Short-Course

Solar PV System Installation and Maintenance

NTQF Level III

Learning Guide -11

Unit of Competence	Determining PV system Customer Requirements
Module Title	Determining PV system Customer Requirements
LG Code	EIS PIM3 M06 0120 LO1-LG11
TTLM Code	EIS PIM3 TTLM 0120v1

LO1: - Assess current and future electrical needs of customer and site characteristics-11.

Instruction Sheet	Learning Guide 11

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

- Company standards & procedures
- Accomplishing forms for site assessment
- Accomplishing forms load assessment
- Conducting interviews
- Conducting assessment within the prescribed time.

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: -

- Understand company standards & procedures
- Understand accomplishing forms for site assessment
- Understand accomplishing forms load assessment
- Understand conducting interviews
- Understand conducting assessment within the prescribed time.

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: 3), Sheet 2 (page: 13), Sheet 3 (page:22), Sheet 4 (page:40), Sheet 5 (page: 44),
4. Accomplish the Self-Check 1 (page: 12), Self-Check 2 (page: 21), Self-Check 3 (page: 35), Self-Check 4 (page: 43), Self-Check 5 (page: 45),
5. Perform the LAP test (page: 39)

LO1: - Assess current and future electrical needs of customer and site characteristics

Information Sheet 1	Company standards & procedures

The assessment of the needs of the customer and the so-called side survey is the most important part of designing a PV system. Only a proper side survey can assure that the system will meet the requirements of the customers. That the PV-generator is big enough to cover the electricity demand, the battery is big enough to provide electricity during days without sunshine and the inverter is big enough to operate all devices. But also, that the system fits to the financial situation of the customers. The main points to survey are:

- General Information (where, what, when)
- Technical information (size of the PV system and battery bank and electricity demand)
- Financial information (budget, funding, loans)

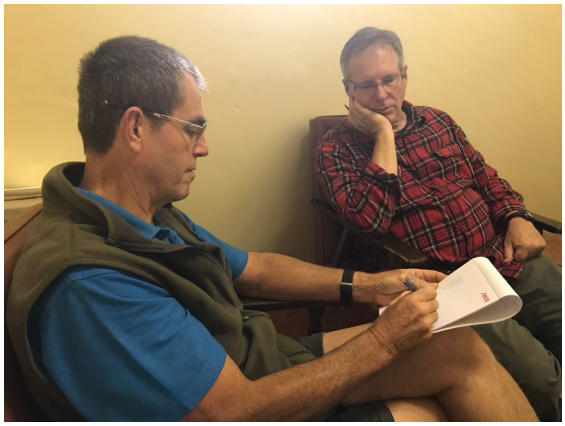


Table 1: Performing a site survey

The chapter “Assess current and future electrical needs of customer and site characteristics” gives you an introduction on which tools to use to perform a proper site survey.

1 Company standards & procedures

The are existing forms and procedures for the performance of a site survey. However, every company has its own procedures and forms to be used for site surveys. Companies develop site survey forms in order to record any of the information they need to acquire while conducting a site survey. Standardized site survey forms keep employees on track by reminding them what to collect and giving a place to write all that down. It also improves the quality of information one walks away with, and saves time when a client whom one employee of a company quoted a PV system two a years ago suddenly calls and says that he's ready to buy. With all the necessary information recorded on your site survey form you can save yourself another trip out to the site.

A good site survey form should easily be replicated by all employees within one organization. Word or Excel forms can be printed out to be completed as hard copies, or computer aided forms to be completed in mobile apps on smartphones or tablets are usually used.

1.1 Forms Content

The following points should be borne in mind during the on-site visit and recording of data, which will form the basis for good planning:

- Customers' wishes in respect of PV system (module type, system concept, method of installation, etc); the client energy use and expectations; desired energy yield;
- The financial framework, taking the respective subsidy conditions into account
- Data on roof: Usable roof, façade, open space surfaces, type of roofing and roof structure, roof's orientation and slop, etc
- Data on shading: daily, seasonal,
- Data on installation: PV generator installation layout, junction box and wiring routes, locations for controller and battery bank, appliances disposition and indoor wiring route; etc
- Important necessary documents: site plan and construction of housing; photographs of the roof and other meter construction.
- The items to be carried to on-site visit: checklists for recording; information material on PV: general information (national guidance, for example); company leaflets; products description; photo of existing PV systems; relevant handbooks
- Tools and equipment: compass, altimeter, folding ruler, protractor, tape measure, pocket torch, shading analyser, digital camera, etc

In order to collect all information, one must go very prepared to a client consultation /site survey. A site survey form is therefore the most essential tool to use to document all data collected during an on-site visit.

