measuring device, LCD and/or RMS)				
4.1.1	Battery Voltage (handheld measuring device) - Evening:		Volt	Battery Voltage (handheld measuring device) - Morning:		Volt
4.1.2	Battery Voltage (LCD or RMS) - Evening:		Volt	Battery Voltage (LCD or RMS) - Morning:		Volt
4.2.1	Discharge Current (handheld measuring device) - Evening:		Amp	Discharge Current (handheld measuring device) - Morning:		Amp
4.2.2	Dircharge Current (LCD or RMS) - Evening:		Amp	Dircharge Current (LCD or RMS) - Morning:		Amp
4.3	Battery room temperature (between batteries) - Evening:		°C	Battery room temperature (between batteries) - Morning:		°C
4.4	Are there hot battery cells (touch by hand each cell if there are temperature differences)?:	No	Yes	If Yes, provide details:		
	Comments:					

5	**Inverter performance**	Inverter measurements at evening (19.00-20:00) and morning (07:00-08:00) Take photos of display readings (handheld measuring device, LCD and/or RMS)					
		Inverter 1		**Inverter 2**		**Inverter 3**	
5.1	Inverter Voltage (measured with handheld device at AC distribution board):		Volt		Volt		Volt
5.2	Inverter Current (measured with handheld device at AC distribution board):		Amp		Amp		Amp
5.3	Inverter Voltage (reading from LCD or RMS):		Volt		Volt		Volt
5.4	Inverter Current (reading from LCD or RMS):		Amp		Amp		Amp
5.5	Total consumed energy since start of operation (reading from LCD or kWh-meter):		kWh		kWh		kWh
5.6	Reading from solar PV Voltage from LCD or RMS:		Volt		Volt		Volt
	Comments:						

Activate Windows
Go to PC settings to activate Windows.

Self –check -4	Written test

Short Answer Type Questions

A	B
1. Pass	A. Specify the nominal test result value
2. Nominal	B. Specify whether the test was passed.
3. Qty Failed	C. Specify whether the gage is expired
4. Gage Expire	D. Specify the quantity that failed.
5. Maximum	E. Specify the maximum test result value.

Note: **Satisfactory rating 4 and above points, Unsatisfactory - below 2.5 points**

Score = ____________

Rating: _____________

List of Reference Materials

1. Robert W Schultz and Amalia Suryani, *Inspection Guide for Photovoltaic Village Power (PV-VP) Systems*, October 2013

2. Seaward Group USA, *Photovoltaic System Commissioning and Testing, A Guide for PV System Technicians and Engineers*,6304 Benjamin Road, Suite 506, Tampa, Florida, 33634

3. http://www.seawardsolar.com/userfiles/pv150-solar-pv-installation-tester.php

Solar PV System Installation and Maintenance

Level-II

Learning Guide -52

Unit of Competence	Inspecting PV Components/ Materials Compliance
Module Title	Inspecting PV Components/ Materials Compliance
LG Code	EIS PIM2 09 LOT 5 LG-52
TTLM Code	EIS PIM2 TTLM 0819V1

LO5. Report test results

Instruction sheet	Learning Guide: - 43

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

- Evaluating test results
- Reporting on the compliance or non-compliance material

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:-**

- Evaluate test results
- Report on the compliance or non-compliance material)

Learning Instructions:-

1. Read the specific objectives of this Learning Guide.
2. Follow the instructions described below 3 to 4.
3. Read the information written in the information Sheet 1, Sheet 2, in pages 84 and 89 respectively.
4. Accomplish the Self-check 1, Self-check 2, in pages 88 and 93 respectively

Information Sheet-1	Evaluating test results

1.1. Definition of Evaluation Test

Test & Evaluation (T&E) is the process by which a system or components are compared against requirements and specifications through testing. The results are evaluated to assess progress of design, performance, supportability, etc.

Developmental test and evaluation (DT&E) is an engineering tool used to reduce risk throughout the acquisition cycle. Operational test and evaluation (OT&E) is the actual or simulated employment, by typical users, of a system under realistic operational conditions.

Figure 11: Evaluation Pyramid

1.2. Subjective Evaluation Methods

In subjective evaluations, tests are designed in such a way that human subjects interact with the system. Subjective measures include level of intelligibility, general impression, annoyance, user friendliness, intuitiveness, level of difficulty, and subjective impression of system response time. The ultimate overall measure is: “Can the task be completed?” This is a measure that includes recognition, error recovery, situational awareness, and feedback. In this sense, the time required to complete the entire test might also be indicative of the quality of the system. General impressions of test subjects can be indicative of how the system performs.

1.3. Evaluation tools (how to evaluate)

Deciding the approach and tools to adopt is one of the most complex issues in evaluation. Techniques and procedures vary from one course to another, and their effectiveness depends on how closely they match course goals, contents and structure on the one hand and educational strategy on the other.

When choosing tools, it is important to decide whether the intention is to evaluate products (a text, project, etc.) or processes/behaviors (group leadership, collaborative interaction, negotiation, debate, etc.). The latter calls for 'situational' testing, whereby situations are created so that the learner can demonstrate skills in human relations, management, etc.

Figure 12: Test Evaluation Report

In order to correctly evaluate a test, at least four attributes should be measured: namely, sensitivity, specificity, accuracy and precision. Sensitivity is the proportion of diseased animals which are correctly identified, whereas specificity is the proportion of healthy animals which are correctly identified.

These two attributes are important, not only because of the reasons implied by their definition but because they influence both the apparent prevalence of disease and proportion of test-positive animals which are actually diseased. The ability of a test to give a true measurement of the substance being measured, its accuracy, and its ability to give consistent results on the same sample, its precision, are good measures of quality control. Both these attributes influence the sensitivity and specificity of the test. Inaccuracies and inconsistencies arise from the test itself, the technician and the nature of the sample being tested.

