GLOBAL WIND ORGANISATION

Solar Technical Training (S-TT)

V1

Publication date: 02 July 2025

CONTENTS

1. LIST OF ABBREVIATIONS

A	Amp
AC	Alternating Current
DC	Direct Current
GFCI	Ground Fault Circuit Interrupter
GSC	Global Solar Council
GWO	Global Wind Organisation
HAVS	Hand Arm Vibration Syndrome
HV	High Voltage
LEV	Local Exhaust Ventilation
LV	Low Voltage
mA	Milliamp
PCS	Power Control System
PE	Protective Earth
PPE	Personal Protective Equipment
PT100	Platinum100 (temperature sensor)
PV	Photovoltaics
PVC	Polyvinyl Chloride
RCD	Residual Current Device
S-TT	Solar Technical Training
TRA	Task Risk Assessment
V	Volts
VAC	Volts Alternating Current
VDC	Volts Direct Current

2. TERMS AND DEFINITIONS

The purpose of this section is to avoid different interpretations of these terms depending on whoever is reading the standard.

Term	Definition
Feedback	Instructor's feedback should focus on what the participant must adjust to perform correctly. Feedback may involve dialogue, where the participant reflects on their understanding or performance.
Function	The purpose or activity something performs; what it is used for
Group discussion	Learning activity involving all participants. Group discussions may be conducted in smaller groups. The instructor should step back and only interfere to facilitate the experience exchange between participants. Optimal group size is 4 participants.
Hazard	A hazard is any source of potential damage, harm or adverse health effect on something or someone.
Installation	Preparation, assembly and completion of components
Must	For clarity where the word 'must' is used in this standard it shall have the same meaning as 'shall'.
Operation	How does it work?
Practice	The participants apply what they are learning.
Risk	A risk is the chance or probability that a person will be harmed or experience an adverse health effect if exposed to a hazard.
Scenario	Refers to a training method that uses fictive simulations to align learning performance with real world job performance.
Shall	Verbal form used to indicate requirements strictly to be followed in order to conform to this training standard and from which no deviation is permitted.
Should	Verbal form used to indicate that among several possibilities one is recommended as particularly suitable, without mentioning or excluding others, or that a certain course of action is preferred but not necessarily required.
Use	How to operate it? How to make it work?
Utility Scale Solar PV	Refer to detailed description in Annex 3
Solar work environment	Refer to detailed description in Annex 3

Toolbox talk	A pre-task safety briefing that takes place at the work site, covering the risks, hazards, control and methods of the task being performed

3. CHANGE LOG

Amendment date	Version	Approved by & date	Description of changes
O2072025	1	GWO - 18062025	First release

4. SCOPE

Global Wind Organisation is a member-led non-profit body. Our members strive for an injury free work environment in the wind turbine industry and Solar PV industry, setting common international standards for safety training and emergency procedures.

The Global Solar Council is a non-profit trade body uniting the voice of the solar industry, representing every part of the solar PV value chain across the world. GSC work directly with industry associations, private sector, governments, international institutions and NGOs to advocate, educate, and strengthen the solar industry.

This standard describes the requirements for Solar Technical Training Modules that are recommended and endorsed by GSC and the members of GWO.

This standard has been developed in response to the demand for recognisable technical training in the industry and has been prepared in co-operation between the members of GWO and GSC based on risk assessments and factual incident statistics.

5. GENERAL REQUIREMENTS FOR THE SOLAR TECHNICAL TRAINING

Upon completion of the GWO Solar Technical Training, participants will possess an awareness of the hazards encountered when working on mechanical, electrical, and installation systems, and how to control and mitigate these hazards, preparing candidates for working in a Utility Scale Solar PV work environment.

5.1 Overview

The Solar Technical Training Standard is divided into 2 modules:

Module 1: Installation
Module 2: Electrical

Each module may be delivered independently as stand-alone training or can be delivered consecutively in adherence to the required module durations.

Installation Module

The Installation Module provides participants with important knowledge, skills, and abilities for installing solar arrays. The training covers key aspects of mechanical prerequisites for installation, assembly of components and electrical assembly.

Electrical Module

The Electrical Module provides participants with important knowledge, skills, and abilities required to connect and commission solar panel system electrical components, and service and maintain during operations. The training covers topics such as electrical safety, electrical components, measuring instruments and circuits.

5.2 Target Group

The Solar Technical Training modules are targeted at candidates who have no previous experience with installation or electrical work in the solar PV sector. It may also be used to upskill candidates who have relevant technical knowledge and skills, but not of its application in the context of a Utility Scale Solar PV site.

5.3 Aims and Objectives

The Solar Technical Training Standard prepares participants for further company specific training by providing them with the necessary training to perform basic installation and electrical tasks.

This course will not make the participant a trained person who is allowed to perform installation or electrical work in a solar work environment without supervision.

5.4 Duration of the Solar Technical Training Standard Modules

The total contact time for completing the Solar Technical Training Standard is 20 hours and 15 minutes. Module durations are summarised below. The training provider must not exceed the time per day given below.

Modules	Duration
S-TT Installation	12 hours 15 minutes
S-TT Electrical	8 hours
TOTAL	20 hours 15 minutes

Table 5.4.1 - Duration of the S-TT modules

	Maximum Duration Per Day
Contact time	8 hours
Total training day	10 hours

Table 5.4.2 - Maximum duration for training days

Note *Contact time includes delivery of course lesson content, practical exercises and activities directly related to these.*

The total training day includes contact time, meals and breaks and travel between training sites (where applicable).

5.5 Validity Period

The Solar Technical Training is an enduring qualification, so a validity period does not apply to this training.

This is based on the expectation that the participant is actively working in a Utility Scale Solar PV site work environment. If there is an extended period of absence from applying the skills, retraining and recertification may be required according to national legislation and company policy.

A maximum interval between successful completion of the S-TT Installation and Electrical Modules does not apply.

5.6 Course Codes

Module	Course Code
Electrical	S-TTE
Installation	S-TTI

Table 5.6.1 – Course codes for S-TT Modules

5.7 Participant Prerequisites

All personnel participating must meet the participant prerequisites described in the GWO Requirements for Training.

5.8 Instructor Qualification Prerequisites

A competent GWO Solar Technical Training instructor must be trained and qualified to adhere with GWO Requirements for Training.

6. GENERAL RESOURCES REQUIRED TO DELIVER THE SOLAR TECHNICAL TRAINING MODULES

The training provider shall ensure that staff, facilities, and equipment are in place to support the training of participants.

6.1 Practical Training Facilities

A practical workshop is required that has enough space to accommodate 8 participants, with a respective work area each of approximately 3 square metres.

6.2 Handouts

Handouts must be given to the participants containing, as a minimum:

a. electrical symbols mentioned in the Solar Technical Training Standard

This handout could be used as reference for the participants during the entire course and also during the test at the end.

7. USING THIS STANDARD TO DEVELOP TRAINING

The training in this standard is designed around the GWO taxonomy described in the GWO Requirements for Training. Theoretical and practical activities must be delivered according to the defined taxonomic level in order to reach the described learning objectives.

Applying skills learned during training to the workplace requires a realistic training environment. Training providers must ensure their facilities closely replicate the actual solar utility-scale work environment, incorporating as many authentic elements as possible. The closer the alignment between the training setting and real working conditions, the more effectively participants can transfer their learning to the workplace.

Note *See Annex 3 – Guidance On The Solar PV Work Environment for elaborate information.*

7.1 Equipment

When teaching about equipment, a generic approach shall be applied to avoid the need for additional product specific training in the workplace where possible. However, national or regional legislation, company gap analysis and location specific risk assessments may require additional product specific familiarisation which is the responsibility of the duty holder.

All training based on this standard and any related training equipment or facilities shall, as a minimum, meet the requirements described in the GWO Requirements for Training.

7.2 Lesson plans

All training developed from this standard must comply with the requirements set forth in the GWO Requirements for Training and must be supported by the development of comprehensive lesson plans based on and referenced to the standard.

7.3 Participant Performance Assessment

The participants will be assessed separately on each module according to the learning objectives, by means of direct observation and supplementary oral questions where appropriate (formative evaluation).

Furthermore, the participants will be subjected summative evaluation in the form of a written test assessing achievement of the learning objectives within each module.

Training providers must have a documented procedure in place for dealing with participants not meeting the stated learning outcome.

Administering the written test

The written test can consist of multiple-choice or descriptive answer questions and shall be set at the same taxonomy level as the objective that they are testing.

The multiple-choice test must be conducted in accordance with the following criteria:

1. There shall be at least one question for each lesson in the module with a minimum of 10 questions for each stand-alone module.

2. There shall be a time limit of 1½ minutes per question.

3. Each participant must complete a written test independently.

4. The participants shall not communicate with each other during the test

5. The participants shall not communicate with any persons via email, telephone, Skype (or similar) or social media during the test

6. Where a participant does not understand the meaning of a question or a multiple-choice option, the instructor shall be allowed to help the participant to understand the meaning of the question or the multiple-choice options. The instructor shall not give the participant the correct answers to any test questions.

   Participants may use:

   a. training material, handouts and their own course notes

   Participants may not use:

   - mobile phones (except for calculator) or wearables (e.g. smart watch, google glasses)
   - laptops, tablets or internet browsers
   - any other devices similar to those listed above

The multiple-choice test questions cannot be used at any other time during the training in such a way that the participants could recognise that they will be test questions at the end.

At least 70% of the questions in the written test must be answered correctly in order to pass the corresponding module.

If a participant fails the test, the instructor will have a discussion with the participant in order to find out the reason for this. If the reason was due to the misunderstanding of a question or due to language difficulties, the instructor can mark a question as correct, provided that the participant is able to demonstrate the right level of understanding. This must be properly documented by the instructor and kept together with the tests, control measures, evaluations, etc.

Throughout each of the Solar Technical Training Modules, the instructor will use the participant performance assessment form (see the GWO Requirements for Training) to evaluate the participant's knowledge and skills, with a high focus on evaluating the participant's safety awareness.

The instructor shall keep a participant performance assessment form (or adaptation) for each participant until the completion/evaluation of each Solar Technical Training Module.

The participant performance assessment form (or adaptation) is a final evaluation tool for the instructors to assess participants during practical elements. It allows measurement of the number of violations regarding safety, competency or attitude.

The participant performance assessment form shall be used as a progressive evaluation tool to discuss the performance of a participant in guiding them to success. It also serves as supporting documentation if a participant passes or fails the module. Training providers may adapt the participant performance assessment form to other media.

GLOBAL WIND ORGANISATION

Solar Technical Training Installation

(S-TTI)

8. SOLAR TECHNICAL TRAINING - INSTALLATION MODULE

8.1 Aims and Objectives of the S-TT Installation Module

The aim of this Solar Technical Training Installation Module is to give the participants the knowledge and skills to carry out basic installation tasks under supervision, using safe working procedures and the correct PPE.

After having successfully completed the module, the participants can:

1) **Describe** the main components, mechanical systems and basic operation of solar arrays (Knowledge, basic level)

2) **Discuss** risks and hazards associated with mechanics (Knowledge, intermediate level)

3) **Explain** the principles of bolted and welded connections and their inspection (Knowledge, intermediate level)

4) **Apply** manual tightening and measuring tools (Skills, intermediate level)

5) **Recognise** the main installation activities (Knowledge, basic level)

6) **Discuss** the overall risks and hazards associated with the installation environment (Knowledge, intermediate level level)

7) **Discuss** the checklist system throughout the complete installation process (Knowledge, intermediate level level)

8) **Describe** the characteristics of the installation environments (Knowledge, basic level)

9) **Recognise** the principles and standards for handling and storing goods and components onsite or within a storage area, before and after installation (Knowledge, basic level)

10) **Describe** the basic preparation of main components before installation (Knowledge, basic level)

11) **Describe** the basic mechanical completion (Knowledge, basic level)

12) **Perform** the basic electrical completion including the principles and standards for handling and installing cables (Skills, intermediate level level)

13) **Recognise** the basis of how to do a handover to commissioning (Knowledge, basic level)

8.2 Duration of the S-TT Installation Module

The total contact time for completing the Solar Technical Training Installation module is 12 hours and 15 minutes.

The training provider must not exceed the time per day given in the table 8.2.1 below.

	Maximum Duration Per Day
Contact time	8 hours
Total training day	10 hours

Table 8.2.1 - Maximum duration for training days

Note *Contact time includes delivery of course lesson content, practical exercises and activities directly related to these.*

The total training day includes contact time, meals and breaks and travel between training sites (where applicable).

8.3 Participant Ratio of the S-TT Installation

The ratio shown for theory sessions indicates the maximum number of participants per instructor attending the course.

Practical ratios indicate the maximum number of participants to be supervised by an instructor during each activity.

Module	Session	Instructor to Participant Ratio
S-TT Installation	Theory	1:12
	Practical	1:8

Table 8.3.1 - Instructor to participant ratio

8.4 Equipment for the S-TT Installation Module

The equipment required for training as listed in Annex 1 must be available and must fulfill national legal requirements.

8.5 Timetable of the S-TT Installation Module

The order in which elements of this module training are delivered may vary according to the lesson plans developed by the training provider.

The delivery of this module must comply with the requirements described in the GWO Requirements for Training.

