Short-Course

Solar PV System Installation and Maintenance

NTQF Level III

Learning Guide -14

Unit of Competence	Install off-grid solar PV system
Module Title	Installing off-grid solar PV system
LG Code	EIS PIM3 M10 120 LO2 LG-14
TTLM Code	EIS PIM3 TTLM 0120 v1

LO 2: Prepare Photovoltaic power apparatus and system – 14

Instruction Sheet	Learning Guide-14

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

- Identifying type and quantity of off grid system components.
- Selecting tools and equipment
- Identifying and selecting Personal protective equipment (PPE)
- Noting unidentified safety hazards and implementing risk control measures
- Specifying and selecting Suitable system components
- Obtaining and checking components needed for the installation work

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

- Identify type and quantity of off grid system components.
- Select tools and equipment
- Identify and select Personal protective equipment (PPE)
- Note unidentified safety hazards and implementing risk control measures
- Specify and select Suitable system components
- Obtain and check components needed for the installation work???

Learning Instructions:

1. Read the specific objectives of this Learning Guide.
2. Follow the instructions described below:
3. Read the information written in the information Sheet 1 (page: 37), Sheet 2 (page: 43), Sheet 3 (page: 47), Sheet 4 (page: 49), Sheet 5 (page: 53), Sheet 6 (page: 65),
4. Accomplish the Self-Check 1 (page: 42), Self-Check 2 (page: 46), Self-Check 3 (page: 48), Self-Check 4 (page: 52), Self-Check 5 (page: 64), Self-Check 6 (page: 67),

LO2. Prepare Photovoltaic power apparatus and systems

Information Sheet 1	Identifying type and quantity of off-grid system components

1 Identifying type and quantity of off-grid system components

1.1 Introduction

The next step is to prepare the material and equipment for the installation. See Figure 22 for a high level overview of the process that will be followed in Module 10. LO2 (in Yellow) deals with identifying and obtaining tools, materials, PPE and equipment for the installation.

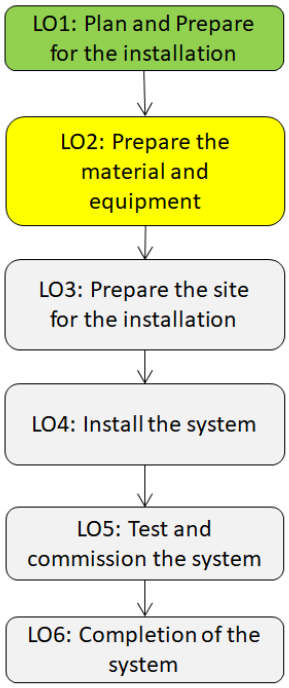


Figure 22: Installation Process

During the preparation for the installation of a PV system, a Bill of Materials (BOM) needs to be assembled to ensure that all components are procured before the installation. This information can be obtained from the design by the System Designer.

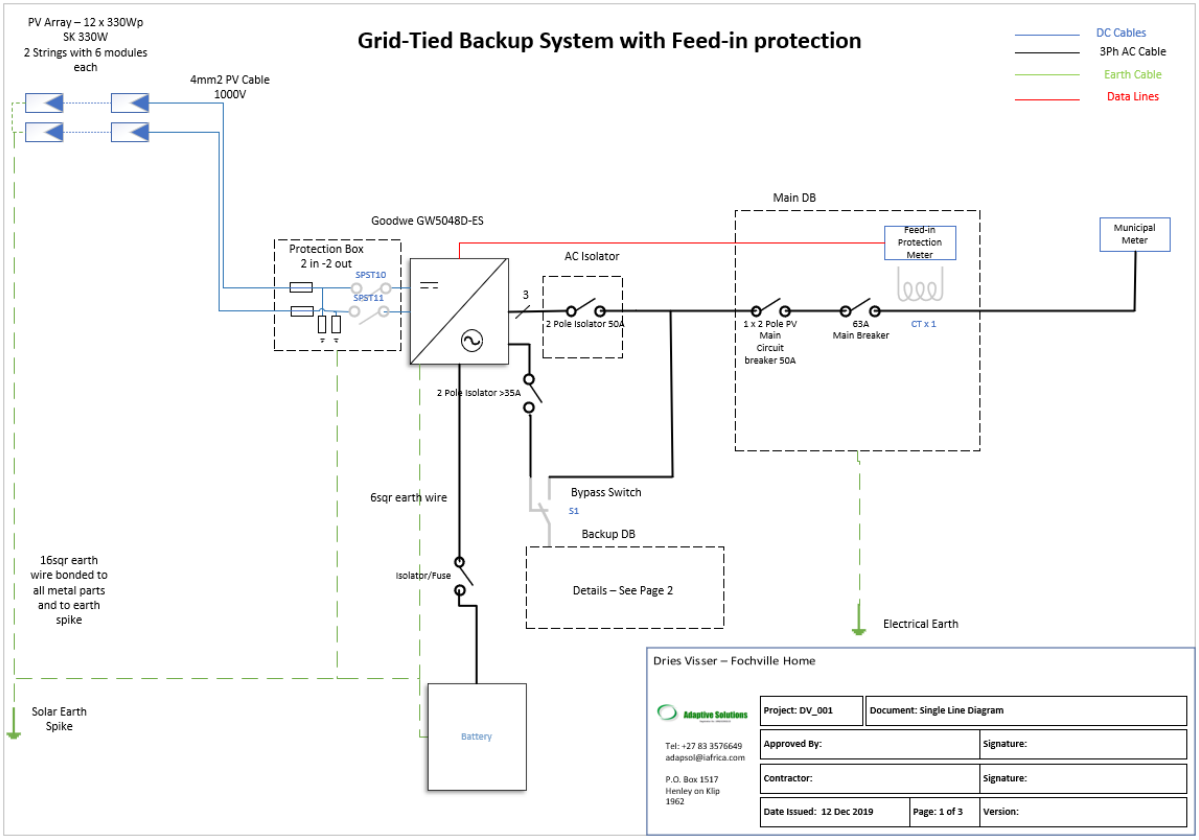


Figure 23: Example of a Single Line Diagram

The design will normally specify all the main components e.g.:

- Main Components
  - PV Modules
  - Charge Controller
  - Off-grid Inverter
  - Batteries

The design may also specify all or some of the Balance of System (BOS) components:

- Balance of System (BOS)
  - Cables (DC and AC)
  - Mounting system (no of rails and length of rails, no of roof hooks, no of clamps etc.)
  - Switches, Fuses and safety devices
  - Fixtures and fittings
  - Monitoring

The design may not necessarily specify the exact mounting system and the exact cable lengths etc. As part of the preparation, ALL the components with quantities need to be specified.