Table 7: Check list for system component

S/N	System component to be identified	Check if it is fulfilled or not fulfilled		Evaluation conditions (Example)
1	Solar PV Modules			
	Installed module type:	Fulfilled	Not fulfilled	Fulfilled if all are installed; state capacity *Additional comments in case of defects (e.g. spots and others)*
	Installed capacity:	Fulfilled	Not fulfilled	State make and model as per manual Fulfilled if as per specification.
2	Inverter			
	Installed Inverter type:	Fulfilled	Not fulfilled	Fulfilled if installed even if defect; In case of defects: additional comment
	Installed capacity:	Fulfilled	Not fulfilled	State make and model as per manual Fulfilled if as per specification
3	Charge controller			
	Installed charge controller type:	Fulfilled	Not fulfilled	Fulfilled: if installed even if defect In case of defects: additional comment
	Installed capacity:	Fulfilled	Not fulfilled	State make and model as per manual Fulfilled: if as per specification
4	Battery system			
	Installed battery type:	Fulfilled	Not fulfilled	Fulfilled: if battery voltage and capacity meets contract (eg. total 48 V/3000 Ah specified). State voltage (V) and recorded time (hh:mm) as per Measurement Sheet Fulfilled: eg. if >50VDC, if 48-50VDC (but with additional comments since voltage

				should be higher) Not fulfilled: if measurement <48VDC
	Installed capacity:	Fulfilled	Not fulfilled	State make and model as per manual Fulfilled: if as per specification
5	Balance of system			
	Electric wiring as specified:	Fulfilled	Not fulfilled	As per Technical Sheet Not fulfilled: in case of obvious deviations (incorrect cables types)
	Grounding as specified:	Fulfilled	Not fulfilled	As per Technical Sheet Fulfilled: in case that grounding had been done in the solar array yard and for all electrical cabinets Not fulfilled: in case that even grounding of one cabinet or of other equipment had not been done (serious risk of life and damage of equipment)
	Array mounting as specified:	Fulfilled	Not fulfilled	As per Technical Sheet Not fulfilled: array materials not as specified or array dimensions and placing not as specified
	Combiner boxes as specified:	Fulfilled	Not fulfilled	As per Technical Sheet Fulfilled: if installed as specified In case of defects: additional comment
	Lightening protection as specified:	Fulfilled	Not fulfilled	As per Technical Sheet Fulfilled: if installed as specified Not fulfilled: missing
	Distribution panel as specified:	Fulfilled	Not fulfilled	As per Technical Sheet Fulfilled: if installed as specified Not fulfilled: in case of major defects
	Street light installed and operating:	Fulfilled	Not fulfilled	State Planned as per contract State Surveyed as per manual Fulfilled: if installed, (make additional comment) Not fulfilled: if surveyed is below planned, if more than 10% defective
	Appliances are functional as specified:	Fulfilled	Not fulfilled	Fulfilled if appliance are operational and not fulfilled if appliance are not getting power.

Self-Check -1	Written test

Say True and False for the following question

1. Developmental test, tests are designed in such a way that human subjects interact with the system.
2. In subjective evaluations and evaluation (DT&E) is an engineering tool used to reduce risk throughout the acquisition cycle.
3. Test & Evaluation (T&E) is the process by which a system or components are compared against requirements and specifications through testing.

Note: **Satisfactory rating 3 and above points, Unsatisfactory - below 3 points**

Score = ___________

Rating: ____________

Information Sheet-2	Making reports on the compliance or non-compliance material

2.1. Definition of Reporting

Spread sheet-based checklist comparing all components (type, specifications, quantity, etc.) installed on site between tender specifications and contractor contract. Assessment is done on the basis of “Fulfilled” or “Not Fulfilled”. Purpose is to determine whether contractors neglected to provide any components as legally required under the contract.

Compliance Reporting. Compliance refers to the reports created by companies in order to comply to rules, standards, laws and regulations set by regulatory bodies and government agencies. Failure to comply means businesses are subject to regulatory penalties, including fines and imprisonment.

In the global business environment, the only certainty is uncertainty. Even in a surging economy, risk abounds. Perhaps your competitor releases a brand-new product or develops a new technology. Perhaps your supply chain is disrupted by political upheaval or natural disasters. Perhaps your leadership is rocked internally by scandal or insider trading. But of all potential risks, the one that can be the most vexing is the problem of compliance. Regulations change with the political winds, meaning your company must keep up-to-date with these developments and adjust its business practices accordingly in order to remain on the right side of the law. Likewise, as your organization expands into new territories and jurisdictions, it will be bound by new laws and mandates, furthering the need for a clear-eyed look at compliance issues.

How then can a company understand its position in relation to overall compliance? Perhaps the most effective way is through compliance reporting. Compliance reports offer detailed accounts of an organization’s progress on particular compliance initiatives, or, taken collectively, can provide a broad summary of your company’s compliance efforts.

2.2. Who Compiles Compliance Reports?

In most large corporations, a compliance report falls under the direction of the Chief Compliance Officer (CCO). The CCO is responsible for establishing company-wide standards and implementing procedures to ensure that an organization's compliance programs can effectively and efficiently identify, prevent, detect and correct issues of noncompliance with applicable laws, regulations, industry standards or company policies. Members of the compliance department may recruit or consult with subject matter experts for the completion of particular reports, and oftentimes, data is gathered from across the organization through grass roots reporting, polling and questionnaires.

2.3. Who Reads Compliance Reports?

Compliance reports can have a variety of different audiences, depending on the particular focus of the report and whether or not the report is internal or outward-facing.

Outward-facing reports are usually part of a standard regulatory regime or specific compliance audit that an organization undergoes as part of a request or review required by regulatory agencies. These reports are read by members of the appropriate regulatory agency and can be integral in determining whether the organization faces fines, sanctions or other penalties. A thorough compliance report indicates that the organization is meeting regulatory requirements or operating in good faith and may sway a regulatory board to work with the company toward remediation.

2.4. What Are the Benefits of Compliance Reporting?

Compliance reports identify areas within the company where compliance initiatives are being met effectively and those areas in which more work is needed to meet the standards of regulation or internal controls. Armed with this knowledge, business leaders can make more effective decisions about resource allocation, risk management and strategic planning for the future. In addition, the completion of annual compliance reports has two key benefits for organizations:

- **Peace of mind.** Perhaps the most obvious benefit of a compliance report is the peace of mind it offers owners and other stakeholders. Compliance is a complicated endeavor, with many of the goals seeming like moving targets. Compliance reporting offers concrete evidence that your organization is on the right side of regulations and controls, and can be the starting place for any plan to reconcile noncompliance issues. Annual compliance reporting can be an integral way of identifying likely problems before they develop into full-fledged violations.
- **Client assurance.** A thorough annual compliance report is like a clean bill of health. With it, your organization can demonstrate to clients and potential investors that your operations and controls are trustworthy. As the list of mandatory regulations grows, more and more clients expect organizations to be able to provide proof of compliance before they enter into contracts or invest funds. Those who cannot do so might be a cause of hesitation or concern for potential business partners.