Lesson		Element		Duration
1.	Introduction	1.1	Safety and emergency procedures	
		1.2	Facilities	
		1.3	Introduction	
		1.4	Aims and objectives	
		1.5	Ongoing assessments	
		1.6	Motivation	
		1.7	Human factors	
			TOTAL	30 min.
2.	Introduction to solar systems and mechanical components	2.1	Main components of the structure	
		2.2	Main mechanical systems	
		2.3	How solar systems works	
			TOTAL	50 min.
3.	Mechanical safety	3.1	Why mechanical safety?	
		3.2	Safety signs	
		3.3	Types of PPE	
		3.4	Hand tool awareness	
			TOTAL	45 min.
4.	The principles of bolted and welded connections	4.1	The principles of bolted connections	
		4.2	The locations of important bolted and welded connections	
		4.3	Inspection of welded connections	
		4.4	Bolt connections and correct tightening tools	
			TOTAL	40 min.
5.	Use of manual tightening and measuring tools	5.1	Metric system	
		5.2	Selecting and using the correct manual tightening tools	
		5.3	Correctly setting and using a torque wrench	
			TOTAL	20 min.
6.	Introduction to installation	6.1	Installation overview	
		6.2	Why installation safety?	
		6.3	The importance of appropriate isolation	
			TOTAL	45 min.
7.	Component Assembly	7.1	Inspection, preparation and assembly	
		7.2	Examples of mechanical completion	
			TOTAL	15 min.

8.	General procedures for working onsite with installation	8.1	Checklists and work instructions	
		8.2	Housekeeping	
			TOTAL	20 min.
9.	Installation environments	9.1	Installation environments	
			TOTAL	20 min.
10.	Handling and storing	10.1	Risks and hazards associated with handling and storing	
		10.2	Reception/Inspection	
		10.3	Unloading, storing and transport of solar components	
		10.4	Tools and equipment	
		10.5	Return of goods and components	
			TOTAL	25 min.
11.	Introduction to electrical assembly	11.1	Introduction to electrical completion	
		11.2	Examples of electrical assembly	
		11.3	Risks and hazards associated with handling and working with cables	
		11.4	Different types of cables	
		11.5	Simple installation diagrams	
		11.6	Cutting and crimping cables	
		11.7	Marking, routing and termination of all cable types	
		11.8	Solar PV connectors	
			TOTAL	360 min.
12.	Summary and theoretical test	12.1	Summary	
		12.2	Theoretical test	
			TOTAL	50 min.
13.	Training review	13.1	Training review	
		13.2	Feedback session	
			TOTAL	15 min.
			GRAND TOTAL	735 min.

Table 8.5.1 – S-TT Installation timetable

8.6 Detailed Description of the S-TT Installation Module

LESSON 1 - INTRODUCTION

30 min.

The aim of this lesson is to enable the participants to engage in the S-TT Installation Module safely and with motivation, while recognising what is expected of them during the training.

Note *If this module is delivered combined with other Solar Technical Training modules to the same participants, the redundant introductory elements shall not be repeated.*

After successfully completing this lesson, the participants can:

14) **Describe** the module content and the facilities involved to ensure a clear understanding of what is expected during the module (Knowledge, basic level)

15) **Name** and point out local emergency procedures and facilities (Knowledge, basic level)

16) **Describe** the relevant human factors and the implications thereof (Knowledge, basic level)

ELEMENT 1.1 - SAFETY INSTRUCTIONS AND EMERGENCY PROCEDURES

Learning objectives:

17) The participants can **recognise** the safety instructions, rules and emergency procedures (Knowledge, basic level)

18) The participants can **show interest** or curiosity in the safety and emergency procedures (Ability, basic level)

The instructor shall:

1.1.1 Explain and ask involving and open-ended questions concerning:

a. safety instructions according to internal procedures

b. emergency procedures and emergency exits in the areas where the participants can be expected to be located during the module

The participants shall:

1.1.2 Engage in answering the above questions

ELEMENT 1.2 - FACILITIES

Learning objectives:

19) The participants can **recognise** the facilities at the training location (Knowledge, basic level)

The instructor shall:

1.2.1 Give a general description of the facilities at the location (administration, dining area, restrooms and toilets, etc.)

The participants shall:

1.2.2 Note relevant facilitates and ask questions when in doubt about facilities

ELEMENT 1.3 - INTRODUCTION

Learning objectives:

20) The participants can **show interest** in fellow participants and the programme of the S-TT Installation Module (Ability, basic level)

The instructor shall:

1.3.1 Explain and ask involving questions about the programme of the Solar Technical Training Installation module, including breaks and mealtimes

1.3.2 Give a short introduction about themselves, including their backgrounds as instructors

1.3.3 Ask for participants' expectations of the training and of their learning outcome

The participants shall:

1.3.4 Give a short introduction about themselves, including job function, and share their expectations of the training and learning outcome for the training

ELEMENT 1.4 - AIMS AND OBJECTIVES

Learning objectives:

21) The participants can **recognise** the scope and main objectives of the Solar Technical Training Installation module (Knowledge, basic level)

The instructor shall:

1.4.1 Explain the scope and main objectives of the Solar Technical Training Installation module

1.4.2 Involve participants through questions about the participants' understandings and individual experiences relevant to the Solar Technical Training Installation module

The participants shall:

1.4.3 Engage in answering questions and share experiences relevant to the Solar Technical Training Installation module

ELEMENT 1.5 - ONGOING ASSESSMENTS

Learning objectives:

22) The participants can **recognise** the reasons for the ongoing assessment, and recognise how the GWO participant assessment form will be used throughout the module (Knowledge, basic level)

The instructor shall:

1.5.1 Explain the reasons for the ongoing assessment

1.5.2 Explain the GWO participant assessment form, and how it will be used

1.5.3 Ask for the participants thoughts on the assessment procedure presented

The participants shall:

1.5.4 Engage in discussions on the assessment procedure

ELEMENT 1.6 - MOTIVATION

Learning objectives:

23) The participants can **show** willingness to be personally involved in the learning activities throughout the Solar Technical Installation module (Ability, basic level)

The instructor shall:

1.6.1 Explain and facilitate discussions on:

a. the importance of personal involvement in the module

b. the need for the Solar Technical Training Installation Module when working in the solar industry specific environment

The participants shall:

1.6.2 Engage themselves in discussions about the importance of personal involvement in the module and the need for the Solar Technical Training Installation Module when working in the solar industry specific environment

ELEMENT 1.7 - HUMAN FACTORS

Learning objectives:

24) The participants can **describe** the relevant human factors, and the implications thereof (Knowledge, basic level)

25) The participants can **show interest** and willingness to focus on human factors during the following practical exercises (Ability, basic level)

The instructor shall:

1.7.1 Present how the human factor has an influence on accidents in the industry specific environment

1.7.2 Lead a discussion about the role of the individual in improving human performance and how this improvement can benefit safety when working in the industry specific environment, by considering factors like:

a. attention and perception

b. group behaviour and peer pressure

c. fitness and health

d. domestic and work-related stress

e. workload (both overload and underload)

f. fatigue

g. time pressure and deadlines

h. alcohol, medication and substance abuse

The participants shall:

1.7.3 Engage in discussions and share understandings about the human factor influence on accidents when working in the solar industry specific work environment

LESSON 2 - INTRODUCTION TO SOLAR SYSTEMS AND MECHANICAL COMPONENTS

50 min.

The aim of this lesson is to give the participants an introduction to solar industry equipment.

ELEMENT 2.1 - MAIN COMPONENTS OF THE STRUCTURE

Learning objectives:

26) The participants can **describe** the main components in a solar array and a solar system (Knowledge, intermediate level)

27) The participants can **recognise** the function and operating principles of the gearbox (Knowledge, basic level)

The instructor shall:

2.1.1 Explain the basic function and location of the:

a. dampeners

b. torque tubes

c. motoring Gearbox

d. drive lines

e. bearings

2.1.2 Facilitate discussions with the participants about the main mechanical components of the structure of a solar array:

a. dampeners

b. torque tubes

c. motoring Gearbox

d. drive lines

e. bearings

2.1.3 Explain the operating principles of the gearbox

2.1.4 Explain the basic function and location of the:

a. Inverter

b. Combiner Box

c. Monitoring System

d. Transformer

e. AC/DC Disconnects

f. Cables

2.1.5 Facilitate discussions with the participants about the main components of the structure

The participants shall:

2.1.6 Engage in discussions about the main mechanical components of the structure of a solar array

2.1.7 Engage in discussion about the main components of the solar system

ELEMENT 2.2 - MAIN MECHANICAL SYSTEMS

Learning objectives:

28) The participants can **discuss** the function, main components and location of the main mechanical systems in a solar array (Knowledge, intermediate level)

The instructor shall:

2.2.1 Present the basic function, main components and location of the:

a. dampeners

b. torque tubes

c. motoring Gearbox

d. drive lines

e. bearings

2.2.2 Facilitate group discussions that challenges the participants to see the connection between the above mechanical systems and the main components of the structure of the solar array, which have been discussed earlier in the lesson.

2.2.3 Give constructive feedback on the participant groups' discussions

The participants shall:

2.2.4 Engage in a group discussion and share understandings about the connection between the above mechanical systems and the main components of the structure of the solar array

ELEMENT 2.3 - HOW SOLAR SYSTEMS WORK

Learning objectives:

29) The participants can **describe** how a solar system works (Knowledge, basic level)

The instructor shall:

2.3.1 Explain how the solar array uses the suns radiance to produce electricity using all main components from Element 2.1

2.3.2 Define and explain wind speed direction and limits

2.3.3 Define and explain radiance

2.3.4 Describe the principles of power production in arrays

2.3.5 Define and explain the function of cables and combiner boxes

2.3.6 Describe the importance of snow and environmental sensors

2.3.7 Facilitate discussions with the participants about energy, radiance and solar arrays

The participants shall:

2.3.8 Engage in discussions about energy, radiance and solar arrays

LESSON 3 - MECHANICAL SAFETY

45 min.

The aim of this lesson is to enable participants to handle mechanical hazards in a solar array.

ELEMENT 3.1 - WHY MECHANICAL SAFETY?

Learning objectives:

30) The participants can **discuss** the safety risks and hazards in mechanical systems (Knowledge, intermediate level)

31) The participants can **explain** the importance of Mechanical Safety (Knowledge, intermediate level)

The instructor shall:

3.1.1 Facilitate group discussions on the safety risks and hazards in mechanical systems (e.g. bruises, squeezing, rotation, chemicals, trapping, slipping, pinching)

3.1.2 Explain the importance of working according to approved working practices (through e.g. the use of storytelling or scenarios)

3.1.3 Show the consequences of not following approved working practices (e.g., pictures, stories or scenarios of injuries related to mechanical incidents)

3.1.4 Explain the need for Safety Data Sheets (SDS)

3.1.5 Ask the participants relevant questions about safe working procedures, identifying the necessary PPE and appropriate tools when working with mechanics

3.1.6 Give constructive feedback on the participants' group discussion and explanations about the safety risks and hazards in mechanical systems and the importance of mechanical safety

The participants shall:

3.1.7 Engage in a group discussion on the safety risks and hazards in mechanical systems

3.1.8 Explain in their own words and share understandings about safe working procedures, identifying the necessary PPE and appropriate tools when working with mechanics

ELEMENT 3.2 - SAFETY SIGNS

Learning objectives:

32) The participants can **describe** different safety signs and their meanings (Knowledge, basic level)

33) The participants can **recognise** the importance of adhering to safety signs (Knowledge, basic level)

34) The participants can **show interest** in adhering to the meaning of different safety signs' (Ability, basic level)

The instructor shall:

3.2.1 Explain how to identify different signs for mechanical danger (e.g. moving parts, pinch point, PPE mandatory)

3.2.2 Show examples of safety signs on different locations in the work environment (e.g. moving parts, pinch point, helmet mandatory)

3.2.3 Explain how to identify different signs in an installation environment

3.2.4 Show examples of and explain safety signs in different locations in an installation environment

3.2.5 Show the consequences of not adhering to safety signs in the work environment through e.g. stories, pictures or examples (injuries related to mechanics)

3.2.6 Facilitate discussions about different safety signs and their meanings

The participants shall:

3.2.7 Engage in discussions about different safety signs and their meanings

ELEMENT 3.3 - TYPES OF PPE

Learning objectives:

35) The participants can **describe** the required PPE for working with mechanics (Knowledge, basic level)

36) The participants can **discuss** the required PPE in an installation environment (Knowledge, intermediate level)

The instructor shall:

3.3.1 Explain and demonstrate examples of the usage and inspection of PPE suitable for mechanical work

3.3.2 Show examples of and explain the usage and inspection of suitable PPE suitable in an installation environment

3.3.3 Ask the participants relevant questions about the required PPE for working with mechanics

3.3.4 Facilitate group discussions about the differences and similarities between the required general PPE when working in an installation environment and the specific PPE required for mechanical work

3.3.5 Give constructive feedback on the participants' group discussions

The participants shall:

3.3.6 Describe in their own words and share understandings about the required PPE for mechanical work

3.3.7 Engage in a group discussion about the differences and similarities between the required general PPE when working in an installation environment and the specific PPE required for mechanical work

ELEMENT 3.4 - HAND TOOL AWARENESS

Learning objectives:

37) The participants can **explain** the connection between the characteristics of a tool in terms of tool hazards, and the potential for short- and long-term injury and common control measures to mitigate this (Knowledge, intermediate level)

38) The participants can **show interest** in following manufacturers documentation (manuals, risk assessments guidelines) and company specific procedures to prevent short- and long-term injury (Ability, basic level)

Note *The ability to take responsibility of preventing injuries from the use of handheld tools must be practiced in following practical exercises where relevant*

The instructor shall:

3.4.1 Pose questions about hazards from using manual and powered handheld tools with moving parts (e.g. manual torque wrench, impact wrenches, hydraulic torque tools, electrical drills) and preventive actions depending on the task at hand including:

a. cutting

b. sanding

c. grinding

d. torquing

3.4.2 Lead discussion on hazards to self or others such as:

a. vibration

b. dust

c. chemical exposure

d. ergonomical hazards

e. entanglement

f. and noise injuries

3.4.3 Ask open ended questions about potential Injuries such as:

a. eye injuries

b. pinching, abrasion

c. cuts, crushing

d. hand arm vibration syndrome (HAVS)

e. respiratory injuries, chemical reactions or allergies

f. musculoskeletal disorders

g. repetitive strain injury

h. hearing reduction or tinnitus

3.4.4 Provide feedback to the participants and present further procedures and risk-mitigating actions applying manufactures documentation

3.4.5 Provide examples of common legal regulations (In terms of accepted levels of exposure or durations of exposure to a hazard e.g. accepted noise levels or work-time limitations on using specific types of PPE) and commonly legally mandated control measures for each individual hazard such as:

a. eye protection

b. protective clothing

c. protective gloves

d. anti-vibration gloves

e. local exhaust ventilation (LEV)

f. respiratory protection

g. manual handling aids

h. hearing protection

The participants shall:

3.4.6 In pairs or small groups, share their own knowledge and provide examples of tool hazards and risks of injury using different kinds of handheld tools to create answers to the instructor's questions

3.4.7 Suggest actions for correct and safe use of powered handheld tools to mitigate injuries relevant in the solar industry

LESSON 4 - THE PRINCIPLES OF BOLTED AND WELDED CONNECTIONS

40 min.