1.2 Identifying Components from the design

Depending on the designer, there may be a complete BOM already, but most likely not all the exact detail will be in the design, specifically on the BOS components. With reference to Figure 24 below, the following information should be obtained:

- Modules
  - Number and size of the modules;
- Strings
  - Number of strings
  - Cable lengths (W1)
  - Number of connectors
- Combiner box
  - Number of string inputs
  - DC Isolator rating
  - Fuses (F1)
- Cable (length and size) to charge controller (W2)
- Charge Controller
- Cable (length and size) to battery (W3)
- Battery Fuse (F2)
- Batteries
  - Quantities
  - Connection (serial/parallel) including link cables
  - Type of connectors
  - Battery rack required
- Cable (size and length) to Inverter (W4)
- Fuse to inverter (F3) if not internal to inverter
- Inverter
- AC DB Board
  - Size of DB board
  - Number and rating of the circuit breakers
  - Protective devices e.g. RCD's

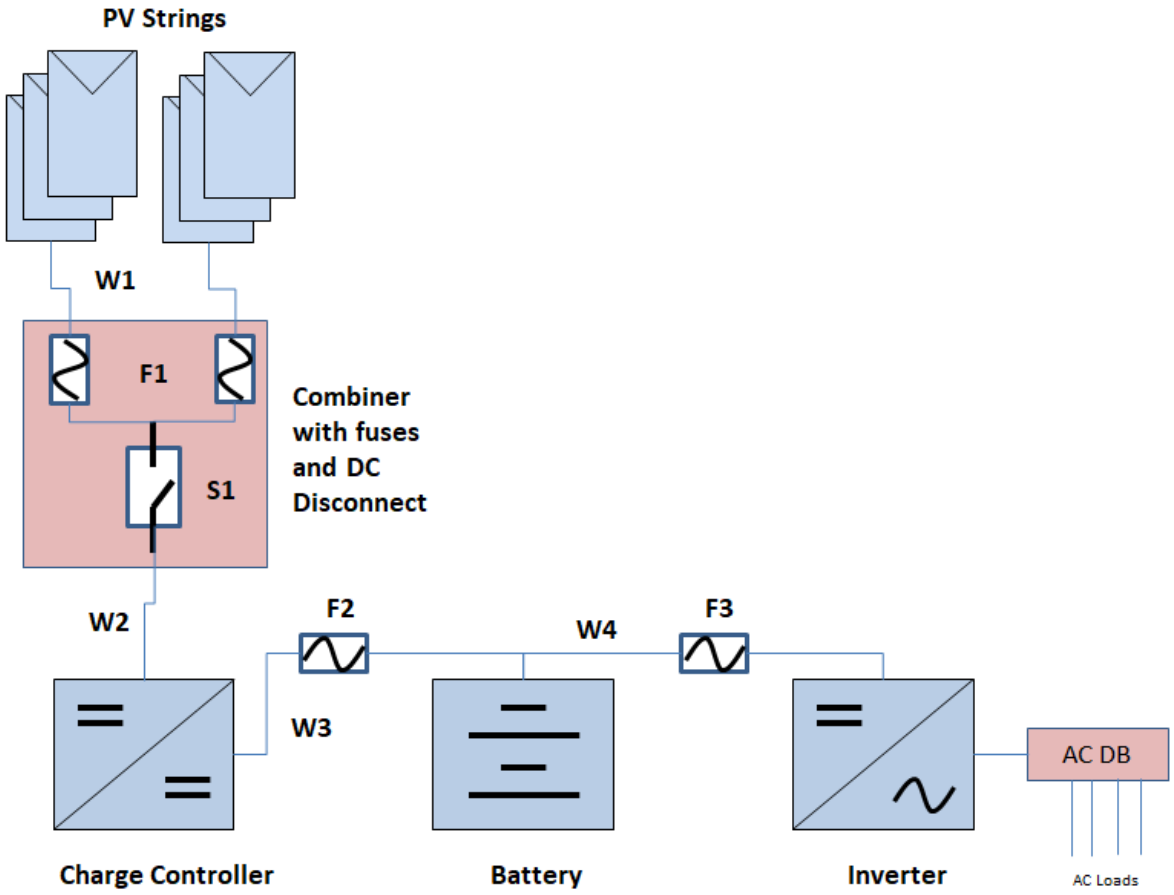


Figure 24: System Block Diagram

1.3 Datasheets

As part of the planning process, all **product** and **installation** datasheets need to be obtained and studied to understand all the installation requirements e.g.:

- Modules
  - Clamping Zones;
  - Clamp sizes;
  - Spacing between module and roof;
  - Wind loading;
  - Thickness of the module (determines size of clamp);
  - Cleaning;
  - Transport and storage.
  - Safe handling of the modules;
  - Safety measures during installation;
  - Grounding;
- Mechanical installation;
  - The correct clamping or mounting of the modules and loads (e.g. Figure 19: Canadian Solar Module Clamping Zones).