2.5. How can entity management technology help?

Compliance reporting can be an arduous and time-consuming task, but it doesn't have to be. Advanced entity management technologies offer several key features that help to make compliance reporting as quick and painless as possible.

- **Single source of corporate data.** The process of creating a compliance report inevitably gathers data from disparate sources across the organization. Entity management technology provides a single source of verifiable corporate data, ensuring that reports are based on current, reliable information.
- **Built-in data analytics applications.** Data analytics applications embedded in entity management software allow users to glean actionable insights from gathered information.
- **Data visualization capabilities**. Users can take advantage of entity management technology's data visualization applications. By deploying these

applications, compliance teams can chart, graph or color-code compliance data, strengthening and clarifying their message to achieve the best possible results.

The increased regulatory environment of the past decade has forced corporations to take a hard, honest look at compliance initiatives. The best way to get a clear picture of your organization's compliance efforts is through regular, thorough compliance auditing and reporting. Entity management technology can help compliance officers produce clear, effective reports quickly and easily. For more information about how Blueprint can help you with compliance reporting, contact an authorized Blueprint representative today.

Table 8: component compliance

S/N	System component to be identified	Check if it is fulfilled or not fulfilled
1	Solar PV Modules	
	Installed module type:	
	Installed capacity:	
2	Inverter	
	Installed Inverter type:	
	Installed capacity:	
3	Charge controller	
	Installed charge controller type:	
	Installed capacity:	
4	Battery system	
	Installed battery type:	
	Installed capacity:	
5	Balance of system	
	Electric wiring as specified:	
	Grounding as specified:	
	Array mounting as specified:	
	Combiner boxes as specified:	
	Lightening protection as specified:	
	Distribution panel as specified:	
	Street light installed and operating:	
	Appliances are functional as specified:	

Self-Check -2	Written test

Say True and False for the following question

1. Guidance reports identify areas within the company where compliance initiatives are being met effectively and those areas in which more work is needed to meet the standards of regulation or internal controls.
2. In most large corporations, a compliance report falls under the direction of the Chief Compliance Officer (CCO).
3. Compliance reports can have a variety of different audiences, depending on the particular focus of the report and whether or not the report is internal or outward-facing.
4. Electrical Reporting Compliance refers to the reports created by companies in order to comply with rules, standards, laws and regulations set by regulatory bodies and government agencies.

Note: **Satisfactory rating 3 and above points, Unsatisfactory - below 2 points**

Score = ___________

Rating: ____________

List of Reference Materials

1. Robert W Schultz and Amalia Suryani, *Inspection Guide for Photovoltaic Village Power (PV-VP) Systems*, October 2013

2. Seaward Group USA, *Photovoltaic System Commissioning and Testing, A Guide for PV System Technicians and Engineers*,6304 Benjamin Road, Suite 506, Tampa, Florida, 33634

3. http://www.seawardsolar.com/userfiles/pv150-solar-pv-installation-tester.php

Solar PV System Installation and Maintenance

Level-II

Learning Guide -53

Unit of Competence	Inspecting PV Components/ Materials Compliance
Module Title	Inspecting PV Components/ Materials Compliance
LG Code	EIS PIM2 09 LOT 6 LG-53
TTLM Code	EIS PIM2 TTLM 0819V1

LO6. Notify completion of work

Instruction sheet	Learning Guide: - 44

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

- Making final checks
- Notifying supervisor
- Cleaning, checking and returning tools, equipment and any surplus resources
- Cleaning up and making safe Work area

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:-**

- Make final checks
- Notify supervisor
- Clean, check and return tools, equipment and any surplus resources
- Clean up and make safe Work area

Learning Instructions:-

1. Read the specific objectives of this Learning Guide.
2. Follow the instructions described below 3 to 4.
3. Read the information written in the information Sheet 1, Sheet 2, Sheet 3, Sheet 4, in pages 97, 102, 105 and 114 respectively.
4. Accomplish the Self-check 1, Self-check 2, Self-check 3, Self-check 4 in pages 101, 104, 113 and 121 respectively

Information Sheet-1	Making final checks

1.1. Definition of making final checks

The inspection and test status of the solar system shall be finally checked by using markings, authorized stamps, tags, labels, routing cards, inspection records, test software, physical location, or other suitable means, which indicate the conformance or nonconformance of work with regard to inspections and tests performed. The identification of inspection and test status shall be maintained, as necessary, throughout the final report submission to ensure that all work has passed the required inspections and testing specified.

1.2. What Is a Checking

A checking is a deposit account held at a financial institution that allows withdrawals and deposits. Also called demand accounts or transactional accounts, checking accounts are very liquid and can be accessed using checks, automated teller machines, and electronic debits, among other methods. A checking account differs from other bank accounts in that it often allows for numerous withdrawals and unlimited deposits, whereas savings accounts sometimes limit both.

Figure 13: Effective decision making

Decision making is the process of making choices by identifying a decision, gathering information, and assessing alternative resolutions.

Using a step-by-step decision-making process can help you make more deliberate, thoughtful decisions by organizing relevant information and defining alternatives. This approach increases the chances that you will choose the most satisfying alternative possible.

- **Step 1: Identify the decision**

  You realize that you need to make a decision. Try to clearly define the nature of the decision you must make. This first step is very important.

- **Step 2: Gather relevant information**

  Collect some pertinent information before you make your decision: what information is needed, the best sources of information, and how to get it. This step involves both internal and external "work." Some information is internal: you'll seek it through a process of self-assessment. Other information is external: you'll find it online, in books, from other people, and from other sources.

- **Step 3: Identify the alternatives**

As you collect information, you will probably identify several possible paths of action, or alternatives. You can also use your imagination and additional information to construct new alternatives. In this step, you will list all possible and desirable alternatives.

- **Step 4: Weigh the evidence**

Draw on your information and emotions to imagine what it would be like if you carried out each of the alternatives to the end. Evaluate whether the need identified in Step 1 would be met or resolved through the use of each alternative. As you go through this difficult internal process, you'll begin to favor certain alternatives: those that seem to have a higher potential for reaching your goal. Finally, place the alternatives in a priority order, based upon your own value system.