The aim of this lesson is to give participants an understanding of bolted and welded connections and their inspection.

ELEMENT 4.1 - THE PRINCIPLES OF BOLTED CONNECTIONS

Learning objectives:

39) The participants can **discuss** the principles of bolted connections (Knowledge, intermediate level)

The instructor shall:

4.1.1 Explain how to identify different types of bolts according to:

a. dimensions

b. thread type

c. material and treatments (hot dip galvanised, electroplated, stainless steel, pre-lubricated)

d. quality

4.1.2 Explain how bolt strength is proportional to the size of the bolt and dependent on material and quality

4.1.3 Explain the function of and types of washers

4.1.4 Explain the importance of bolt thread lubrication

4.1.5 Explain the importance of the same temperature for all set components

4.1.6 Define and explain torque

4.1.7 Explain the principles of angular tightening

4.1.8 Show the importance of correct tightening (e.g. compromised integrity of structure, electrical fires)

4.1.9 Facilitate group discussions on:

a. bolts, threads, lubricants, strengths of materials and temperature influences

b. force and torque

4.1.10 Give constructive feedback on the participant groups' discussions about bolted connections

The participants shall:

4.1.11 Engage in a group discussion and share understandings about bolts, threads, lubricants, strengths of materials and temperature influences

4.1.12 Engage in a group discussion and share understandings about force and torque

ELEMENT 4.2 - THE LOCATIONS OF IMPORTANT BOLTED AND WELDED CONNECTIONS

Learning objectives:

40) The participants can **describe** the location of important bolted and welded connections (Knowledge, basic level)

The instructor shall:

4.2.1 Show and explain an example of a bolted connection and a welded connection for:

a. dampeners

b. torque tubes

c. motoring gearbox

d. drive lines

e. bearings

f. solar array structure

4.2.2 Ask the participants relevant questions about the location of important bolted and welded connections

The participants shall:

4.2.3 Describe in their own words and share understandings about the location of important bolted and welded connections

ELEMENT 4.3 - INSPECTION OF WELDED CONNECTIONS

Learning objectives:

41) The participants can **describe** how to visually inspect a welded connection (Knowledge, basic level)

The instructor shall:

4.3.1 Explain how to perform visual inspections of welded connections and document the findings (e.g. paint damage, corrosion, cracks)

4.3.2 Ask the participants relevant questions on how to perform visual inspections of welded connections and document the findings

The participants shall:

4.3.3 Describe in their own words and share understandings about how to perform visual inspections of welded connections and document the findings

ELEMENT 4.4 - BOLTED CONNECTIONS AND CORRECT TIGHTENING TOOLS

Learning objectives:

42) The participants can **describe** how to tighten and inspect bolted connections (Knowledge, basic level)

The instructor shall:

4.4.1 Explain how to tighten a bolt connection (torque) using a torque wrench

4.4.2 Explain how to inspect if a bolt is loose (visual inspection or with tightening tools)

4.4.3 Ask the participants relevant questions on how to tighten and inspect bolt connections

The participants shall:

4.4.4 Describe in their own words and share understandings about how to tighten and inspect bolt connections

LESSON 5 - USE OF MANUAL TIGHTNING AND MEASURING TOOLS

20 min.

The aim of this lesson is to enable the participants to use manual tightening and measuring tools.

ELEMENT 5.1 - METRIC SYSTEM

Learning objectives:

43) The participants can **recognise** the basic units of the metric system (Knowledge, basic level)

The instructor shall:

5.1.1 Explain the key units used in the metric system for:

a. temperature

b. length

c. speed

d. torque

The participants shall:

5.1.2 Describe in their own words and share understandings about the metric system

ELEMENT 5.2 - SELECTING AND USING THE CORRECT MANUAL TIGHTENING TOOLS

Learning objectives:

44) The participants can **apply** the correct use of manual tightening tools (Skills, intermediate level)

45) The participants can **discuss** the importance of and how to perform a pre-use check on tools (Knowledge, intermediate level)

The instructor shall:

5.2.1 Present the types of manual tightening tools (spanners, sockets, screwdrivers)

5.2.2 Facilitate group discussions on the importance and performance of a pre-use check on tools

5.2.3 Demonstrate the correct application and size of a manual tightening tool

5.2.4 Show the consequences of incorrect manual tightening tool use (e.g. through examples or storytelling)

5.2.5 Demonstrate how to use an electric impact gun (awareness of not surpassing bolt torque)

5.2.6 Facilitate practice for the participants in selecting and using manual tightening tools

5.2.7 Give constructive feedback on the participants' discussions about pre-use check on tools and the participants' selection and use of manual tightening tools

The participants shall:

5.2.8 Engage in a group discussion about the importance and performance of a pre-use check on tools

5.2.9 Practice selecting and using manual tightening tools

ELEMENT 5.3 - CORRECTLY SETTING AND USING A TORQUE WRENCH

Learning objectives:

46) The participants can **apply** a torque wrench correctly (Skills, intermediate level)

47) The participants can **recognise** the importance of making a pre-use check on tools (Knowledge, basic level)

The instructor shall:

5.3.1 Explain the function of a torque wrench

5.3.2 Show the importance of pre-use checks and calibration in terms of safety and quality

5.3.3 Demonstrate how to set and use the torque wrench

5.3.4 Facilitate practice for the participants in setting and using torque wrenches

5.3.5 Give constructive feedback on the participants' setting and use of torque wrenches

The participants shall:

5.3.6 Practice setting and using torque wrenches

LESSON 6 - INTRODUCTION TO INSTALLATION

45 min.

The aim of this lesson is to give the participants an overview of the installation activities of a Utility Scale Solar PV site and enable the participants to handle installation hazards in an installation environment.

ELEMENT 6.1 - INSTALLATION OVERVIEW

Learning objectives:

48) The participants can **describe** the main installation activities (Knowledge, basic level)

The instructor shall:

6.1.1 Present the main activities required for the installation of solar arrays. This will include:

a. incoming inspection of components

b. unloading

c. storage and preservation

d. preparation

e. lifting / assembly

f. tightening

g. cable work

h. finishing (Mechanical and Electrical)

6.1.2 Ask the participants relevant questions about the main activities required for the installation of solar arrays

The participants shall:

6.1.3 Describe in their own words and share understandings about the main activities required for the installation of solar arrays

ELEMENT 6.2 - WHY INSTALLATION SAFETY?

Learning objectives:

49) The participants can **describe** how to identify known and suspected hazards involved in the installation of solar arrays (Knowledge, basic level)

50) The participants can **describe** the health risks associated with the hazardous situations (Knowledge, basic level)

51) The participants can **describe** the means to reduce the risk exposure to acceptable levels (Knowledge, basic level)

52) The participants can **discuss** the importance of installation safety (Knowledge, intermediate level level)

The instructor shall:

6.2.1 Explain how to identify known and suspected hazards involved in the installation of solar arrays. This will include:

a. all sources of hazardous situations, e.g. electricity, dropped objects, crushing damage, sharp items, hazardous materials and/or substances used in the work environment

b. tools/equipment malfunctioning due to poor control and/or handling during installation.

6.2.2 Ask the participants relevant questions about how to identify known and suspected hazards involved in the installation of solar arrays

6.2.3 Explain the health risks associated with the hazardous situations, including:

a. electrical shocks, arc flash, electrocution etc.

b. exposure to hazardous substances, eg. silica dust, adhesives, lubricants, etc.

c. dropped objects may result in broken limbs and/or bruises

d. mechanical tools malfunctioning may cause minor or major cuts and/or crushing damage

e. entrapment

f. human factors

g. environmental exposure (weather, wildlife, terrain)

h. physical exposure (fatigue, dehydration, etc)

i. repetitive work

6.2.4 Ask the participants relevant questions about the health risks associated with the hazardous situations

6.2.5 Explain the means to reduce the exposure to acceptable levels, e.g.:

a. do not work on live, electrical equipment until it has been put in a safe condition by a qualified electrician

b. the hierarchy of controls (Elimination, Substitution, Engineering Controls, Administrative Controls, PPE)

c. safe work procedures

d. using work equipment properly

e. what to do if something goes wrong

6.2.6 Ask the participants relevant questions about the means to reduce the exposure to acceptable levels

6.2.7 Facilitate group discussions with the participants about the importance of safe working procedures, identifying the necessary PPE and the appropriate tools when working in an installation environment

6.2.8 Give constructive feedback on the participants' group discussion about the importance of safety when working in an installation environment

The participants shall:

6.2.9 Describe in their own words and share understandings about how to identify known and suspected hazards involved in the installation of solar arrays

6.2.10 Describe in their own words and share understandings about the health risks associated with the hazardous situations

6.2.11 Describe in their own words and share understandings about the means to reduce the exposure to acceptable levels

6.2.12 Engage in a group discussion about the importance of safe working procedures, identifying the necessary PPE and the appropriate tools when working in an installation environment

ELEMENT 6.3 - THE IMPORTANCE OF APPROPRIATE ISOLATION

Learning objectives:

53) The participants can **discuss** the importance of proper isolation when working in an installation environment (Knowledge, intermediate level)

The instructor shall:

6.3.1 Explain using stories or scenarios the importance of using appropriate isolations when in an installation environment.

6.3.2 Facilitate group discussions with the participants on the importance of proper isolation when in an installation environment

6.3.3 Give constructive feedback on the participants' group discussion about the importance of proper isolation when in an installation environment

The participants shall:

6.3.4 Engage in a group discussion about the importance of proper isolation when in an installation environment and why it is important to respect isolation locks and tags in place

LESSON 7 - COMPONENT ASSEMBLY

15 min.

The aim of this lesson is to give participants basic knowledge of the preparation of main components before installation and basic knowledge of mechanical completion.

ELEMENT 7.1 - INSPECTION, PREPARATION AND ASSEMBLY

Learning objectives:

54) The participants can **describe** the preparation of the different types of main components, dampeners, torque tubes, motoring gearbox, drive lines, bearings, inverters, cables, combiner boxes (Knowledge, basic level)

55) The participants can **recognise** the importance of identifying damage to components and replace them before installation (Knowledge, basic level)

The instructor shall:

7.1.1 Give examples of and explain the difference between:

- Inspection e.g. inspecting components
- Preparation e.g. gathering tools
- Assembly e.g. assembly of main components of the array itself

7.1.2 Explain why inspection, preparation and assembly is performed prior to installation

7.1.3 Explain and demonstrate preparation of parts and tools and particular inspection routines for:

a. dampeners
b. torque tubes
c. motoring gearbox
d. drive lines
e. bearings
f. inverters
g. cables
h. combiner boxes

7.1.4 Explain and show why it is important to replace damaged components before installation

The participants shall:

7.1.1 Engage in discussions about different tasks for preparation and installation of solar arrays at the industry work environment

ELEMENT 7.2 - EXAMPLES OF MECHANICAL COMPLETION

Learning objectives:

56) The participants can **repeat** using a documented checklist required for the mechanical completion of solar array (Skills, basic level)

57) The participants can **describe** the requirement to take photographs if they see something wrong to help document the problem (Knowledge, basic level)

The instructor shall:

7.2.1 Facilitate practice for the participants to document on a checklist the mechanical completion of a solar array.

a. Provide participants with a realistic solar installation mechanical completion task to conduct using real equipment or a simulated installation (aids to be used may include images, video or 3D VR models)

7.2.2 Ask the participants relevant questions about the requirement to take photographs if they see something wrong to help document the problem.