    - Distance to the roof;
    - Spacing between modules.
- Combiner box
    - Size and space requirements
- Charge Controller or Hybrid inverter
    - Mounting holes;
    - Required ventilation space around;
    - Type and size of PV (e.g. MC4 or screw terminal) and Battery connections
    - Battery cable and fuse sizes;
    - Connection sequence (e.g. connect batteries first before PV modules);
    - Startup sequence;
    - Safe handling and safety gear;
    - Battery and communication cable connections (e.g. Figure 18: Pylontech cable connections);
    - Troubleshooting;
    - Emergency procedures.
    -
- Off-grid inverter
    - Mounting holes;
    - Required ventilation space around;
    - Input and output connectors or terminal sizing
    - Safety information and warnings;
    - LED/Screen status and interpretation;
    - Switch settings;
    - Installation and mounting (e.g. see Figure 20: Mounting instructions for Steca Solaris);
    - Connections, cable sizes and fuses;
    - Operation;
    - Maintenance and service;
    - Troubleshooting.
- Batteries
    - Size and space requirement;
    - Mounting options e.g. racking or stand;
    - Ventilation requirements;

Self-Check - 1	Written Test

Answer all the questions listed below. Use the Answer sheet provided in the next page:

N°	Questions and answers
1	**What components can be identified from the design drawings? (4)**
2	**What can we learn from a module installation manual? (4)**

Satisfactory	6 points
Unsatisfactory	Below 5 points

Answer Sheet

Score = _____

Rating: _____

Name

Date

Information Sheet 2	Select tools and equipment

2 Select tools and equipment

2.1 Selecting tools

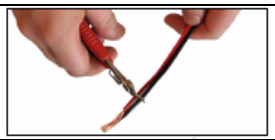
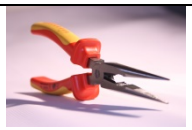
Most of the tools needed for a PV install are commonly used and easily found. There are very few highly specialized tools. Below are several lists that describe many of the tools needed for an installation.

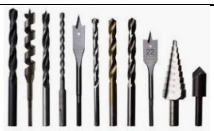
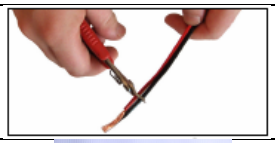
Prepare Check list and collect all tools you need before your trip to the installation location.

2.2 Tool list

In the following table list some basic tools which are necessary for installing Solar PV. The tools will depend on the type of system to be installed e.g. the type of roof covering etc.

Table 3: Tools

Tools	Pictures of tool	Tools	Pictures of tool
Wire cutter		Long nose Plier	
Screw driver (crosshead and flathead)		Rivet gun	
Compass		Side Cutter	
Cable insulation remover/strippers		Different size spanners	
Distance Meter		Multi Meter	
Assembly Key for MC4 connectors		Universal Plier	
Crimping Plier		Safety equipment	

Cordless Drill		Electrical insulation tape	
Silicon gun with sealant		Utility Knife	
Different size ladder		Hammer	
Different size steel/wood and concrete drill bits		Water Level	
Hack Saw and Wood Saw		Torque Wrench with deep sockets	
Angle Finder/Incline Meter		Solar Path finder/if available	
Tools	Pictures of tool	Tools	Pictures of tool
Wire cutter		Long nose Plier	
Screw driver (crosshead and flathead)		Rivet gun	
Compass		Side Cutter	
Cable insulation remover/strippers		Different size spanners	
Distance Meter		Multi Meter	

- Basic Tools Needed for Installation
  - Angle finder
  - Water level
  - Chalk line
  - Cordless drill, multiple batteries, Charger
  - Multiple drill bits (wood, metal, masonry)
  - Torque wrench with deep sockets

- Wire strippers
- Screw Drivers
- Assembly key for MC4 connectors
- Crimping Plier
- Long-nose pliers
- Side Cutter
- Different size spanners
- Universal plier
- Wire cutters
- Multi meter
- Insulation Tape
- Utility Knife
- Hammer
- Hacksaw
- Blanket, cardboard or black plastic to keep modules from going “live” during installation
- Rivet Gun
- Silicon gun with Sealant
- Ladder
- Safety Equipment

2.3 Packing

In order to finish the installation in a fast and efficient way, all materials should be checked and packed before going on site. Check the electrical drawings and material lists and pack the things accordingly. Usually installations start early in the morning, so the car should be packed already the night before.

What to check when preparing the installation:

- Take correct models and sizes and number of components with you
- Pack spare parts of items that are likely to break or get lost (e.g. extra screws)
- Check the manuals of the components, are any special tools needed?
- Pack universal materials that are useful to solve unexpected problems: cable ties, tape, a ladder, pen
- Print wiring diagrams and drawings, also print manuals of components or download them to your computer or smartphone

Self-Check - 2	Written Test

Answer all the questions listed below. Use the Answer sheet provided in the next page:

N°	Questions and answers
1	Which tools are very important for your installation? List 6.

Satisfactory	5 points
Unsatisfactory	Below 3 points

Answer Sheet

Score = _____

Rating: _____

Name

Date

Information Sheet 3	Identifying and selecting personal protective equipment (PPE)

3 Identifying and selecting personal protective equipment (PPE)

Table 4: Personal Protective Equipment (PPE)

No	Equipment	Description	Picture
1	Hard hat	used in workplace environments such as industrial or construction sites to protect the head from injury due to falling objects	
2	Safety shoes	Protective, safety footwear is essential to ensure safe and healthy feet.	
3	Gloves	Are rubber insulating gloves worn by hands to provide the mechanical protection needed against cuts, abrasions, punctures and electrical injuries	
4	Safety belt	A belt is used to protect from the probability of falling from higher working position/height	
6	Eye glass	Eye protection is a type of personal protective equipment (PPE) designed to prevent injury to the eye. Eyes are easily injured by many things such as small particles, chemicals, biological agents, strong visible light and non-visible rays. Eyes should be protected by using appropriate eye protection.	
7.	Electrician safety cloth	The main hazards that electrical worker safety clothing needs to protect against are arc flash and electric shock, but also visibility hazards when work involves construction sites.	

Self-Check - 3	Written Test

Answer all the questions listed below. Use the Answer sheet provided in the next page:

N°	Questions and answers
1	Describe the use of Glove
2	Why do you have to wear Electrician safety cloth?

Satisfactory	6 points
Unsatisfactory	Below 4 points

Answer Sheet

Score = _____

Rating: _____

Name

Date

Information Sheet 4	Noting unidentified safety hazards and implementing risk control measures

4 Noting unidentified safety hazards and implementing risk control measures

4.1 Potential hazards

4.1.1 Physical (Non-Electrical, Non-Chemical) Hazards

When working on a PV array, you will be working outdoors, possibly in remote areas, and using hand and power tools on metal and wire equipment.

4.1.2 Exposure

When designed properly, PV arrays are installed when the sun is brightest, where no shading occurs. When working on a PV array, you should wear a hat and keep your limbs covered. Drink plenty of fluids (preferably water, and never alcohol) and take regular breaks in the shade for a few minutes each hour.