Manufacturers and wholesalers provide templates for companies, like the one from SMA below. When going for a site survey one has to make sure to use the right form. In the case where the company has no form in place, it is recommended to develop a form with the team based on public available forms and the specific requirements of the company. Word or even excel are suitable programmes to develop a company template.

Off-Grid Questionnaire

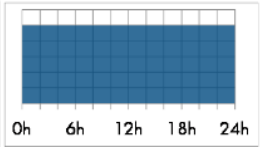
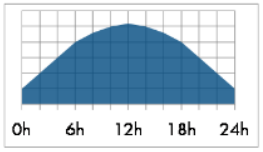
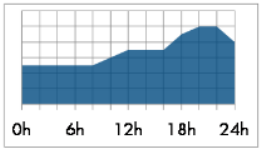
General Data						
Project/Use				☐ New plant		
Customer				☐ Refurbishment		
Site data						
Country			City			
Latitude			Longitude			
	Altitude		AMSL			
	Ambient temperature		°C minimal		°C maximal	
Plant data						
Grid	Voltage (L-N):		VAC	☐ Island system	or	☐ Backup
	Frequency:		Hz	☐ 1-phase	or	☐ 3-phase
Battery	Capacity:		Ah	or autonomy time		days
Energy sources	☐ Generator	☐ PV		☐ Others		
Communication	☐ Remote access					
Loads / Users						
	Daily		Summer		Winter	Yearly
Energy		kWh/d		kWh/d	kWh/d	kWh/a
Nominal load		kW		kW	kW	kW
Maximal load		kW		kW	kW	kW
When runs the main load?						

Table 2: Off-Grid Questionnaire (source : www.sma.de)

1.2 Form templates

The following template has been developed by the team of the German Solar Energy Society, short DGS, during the last years while working In Africa, Asia and Latin America. It is especially designed to be used for teams. As it is very comprehensive and enables companies to assign one person to go for the site survey and another person to do the planning and design.

CHECKLIST Location Evaluation PV-plants

1. General Information

Name, given name	
Address	
Phone	
Fax	
Email	

Location of PV power plant

Address		
GPS Coordinates		
Altitude		
Picture (photo or link)		
Internet connection		
		Available with limitless data flat rate
		Available with limited data flat rate of: .....GB
		Available without data flat rate
		Not available
Type of internet connection		DSL connection
		ADSL connection
		Dial up internet
		ISDN
		Other:
Prices and flat rates -Would your connection allow a permanent internet connection of the PV monitoring device with high up- and download traffic?		
		yes
		No
Comments:		

2. Building and Roof Drawings and Pictures

Please provide drawings and insert pictures of the following spots:

Building	roof
installation location (roof)	cable path
Electricity meter	Electricity meter cabinet
Electricity meter (type name)	
Access to the roof	relevant wiring situation

Please describe the present situation of the building (type of building, number of floors, usage, electricity installation) as focusing on the existing electrical installation in a few words:

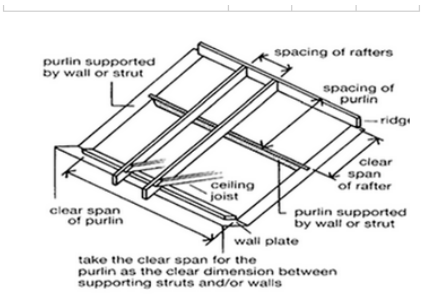
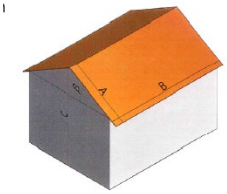
3. Location and Size of the Roof/side for the PV system

Mounting area*:	

Existing mounting frame:	
Roof area available for the PV system:	
Shading (Is there any other building, tries, etc. which shades the roof area?)	
Further information:	

*pitched roof, flat roof, open space, other

4. Roof structure, Roof Covering and Roof Waterproofing

	
Roof height A:	
Roof width B:	
Height Attica D (if existing):	
Building height C:	
Slope of the roof β:	
Roof orientation: 0° (North), 90° (East), 180 (South), 270° (West)	
Roof inclination β: 0° (Horizontal) to 90° (Vertical)	
Rafter size:	
Rafter cm wide / high/length in cm	
Spacing of rafters in cm:	
Amount of rafters:	
Tile/Brick material*:	
Tile/ Brick size in cm:	
Roof age in years: Please indicate if correct figure or estimated	

* clay, concrete, fibre cement, concrete, roofing paper, reinforce concrete, fibre cement, Hollow concrete blocks, gravel, Reed, bitumen, others