7.2.3 Give constructive feedback on the participants' documentation in a checklist of the mechanical completion of a solar array

The participants shall:

7.2.4 Practice documenting on a checklist the mechanical completion of a solar array

7.2.5 Describe in their own words and share understandings about the requirement to take photographs if they see something wrong to help document the problem

LESSON 8 - GENERAL PROCEDURES FOR WORKING ONSITE WITH INSTALLATION

20 min.

The aim of this lesson is to give participants an understanding of the checklist system through the complete installation process.

ELEMENT 8.1 - CHECKLISTS AND WORK INSTRUCTIONS.

Learning objectives:

58) The participants can **recognise** the checklist system throughout the complete installation process (Knowledge, basic level)

59) The participants can **describe** the importance of working according to the approved working practices (Knowledge, basic level)

60) The participants can **describe** the importance of completing a task properly before starting the next (Knowledge, basic level)

61) The participants can **describe** the importance of performing toolbox talks every day (Knowledge, basic level)

The instructor shall:

8.1.1 Explain the purpose of checklist, work instructions, or similar (show an example of a checklist, work instructions, or similar.)

8.1.2 Facilitate discussions with the participants about the importance of:

a. working according to the approved working practices (checklist, work instructions, etc.)

b. completing a task properly before starting the next

c. performing toolbox talks every day to discuss the specifics about the work to be performed during the day

The participants shall:

8.1.3 Engage in discussions about the importance of working according to the approved working practices (checklist, work instructions, etc.)

8.1.4 Engage in discussions about the importance of completing a task properly before starting the next

8.1.5 Engage in discussions about the importance of performing toolbox talks every day to discuss the specifics about the work to be performed during the day

ELEMENT 8.2 - HOUSEKEEPING

Learning objectives:

62) The participants can **describe** the importance of good housekeeping and the consequences of poor housekeeping when working in an installation environment (Knowledge, basic level)

The instructor shall:

8.2.1 Facilitate discussions with the participants about:

a. the importance of having everything clean and tidy, and its impact on safety and quality

b. the consequences of poor housekeeping

c. the importance of personal commitment to good housekeeping

d. the importance of removal of waste, leftover materials and trash

The participants shall:

8.2.2 Engage in discussions about the importance of having everything clean and tidy and its impact on safety and quality

8.2.3 Engage in discussions about the consequences of poor housekeeping

8.2.4 Engage in discussions about the importance of personal commitment to good house keeping

LESSON 9 - INSTALLATION ENVIRONMENTS

20 min.

The aim of this lesson is to give the participants an understanding of the characteristics of the installation environments.

ELEMENT 9.1 - INSTALLATION ENVIRONMENTS

Learning objectives:

63) The participants can **describe** the characteristics of installation environments, including site induction, various key working areas, safety behaviour and personnel roles (Knowledge, basic level)

The instructor shall:

9.1.1 Explain key on-site working areas (administration, hardstand, storage, etc.)

9.1.2 Describe the layout of a typical hardstand

9.1.3 Explain safety behaviour and limitations in the different key areas (refer to Site induction / Site orientation, site specific safety rules)

9.1.4 Explain personnel roles (Site Manager, Site Supervisors, Team Leaders, installation crew, admin staff, Health & Safety, third parties etc.)

9.1.5 Explain what is meant by site Induction, and relate it to the previous point

The participants shall:

9.1.6 Engage in discussions about on-site working areas, onsite organisation typical roles and responsibilities, communication, and the interaction between them

LESSON 10 - HANDLING AND STORING

25 min.

The aim of this lesson is to give the participants knowledge about the principles and standards of handling and storing goods and components onsite or within a storage area, before and after installation.

ELEMENT 10.1 - RISKS AND HAZARDS ASSOCIATED WITH HANDLING AND STORING

Learning objectives:

64) The participants can **discuss** the risks and hazards associated with handling and storing goods and components (Knowledge, intermediate level)

The instructor shall:

10.1.1 Facilitate group discussions on examples of the risks and hazards associated with handling and storing

10.1.2 Give constructive feedback on the participants' group discussion on examples of the risks and hazards associated with handling and storing

The participants shall:

10.1.3 Engage in a group discussion on examples of the risks and hazards associated with handling and storing

ELEMENT 10.2 - RECEPTION/INSPECTION

Learning objectives:

65) The participants can **recognise** the importance of inspecting goods and components before being unloaded (Knowledge, basic level)

66) The participants can **recognise** the importance of notifying a supervisor about any damage found before unloading, and tag "out of service" (or "do not use" or similar) if something is broken while being used (Knowledge, basic level)

67) The participants can **perform** reception/inspection of goods and components (Skills, intermediate level)

The instructor shall:

10.2.1 Explain the importance and responsibility of inspecting goods and components before being unloaded including:

a. panels

b. torque tubes

c. drive lines

d. bearings

e. other goods, e.g. solar connectors, combiner boxes, PCS

10.2.2 Explain the importance of notifying a supervisor about any damage found before unloading

a. damage report could be completed by a supervisor to register the damages found

10.2.3 Emphasise the importance of notifying a supervisor and tag "out of service" (or "do not use" or similar) if something is broken while being used.

10.2.4 Demonstrate how to perform inspections in accordance with work instructions, checklists, etc.

10.2.5 Facilitate practice for the participants to perform an inspection and document it on a checklist

10.2.6 Give constructive feedback on the participants' inspection and documentation of this on a checklist

The participants shall:

10.2.7 Practice and perform an inspection and document it on a checklist (the focus is on the use of the checklist, not on the inspection itself)

ELEMENT 10.3 - UNLOADING, STORING AND TRANSPORT OF SOLAR COMPONENTS

Learning objectives:

68) The participants can **recognise** how to unload and store goods and components in a correct and safe manner (Knowledge, basic level)

69) The participants can **recognise** the importance of securing dry conditions for hardware during storage (Knowledge, basic level)

70) The participants can **recognise** the cost and consequence of the incorrect handling and storage of main components (Knowledge, basic level)

71) The participants can **describe** the importance of ownership by everyone on site (ownership culture) (Knowledge, basic level)

The instructor shall:

10.3.1 Describe how to unload the main components in a correct and safe manner

10.3.2 Describe how to store the main components correctly onsite

10.3.3 Describe the importance of securing dry conditions for tower bolts during storage

10.3.4 Describe the cost and consequence of incorrect handling and storage of main components.

10.3.5 Facilitate discussions with the participants about the importance of ownership by everyone on site (ownership culture)

The participants shall:

10.3.6 Engage in discussions about the importance of ownership by everyone on site (ownership culture)

ELEMENT 10.4 - TOOLS AND EQUIPMENT

Learning objectives:

72) The participants can **describe** how to maintain tools and equipment during installation (Knowledge, basic level)

The instructor shall:

10.4.1 Describe the importance of keeping the tools and the tool container clean and regularly maintained

10.4.2 Explain that an inventory list can usually be found in the tool container, and should be cross referenced to make sure that all tools delivered on site are returned

10.4.3 Ask the participants relevant questions about how to maintain tools and equipment during installation

The participants shall:

10.4.4 Describe in their own words and share understandings about how to maintain tools and equipment during installation

ELEMENT 10.5 - RETURN OF GOODS AND COMPONENTS

Learning objectives:

73) The participants can **recognise** what needs to be returned, and how to prepare for returning goods and components (Knowledge, basic level)

74) The participants can **describe** how tools should be returned (Knowledge, basic level)

75) The participants can **distinguish** between the correct and incorrect way to fill in a return goods report (Skills, intermediate level)

The instructor shall:

10.5.1 Explain what goods need to be returned

10.5.2 Facilitate discussions with the participants on how to return tools:

a. ensure they are tidy and clean

b. ensure they are working properly

c. tools and equipment returned in the tool container must be correctly packed and stored

d. ensure defective tools are labelled

10.5.3 Show examples of and describe the return goods report

10.5.4 Facilitate practice to improve the participants' skill to fill in a return goods report

10.5.5 Give constructive feedback on the participants' skill to fill in a return goods report

The participants shall:

10.5.6 Engage in discussions about how to return tools

10.5.7 Practice the ability to fill in a return goods report

LESSON 11 - INTRODUCTION TO ELECTRICAL ASSEMBLY

360 min.

The aim of this lesson is to give participants basic knowledge and practical skills for electrical completion, including the principles and standards for handling and installing cables.

ELEMENT 11.1 - INTRODUCTION TO ELECTRICAL ASSEMBLY

Learning objectives:

76) The participants can **recognise** electrical assembly principles and application (Knowledge, basic level)

The instructor shall:

11.1.1 Explain the electrical tasks to be assembled in the solar panel system after the main components have been installed

ELEMENT 11.2 - EXAMPLES OF ELECTRICAL ASSEMBLY

Learning objectives:

77) The participants can **describe** examples of tasks related to electrical assembly (Knowledge, basic level)

The instructor shall:

11.2.1 Give examples of and describe electrical tasks that need to be completed after the installation of the main components:

a. installing ventilators

b. routing of cables

c. termination of cables.

11.2.2 Ask the participants relevant questions about examples of tasks related to electrical assembly

The participants shall:

11.2.3 Describe in their own words and share understandings about examples of tasks related to electrical assembly

ELEMENT 11.3 - RISKS AND HAZARDS ASSOCIATED WITH HANDLING AND WORKING WITH CABLES

Learning objectives:

78) The participants can **discuss** the risks and hazards associated with electrical completion (Knowledge, intermediate level)

79) The participants can **recognise** that the incorrect use if cutting and crimping tools could cause personal injury (Knowledge, basic level)

80) The participants can **recognise** that the incorrect use of cutting and crimping tools could lead to damage to the insulation or a poor connection, resulting in serious damage or fire (Knowledge, basic level)

81) The participants can **describe** the importance of appropriate isolation/locking techniques (Knowledge, basic level)

82) The participants can **describe** the correct PPE for electrical completion (Knowledge, basic level)

The instructor shall:

11.3.1 Facilitate group discussions on the risks and hazards associated with electrical completion

11.3.2 Explain that the incorrect use of cutting and crimping tools could cause personal injury

11.3.3 Facilitate group discussions on the risks associated with the installation of cables and wire management

11.3.4 Explain that the incorrect use of cutting and crimping tools could lead to damage to the insulation or a poor connection, resulting in serious damage or fire

11.3.5 Facilitate discussions about the importance of appropriate isolation/locking techniques and the correct PPE

11.3.6 Give constructive feedback on the participants' group discussions about the hazards associated with electrical completion and wire management

11.3.7 Facilitate discussions on best practice in relation to working daytime and nighttime

The participants shall:

11.3.8 Describe safe manner use of correct tools to avoid injury or damage in their own words

11.3.9 Engage in a group discussion about the risks and hazards associated with cable work and wire management

11.3.10 Engage in discussions about the importance of appropriate isolation/locking techniques (e.g. Lock Out Tag Out)

11.3.11 Engage in discussions about the correct PPE

ELEMENT 11.4 - DIFFERENT TYPES OF CABLES

Learning objective:

83) The participants can **explain** the purpose and application of different types of cables – e.g. small signal, main power (LV&HV) and fibre optic cables (Knowledge, intermediate level)

The instructor shall:

11.4.1 Show examples of and explain different types and purposes of cables:

a. Small signal cables: shielded and unshielded, rubber, PVC, cable glands

b. Main power (HV&LV) cables: copper, aluminium, rubber and PVC insulation types

c. Fibre optic cables: glass core, plastic core

11.4.2 Ask the participants relevant questions about the purposes and application of the different cable types in the work environment

11.4.3 Give constructive feedback on the participants' explanations of the purposes and application of the different cable types in the work environment

The participants shall:

11.4.4 Explain in their own words and share understandings about the purposes and application of the different cable types in the work environment

ELEMENT 11.5 - SIMPLE INSTALLATION DIAGRAMS

Learning objective:

84) The participants can **perform** the installation of cables by following simple installation diagrams (Skills, intermediate level)

The instructor shall:

11.5.1 Explain and demonstrate how to use simple electrical diagrams to mount cables (e.g. installation of lights) by identifying:

a. colour and numbering codes (explain that there should be a reference to applicable local standards: e.g. ISO or ANSI and also company-specific work instructions)

b. cable list (explain that there should be a reference to applicable local standards: e.g. ISO or ANSI and also company-specific work instructions)

c. cable core list

11.5.2 Facilitate practice for the participants in reading a simple electrical diagram, cable list and cable core list in order to complete installation of simple components (e.g. light sources or fans)

11.5.3 Give constructive feedback on the participants' reading of a simple electrical diagram, cable list and cable core list in order to complete installation of simple components

The participants shall:

11.5.4 Practice reading a simple electrical diagram, cable list and cable core list in order to complete installation of simple components (e.g. light sources or fans)

ELEMENT 11.6 - CUTTING AND CRIMPING CABLES

Learning objectives:

85) The participants can **perform** the cutting and crimping of small signal and main power LV cables (Skills, intermediate level)

The instructor shall:

11.6.1 Explain the different types and purposes of tools used for cutting and crimping cables:

a. knives and special cutting tools

b. stripping tools to remove cable insulation

c. crimping tools for signal cables and main cables: manual and hydraulic tools

11.6.2 Explain and demonstrate how to cut and crimp small signal cables:

a. shielded and unshielded

b. rubber and PVC insulation types

11.6.3 Explain and demonstrate how to cut and crimp main LV power cables:

a. copper and aluminium (special attention to correct cable die-set)

b. rubber and PVC insulation types

c. install heat/cold shrink tube on top of cable and cable lug, after cable lug has been crimped