4.1.3 Insects

Spiders and a number of insects, including wasps, often move in and inhabit junction boxes, array framing and other enclosures of a PV system. Always be prepared for the unexpected when you open junction boxes and other enclosures.

4.1.4 Cut and Bumps

Most PV arrays use metal framing, Junction boxes, bolts, nuts, guy wires and anchor bolts, etc. Many of these common items have sharp edges and can cause injury if you are not careful. You should wear gloves when handling metal, particularly if you are drilling or sawing. Metal slivers from a drill bit often remain around the edges of a hole, and these can cause severe cuts to a bare hand. Wear a hard-hat at all times when you are working under an array or on a system with hard ware higher than your head.

4.1.5 Falls, Sprains, Strains and Fractures

Some PV systems are installed in buildings located in an active building site and sometimes the ground could be rough terrain. The PV array is often mounted on the roof of a building on high structures. Ladders must be secured and safety harness or scaffolding should be used. Walking to and around the site, particularly carrying systems components and test equipment can result in falls and or sprains. Wear comfortable shoes, preferably with soft soles. Be careful when lifting and carrying heavy equipment, particularly large inverters, batteries and large solar modules. Lift with your legs and not with your back to avoid back strains. If climbing is required, be sure the ladder is firmly anchored and that you have a partner available to hold the ladder and assist with handling equipment. Also remember that a PV module can act as a wind-sail and knock you off a roof on windy days.

Figure 25: Safety working on roof (pinterest)

Figure 26: Lifting Safety (pinterest)

4.1.6 Thermal burns

Metal left exposed to the sun can reach temperatures of 80°C. This is too hot to handle, but it is unlikely to cause burns if you break contact quickly. To be safe, however, always wear gloves while working on PV arrays. Survey the system prior to

beginning work to be aware of any elements that might become hot. [(GSES, 2014) chapter 2]

Self-Check - 4	Written Test

Answer all the questions listed below. Use the Answer sheet provided in the next page:

N°	Questions and answers
1	**Name 5 lifting do's and Don'ts? (5)**

Satisfactory	4 points
Unsatisfactory	Below 3 points

Answer Sheet

Score = _____

Rating: _____

Name

Date

Information Sheet 5	Specifying and selecting suitable system components

5 Specifying and selecting suitable system components

5.1 Introduction

All the equipment and material needs to be specified in the Bill of Material. This includes:

- Main Components
  - PV Modules
  - Off-grid Inverter
  - Charge Controller
  - Hybrid Inverter
  - Batteries
- Balance of System (BOS)
  - Cables (DC and AC)
  - Mounting system (no and length of rails, no of roof hooks, no of clamps etc.)
  - Switches and safety devices
  - Fixtures and fittings
  - Monitoring

Bases on the information gathered in LO2-Information sheet 1, a comprehensive Bill of Material can be compiled (see Table 5 for an example used for the system to be installed at Adama, Ethiopia). It is important that all components and accessories needs to be specified.

It may be that some of the components required are not in stock or available from the suppliers and alternatives need to be found. Alternatives should be discussed with the Design Engineer, specifically if the specifications differ from the original specified.

Table 5: Bill of Material sample 5kW system

Item	Art.-No.	Description	Quantity	Unit
		A1 - Complete quality 5,1 kWp off-grid backup PV Systems		
1	310363	Solar Module Phaesun PN6M72-350 E 350 W, 24 VDC, Standard4, 72 cells, mono, alu frame (silver), tempered glass, back-sheet (white), cable 1250 mm / 4 mm²  Dimension 1956 x 992 x 40mm EU Customs tariff no. 85414090 Country of origin Italy	60,00	pcs
2	161103	Module Support Structure PN-ASS 03 alluminium support structure for 3 solar modules, incl. mounting clamps for modules, screws, connectors and heavy duti anker bolts  EU Customs tariff no. 76041090 Country of origin Turkey	20,00	pcs
3	390003	Corrugated Sheet Roof Screw Fitting 160mm for connection between crosstie profile rail and rafter including hanger bolt M10, connecting plate, screws, nuts and V2A blocking screw Dimension 160mm EU Customs tariff no. 73181535	80,00	pcs
4	321728	Inverter / Hybrid Charger Phocos PSW-H-5KW-230/48V	4,00	pcs

		5000 W, 48 VDC, 230 VAC / 40 - 63 Hz, charge current 80 A PV + AC / 40 A transfer, 450 Voc, self consumption 14 W / 40 W, sinewave, electronic protection, screw terminal PV 16 mm² / AC 10 mm², connection Bat M8 - 50 mm², air cooling, LCD, programmable, USB, RS232, RS485, Bluetooth, Parallel-Kit, IP21 Dimension 478 x 309 x 143mm EU Customs tariff no. 85044084 Country of origin China	
5	500090	Connection Box GCB 5-1 200V/50A_gland 200 VDC, Input 5x 12 A, output 1x 50A, switch (1x), cable gland, screwed cover (grey), IP65, single package Dimension 420 x 260 x 120mm EU Customs tariff no. 85371098 Country of origin France	4,00 pcs 
6	390900	PV Standard4 Connector 4-6 mm² Set WM 30 A, 1000V, male + female, cross section 4-6 mm², cable diameter 5,0-7,5 mm, compatible with Standard4, tool free connection, IP65 EU Customs tariff no. 85366990 Country of origin Romania	20,00 pcs 
7	303588	Cable Solarflex-X 1x 4 black cross section 1x 4mm², outer diameter 5,4mm, 1500 VDC, 1000 VAC, CU / fine-wire / verzinnt, double isolated, protection class II, UV-resistant, ozone resistant EU Customs tariff no. 85444995 Country of origin European Union	400,00 meter 
8	340026	Battery OPzS Hoppecke sun | power V L 2-730 GUG lead acid batteries 2V filled & charged 490 Ah (C10) 730 Ah (C100) incl. accessories Dimension 168 x 208 x 535mm EU Customs tariff no. 85072020 Country of origin Germany	96,00 pcs 
9	303417	Transport Box Hoppecke Sea Freight 120x80 Sea freight transport box made of strong cardboard, height depends on the packed batteries Dimension 1200 x 800mm EU Customs tariff no. 48192000 Country of origin Germany	8,00 pcs
10	108010	Battery Rack Kunstmann 1E.B560.R2 Steel floor rack with 2 battery rows Flamulit coated gray RAL 700,1 max. insulator load:136kg Dimension 2400 x 586 x 90mm EU Customs tariff no. 73089098 Country of origin Germany	4,00 pcs