Please provide any further information:
Designed and erected mounting is needed

5. Power Consumption (Please Complete)

The building is used as:

Residence

Office

Other:

No.	Technical device	AC or DC	Quantity	Power [W]	Operation time [h]	Operation hours a day or night, please describe the usage patterns
1						
2						
3						
4						
5						
6						
7						
8						
9						
10						
11						
12						
13						

6. Only for advanced users Loads/consumptions

	Daily	Summer	Winter	Yearly
Energy consumption in kWh/d				
Nominal total load in kW				
Maximum load in kW				
Minimum load in kW				

Please provide more information on load peaks or consumers with high starting currents if available

	Please tick if you attach load curves		Please tick if you attach electricity bills

7. Customer Requirements (please tick)

Type of plant		Off-grid		On-grid		combined	
		hybrid		Other:			
Type of mounting		Roof-top installation		In-roof installation		Erected-mounting	
		Facade-mounted		portable		Other:	
System design constraints:		Design for max. income		Design with max. investment costs of:		Design for max. use of	

	Design for self-consumption		Other:		area

8. Given Electrical Conditions on Site

Present electricity costs		..../kWh	
Grid connection		yes	
		no	
Type of grid	Voltage in V:		
	Frequency in Hz		
	Phases:		
	Other relevant information:		
Electricity meter		yes	
		no	
	Type of meter		
	Can the meter count in 2 directions?		
Grid feeding systems		yes	
		no	
Is there lightning protection?		yes	
		no	
Where can the PV array be grounded?			

Existing power generators

	Existing generators	Power in kW	Voltage in V	Frequency in Hz	phases	Manufacturer	Model
	Diesel generator						
	PV						
	Wind						
	Others:						

Please provide any further information on Existing Power Generators, Grid Power cuts, usage patterns.

9. Technical Planning (Batteries)

Is there a room for batteries?		yes
		no
Where is the room?		
Distance to the PV modules in m		
Distance to the inverters in m		
How is the ventilation of the room, windows?		

Picture of the room:

10. Technical Planning inverter

Can the inverter be installed in the battery room?

☐ yes ☐ no

If no, where can they be installed?	
Distance to the PV modules in m	
Distance to the batteries in m	
How is the ventilation of the location? (windows, air-conditioning, ...)	

Picture of the room:

11. Technical planning grid connection

Only electricians are allowed

How are the feed in regulation?	
Who will do the AC installation?	
Whom we have to inform to connect the system to the grid?	

12. Additional notes by the customer:

13. Attachments

Self-Check - 1	Written Test

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

N°	Questions and answers
1	**Site surveys are the last step of PV installation project.**
	True or false:
2	**It is needed to collect all information needed to evaluate the electricity consumption of the customer.**
	True or false:

Note: the satisfactory rating is as followed

Satisfactory	2 points
Unsatisfactory	Below 2 points

Answer Sheet

Score = _____

Rating: _____

Name

Date

Information Sheet 2	Accomplishing forms for site assessment

2 Accomplishing forms for site assessment

A professional site assessment is the first important step in the process of selection, design and installation of an appropriate renewable energy production system for your home or business. The assessment starts with phone or email conversations with you, includes an in-person site visit, and results in the delivery to you of a carefully written report. The report will help you to design a solar system which meets the requirements of the customer. Every site is different and needs evaluation specific to the site--there is no "one-size-fits-all solution" when it comes to renewable energy systems.

2.1 Objective of a site assessment

According to the German Solar Energy Society, installers have to consider the following points while performing a site assessment (DGS, 2010):

- Customers' wishes with regard to module type, system concept and method of installation.
- Desired PV power or the desired energy yield.
- The financial framework, taking the respective subsidy conditions into account.
- Usable roof, facade and open space surfaces.
- Orientation and angle of inclination.
- Roof shape, roof structure, roof substructure and type of roofing.
- Usable roof openings (vent tiles, free chimney flues, etc.).
- Data on shading.
- Installation sites for PV combiner/junction boxes, isolating facility and inverter.
- Meter cupboard and space for extra meters.
- Cable lengths, wiring routes and routing method.
- Access, particularly when equipment is required for installing the PV array (crane, scaffolding, etc.).

Forms to collect all the above listed information for site surveys are provided in LO1.

These forms are an essential tool to record all data gathered during a site assessment. They have to be filled out on site and ideally should be even signed by the customer. Forms can be printed out, but also completed digitally.

2.2 Tools for a site assessment

The most important tool for a site survey is your camera, or nowadays your smart phone. Pictures help you to memorize the site, but also to plan the system. You phone gives you the GPS of the location, but you also could use it as compass or even to complete the site survey form if your company provides you with a smartphone app to do so. You could even use your phone for a quick pre-planning, irradiation evaluation or inclination measuring.