11.6.4 Facilitate practice for the participants in cutting and crimping small signal cables and main LV power cables

11.6.5 Give constructive feedback on the participants' cutting and crimping of small signal and main LV power cables

The participants shall:

11.6.6 Practice cutting and crimping small signal cables:

a. shielded and unshielded

b. rubber and PVC insulation types

c. install heat/cold shrink tube on top of cable and cable lug, after cable lug has been crimped

11.6.7 Practice cutting and crimping main LV power cables:

a. copper and aluminium (special attention to the correct cable die-set)

b. rubber and PVC insulation types

ELEMENT 11.7 - MARKING, ROUTING AND TERMINATION OF ALL CABLE TYPES

Learning objectives:

86) The participants can **describe** typical faults during termination, and ways to mitigate these typical faults (Knowledge, basic level)

87) The participants can **perform** the marking, routing and termination of all cable types (Skills, intermediate level)

The instructor shall:

11.7.1 Show examples of and explain different types of marking and their purposes for all cable types:

a. cable and conductor

b. cabinet diagram

11.7.2 Show examples of and explain important factors when routing all cable types, informing participants to refer to work instructions for the specifics:

a. bending radius (why a minimum is important)

b. not twisted

c. distance between cable types and groups

d. fastening of cables: fixed vs flexible

e. cable protection tubes or edge protection

f. cable glands

11.7.3 Show examples of and explain important factors when handling fibre optic cables:

a. handle with care due to fragility (lower cables individually, do not combine with other cables when handling)

b. excess cable should not be cut out, but coiled

c. how to bend in accordance with work instructions considering the coil bending radius

d. end protection caps are only to be removed just before the cable is connected to the individual processor

11.7.4 Demonstrate how to perform termination on signal cables:

a. mounting of ferrules

b. mounting in clamp and screw terminals

c. shield termination types

11.7.5 Demonstrate how to perform termination on main power cables (copper/aluminium):

a. mounting of cable lugs on busbar (correct torque)

b. mounting of cable to connectors (correct torque)

11.7.6 Facilitate discussions about typical faults during termination

11.7.7 Facilitate practice for the participants to mark, route and terminate all cable types

11.7.8 Give constructive feedback on the participants' marking, routing and termination of all cable types

The participants shall:

11.7.9 Engage in discussions about typical faults during termination:

a. insulation in terminal and loose cores

b. incorrect torque – generates heat

c. poor crimping – all kinds of scenarios

11.7.10 Practice mounting markings in accordance with an electrical diagram:

a. cable and conductor

b. cabinet diagram

11.7.11 Practice routing all cable types applying these factors:

a. bending radius

b. distance between cable types and groups

c. fastening of cables: fixed vs flexible

d. cable protection tubes or edge protection

e. cable glands

11.7.12 Practice routing fibre optic cables

11.7.13 Practice correctly terminating signal cables:

a. mounting of ferrules

b. mounting in clamp and screw terminals

c. shield termination types

11.7.14 Practice correctly terminating main power cables (copper/aluminium):

a. mounting of cable lugs on busbar (correct torque)

b. mounting of cable to connectors (correct torque)

ELEMENT 11.8 - SOLAR PV CONNECTORS

Learning objectives:

88) The participants can **explain** the purpose and application of tooling relevant for PV connector installation (Knowledge, intermediate level)

89) The participants can **perform** installation tasks related to PV connectors (Skills, intermediate level)

90) The participants can **recognise** damaged components and safety risks related to PV connectors (Knowledge, basic level)

The instructor shall:

11.8.1 Show examples and explain the different tools used for PV connector preparation:

a. stripping pliers

b. crimping pliers

c. assembly & unlocking tools

d. torques

e. test plugs

f. cable cutters

11.8.2 Show examples of different brands and types of connectors. Highlight issues on incompatibility e.g. similar appearance but not compatible.

11.8.3 Demonstrate installation tasks using PV connectors following manufacturer instructions:

a. male connector fitting

b. crimping of cable

c. nut on cable

d. cable insertion

e. rubber washer

f. female crimp

g. cable insertion

h. continuity test before connecting

i. cap torquing

j. sealing

11.8.4 Give constructive feedback on the participants' installation of PV connectors

11.8.5 Show examples of damaged components

11.8.6 Use a case study, maintenance report or incident report to facilitate a discussion on typical equipment damage and safety issues related to improper installation (dirt, debris, moisture, corrosion, heat, etc.)

The participants shall:

11.8.7 Engage in discussion about the application of tools used for PV connector preparation:

a. stripping pliers

b. crimping pliers

c. assembly & unlocking tools

d. torques

e. test plugs

f. cable cutters

11.8.8 Engage in discussion about issues of incompatibility and distinguish between different brands and types of connectors.

11.8.9 Practice installation tasks using PV connectors following manufacturer instructions:

a. male connector fitting

b. crimping of cable

c. nut on cable

d. cable insertion

e. rubber washer

f. female crimp

g. cable insertion

h. continuity test before connecting

i. cap torquing

j. sealing

11.8.10 Engage in discussion on typical equipment damage, damaged components and safety issues related to improper installation (dirt, debris, moisture, corrosion, heat, etc.)

LESSON 12 - SUMMARY AND THEORETICAL TEST

50 min.

The aim of this lesson is to summarise the S-TT Installation Module and to conduct a theoretical test with the participants.

ELEMENT 12.1 - SUMMARY

Learning objectives:

91) The participants can **recall** the objectives that have been covered within this module

The instructor shall:

12.1.1 Summarise the S-TT Installation Module referring to the objectives

ELEMENT 12.2 - THEORETICAL TEST

After having successfully completed this element participants will be able to pass the final test

The instructor shall:

12.2.1 Introduce the test to the participants, explaining the rules to be followed during the test

12.2.2 Conduct the test with the participants (20 questions / 30 min)

12.2.3 Check the test results and give feedback to the participants about the test results

12.2.4 If a participant fails the test, conduct an interview with the participant according to the Participant Performance Assessment' section

The participants shall:

12.2.5 Complete the test (20 questions / 30 min)

LESSON 13 - TRAINING REVIEW

15 min.

The aim of this lesson is to enable the participants to reflect on and process their learning outcome and their key takeaways from the module, aiming to achieve a high learning transfer from the module to their way of working.

ELEMENT 13.1 - TRAINING REVIEW

The instructor shall:

13.1.1 Present the overall aims and learning objectives of the module for the participants' comparison of their learning outcomes and the achievement of their previously stated expectations for the module

The participants shall:

13.1.2 Reflect on their learning outcome and key takeaways from the S-TT Installation Module, aiming to achieve a high learning transfer from the module to their way of working, by means of e.g.:

a. group discussions or walk and talk

b. questions and answers in class, or where suitable

Note *The instructor may additionally conduct a local evaluation of the training.*

ELEMENT 13.2 - FEEDBACK SESSION

The instructor shall:

13.2.1 Give overall feedback and feed forward on the participants' learning outcome inspired by the training as well as from the training-review-session

13.2.2 Encourage the participants to examine and grow awareness of which specific elements in their own work environment differ from the training scenario environment (to visualise and enhance learning transfer), and to discuss with colleagues about how the S-TT content, methods and techniques are similar or different to the local specific conditions identified after the module completion

GLOBAL WIND ORGANISATION

Solar Technical Training Electrical

(S-TTE)

9. SOLAR TECHNICAL TRAINING - ELECTRICAL MODULE

9.1 Aims and objectives of the S-TT Electrical Module

The aim of this S-TT Electrical Module is to give the participants the knowledge and skills to carry out basic electrical tasks (supervised by an experienced technician), using safe working procedures and the correct PPE.

After having successfully completed the S-TT Electrical Module, the participants can:

1) **Explain** the basics of electricity (Knowledge, intermediate level)

2) **Explain** risks and hazards associated with electrical work (Knowledge, intermediate level)

3) **Recognise** the function and symbol of electrical components (Knowledge, basic level)

4) **Explain** the function of different types of sensors (Knowledge, intermediate level)

5) **Explain** the components on a simple electrical diagram (Knowledge, intermediate level)

6) **Perform** assembly of a simple electrical circuit (Skills, intermediate level)

7) **Perform** correct and safe electrical measurements (Skills, intermediate level)

9.2 Duration of the S-TT Electrical Module

The total contact time for completing the S-TT Electrical Module is 8 hours.

The training provider must not exceed the time per day given below.

	Maximum Duration Per Day
Contact time	8 hours
Total training day	10 hours

Table 9.2.1 - Maximum duration for training days

Note *Contact time includes delivery of course lesson content, practical exercises and activities directly related to these.*

The total training day includes contact time, meals and breaks and travel between training sites (where applicable).

9.3 Participant Ratio of the S-TT Electrical Module

The ratio shown for theory sessions indicates the maximum number of participants per instructor attending the course.

Practical ratios indicate the maximum number of participants to be supervised by an instructor during each activity.

Module	Session	Instructor to Participant Ratio
S-TT Electrical	Theory	1:12
	Practical	1:8

Table 9.3.1 – Instructor to participant ratio

9.4 Equipment for the S-TT Electrical Module

The equipment required for training as listed in Annex 1 must be available and must fulfil national legal requirements.

9.5 Timetable of S-TT Electrical Module

The order in which elements of this module training are delivered may vary according to the lesson plans developed by the training provider.

The delivery of this module must comply with the requirements described in the GWO Requirements for Training.

Lesson	Element		Duration
1. **Introduction to the training**	1.1	Safety and emergency procedures	
	1.2	Facilities	
	1.3	Introduction	
	1.4	Aims and objectives	
	1.5	Ongoing assessments	
	1.6	Motivation	
	1.7	Human factors	
		TOTAL	30 min.
2. **Introduction to electricity**	2.1	Direct current	
	2.2	Ohm's law and Watts Law	
	2.3	Kirchoff´s Law	
	2.4	Alternating current	
	2.5	Alternating current/direct current	

			TOTAL	60 min.
3.	Electrical safety	3.1	Why electrical safety?	
		3.2	Low/high voltage	
		3.3	PE and GFCI/RCD	
		3.4	Stored energy	
		3.5	Static electricity	
		3.6	Safety signs	
		3.7	Types of PPE	
		3.8	The importance of appropriate isolation	
			TOTAL	70 min.
4.	Electrical components and sensors	4.1	Resistors	
		4.2	Batteries	
		4.3	Switches	
		4.4	Contactors	
		4.5	Relays	
		4.6	Diodes	
		4.7	Bridge rectifiers	
		4.8	Capacitors	
		4.9	Transformers	
		4.10	Motors	
		4.11	Fuses and circuit breakers	
		4.12	Power control systems	
		4.13	Introduction to sensors	
		4.14	Application of sensors	
			TOTAL	100 min.
5.	Electrical measuring instruments	5.1	Symbols and settings on electrical instruments	
		5.2	How to measure with electrical measuring instruments	
		5.3	Measuring points	
			TOTAL	60 min.
6.	Electrical circuits	6.1	Symbols and diagrams	
		6.2	Assembly of an electrical circuit	
			TOTAL	110 min.
7.	Cooling system	7.1	Inspection and function of the cooling system	
			TOTAL	10 min.

8.	Summary and theoretical test	8.1	Summary	
		8.2	Theoretical test	
			TOTAL	25 min.
9.	Training review	9.1	Training review	
		9.2	Feedback session	
			TOTAL	15 min.
			GRAND TOTAL	480 min.

Table 9.5.1 - S-TT Electrical timetable

9.6 Detailed Description of the S-TT Electrical Module

LESSON 1 - INTRODUCTION TO THE TRAINING

30 min.

The aim of this lesson is to enable the participants to engage in the S-TT Electrical training safely and with motivation, while recognising what is expected of them during the training.

Note *If this module is delivered combined with other S-TT modules to the same participants, the redundant introductory elements shall not be repeated.*

After successfully completing this lesson, the participants can:

8) **Describe** the module content and the facilities involved to ensure a clear understanding of what is expected during the module (Knowledge, basic level)

9) **Name** and point out local emergency procedures and facilities (Knowledge, basic level)

10) **Describe** the relevant human factors and the implications thereof (Knowledge, basic level)

ELEMENT 1.1 - SAFETY INSTRUCTIONS AND EMERGENCY PROCEDURES

Learning objectives:

11) The participants can **recognise** the safety instructions, rules and emergency procedures (Knowledge, basic level)

12) The participants can **show interest** or curiosity in the safety and emergency procedures (Ability, basic level)

The instructor shall:

1.1.1 Explain and ask involving questions concerning:

a. safety instructions according to internal procedures

b. emergency procedures and emergency exits in the areas where the participants can be expected to be located during the module

The participants shall:

1.1.2 Engage in answering the above questions

ELEMENT 1.2 - FACILITIES

Learning objectives:

13) The participants can **recognise** the facilities at the training location (Knowledge, basic level)

The instructor shall:

1.2.1 Give a general description of the facilities at the location (administration, dining area, restrooms and toilets, etc.)