5.2 Hybrid inverter

The following components were specified for a 5kW system in Adama, Ethiopia:

PSW-H (3 kW/5 kW)

Any-Grid™ Hybrid Inverter Charger

phocos

Technical Data

Type	PSW-H-3KW-120/24V	PSW-H-3KW-230/24V	PSW-H-5KW-120/48V	PSW-H-5KW-230/48V
Output Waveform	Pure Sine Wave			
System Voltage	24 Vdc		48 Vdc	
Rated AC Output Power	3000 VA / 3000 W		5000 VA / 5000 W	
Max. Charge Current (PV)	80 Adc			
Max. Charge Current (AC)	80 Adc			
Max. Total Charge Current	80 Adc			
Max. AC Input Current	40 Aac	30 Aac	63 Aac	40 Aac
Float Charge	27.6 Vdc (adjustable)		55.2 Vdc (adjustable)	
Boost Charge	28.8 Vdc (adjustable)		57.6 Vdc (adjustable)	
Equalization Charge	29.6 Vdc (adjustable)		59.2 Vdc (adjustable)	
Deep-Discharge Protection	22 Vdc (adjustable)		44 Vdc (adjustable)	
Reconnect Level	27.1 Vdc (adjustable)		54.7 Vdc (adjustable)	
Overvoltage Protection	33 Vdc		66 Vdc	
Undervoltage Protection	18.8 Vdc		37.5 Vdc	
Battery Discharge Current Requirement	168 Adc continuous 336 Adc surge (5s)		140 Adc continuous 280 Adc surge (5s)	
Max. PV Panel Voltage	250 Vdc	450 Vdc	250 Vdc x 2 (2 MPPTs)	450 Vdc
PV Panel MPP Voltage	90 ~ 230 Vdc	90 ~ 430 Vdc	90 ~ 230 Vdc x 2 (2 MPPTs)	120 ~ 430 Vdc
Max. Usable PV Power	4000 W (2400 W for battery charging)		4800 W	
Max. PV Array Power	4000 Wp	5000 Wp	6000 Wp	
AC Frequency	50 / 60 Hz auto recognition			
AC Output Voltage	110 ~ 127 Vac ± 5% (adjustable)	220 ~ 240 Vac ± 5% (adjustable)	110 ~ 127 Vac ± 5% (adjustable)	220 ~ 240 Vac ± 5% (adjustable)
Surge Power	2x rated power for 5 seconds			
Extensibility	Up to 9 units in parallel or 3-phase	Up to 9 units in parallel, 3-phase or split-phase		Up to 9 units in parallel or 3-phase
Inverter Efficiency (from Battery)	> 90 % peak	> 91 % peak	> 90 % peak	> 93 % peak
Inverter Efficiency (from PV)	> 96 % peak			
Idle Self-Consumption	< 40 W on, < 14 W Green Mode			
Grounding	Galvanically isolated battery allows positive or negative battery grounding			
Ambient Temperature	-10 to +50 °C			
Storage Temperature & Humidity	-15 to +60 °C, 5-95 % (non-condensing)			
Max. Altitude	4,000 m above sea level, 1 % power de-rating per 100m above 1,000 m above sea level			
Battery Type	Lead acid (gel, AGM, flooded), Lithium			
Datalogger	60 days			
Max. Wire Cross Section	Battery: 50 mm² (AWG 0), PV: 16 mm² (AWG 4), AC: 10 mm² (AWG 7)		Battery: 50 mm² (AWG 0), PV: 16 mm² (AWG 4), AC: 16 mm² (AWG 6)	Battery: 50 mm² (AWG 0), PV: 16 mm² (AWG 4), AC: 10 mm² (AWG 7)
Dimensions (WxHxD)	478 x 309 x 143 mm / 18.8 x 12.2 x 5.6 in		554 x 433 x 148 mm / 21.8 x 17 x 5.8 in	478 x 309 x 143 mm / 18.8 x 12.2 x 5.6 in
Weight	12 kg / 27 lbs	11 kg / 24 lbs	tbd	11.8 kg / 26 lbs
Ingress Protection	IP21			
Certificates	CE compliant, RoHS compliant			
Warranty	2 years			

Figure 27: Hybrid inverter Specification sample [Phocos]