- **Step 5: Choose among alternatives**

Once you have weighed all the evidence, you are ready to select the alternative that seems to be best one for you. You may even choose a combination of alternatives. Your choice in Step 5 may very likely be the same or similar to the alternative you placed at the top of your list at the end of Step 4.

- **Step 6: Take action**

You're now ready to take some positive action by beginning to implement the alternative you chose in Step 5.

- **Step 7: Review your decision & its consequences**

In this final step, consider the results of your decision and evaluate whether or not it has resolved the need you identified in Step 1. If the decision has *not* met the identified need, you may want to repeat certain steps of the process to make a new decision. For example, you might want to gather more detailed or somewhat different information or explore additional alternatives.

1.3. Make Check Payments

You can issue electronic and manual checks in Business Central. Both methods use the payment journal to issue checks to vendors. You can also void checks and view check ledger entries.

The following procedure shows how to pay a vendor with a computer checks by applying the payment to the relevant vendor invoice, printing the check, and then posting the payment as paid. This results in positive vendor ledger entries, applied to negative bank ledger entries, and physical checks for processing in the bank.

You can pay with two types of checks. For both types, the **Bal. Account Type** or the **Account Type** field must contain **Bank Account**.

- **Computer Check**: Select this option if you want to print a check for the amount on the payment journal line. You must print the checks before you can post the journal lines.
- **Manual Check**: Select this option if you have created a check manually and want to create a corresponding check ledger entry for this amount. By using this option, you cannot print the check.

Self-Check -1	Written test

Choose the best Answer

1. From the following witch one is Effective decision making
   - A. Identify the decision
   - B. Gather information
   - C. Identify alternatives
   - D. Take Action
   - E. All………………..F. Non

Note: **Satisfactory rating 1 and above points, Unsatisfactory - below 1 points**

Score = ___________

Rating: ____________

Information sheet-2	Notifying supervision upon completion of work

2.1. Definition Notifying

When the final checking of test process is completed it will be important to notify the superior that the inspection and test status of the solar system is completed and the final checking process is done all the documentation and report checklists which are singed by the inspector has to be submitted to the supervisor.

2.2. YOU AND YOUR SUPERVISOR

Your supervisor, as leader of your work unit, is responsible for assuring that all employees know how to do their work safely, and that they have the materials, tools, and other means necessary to perform their work at a satisfactory level. Your supervisor is interested in your job development and advancement. The supervisor relies on you, the employee, to complete your share of the assigned work. You are expected to advise your supervisor of any problems you may encounter in the course of completing your assigned tasks. You should notify your supervisor when you will be late or absent from work. Mutual trust and communication between you and your supervisor are essential in building a sound working relationship.

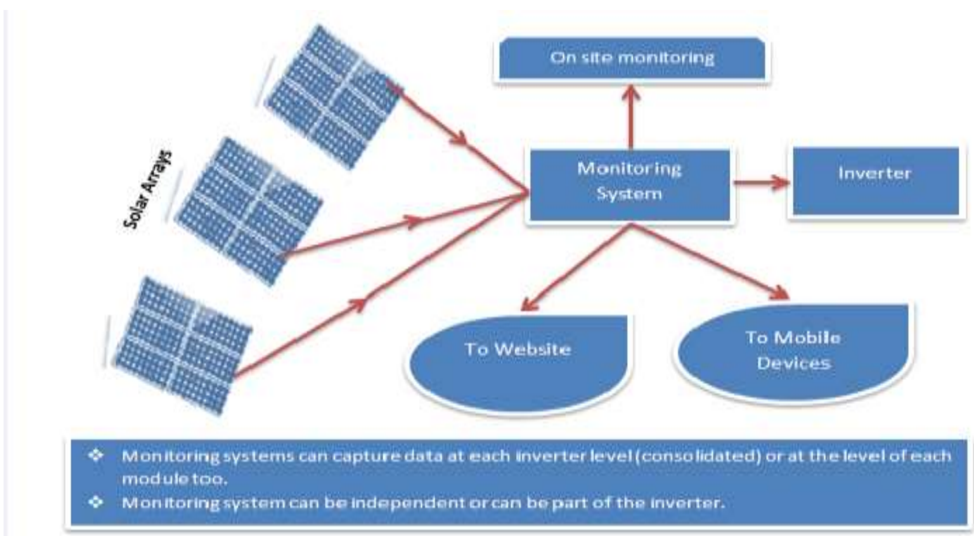


Figure 14: Solar Monitoring Systems – Keeping Track of Your Solar Farm

Each employee has a “direct” supervisor. This supervisor (State or RF employee) has access to approve the employee’s time report in SOLAR. In order to have sufficient backup for approving time reports, a hierarchy of supervisors exists for up to 3 levels. For instance, in the example below, the employee has a "direct" supervisor, the direct supervisor has a supervisor and that supervisor has a supervisor. In this case, all 3 supervisors can approve the employee's timesheet.