The participants shall:

1.2.2 Note relevant facilitates and ask questions when in doubt about facilities

ELEMENT 1.3 - INTRODUCTION

Learning objectives:

14) The participants can **show interest** in fellow participants and the programme of the S-TT Electrical Module (Ability, basic level)

The instructor shall:

1.3.1 Explain and ask involving questions about the programme of the S-TT Electrical Module, including breaks and mealtimes

1.3.2 Give a short introduction about themselves, including their backgrounds as instructors

1.3.3 Ask for participants' expectations of the training and of their learning outcome

The participants shall:

1.3.4 Give a short introduction about themselves, including job function, and share their expectations of the training and learning outcome expectation for the training

ELEMENT 1.4 - AIMS AND OBJECTIVES

Learning objectives:

15) The participants can **recognise** the scope and main objectives of the S-TT Electrical Module (Knowledge, basic level)

The instructor shall:

1.4.1 Explain the scope and main objectives of the S-TT Electrical Module

1.4.2 Involve participants by means of questions about the participants' understandings and individual experiences relevant to the S-TT Electrical Module

The participants shall:

1.4.3 Engage in answering questions and share experiences relevant to the S-TT Electrical Module

ELEMENT 1.5 - ONGOING ASSESSMENTS

Learning objectives:

16) The participants can **recognise** the reasons for the ongoing assessment, and recognise how the GWO participant assessment form will be used throughout the module (Knowledge, basic level)

The instructor shall:

1.5.1 Explain the reasons for the on-going assessment

1.5.2 Explain the GWO participant assessment form and how it will be used

1.5.3 Ask for the participants thoughts on the assessment procedure presented

The participants shall:

1.5.4 Engage in discussions on the assessment procedure

ELEMENT 1.6 - MOTIVATION

Learning objectives:

17) The participants **show a willingness** to be personally involved in the learning activities throughout the S-TT Electrical Module (Ability, basic level)

The instructor shall:

1.6.1 Explain and facilitate discussions on:

a. the importance of personal involvement in the module

b. the need for the S-TT Electrical Module when working in the industry specific work environments

The participants shall:

1.6.2 Engage themselves in discussions about the importance of personal involvement in the module and need for the S-TT Electrical Module when working in the industry specific environments

ELEMENT 1.7 - HUMAN FACTORS

Learning objectives:

18) The participants can **describe** the relevant human factors and the implications thereof (Knowledge, basic level)

19) The participants can **show interest** and willingness to focus on human factors during the following practical exercises (Ability, basic level)

The instructor shall:

1.7.1 Present how human factors have an influence on accidents in the industry specific environment

1.7.2 Lead a discussion about the role of the individual in improving human performance, and how this improvement can benefit safety when working in the industry specific environment, by considering factors like:

a. attention and perception

b. group behaviour and peer pressure

c. fitness and health

d. domestic and work-related stress

e. workload (both overload and underload)

f. fatigue

g. time pressure and deadlines

h. alcohol, medication and substance abuse

The participants shall:

1.7.3 Engage in discussions and share understandings about the human factor influence on accidents when working in the solar industry specific environment

LESSON 2 - INTRODUCTION TO ELECTRICITY

60 min.

The aim of this lesson is to give the participants basic knowledge about electricity.

ELEMENT 2.1 - DIRECT CURRENT

Learning objectives:

20) The participants can **explain** what direct current is (Knowledge, intermediate level)

The instructor shall:

2.1.1 Explain electrical current definition and units

2.1.2 Describe the basic concept between the current flow and the resistance

2.1.3 Explain voltage definition and units

2.1.4 Explain resistance definition and units. Variable resistance (PT100-temp)

2.1.5 Ask the participants relevant questions about what direct current is

2.1.6 Give constructive feedback on the participants' explanations about what direct current is

The participants shall:

2.1.7 Explain in their own words and share understandings about what direct current is

ELEMENT 2.2 - OHM'S LAW AND WATTS LAW

Learning objectives:

21) The participants can **describe** the relationship between current, voltage and resistance (Knowledge, basic level)

22) The participants can **apply** Ohm's Law (voltage, current & resistance) (Skill, intermediate level)

23) The participants can **describe** Watts Law (power, voltage and current) (Knowledge, basic level)

The instructor shall:

2.2.1 Explain practical examples of Ohm's Law (current, voltage and resistance) using a simple circuit diagram of battery and resistor

2.2.2 Facilitate discussions with the participants about the relationship between current, voltage and resistance

2.2.3 Create a learning activity where the participants can practice the use of Ohm's Law

2.2.4 Give constructive feedback on the participants' use of Ohm's Law

2.2.5 Explain practical examples of Watt's Law (power, voltage and current) using a simple circuit diagram of battery and resistor

2.2.6 Facilitate discussions with the participants about the relationship between power, voltage and current

The participants shall:

2.2.7 Engage in discussions on the relationship between current, voltage and resistance

2.2.8 Engage in discussions on the relationship between power, voltage and current

2.2.9 Practice the use of Ohm's Law

2.2.10 Describe Watt´s Law

ELEMENT 2.3 - KIRCHOFF´S LAW

Learning objectives:

24) The participants can **describe** Kirchoff's Law (current entering equals current leaving) (Knowledge, basic level)

The instructor shall:

2.3.1 Explain Kirchoff's Law (current entering equals current leaving) and present practical examples using a simple circuit diagram of battery and resistor

The participants shall:

2.3.2 Engage in discussions on current entering and current leaving

ELEMENT 2.4 - ALTERNATING CURRENT

Learning objectives:

25) The participants can **explain** what alternating current is (Knowledge, intermediate level)

The instructor shall:

2.4.1 Explain the theory behind alternating current

2.4.2 Explain the location of AC in a basic electrical circuit diagram

2.4.3 Ask the participants relevant questions about what alternating current is

2.4.4 Give constructive feedback on the participants' explanations about what alternating current is

The participants shall:

2.4.5 Explain in their own words and share understandings about alternating current

ELEMENT 2.5 - ALTERNATING CURRENT/DIRECT CURRENT

Learning objectives:

26) The participants can **discuss** the difference between direct and alternating current (Knowledge, intermediate level).

The instructor shall:

2.5.1 Facilitate group discussions with the participants on the difference between alternating and direct current.

2.5.2 Give constructive feedback on the participants' group discussion about the difference between direct and alternating current

The participants shall:

2.5.3 Engage in a group discussion about the difference between direct and alternating current

LESSON 3 - ELECTRICAL SAFETY

70 min.

The aim of this lesson is to give the participants the necessary awareness, knowledge and understanding to handle electrical hazards in a solar panel system.

ELEMENT 3.1 - WHY ELECTRICAL SAFETY?

Learning objectives:

27) The participants can **explain** the dangers of electricity and the effects of electricity on the human body (Knowledge, intermediate level)

28) The participants can **recognise** the importance of Electrical Safety (Knowledge, basic level)

29) The participants can **describe** the relation between current and contact time (Knowledge, basic level)

The instructor shall:

3.1.1 Explain the dangers of electricity:

a. difficult to detect (invisible)

b. potential to be deadly or life-altering

3.1.2 Explain the effects (including late effects) of electricity on the human body

3.1.3 Show the importance of working according to approved working practices (through e.g. storytelling, examples or scenarios)

3.1.4 Ask the participants relevant questions about how the dangers and effects of electricity are different to other hazardous energies, such as mechanics

3.1.5 Facilitate discussions about the relationship between current and contact time

3.1.6 Give constructive feedback on the participants' explanations about how the dangers and effects of electricity are different to other hazardous energies, such as mechanics

The participants shall:

3.1.7 Explain in their own words and share understandings about how the dangers and effects of electricity are different to other hazardous energies, such as mechanics

3.1.8 Engage in discussions about the relationship between current and contact time

ELEMENT 3.2 - LOW/HIGH VOLTAGE

Learning objectives:

30) The participants can **recognise** the definitions of low and high voltage (Knowledge, basic level)

31) The participants can **describe** the risks and hazards of low and high voltage (Knowledge, basic level)

32) The participants can **recognise** HV safety signs and HV restricted areas (Knowledge, basic level)

33) The participants can **recognise** the requirement of having HV training before performing any HV work (Knowledge, basic level)

The instructor shall:

3.2.1 Define low and high voltage (dependent on the country)

3.2.2 Explain the basic difference between hazards of high voltage and low voltage

3.2.3 Show examples of HV safety signs and HV restricted areas (e.g. HV transformer, HV transformer room, switchgear, HV cable, megohmmeters, substation…)

3.2.4 Explain the requirement for HV training before performing any HV work

3.2.5 Facilitate discussions with the participants about the risks and hazards of low and high voltage

The participants shall:

3.2.6 Engage in discussions about the risks and hazards of low and high voltage

ELEMENT 3.3 - PE AND GFCI/RCD

Learning objectives:

34) The participants can **explain** the function, importance and symbol of GFCI/RCD and PE (Knowledge, intermediate level)

35) The participants can **recognise** how to identify double isolated tools and that they do not require grounding (Knowledge, basic level)

36) The participants can **recognise** the importance of grounding an external generator in accordance with the manufacturer's manual, local legislation and company rules (Knowledge, basic level)

37) The participants can **recognise** examples of and explain the symbol of GFCI/RCD and PE (Knowledge, basic level)

38) The participants can **recognise** that not all circuits on a solar array are protected by GFCI/RCD's (Knowledge, basic level)

39) The participants can **recognise** the relationship between current and contact time (Knowledge, basic level)

40) The participants can **recognise** the consequences of receiving a shock on a circuit protected by a GFCI and on a circuit without GFCI (Knowledge, basic level)

The instructor shall:

3.3.1 Explain the function and importance of GFCI/RCD and protective earth in tools and equipment.

3.3.2 Explain what can happen when a tool is used without protective earth and GFCI/RCD, and the consequence of improper grounding on tools or equipment in e.g. different situations:

a. situation, where there is no PE and, no GFCI/RCD

b. situation, where there is PE but, no GFCI/RCD

c. situation, where there is both PE and GFCI/RCD

3.3.3 Explain how to identify double isolated tools and that they do not require grounding.

3.3.4 Explain the importance of grounding an external generator in accordance with the manufacturer's manual, local legislation and company rules.

3.3.5 Show examples of and explain the symbol of GFCI/RCD and PE.

3.3.6 Explain that not all circuits on a solar panel system are protected by GFCI/RCD's.

3.3.7 Compare the consequences of receiving a shock on a circuit protected by a GFCI and on a circuit without GFCI.

3.3.8 Test the participants' understanding of PE and GFCI/RCD (e.g. with a questionnaire or multiple-choice questions about PE and GFCI/RCD)

3.3.9 Give constructive feedback on the results of the participants' answers, explain the reasons why the answers were correct or incorrect, and e.g. show the realistic consequences of a correct or incorrect answer to provide the participants with a sense of the real-world consequences

The participants shall:

3.3.10 Provide answers to the test about PE and GFCI/RCD

ELEMENT 3.4 - STORED ENERGY

Learning objectives:

41) The participants can **describe** the risks and hazards of stored energy in electrical systems (Knowledge, basic level)

The instructor shall:

3.4.1 Explain the risks related to:

a. the UPS system - e.g. risk of back feed

b. capacitors - e.g. risk of stored energy and arc flash

c. batteries - e.g. risk of stored energy and arc flash

d. solar panels - e.g. risk of back feed

3.4.2 Ask the participants relevant questions that challenge the participants to describe the risks and hazards, and how these risks and hazards can be mitigated

The participants shall:

3.4.3 Describe in their own words the risks and hazards of static electricity, and how these risks and hazards can be mitigated

ELEMENT 3.5 - STATIC ELECTRICITY

Learning objectives:

42) The participants can **describe** the risks and hazards of static electricity (Knowledge, basic level)

The instructor shall:

3.5.1 Present the risks and hazards of static electricity, grounding of components and lightning protection systems

3.5.2 Ask relevant questions to the participants that challenge the participants to describe the risks and hazards, and how these risks and hazards can be mitigated

The participants shall:

3.5.3 Describe in their own words the risks and hazards of static electricity, and how these risks and hazards can be mitigated

ELEMENT 3.6 - SAFETY SIGNS

Learning objectives:

43) The participants can **describe** different safety signs and their meanings (Knowledge, basic level)

The instructor shall:

3.6.1 Explain how to identify the sign for "Danger Electricity"

3.6.2 Show examples of safety signs on different locations in the work environment

3.6.3 Facilitate discussions about the meaning of different safety signs

The participants shall:

3.6.4 Engage in discussions about different safety signs and their meanings

ELEMENT 3.7 - TYPES OF PPE

Learning objectives:

44) The participants can **use** the required PPE for working with electricity (Skills, intermediate level)

The instructor shall:

3.7.1 Explain and demonstrate examples of usage and the inspection of PPE suitable for electrical work

3.7.2 Give constructive feedback on the participants' practice of the usage of the required PPE for working with electricity

The participants shall:

3.7.3 Practice the usage of the required PPE for working with electricity

ELEMENT 3.8 - THE IMPORTANCE OF APPROPRIATE ISOLATION

Learning objectives:

45) The participants can **describe** why it is important to prevent unexpected start-up when working with electricity (Knowledge, basic level)

46) The participants can **discuss** the importance of proper isolation when working with electricity (Knowledge, intermediate level)

47) The participants can **recognise** typical solar array reactions when an emergency stop button is pressed, and that an emergency stop button is not normally considered as an isolation (Knowledge, basic level)

The instructor shall:

3.8.1 Facilitate group discussions about the importance of appropriate isolation when working with electricity

3.8.2 Show the importance of emergency stop buttons in a solar panel system

3.8.3 Describe typical solar panel system reactions when an emergency stop button is pressed

3.8.4 Explain that an emergency stop button is not normally considered as an isolation

3.8.5 Facilitate discussions about why it is important to prevent unexpected start-up when working with electricity

3.8.6 Give constructive feedback on the participants' group discussion about the importance of appropriate isolation when working with electricity

The participants shall:

3.8.7 Engage in a group discussion about the importance of appropriate isolation when working with electricity

3.8.8 Engage in discussions about why it is important to prevent unexpected start-up when working with electricity

LESSON 4 - ELECTRICAL COMPONENTS AND SENSORS

100 min.