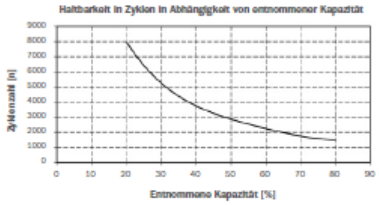
HOPPECKE
POWER FROM INNOVATION

OPzS solar.power

Typenübersicht

Kapazitäten, Abmessungen und Gewichte

Typ	C_{100}/1,85 V Ah	C_{50}/1,85 V Ah	C_{24}/1,83 V Ah	C_{10}/1,80 V Ah	C_5/1,77 V Ah	max. Gewicht kg	Gewicht Elektrolyt kg (1,24 kg/l)	max.* Länge L mm	max.* Breite B mm	max.* Höhe H mm	Abb.
4 OPzS solar.power 280	280	265	245	213	182	17,1	4,5	105	208	420	A
5 OPzS solar.power 350	350	330	307	266	227	20,7	5,6	126	208	420	A
6 OPzS solar.power 420	420	395	370	320	273	24,6	6,7	147	208	420	A
5 OPzS solar.power 520	520	490	454	390	345	29,1	8,5	126	208	535	A
6 OPzS solar.power 620	620	585	542	468	414	34,1	10,1	147	208	535	A
7 OPzS solar.power 730	730	685	634	546	483	39,2	11,7	168	208	535	A
6 OPzS solar.power 910	910	860	797	686	590	46,1	13,3	147	208	710	A
7 OPzS solar.power 1070	1070	1002	930	801	691	59,1	16,7	215	193	710	B
8 OPzS solar.power 1220	1220	1145	1063	915	790	63,1	17,3	215	193	710	B
9 OPzS solar.power 1370	1370	1283	1192	1026	887	72,4	20,5	215	235	710	B
10 OPzS solar.power 1520	1520	1425	1325	1140	985	76,4	21,1	215	235	710	B
11 OPzS solar.power 1670	1670	1572	1459	1256	1086	86,6	25,2	215	277	710	B
12 OPzS solar.power 1820	1820	1715	1591	1370	1185	90,6	25,8	215	277	710	B
12 OPzS solar.power 2170	2170	2010	1843	1610	1400	110,4	32,7	215	277	855	B
14 OPzS solar.power 2540	2540	2349	2163	1881	1632	142,3	46,2	215	400	815	C
16 OPzS solar.power 2900	2900	2685	2472	2150	1865	150,9	45,9	215	400	815	C
18 OPzS solar.power 3250	3250	3015	2765	2412	2097	179,1	56,4	215	490	815	D
20 OPzS solar.power 3610	3610	3350	3072	2680	2330	187,3	55,7	215	490	815	D
22 OPzS solar.power 3980	3980	3685	3388	2952	2562	212,5	67,0	215	580	815	D
24 OPzS solar.power 4340	4340	4020	3696	3220	2795	221,2	66,4	215	580	815	D
26 OPzS solar.power 4700	4700	4355	4004	3488	3028	229,6	65,4	215	580	815	D



C_{100}, C_{50}, C_{24}, C_{10} und C_5 =
Kapazität bei 100-, 50-, 24-, 10- und 5-stündiger Entladung
* gemäß DIN 40736-1 sind diese Angaben als Maximalwerte zu verstehen

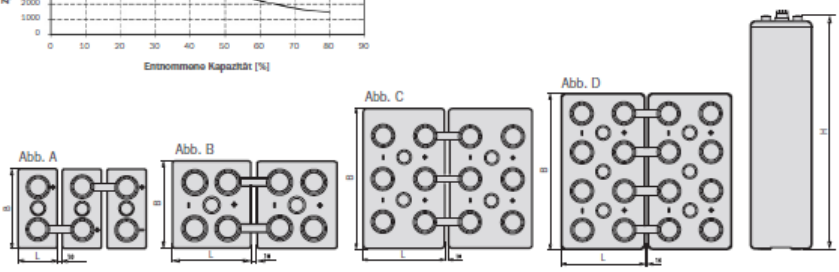


Figure 28: Hoppecke Batteries (OpzS 730)

Technical Data	Technische Daten			PN6M72-350 E	PN6M72-360 E
Nominal voltage	Systemspannung			24	
Power	Nennleistung	Pmp	W	350	360
Voltage at max. power	Spannung bei Max. Leistung	Vmp	V	38,6	38,4
Current at max. power	Strom bei Maximalleistung	Imp	A	9,08	9,37
Open circuit voltage	Leerlaufspannung	Voc	V	47,2	46,9
Short circuit current	Kurzschlußstrom	Isc	A	9,56	9,72
Cell	Zellen			72 mono	
Cell dimension	Zellabmessung		mm	156 x 156	
Cell efficiency	Zellen Wirkungsgrad		%	20,0	20,5
Module efficiency	Modul Wirkungsgrad		%	18,0	18,5
Max. tolerance	Max. Leistungstoleranz		%	-0/+5	
Max. system voltage	Max. Systemspannung		V	1000	
Operating module temp.	Min. Betriebstemperatur		°C	-40...+85	
Front	Vorderseite			tempered glass | gehärtetes Glas	
Glass thickness	Frontglas Dicke		mm	3,2	
Backside color	Rückseite Farbe			white | Weiß	
Frame	Rahmen			clear anodized aluminium | silber eloxiertes Aluminium	
Frame color	Rahmenfarbe			silver | Silber	
By-Pass Diodes	By-Pass Dioden			3	
Junction box protection	Anschlussdose Schutzklasse			IP67	
Module cable: cross section	Modulkabel: Querschnitt		mm²	4,0	
Module cable: length	Modulkabel: Länge	l	mm	1000	
Module cable: connector	Modulkabel: Stecker			Standard4	
Dimension	Abmessung	X x Y x Z	mm	1956 x 992 x 40	
Mounting holes pitch	Befestigungslöcher	x1 / y / x2	mm	1176 / 942 / 1676	
Weight	Gewicht		kg	24,0	
Temperature coefficient: Power	Temperaturkoeffizient: Leistung		%/K	-0,410	
Temperature coefficient: Voc	Temperaturkoeffizient: Voc		%/K	-0,300	
Temperature coefficient: Isc	Temperaturkoeffizient: Isc		%/K	0,040	
Pallet: dimension	Paletten: Abmessung	L x W x H	mm	2025 x 1110 x 1200	
Pallet: weight	Paletten: Gewicht		kg	687	
Pallet: module quantity	Paletten: Anzahl Module		pcs. /Stk.	27	
Container: quantity palettes/modules	Container: Anzahl Paletten/Module	20 ft	pcs. / Stk.	10 / 270	
		40 ft		22 / 594	
NOCT	NOCT		°C	45	
Static / dynamic load	Statische / dynamische Last		kN/m²	5,4 / 2,4	
Hail impact	Hagelschlag			Ø 25 mm, 23 m/s	
Certificates	Zertifikate			IEC61215 (design qualification) | IEC61730 (safety)	
Article Number	Artikelnummer			310363	310364