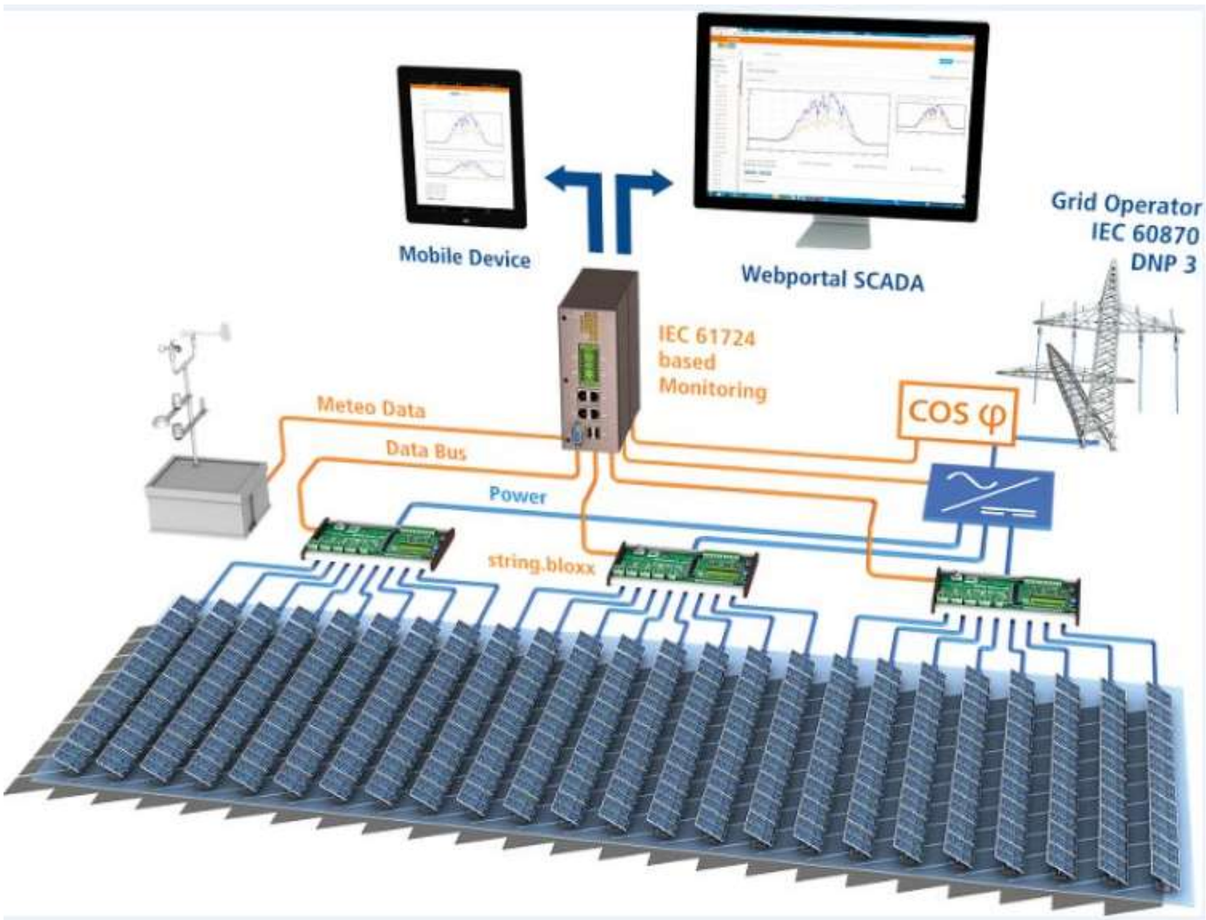


Figure 15: Distribution Site Supervision

Self-Check -2	Written test

Say True and False for the following question below

1. When the final checking of test process is completed it will be important to notify the superior that the inspection and test status of the solar system
2. Your supervisor, as leader of your work unit, is responsible for assuring that all employees know how to do their work safely, and that they have the materials, tools, and other means necessary to perform their work at a satisfactory level.
3. Each employee has a "Indirect" supervisor. This supervisor (State or RF employee) has access to approve the employee's time report in SOLAR.

Note: **Satisfactory rating 2 and above points, Unsatisfactory - below 1.5 points**

Score = ___________

Rating: ____________

Information Sheet-3	Cleaning, Checking and returning tools, equipment and surplus resources.

3.1. Definition of equipment and surplus resource

The inspector shall develop inspection checklist for proper cleaning and checking procedures. The inspection checklist shall be reviewed and updated whenever there is a change in work nature or work location and re-submitted for approval by the responsible person. The inspection checklist shall include an assessment on the cleanliness and tidiness of all work locations. Items to be checked against for each work location shall include, but not limited to, the following:

A surplus employee is someone that a business or government agency no longer needs. A company may reassign surplus employees from one business unit to current or vacant positions elsewhere in an organization. The company may also implement temporary or permanent layoffs.

- Maintenance of passageways, common accesses and public areas free of obstruction;
- Proper storage and stacking of materials;
- Proper placement and storage of tools and equipment after work;
- Proper sorting, storage and /or disposal of waste materials in accordance with the Waste Management Plan;
- Proper securing of hoarding, barriers, guarding, lighting and signing of works.
- Prevention and removal of toxic leftovers such as excess battery acid etc …

3.2. Three ways to reduce surplus in a market:

1. Increase Demand - Marketing, advertising, promotions. Get more people to buy.
2. Decrease Supply - Shift or stop production. The value (profit margin) has decreased, so target a market with better margins.
3. Remove the Surplus - Buy the surplus out of the market.

A surplus describes the amount of an asset or resource that exceeds the portion that's actively utilized. A surplus can refer to a host of different items, including income, profits, capital, and goods. In the context of inventories, a surplus describes products that remain sitting on store shelves, un purchased. In budgetary contexts, a surplus occurs when income earned exceeds expenses paid. A budget surplus can also occur within governments when there's leftover tax revenue after all governmental programs are fully financed.

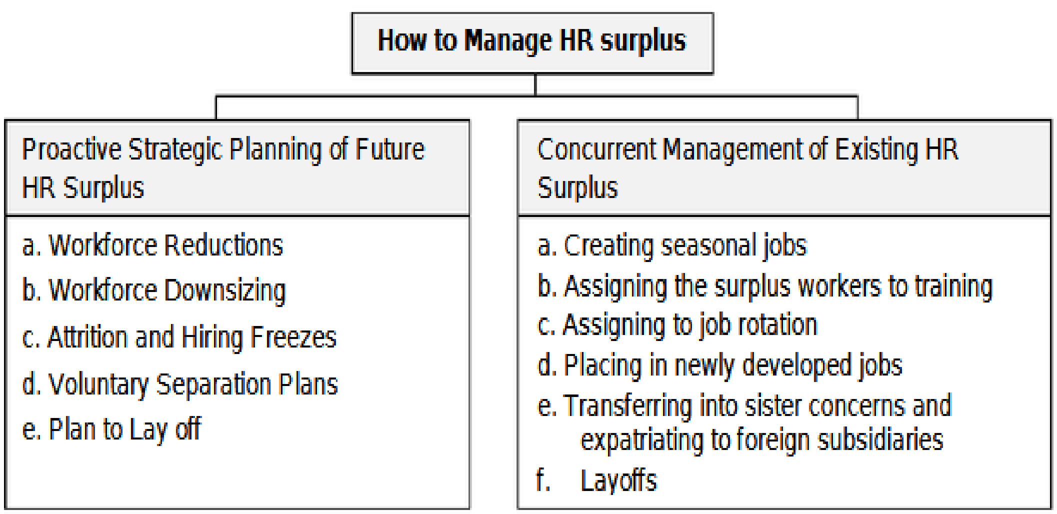


Figure 16: Strategies on Human Resource Surplus Management

3.3. Key takeaway

- A surplus describes a level of an asset that exceeds the portion used.
- An inventory surplus occurs when products that remains unsold.
- Budgetary surpluses occur when income earned exceeds expenses paid.
- A surplus results form a disconnect between supply and demand for a product, or when some people are willing to pay more for a product than other consumers.