The aim of this lesson is to give the participants basic knowledge and understanding of electrical components and different sensors in an electric circuit.

ELEMENT 4.1 - RESISTORS

Learning objectives:

48) The participants can **describe** the function of resistors (Knowledge, basic level)

49) The participants can **recognise** resistors on a diagram (Knowledge, basic level)

The instructor shall:

4.1.1 Explain the function of resistors

4.1.2 Show examples of and explain the symbol for resistors

4.1.3 Show examples of and explain the position of resistors in a circuit

4.1.4 Ask the participants relevant questions about the function of resistors

The participants shall:

4.1.5 Describe in their own words and share understandings about the function of resistors

ELEMENT 4.2 - BATTERIES

Learning objectives:

50) The participants can **describe** the function of batteries (Knowledge, basic level)

51) The participants can **recognise** batteries on a diagram (Knowledge, basic level)

52) The participants can **describe** the risk and hazards associated with stored energy (Knowledge, basic level)

The instructor shall:

4.2.1 Explain the function of batteries

4.2.2 Show examples of and explain the symbols for batteries

4.2.3 Explain the position of batteries in a circuit

4.2.4 Explain the risks and hazards associated with stored energy

4.2.5 Ask the participants relevant questions about the function of batteries and the risk and hazards associated with stored energy

The participants shall:

4.2.6 Describe in their own words and share understandings about the function of batteries, and the risk and hazards of the stored energy

ELEMENT 4.3 - SWITCHES

Learning objectives:

53) The participants can **describe** the function of switches (Knowledge, basic level)

54) The participants can **recognise** switches on a diagram (Knowledge, basic level)

The instructor shall:

4.3.1 Explain the function of switches

4.3.2 Show examples of and explain the operation of switches (manual, part of a relay, part of a contactor…)

4.3.3 Show examples of and explain the symbols for different switches (NO, NC)

4.3.4 Explain the position of switches in a circuit

4.3.5 Ask the participants relevant questions about the function of switches

The participants shall:

4.3.6 Describe in their own words and share understandings about the function of switches

ELEMENT 4.4 - CONTACTORS

Learning objectives:

55) The participants can **describe** the function of contactors (Knowledge, basic level)

56) The participants can **recognise** contactors on a diagram (Knowledge, basic level)

The instructor shall:

4.4.1 Explain the function of contactors

4.4.2 Explain the operation of contactors

4.4.3 Show examples of and explain the symbol for contactors

4.4.4 Explain the position of contactors in a circuit

4.4.5 Ask the participants relevant questions about the function of contactors

The participants shall:

4.4.6 Describe in their own words and share understandings about the function of contractors

ELEMENT 4.5 - RELAYS

Learning objectives:

57) The participants can **describe** the function of relays (Knowledge, basic level)

58) The participants can **recognise** relays on a diagram (Knowledge, basic level)

The instructor shall:

4.5.1 Explain the function of relays

4.5.2 Explain the operation of relays

4.5.3 Show examples of and explain the symbol for relays

4.5.4 Explain the position of relays in a circuit

4.5.5 Ask the participants relevant questions about the function of relays

The participants shall:

4.5.6 Describe in their own words and share understandings about the function of relays

ELEMENT 4.6 - DIODES

Learning objectives:

59) The participants can **describe** the function of diodes (Knowledge, basic level)

60) The participants can **recognise** a diode on a diagram (Knowledge, basic level)

The instructor shall:

4.6.1 Explain the function of diodes

4.6.2 Show examples of and explain the symbol for diodes

4.6.3 Explain the position of diodes in a circuit

4.6.4 Explain how to check a diode with the multimeter

4.6.5 Ask the participants relevant questions about the function of diodes

The participants shall:

4.6.6 Describe in their own words and share understandings about the function of diodes

ELEMENT 4.7 - BRIDGE RECTIFIERS

Learning objectives:

61) The participants can **describe** the function of bridge rectifiers (Knowledge, basic level)

62) The participants can **recognise** bridge rectifiers on a diagram (Knowledge, basic level)

The instructor shall:

4.7.1 Explain the function of bridge rectifiers

4.7.2 Explain the operation of bridge rectifiers

4.7.3 Show examples of and explain the symbol for bridge rectifiers

4.7.4 Explain the position of bridge rectifiers in a circuit

4.7.5 Ask the participants relevant questions about the function of bridge rectifiers

The participants shall:

4.7.6 Describe in their own words and share understandings about the function of bridge rectifiers

ELEMENT 4.8 - CAPACITORS

Learning objectives:

63) The participants can **describe** the function of capacitors (Knowledge, basic level)

64) The participants can **recognise** capacitors on a diagram (Knowledge, basic level)

65) The participants can **describe** the risk and hazards of the stored energy (Knowledge, basic level)

The instructor shall:

4.8.1 Explain the function of capacitors

4.8.2 Show examples of and explain the symbol for a capacitor

4.8.3 Define the unit for capacitance (farads) and its divisions

4.8.4 Explain the position of capacitors in a circuit

4.8.5 Explain the risks and hazards associated with stored energy

4.8.6 Ask the participants relevant questions about the function of capacitors and the risk and hazards of stored energy

The participants shall:

4.8.7 Describe in their own words and share understandings about the function of capacitors and the risk and hazards of stored energy

ELEMENT 4.9 - TRANSFORMERS

Learning objectives:

66) The participants can **describe** the function of transformers (Knowledge, basic level)

67) The participants can **recognise** transformers on a diagram (Knowledge, basic level)

The instructor shall:

4.9.1 Explain the function of transformers

4.9.2 Show examples of and explain the symbol for transformers

4.9.3 Explain the position of transformers in a circuit

4.9.4 Ask the participants relevant questions about the function of transformers

The participants shall:

4.9.5 Describe in their own words and share understandings about the function of transformers

ELEMENT 4.10 - MOTORS

Learning objectives:

68) The participants can **describe** the function of motors (Knowledge, basic level)

69) The participants can **recognise** motors on a diagram (Knowledge, basic level)

The instructor shall:

4.10.1 Explain the basic function of motors

4.10.2 Show examples of and explain the symbols for motors

4.10.3 Explain the position of motors in a circuit

4.10.4 Ask the participants relevant questions about the basic function of motors

The participants shall:

4.10.5 Describe in their own words and share understandings about the function of motors

ELEMENT 4.11 - FUSES AND CIRCUIT BREAKERS

Learning objectives:

70) The participants can **describe** the function of fuses and circuit breakers (Knowledge, basic level)

71) The participants can **recognise** fuses and circuit breakers on a diagram (Knowledge, basic level)

The instructor shall:

4.11.1 Explain the function of fuses

4.11.2 Explain the function of circuit breakers

4.11.3 Show examples of and explain the symbol for fuses

4.11.4 Show examples of and explain the symbol for circuit breakers

4.11.5 Explain the position of fuses and circuit breakers in a circuit

4.11.6 Ask the participants relevant questions about the function of fuses and circuit breakers

The participants shall:

4.11.7 Describe in their own words and share understandings about the function of fuses and circuit breakers

ELEMENT 4.12 - POWER CONTROL SYSTEMS

Learning objectives:

72) The participants can **recognise** the function of the Power Control System (PCS) and its position in the diagram and communication between components (Knowledge, basic level)

The instructor shall:

4.12.1 Explain the function of a Power Control System (PCS) and how the controls system communicates with components via copper signal cable, optical cable or data cable

4.12.2 Explain the position of the Power Control System in the circuit

The participants shall:

4.12.3 Describe in their own words and share understandings about the function of Power Control Systems

ELEMENT 4.13 - INTRODUCTION TO SENSORS

Learning objectives:

73) The participants can **explain** the function of sensors (Knowledge, intermediate level)

The instructor shall:

4.13.1 Explain the function of sensors

4.13.2 Explain the difference between analogue & digital signals

4.13.3 Ask the participants relevant questions about the function of sensors

4.13.4 Give constructive feedback on the participants' explanations about the functions of sensors

The participants shall:

4.13.5 Explain in their own words and share understandings about the function of sensors

ELEMENT 4.14 - APPLICATION OF SENSORS

Learning objectives:

74) The participants can **describe** the function of the different types of sensors (Knowledge, basic level)

75) The participants can **recognise** how to identify different types of sensors on a diagram (Skills, basic level)

The instructor shall:

4.14.1 Explain the function of different sensor types including:

a. wind
b. temperature
c. position
d. pyranometer
e. soiling
f. etc.

4.14.2 Show examples and explain symbols of different sensor types in a circuit including:

a. wind
b. temperature
c. position
d. pyranometer
e. soiling sensor
f. etc.

4.14.3 Ask the participants relevant questions about the function of different sensor types and what is distinctive about them

The participants shall:

4.14.4 Describe in their own words and share understandings about the function of different types of sensors and what is distinctive about them

LESSON 5 - ELECTRICAL MEASURING INSTRUMENTS

60 min.

The aim of this lesson is to give the participants the basic knowledge about the correct and safe way to measure current, voltage, resistance, continuity, diodes and capacitance.

ELEMENT 5.1 - SYMBOLS AND SETTINGS ON ELECTRICAL INSTRUMENTS

Learning objectives:

76) The participants can **recognise** the symbols and settings used for current, voltage and resistance in the measuring instruments (Knowledge, basic level)

77) The participants can **describe** how to identify the validity of tools (Knowledge, basic level)

The instructor shall:

5.1.1 Explain and demonstrate settings on the Electrical Measuring Instruments including:

a. VAC and VDC

b. A and mA

c. Ohms/continuity

5.1.2 Explain and demonstrate the visual inspection of test instruments and leads

5.1.3 Facilitate discussions with the participants about how to identify the validity of tools

The participants shall:

5.1.4 Engage in discussions about how to identify the validity of tools

ELEMENT 5.2 - HOW TO MEASURE WITH ELECTRICAL MEASURING INSTRUMENTS

Learning objectives:

78) The participants can **perform** the measurement of current, voltage, resistance, PT100, continuity, diodes, bridge rectifiers and capacitance (Skills, intermediate level)

The instructor shall:

5.2.1 Explain and demonstrate the measurement of, and facilitate practice for the participants in:

a. VAC and VDC

b. A and mA

c. Ohms / continuity

d. Diode and bridge rectifier

e. Capacitor

f. PT100

5.2.2 Give constructive feedback on the participants above practice

The participants shall:

5.2.3 Practice the skill to measure voltage, current and resistance

5.2.4 Practice the skill to measure continuity

5.2.5 Practice the skill to measure a diode and a bridge rectifier

5.2.6 Practice the skill to measure a capacitor

5.2.7 Practice the skill to measure a PT100

ELEMENT 5.3 - MEASURING POINTS

Learning objectives:

79) The participants can **describe** measuring points in a physical circuit (Knowledge, basic level)

80) The participants can **describe** how to identify measuring points on a diagram (Knowledge, basic level)

The instructor shall:

5.3.1 Facilitate discussions with the participants about the measuring points in a physical circuit

5.3.2 Facilitate discussions with the participants about identifying measuring points in a diagram

The participants shall:

5.3.3 Engage in discussions about the measuring points in a physical circuit

5.3.4 Engage in discussions about identifying measuring points in a diagram

LESSON 6 - ELECTRICAL CIRCUITS

110 min.

The aim of this lesson is to give the participants basic knowledge of how to read and interpret a simple electrical diagram and how to assemble it on a circuit

ELEMENT 6.1 - SYMBOLS AND DIAGRAMS

Learning objectives:

81) The participants can **explain** electrical components and how to interpret basic electrical diagrams (Knowledge, intermediate level)

The instructor shall:

6.1.1 Show an example of an electrical diagram covering the components mentioned in the equipment list for the S-TT Electrical Module

6.1.2 Explain how to interpret the electrical diagram

6.1.3 Create a short learning activity, where the participants have to identify different components in the diagram

6.1.4 Ask the participants relevant questions about electrical components and how to interpret basic electrical diagrams

6.1.5 Give constructive feedback on the participants' explanations about the electrical components and how to interpret basic electrical diagrams

The participants shall:

6.1.6 Identify different components in the diagram

6.1.7 Explain in their own words and share understandings about electrical components and how to interpret basic electrical diagrams

ELEMENT 6.2 - ASSEMBLY OF AN ELECTRICAL CIRCUIT

Learning objectives:

82) The participants can **perform** the assembly of a simple electric circuit (Skills, intermediate level)

The instructor shall:

6.2.1 Facilitate practice to improve the participants' ability to assemble an electrical circuit following a basic electrical diagram including the components mentioned in the equipment list for the S-TT Electrical Module

6.2.2 Facilitate practice in the correct operation of the circuit

6.2.3 Give constructive feedback on the above practice

The participants shall:

6.2.4 Practice the skill of assembling an electrical circuit following a basic electrical diagram including the components mentioned in the equipment list for the S-TT Electrical Module

6.2.5 Practice the correct operation of the circuit

LESSON 7 - COOLING SYSTEM

10 min.