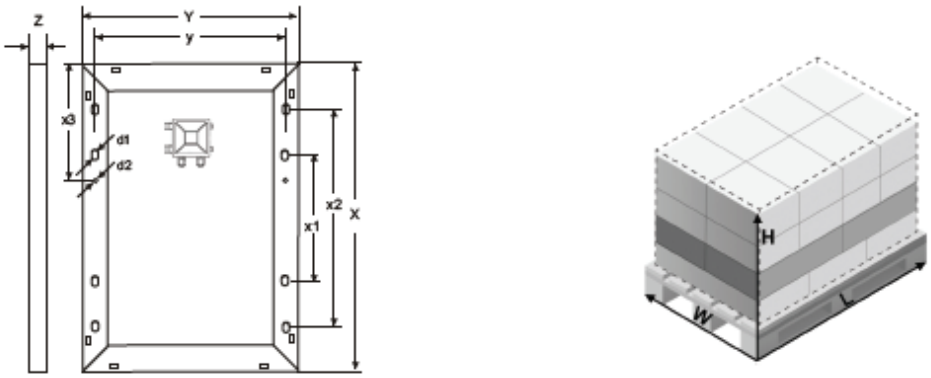


Figure 29: Phaesun 350W modules

Phocos Any-Grid™ series

Pure Sine Wave Hybrid Inverter Charger with
MPPT Solar Charge Controller

PSW-H-5kW-230/48V
PSW-H-3kW-230/24V
PSW-H-5kW-120/48V
PSW-H-3kW-120/24V

User and Installation Manual

English

For further languages see
Für weitere Sprachen siehe
Pour autres langues voir
Para otros idiomas ver
对于其他语言请参阅

www.phocos.com

Figure 30: Installation Manual

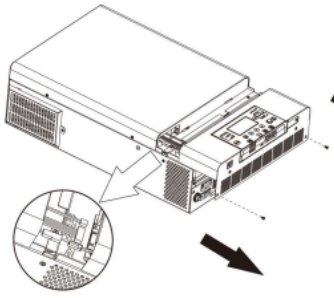


Fig. 4: Removal of bottom cover

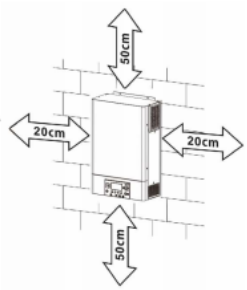


Fig. 5.1: Minimum distance to other objects

WARNING: Only mount this unit on concrete or another solid non-combustible surface capable of securely holding the weight of the unit.

- Install this inverter at eye level to ensure legibility of the display
- Ensure the ambient temperature is between -10 ~ 50 °C, 14 ~ 122 °F at all times. In order to fulfill UL requirements, inverters must be operated at an ambient temperature of -10 ~ 40 °C, 14 ~ 104 °F.
- Avoid excessively dusty environments
- The unit is designed for vertical installation on a solid wall
- Ensure a minimum distance to other objects and surfaces as shown in **Fig. 5.1** to guarantee sufficient heat dissipation and to have enough space for removing wires.
- Install in a room where noise is not an issue as the unit has fans for cooling

Install the unit by using three M4 or M5 screws (**Fig. 5.2**) appropriate for the weight of the unit and wall material, use wall plugs. The bottom screw hole is only accessible after removal of the bottom cover (**Fig. 4**). This bottom cover must remain removed for the rest of this "**Installation**" chapter until instructed otherwise.

Fig. 5.2: Mounting holes

Figure 31: Mounting Instructions

5.3 Smaller SHS with charge controller

Table 6 shows the BOM for a smaller SHS.

Table 6: System components type and quantity identified

No	Components	Selected Component Type	Size	Quantity
1	Solar Module	Phaesun Sun Plus 50s	50Watt	2
2	Battery	Phaesun Sun store 165	165Ah	1
	Charge Controller	Steca PR1010	10A	1
	Fuse(Solar Module to Charge Controller)		15A	1
	Fuse(Solar Module to Charge Controller)		5A	1

Read selected system components specifications and operating instructions carefully before your proceed to install or work on them.

5.4 Solar Module specification

Technical Data		Technische Daten				Sun Plus S 50	Sun Plus S 100
Systemvoltage		Systemspannung		(VDC)	[V]	12	
Power		Nennleistung		(Pmp)	[W]	50	100
Voltage at max. power		Spannung bei Max. Leistung		(Vmp)	[V]	17,6	
Current at max. power		Strom bei Maximalleistung		(Imp)	[A]	2,84	5,68
Open circuit voltage		Leerlaufspannung		(Voc)	[V]	21,6	
Short circuit voltage		Kurzschlußstrom		(Isc)	[A]	3,07	6,14
Cell		Zellen				36 x mono	
Cell efficiency		Zellen Wirkungsgrad				18,43	17,77
Module efficiency		Modul Wirkungsgrad			[%]	15,2	15,4
Max. tolerance		Max. Leistungstoleranz			[%]	+/–3	
Max. system voltage		Max. Systemspannung			[V]	70	
Operating module temp.		Min. Betriebstemperatur			[°C]	–40 ... +85	
Front		Vorderseite				tempered glass | gehärtetes Glas	
Frame		Rahmen				clear anodized aluminium | silber eloxiertes Aluminium	
Junction box protection		Anschlussdose Schutzklasse				IP65	
Module cable	cross section	Modulkabel	Querschnitt		[mm²]	2,5	4
	length		Länge		[mm]	900	
	connector		Stecker			Standard4	
Dimension (l x w x h)		Abmessung (L x B x H)			[mm]	650 x 505 x 35	1200 x 540 x 35
Mounting holes pitch		Befestigungslöcher		(y/x1/x2)	[mm]	477/325	500/705/1005
Mounting hole Ø		Befestigungslöcher Ø			[mm]	6 x 9	9 x 14
Weight		Gewicht			[kg]	4,8	8,2
By-Pass diode number		By-Pass Dioden Anzahl				1	2
Temperature coefficient	Power	Temperatur-koeffizient	Leistung		[%]	–0,45	
	Voc		Voc		[%]	–0,37	
	Isc		Isc		[%]	0,081	
Package type		Verpackungstyp				single box	
Certificates		Zertifikate				CE, RoHS	
Origin		Ursprungsland				China	
Article Number		**Artikelnummer**				**310200**	**310214**

Figure 32: Solar Module Specification [Phaesun GmbH]

5.5 Solar Battery Specification

The Phaesun Sun Store AGM batteries are very robust, waterproof, cycle-proof and have an extremely long life expectancy. They are highly efficient and best suitable as allround-batteries.

Die Phaesun Sun Store AGM Batterien sind sehr robust, wasserdicht, zyklusfest und haben eine lange Lebensdauer. Sie sind sehr effizient und am besten als Allround-Batterien geeignet.