3.4. Reasons for Surplus

A surplus occurs when there is some sort of disconnect between supply and demand for a product, or when some people are willing to pay more for a product than others. Hypothetically speaking, if there were a set price for a certain popular doll, that everyone was unanimously expected and willing to pay, neither a surplus nor a shortage would occur. But this rarely happens in practice, because various people and businesses have different price thresholds--both when buying and selling.

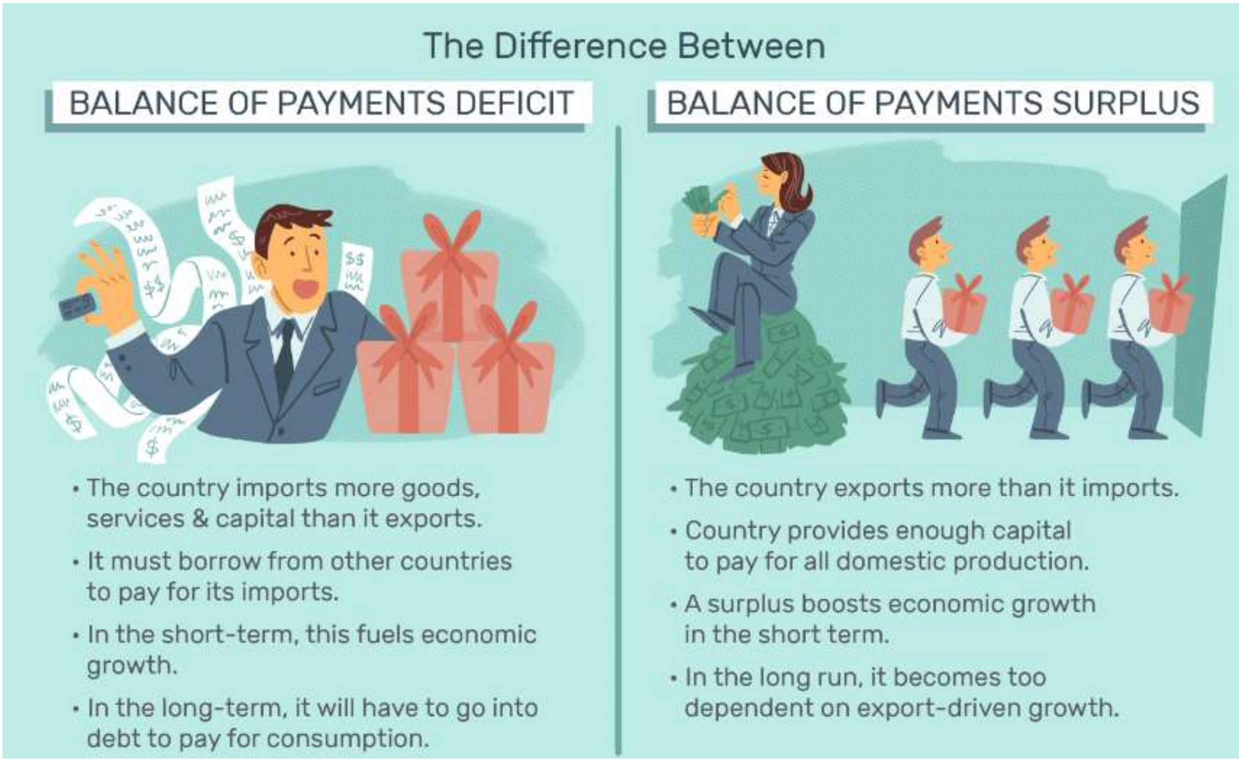


Figure 17: Balance of Payments: Definition, Components, Deficit

3.5. Checking how your system is installed

1. System Size (S) in kW?

S	kW	e.g 4 kW

How do I find my system size?

If you don't know the size, you can calculate it by knowing how many panels you have and the rough age of the panels.

For systems older than 5yrs multiply the number of panels you have by 0.2

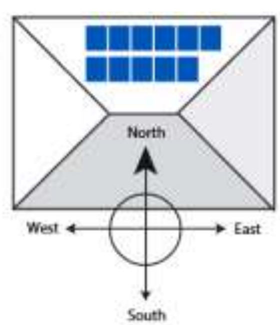
For systems newer than 5yrs, multiply the number of panels you have by 0.25

2. Orientation (O). Which way are the panels facing?

The direction (sometimes called orientation) of your panels affect their performance.

If your panels are facing more than one direction, list both directions.

O		e.g North



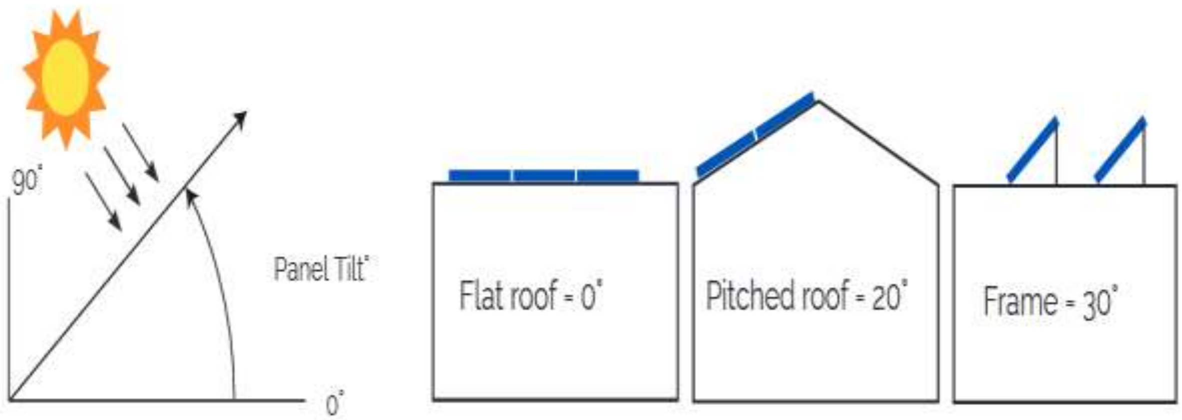
3. Angle (A). What angle are the panels tilted to (To the nearest 10°)?