The aim of this lesson is to give the participants basic knowledge of the cooling system.

ELEMENT 7.1 - INSPECTION AND FUNCTION OF THE COOLING SYSTEM

Learning objectives:

83) The participants can **describe** the basic function of the cooling system and its components (Knowledge, basic level)

84) The participants can **recognise** the importance of visual inspection of the cooling system (Knowledge, basic level)

85) The participants can **describe** the hazards related to the cooling system and isolation (Knowledge, basic level)

The instructor shall:

7.1.1 Explain how heat is produced in the different systems and components (e.g. inverters, transformers, circuits…)

7.1.2 Explain that heat can be transferred from component to component

7.1.3 Explain overheating problems

7.1.4 Facilitate discussions with the participants about:

a. the consequences of inadequate cooling and importance of visual inspection of the cooling system

b. the hazards associated with the cooling system (e.g. how the hazards of the cooling system compare to the hazards of inverters, transformers, circuits, etc…)

c. the importance of appropriate isolation/locking techniques (e.g. Lock Out Tag Out)

The participants shall:

7.1.5 Engage in discussions about the consequences of inadequate cooling and importance of visual inspection of the cooling system

7.1.6 Engage in discussions about the hazards associated with the cooling system

7.1.7 Engage in discussions about the importance of appropriate isolation/locking techniques (e.g. Lock Out Tag Out)

LESSON 8 - SUMMARY AND THEORETICAL TEST

25 min.

The aim of this lesson is to summarise the S-TT Module and to conduct a theoretical test with the participants.

ELEMENT 8.1 - SUMMARY

Learning objectives:

86) The participants can **recall** the objectives that have been covered within this module.

The instructor shall:

8.1.1 Summarise the S-TT module referring to the objectives.

ELEMENT 8.2 - THEORETICAL TEST

After having successfully completed this element participants will be able to pass the final test

The instructor shall:

8.2.1 Introduce the test to the participants, explaining the rules to be followed during the test

8.2.2 Conduct the test with the participants

8.2.3 Check the test results and give feedback on the participants about the test results

8.2.4 If a participant fails the test, conduct an interview with the participant according to "Participants Performance Assessment" section

The participants shall:

8.2.5 Complete the test

LESSON 9 - TRAINING REVIEW

15 min.

The aim of this lesson is to enable the participants to reflect on and process their learning outcome and key takeaways from the module, aiming to achieve a high learning transfer from the module to their way of working.

ELEMENT 9.1 - TRAINING REVIEW

The instructor shall:

9.1.1 Re-present the overall aims and learning objectives of the module for the participants' comparison of their learning outcomes and the achievement of their previously stated expectations for the module

The participants shall:

9.1.2 Reflect on their learning outcome and key takeaways from S-TT Electrical Module, aiming to achieve a high learning transfer from the module to their way of working by means of e.g.:

9.1.3 Group discussions or walk & talk

9.1.4 Questions & answers in class, or where suitable

Note *The instructor may additionally conduct a local evaluation of the training.*

ELEMENT 9.2 - FEEDBACK SESSION

The instructor shall:

9.2.1 Give an overall feedback and feed forward on the participants' learning outcome inspired by the training as well as from the training review.

9.2.2 Encourage the participants to examine and grow awareness of which specific elements in their own industry work environment differ from the training scenario environment (to visualise and enhance learning transfer) and to discuss with colleagues about how the S-TT content, methods and techniques are similar or different to the local specific conditions identified after the module completion.

GLOBAL WIND ORGANISATION

Annexes

ANNEX 1 - EQUIPMENT LIST

The following pages contain the lists of equipment required for delivering the Solar Technical Training Standard. The tools, materials and equipment listed are needed for the execution of the modules must be available and must fulfil national legal requirements where applicable.

Any equipment used during this GWO training module shall meet or exceed the minimum requirements of the national standards in the country where the training is taking place. When working in a country where there is no applicable national standard then the equipment shall meet or exceed the minimum requirements of the European standards.

Each participant shall have access to a tool kit which contains sufficient tools for them to be able to complete the exercises as detailed in the module and shall be provided with PPE appropriate to the task they are performing.

Note *All equipment shall be maintained and where appropriate, inspected and tested in accordance with current national standards/ legislation and manufacturers' recommendations.*

1. Equipment list: S-TT Installation Module

The following equipment is required during the entire duration of this training to meet the needs of the S-TT Installation Module:

PPE suitable for mechanical and installation work

- Mechanical gloves, safety shoes or boots and working clothing, safety coverall, safety googles that can be worn on top of prescription glasses, general protective work clothing

Tools suitable for mechanical and installation work

- An impact gun
- Spanners (1 per two participants)
- Torque wrenches (at least two different ranges)
- Sockets
- Screwdrivers
- Cable ties
- Heat shrinks / cold shrinks
- Hexagon (Allen) keys
- Tool set for cutting, stripping and crimping small cables (smaller than 6mm2) – 1 set for 2 participants

- Tool set for cutting and stripping main cables (massive & core conductors, bigger than 35mm2) – 1 set for 2 participants
- Tool set for crimping wires bigger than 35mm2 (electric or electro-hydraulic) – 1 set for 4 participants
- Lock Out Tag Out kit (this kit is optional considering the setup available for the practise)

Mock-up for cable work including:

- Electrical cabinets with standard DIN rails for mounting terminals (clamp, screw type)
- Clamp, screw type terminals
- Cable glands
- Cable trays
- Bus bars (copper) with holes to connect cables with cable lugs

Solar PV Connector Tooling & Components (must be brand specific in relation to connector brand)

- suitable cable types
- insulation piercing connectors
- stripping pliers
- crimping pliers
- Solar assembly and unlocking tools (brand specific like MC4...)
- applicable torque wrench & torque driver
- test plugs
- cable cutters
- connector parts: (brand specific and applicable with connector tools)
- male connector
- crimping cable
- nut and fist
- rubber washer
- female connector
- cap torque

- seal

Electrical Training Prop

- Panel - high fidelity
- Combiner box - high fidelity
- Cabinet - high fidelity
- Mounting frame - high fidelity
- Inverters - optional
- Torque tube - optional
- Sensors - optional

Note *High fidelity elements can be simulated, but must be suited for all exercises*

2. Equipment list: S-TT Electrical

The following equipment is required during the entire duration of this S-TT Electrical Training to meet the needs of the S-TT Electrical Module.

PPE suitable for mechanical and electrical work

- Mechanical gloves, safety goggles, safety shoes or boots and suitable working clothing
- Insulating gloves (at least one pair per two participants)

Tools suitable for electrical work

- Lock Out Tag Out equipment
- Measuring devices:
  - DC rated Multimeter (at least 1 per two participants)
  - Two Pole voltage detector (at least 1 per 6 participants)
  - Low voltage meter (category 4 tester - up to 1500 V for DC).
  - HV Clamp Meter

Electrical training panel with standard DIN rail for mounting an electrical circuit (1 per two participants) with the following components:

- Power supply or transformer and a bridge rectifier
- Electrical protection

- Appropriate electrical wires
- Different value resistances
- Lamps
- Switches
- Capacitors
- Diodes
- Terminals for rail
- Push buttons (NO and NC)
- Contactors
- Relays
- Emergency stop button
- PT 100 sensor
- Sensors (wind, temperature, position, pyranometer, soiling, infrared, etc) - sensors are optional

Electrical Training prop

- Panel - high fidelity
- Combiner box - high fidelity
- Cabinet - high fidelity
- Mounting frame - high fidelity
- Inverters - optional
- Torque tube - optional
- Sensors - optional

Note *High fidelity elements can be simulated, but must be suited for all exercises*

ANNEX 2 - VERSION HISTORY

Amendment date	Version	Approved by & date	Description of changes
02072025	1	GWO - 18062025	First release

ANNEX 3 - GUIDANCE ON THE SOLAR PV WORK ENVIRONMENT

Utility Scale Solar PV workers are the main target audience for training developed from this standard.

1. What is Utility-Scale Solar?

Utility-scale solar refers to large-scale photovoltaic (PV) power plants designed to generate electricity primarily for distribution through the grid network. The plants are typically ground-mounted systems constructed to deliver renewable electricity to utilities and grid operators.

Exact definitions of utility scale sites and their work environment may vary in different countries and different organisations, but unlike smaller residential or commercial installations, utility-scale solar PV is generally defined as having a minimum capacity around 5 megawatts (MW) to over 1 gigawatt (GW). Utility-scale solar provides significant cost advantages due to economies of scale, leading to reduced per-watt installation costs compared to smaller-scale solar projects.

For the purposes of the GWO training standards, the term 'Utility Scale Solar PV' refers to a solar working environment at the industrial scale, which is distinct from a rooftop installed solar PV work environment, at either domestic or commercial scale.

There is no specific scale at which at solar PV array must be considered utility scale and the standard can also be used to train workforce performing tasks at smaller, net-metered installations, which otherwise would not be associated with utility scale operations.

However, this standard is not designed for rooftop working or related hazards, where a perimeter barrier may not be present to separate the solar arrays from a rooftop edge.

2. The Work Environment for Utility-Scale Solar

Utility-scale solar farms can range in size from a few acres to hundreds of acres and are typically situated in remote or rural areas where there's ample sunlight and land availability. This means sites are often located far from urban centres, increasing the challenge for ensuring a timely response by emergency response services in the event of an incident.

Utility-scale solar farms present unique emergency response challenges due to their size, remote locations, and the potential for electrical and fire hazards associated with their equipment. These challenges include developing robust emergency plans, ensuring effective communication, and training personnel to handle specific incidents. Additionally, extreme weather and the large-scale nature of these farms necessitate training, equipment and procedures for responding to incidents.

Large-Scale Nature and Remote Locations:

Utility-scale solar farms are often located in remote areas, making access for emergency responders difficult and potentially delaying response times. The large scale of these farms can make locating a work party or a casualty particularly challenging in the case of an emergency.

The large scale of the installation creates challenges for the management of manual handling and ergonomics, due to extensive repetitive work required during component mounting and installation. Moving

of solar panels also presents a particular manual handling hazard, due to the large dimensions and exposure to wind in the environment.

Electrical Hazards:

Solar farms utilise high-voltage electrical systems presenting a risk of arc flash, electrical burns or electrocution during serious faults or emergencies. Specialised electrical equipment like inverters, transformers, and battery energy storage systems, require trained personnel to handle incidents involving these technologies.

Fire Hazards:

The large number of panels, wiring, and equipment creates a high fire load, and fires can spread rapidly, potentially damaging equipment and disrupting power generation. Organic materials growing within the solar farm can provide a further fire load meaning careful management and removal of dry growth must be ensured to reduce serious fire hazards.

Coordination and Communication:

Effective communication and coordination between site workers, emergency responders, utility personnel, and local authorities are crucial for managing emergencies at solar farms. Fires or other incidents at solar farms can pose a risk to nearby communities and require a coordinated response to ensure public safety.

Extreme Weather:

Due to the remote and open area locations selected for utility-scale solar farms, they may be susceptible to extreme weather events like hail, wind, and lightning, which can damage panels, inverters, and other infrastructure and create challenges for safe work and emergency response.

Environmental Concerns:

Waste materials on utility-scale solar sites can have environmental consequences, requiring planned management, control and disposal of site waste, as well as specialised cleanup procedures and coordination with environmental agencies.

3. Major Components for Utility-Scale Solar PV

A utility-scale solar PV power plant includes several key components working together efficiently to convert solar energy into usable electrical power:

Photovoltaic (PV) Modules / Solar Panels

- PV Modules or Solar Panels are composed of solar cells converting sunlight directly into electrical current.
- Panels are systematically arranged in extensive arrays, optimally angled and positioned to maximise exposure to sunlight throughout the year.

Inverters

- Inverters are essential for converting the direct current (DC) output from the PV panels into alternating current (AC), enabling grid integration.

- Inverters manage and optimise power conversion for the entire PV system, ensuring performance efficiency and reliability.

Mounting Systems

- Robust mounting systems securely hold PV panels at optimal angles and heights, facilitating maximum solar irradiance and ease of maintenance.
- Utility-scale installations typically employ tracking systems to rotate panels to optimise sunlight exposure.

Tracking Equipment

- Single-axis trackers rotate panels from east to west, while advanced dual-axis trackers provide even higher efficiency by aligning panels continuously with the sun's trajectory throughout the day.
- Site-specific conditions such as geography, soil type, and climate will influence the choice of tracking system.

4. Ensuring a realistic training environment

Providers should ensure training scenarios accurately mirror the scale, operational complexity, and logistical considerations involved in real-world utility-scale solar installation, assembly, and commissioning processes. This realistic training will better prepare participants for the competencies required in actual industry conditions.

To effectively replicate a utility-scale solar environment for training purposes, providers should include the following realistic elements:

- Installation of panel mounting systems and securing of PV modules.
- Assembly and installation of electrical components including power cabling, solar PV connectors, panels and combiner boxes.
- Performance of electrical connections ensuring adherence to safety standards and quality assurance.
- Implementation of robust installation protocols, including conducting a full system installation inspection walk down.