Sun Store 75

Technical Data	Technische Daten		Sun Store 75	Sun Store 85	Sun Store 115	Sun Store 140	Sun Store 165	Sun Store 230
Nominal voltage	*Nennspannung*	VDC	12					
Capacity	*Kapazität*	Ah (C5)	56	61	87	104	129	174
		Ah (C20)	70	75	107	128	156	214
		Ah (C100)	82	88	126	154	177	254
Max. Discharge Current	*Max. Entladestrom*	A @ 1s	780	840	1200	1300	1500	2000
Max. Charge Current	*Ma. Ladestrom*	A	19,5	21	30	36	45	60
Standbye Charge at	*Erhaltungsladen*	VDC @ 25°C	13,5-13,8					
Cycle Charge	*Zyklisierung*	VDC @ 25°C	14,4-15,0					
Temp. coefficient stand-by	*Temp. Koeffizient Erhaltungsladung*	mV / K	-20					
Temp. coefficient cycle charge	*Temp. Koeffizient Zyklisierung*	mV / K	-30					
Operating temperature	*Betriebstemperatur*	°C	-15 - +40 °C					
Terminal Type	*Terminal Type*		M6	M6	M8	M8	M8	M8
Dimensions	*Abmessungen*	mm	348 x 167 x 178	348 x 167 x 178	330 x 173 x 220	408 x 177 x 225	483 x 170 x 239	522 x 240 x 224
Weight	*Gewicht*	kg	21	23,5	30,6	36,6	43,2	71
Terminal position	*Endposition*							
Container material	*Behältermaterial*		ABS					
Article No.	*Artikel Nr.*		**340141**	**340094**	**340093**	**340092**	**340091**	**340090**

Figure 33: Solar Battery specification, [Phaesun]

5.6 Solar Charge Controller Specification

Technical Data:

With LCD	Steca PR1010	Steca PR1515	Steca PR2020	Steca PR3030
Max. Charge Current at 50° C	10 A	15 A	20 A	30 A
Max. Load Current at 50° C	10 A	15 A	20 A	30 A
Max. admissable current	110 %	110 %	110 %	110 %
Load overcurrent disconnection after 1sec	125 %	125 %	125 %	125 %
Max. self consumption	12 mA	12 mA	12 mA	12 mA
Admissable ambient Temperature	- 10 ° ... + 50 ° C	- 10 ° ... + 50 ° C	- 10 ° ... + 50 ° C	- 10 ° ... + 50 ° C
Connection Terminal (fine/single wire)	16/25 mm²	16/25 mm²	16/25 mm²	16/25 mm²
Weight	350 g	350 g	350 g	350 g
Dimensions	187x96x44 mm	187x96x44 mm	187x96x44 mm	187x96x44 mm
Protection	IP 22	IP 22	IP 22	IP 22
System Voltage	12/24 V	12/24 V	12/24 V	12/24 V

Figure 34: Solar Charge controller Specification sample [Steca]

Self-Check - 5	Written Test

Answer all the questions listed below. Use the Answer sheet provided in the next page:

N°	Questions and answers
1	**Why we need component specifications?**

Satisfactory	3 points
Unsatisfactory	Below 2 points

Answer Sheet

Score = _____

Rating: _____

Name

Date

Information Sheet 6	Obtaining and checking components needed for the installation work

6 Obtaining and checking components needed for the installation work

6.1 Introduction

Once all components have been specified and selected (LO2 Information Sheet 5), it needs to be procured or reserved in the store.

6.2 Procurement

Before procuring, always double check the BOM. Depending on the company policy, two or more quotations may be required from suppliers. Also, not all suppliers will have all components in their itinerary. The following process can be followed:

- If your company keeps stock, determine which components are available in store and reserve it;
- Compile a list of equipment and material to be sent to one or more suppliers for quotations;
- When the quotations are received, prepare purchase orders for the equipment. Who to purchase what from can be based on a number criteria:
  - Price;
  - Payment terms;
  - Stock Availability;
  - Local support;
  - Warranty period;
  - Delivery options;
  - Previous experience with the supplier etc.

6.3 Delivery

Make sure that the equipment delivered or picked up from the supplier is checked into the store and that all paperwork is done. Do the following:

- Check the equipment when delivered for:
  - Correct model number and type;
  - Correct quantity;
  - Check for damages to the packaging, open packages and visible defects e.g. scratches or cracked glass etc.;
- Obtain a copy of the signed delivery note;
- Note on the delivery note that the equipment was checked but not tested.
- Check the equipment into your store against the specific job;
- If possible, test the equipment (or a sample of it) before installation.

Table 7: Bill of Material Adama 5kW

Pos.	Item no.	Description	Quantity	Unit
1	310363	Phaesun PN6M72-350E Modules	14	Pcs
2	340026	Battery OPzS Hoppecke sun | power V L 2-730	24	Pcs
3	321728	Inverter / Hybrid Charger Phocos PSW-H-5KW230/48V	1	Pcs
4	161103	Module Support Structure PN-ASS 03	4	
5		Middle Clamp included in 4	18	Pcs
6		End Clamp included in 4	20	Pcs
7	390003	Corrugated Sheet Roof Screw Fitting 160mm	20	bar
8	704230	SOLARFLEX ® - X PV1-F 25mm²	35	m
9	704232	SOLARFLEX ® - X PV1-F 50mm²	100	m
10	303588	Cable Solarflex-X 1x 4 black 4mm²	25	m
11	390900	PV Standard4 Connector 4-6 mm² Set WM	5	Pcs
13	500090	Connection Box GCB 5-1 200V/50A_gland	1	Pcs
14	108010	Battery Rack Kunstmann 1E.B560.R2	1	Pcs
15		Fuse 100 Amp DC	1	Pcs
18		Fuse 15 Amp DC	4	Pcs

6.4 Installation for EPC

Often installers only install as subcontractors and do not do the design in-house. The EPC supply all the material to the installer. In cases like that, a good contract between the ECP and subcontractor is essential and should include:

- Definition of responsibilities;
- Time frames;
- How to handle deviations;
- How to handle disputes;
- Payment terms;
- Warranty terms for the installation;
- Liabilities.

Self-Check - 6	Written Test

Answer all the questions listed below. Use the Answer sheet provided in the next page:

N°	Questions and answers
1	What 'BOM' stands for?
2	Who to purchase what from can be based on a number criteria, name 5

Satisfactory	5 points
Unsatisfactory	Below 4 points

Answer Sheet

Score = _____

Rating: _____

Name

Date