A	°(degrees)

e.g 20°

How do I find the angle?

Flat panels are 0°. Most roofs are pitched around 20°. If your panels are on a frame, they're probably at about 30°.



3.6. Take readings from your solar inverter

Your solar inverter will have a display on it which allows you to find the following information. Most inverters have displays showing either current energy production or log data. You might need to press buttons near the display to make it show you the right screen. If you're having trouble you might need to look up the manual for the inverter to figure out how to access these figures.

Figure 18: Inverter

4. What is the total (T) amount of energy generated since the system was installed?

This is normally a figure called **E-tot**, or simply just **Total** and might need to be accessed through the LOG screen.

T	kWh	e.g 19345 kWh

5. Real-time Power Check (P)

On a sunny day, at midday, note the current output power of the system on the inverter. You might need to access the NOW screen to see this.
Look for a figure called **P-ac, P-out or Power.**

P	kW

e.g 2.95 kW

3.7. Find out when your system was installed

1. System installation date (I)

I	DD/ MM / YYYY

How do I find this?

Find an old invoice, email or calendar entry that recalls when your system was first installed and switched on. You might also be able to contact your electricity retailer to find out when it was connected.

Self-Check -3	Written test

Short Answer Type Questions

1. A Solar system describes a level of an asset that exceeds the portion used.
2. A Budgetary surplus occurs when products that remains unsold.
3. Inventory surpluses occur when income earned exceeds expenses paid.

Mach the given question below From B to A

A	B
1. Increase Demand	A. Buy the surplus out of the market
2. Decrease Supply	B.Get more people to buy.
3. Remove the Surplus	C. Shift or stop production.

Note: **Satisfactory rating 4 and above points, Unsatisfactory - below 3 points**

Score = ____________

Rating: _____________

Information Sheet-4	Cleaning up and making safe work area

4.1. Definition of cleaning up work area

Standard solar pre-cautions to keep you safe when working with solar power.

Solar safety is just as important as every other subject covered on this site, actually much more important. When working with solar photovoltaic energy systems, you will be working with equipment that can produce several hundred watts of power, so it is important that you are familiar with the general **photovoltaic safety rules** to minimize the risk of injury due to accidental electric shock or other physical harm. Therefore, inspection and testing activities will involves working with the entire electrical and mechanical components of the solar system, and hence it requires that the working area or the site should be free from any hazards and the inspectors should make sure that they leave the work site area clean and safe for all.

- **Cleaning System**
  1. The selected system should be technically robust for the respective operating environment. No sensitive parts should be ex-posed in desert conditions.
  2. Minimal maintenance of the cleaning device should be required. Ideally unskilled, low-cost labor can be used to perform maintenance on the cleaning devices. Maintenance should be easy, fast and require few tools.
  3. In the case of semi-automated, autonomous and fully-automated devices the number of hours required for battery charging and the battery lifetime should be considered. Re-mote battery status monitoring is preferred.

4.2. Focus on dry cleaning

There are many different types of cleaning systems available on the market, each with its own ad-vantages and disadvantages. In dry subtropical regions, PV module cleaning using water is rarely the optimal solution. In many cases, access to water is severely limited and can only be procured at high cost depending on the location. In some cases water may be easily available, but in the long run the use of water for cleaning puts too much strain on groundwater supplies.

Local authorities may also prohibit the use of water for cleaning altogether. Considering that cleaning is mostly used in desert regions, cleaning with water covers only a small portion of systems deployed. Therefore this paper only deals with systems that use dry cleaning methods. Nevertheless, some systems have an option that al-lows cleaning with water at least occasionally.

4.3. Potential impact of cleaning on PV modules

In general dry cleaning is less effective than wet cleaning. The first reason is that water or other chemicals involved in wet cleaning serve as a medium through which dust layers containing salt or similar chemical deposits can be dissolved. The fluid also serves as a medium through which these particles can be transported away from the PV module surface. For dry cleaning, dried layers of dusty materials are released through friction, and air is then the only medium through which particles can be transported away from the PV module surface. Both of these factors increase the difficulty of cleaning effectively without water or another fluid.

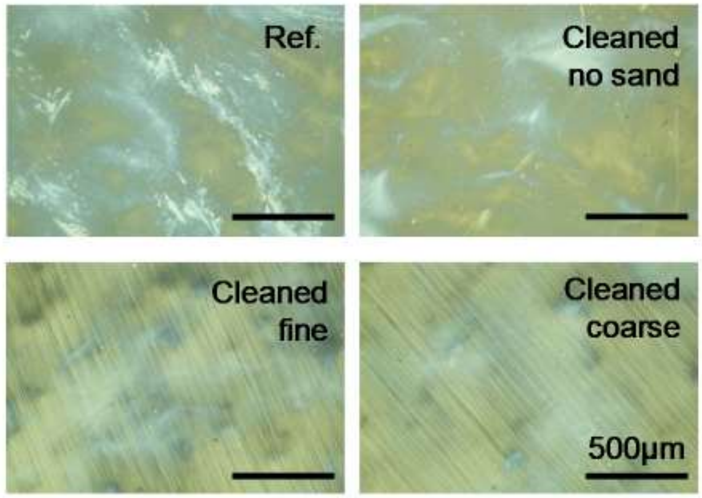


Figure 19: Light microscopy at x200 magnification after 1000 cleaning cycles on a reference glass surface and on glass surfaces exposed to cleaning without sand and cleaned with fine and coarse sand

The second concern with dry cleaning is that it may damage the PV modules due to the friction necessary to overcome the adhesion of the particles on the glass surface. Even when the brushing materials are soft, the dust particles themselves may scratch the surface. Additionally, in the case of ‘sticky’ dust, and if the cleaning frequency is not high enough, harder brushes may be required to remove the particles. Harder brushes must be tested for their abrasion impact on the PV modules. PV module glass with an anti-reflective coating (ARC) is used by most PV module manufacturers in order to reduce reflection loss from the glass surface by up to 4 %. Yield losses may occur due to ARC abrasion or surface scratches which decrease the anti-reflective properties of the glass surface treatment.

Some cleaning devices use the module frame as the ‘carrying’ point for the cleaning system. In such cases, it must be determined whether the PV modules can take the additional load without being damaged. Also, the cleaning load or pressure that acts directly on the front of the modules should not exceed the mechanical load carrying capability of the module. For modules with crystalline cells, a heavy or non-uniform load can lead to cell breakage or micro-cracking which in turn can lead to hot spots or power loss. Semi-automated systems have a particular risk of causing this type of damage because they have to be placed manually on every table of PV modules. The weight of these systems is generally between 35 and 65 kg.

In addition, cleaning during the day needs to be carefully carried out because there is a potential risk of harming the PV modules due to hot-spot generation as a result of partial shading. The hot-spot effect occurs when individual solar cells within the series circuit in the PV module are covered and shaded. This effect can be particularly critical in case of thin film modules without bypass diodes, as since single cells can be covered by the movement of the brush. To be on the safe side, the cleaning of the modules should happen at night in these situations.

4.4. PV module

- **Soiling Climate zones and power reduction**

  Depending on the latitude of the PV system, PV modules are installed at different tilt angles in different climate zones resulting in different soiling patterns as well as differing abilities of the PV modules to self-clean. With decreasing latitude and PV Module Cleaning - Market Overview and Basics The leading technical advisor, risk manager and quality assurance provider for PV plants and equipment3lower tilt angles, sand and dust play a more significant role in soiling. In moderate temperature zones, module cleaning plays a less important role (except in the case of anthropogenic soiling as described below). In these climates, tilt angles above 12° and precipitation throughout the year leads to a good self-cleaning of the PV module surfaces. In Germany, for example, soiling-related performance losses are usually only around 1 % without cleaning. Disadvantages of this climatic zone are the good conditions which exist for plant growth such as mosses and lichens, which can occur after a certain period of time (months to years).

Figure 20: Power plant in Israel, with soiling losses measured > 20 %

With increasing proximity to the equator, semi-arid and arid regions becomes more common. Less precipitation results in a less of self-cleaning effect. Furthermore hot temperatures, less vegetation and higher winds lead to sand and dust becoming the main soiling concern. These regions suffer from a high concentration of atmospheric dust as well as sand storms.

Figure 21: Example of dust storms

With tracking systems, soiling can be reduced during sand storms and at night by placing the modules at their maximum tilt angle in order to minimize dust accumulation. In any case, the variable tilt angle of trackers increases the natural cleaning due to gravitational forces. Tracking systems have been proven to have smaller angular losses due to soiling in comparison to fixed modules [6]. Due to the lack of precipitation in arid areas, the sand or dust can fairly easily be wiped off the modules. In contrast, in regions with some level of humidity or salinity in the air [3], dew may lead to a cementation of the sand or dust on the surface. Cemented particles require more effort to clean the surface.

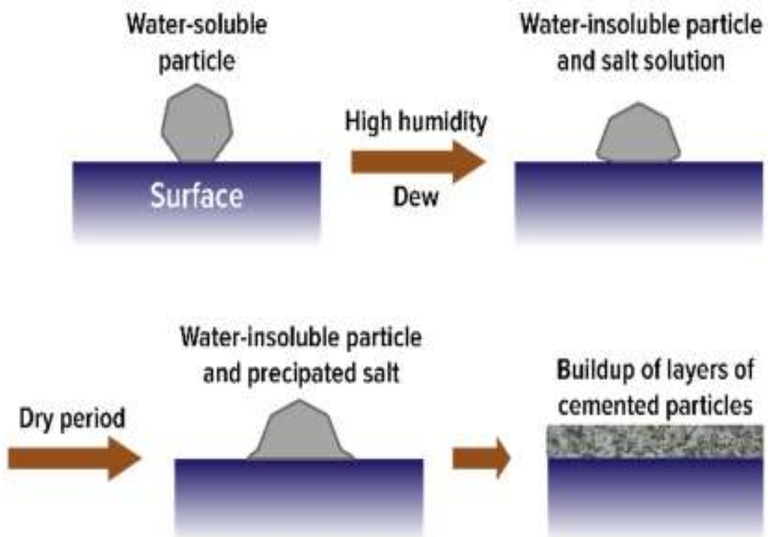


Figure 22: Cementation effect due to dirt (simplified)

4.5. Soiling particle types

The exact system location plays a major role in the prevailing sand and dust type, their properties, and consequently their ability to be easily removed. Studies have shown that fine sand particles are more challenging than coarse sand particles. First of all, fine sand has a much higher shading impact on the PV modules compared with the same amount of coarse sand causing higher power losses. The second major impact is on self-cleaning.

Coarse sand particles can be more easily blown off by the wind compared to fine sand. This also applies to module cleaning solutions that use high-pressure water without any manual scrubbing. Small particles can remain stuck to the module [8]. On the other hand, sand with large grain sizes and a variety of different particle shapes have an in-creased abrasive effect on the module's anti-reflective coating (ARC) layer and glass surface during cleaning and sand storms. For proper laboratory testing of cleaning systems, the specific type of sand expected at the system location must be used.

Figure 23: Sample sand from the region of the Rub’al Khali desert

Self-Check -4	Written test

Say True and False for the following question below

1. The selected system should be technically robust for the respective operating environment.
2. Business maintenance of the cleaning device should be required. Ideally unskilled, low-cost labor can be used to perform maintenance on the cleaning devices. Maintenance should be easy, fast and require few tools.
3. Electrical the exact system location plays a major role in the prevailing sand and dust type, their properties, and consequently their ability to be easily removed.
4. Depending on the latitude of the PV system, PV modules are installed at different tilt angles in different climate zones resulting in different soiling patterns as well as differing abilities of the PV modules to self-clean.

Note: **Satisfactory rating 3 and above points, Unsatisfactory - below 2 points**

Score = ___________

Rating: ____________

List of Reference Materials

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3. Sayyah, M. N. Horenstein, M. K. Mazumder: “Energy Yield loss caused by dust deposition on photovoltaic panels”, Solar Energy 107 (2014) 576–604.

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