What Should one Take with?

- Compass (or smart phone)
- Tape measure (up to 25 m), yardstick
- Digital camera (or smart phone)
- Inclinometer for finding the slope of the roof (or smart phone)
- Calculator (or smart phone)
- A shading-analysis tool (if available)
- Screwdriver or multi tool
- Flashlight (a headlight would give you the opportunity to note and see, as it keeps your hands free)
- Ladder (either you bring your own, or you make sure that the client provides one)
- Clipboard and notebook with pens and pencils
- Survey form
- Data sheets for modules, inverters, substructures (if you work with standard products)
- Samples, if available (i.e. substructures, modules, cells, ...)

Ryan Mayfield, recommends in his handbook “Photovoltaic for Dummies” to use a survey bag to ensure that you can carry all needed tools while climbing roofs, leaders and speaking with the client.

2.3 Procedure

The site survey form is your guideline to collect all relevant data. How to use it is explained in this chapter.

Please follow the following procedure to collect your data:

- Sit down with the client, get to know him and understand where he is coming from.
- Start to complete the form during the discussion and explain the client why you collect all these data.
- Visit the side with the client, make notes and take pictures
- Sit down again with the client, go through the notes, complete the notes, get additional information.
- Get the signature from the client on the site survey form

The two most important things is to:

- Get familiar with the client and to listen to what he really wants and
- To get his signature and thus his confirmation on the collected data.

But why do you need the signature of the client. You need it as proof, that the collected data is correct and to make sure that all that you agree with the client is documented.

Read the following example to understand why the client signature is so important.
Dave is a PV installer. 2015 he visited his client the first time. His client had no access to electricity and wanted to investigate solar as an option for him. Dave completed the site survey and discussed possible options for the client. But there was a big tree in front of the house of the client which caused shadows on the roof of the house. Dave

explained to the client that this shadow will reduce the electricity production of the solar system and the client said that he wanted to cut down the tree anyhow. Dave noted this information in the site survey form and both, Dave and the client, signed the form. In 2016, Dave installed the system and the tree was still there, but the client confirmed again that he will cut it. In 2018 the client called Dave and He was very angry as the system did not perform as predicted and he even wanted his money back. Dave went on-site and the tree was still there. Dave explained to the client that the tree is the reason for the bad performance and the client complained, that Dave should have said this earlier. Dave showed the client the signed site assessment form and thus could proof that he informed the client already during the site survey. This saved his reputation and his money.

This example should show you how important it is to have a good documentation and even get the approval from the clients.

2.3.1 General Information

First you have to collect general information about your customer, which you need to prepare a quote. But you also need to know exactly where the location is and if there is an internet connection. The internet connection is important in case you plan to run or monitor the system remotely. You need to collect:

- Name and address of the customer
- Location of PV power plant (GPS Coordinates, Altitude, photo)
- Internet connection (type, costs, accessibility)

The best tool to get the exact location are tools like Google maps.

2.3.2 Building and Roof Drawings and Pictures

In order to plan the PV system, one needs to know not only where to mount the modules, but also where to mount or place the inverter and the batteries, how to connect the system to existing electrical installations and generators and where to mount the equipment. Pictures of the following have to be taken and copied in the site survey form:

- Building
- Roof
- Access to the roof
- installation location (roof)
- cable path
- relevant wiring situation
- Electricity meter
- Electricity meter cabinet
- Electricity meter (type name)
- Existing electricity supply (batteries, generator…)

Please describe the present situation of the building (type of building, number of floors, usage, electricity installation) as focusing on the existing electrical installation in a few words.

2.3.3 Location and Size of the Roof/side for the PV system

One has to document with a little drawing the area dedicated for the PV system. Solar modules could be mounted on a roof, on a pole or even get ground mounted. This drawing will be the basis for the planning on how and where to install the PV system.

It is always good to make some drawing, even additionally to pictures. Here it is always good to have as much information as possible relevant for the PV system. Where is which tree, is it a deciduous tree or a conifer, what else can put shadow on the PV array. Such a drawing should include the following data:

- Included in the drawing:
- Roof area (with attention to the orientation)
- Usable area for the PV system (situate the middle of the PV system at the coordinate origins, additional photos can be taken)
- Chimney, antenna, satellite systems
- Near lying buildings (approximate distance and height)
- Trees (approximate distance and height)
- Freestanding cables (i.e. electricity or telephone lines)
- Other shading sources: building projections, etc...

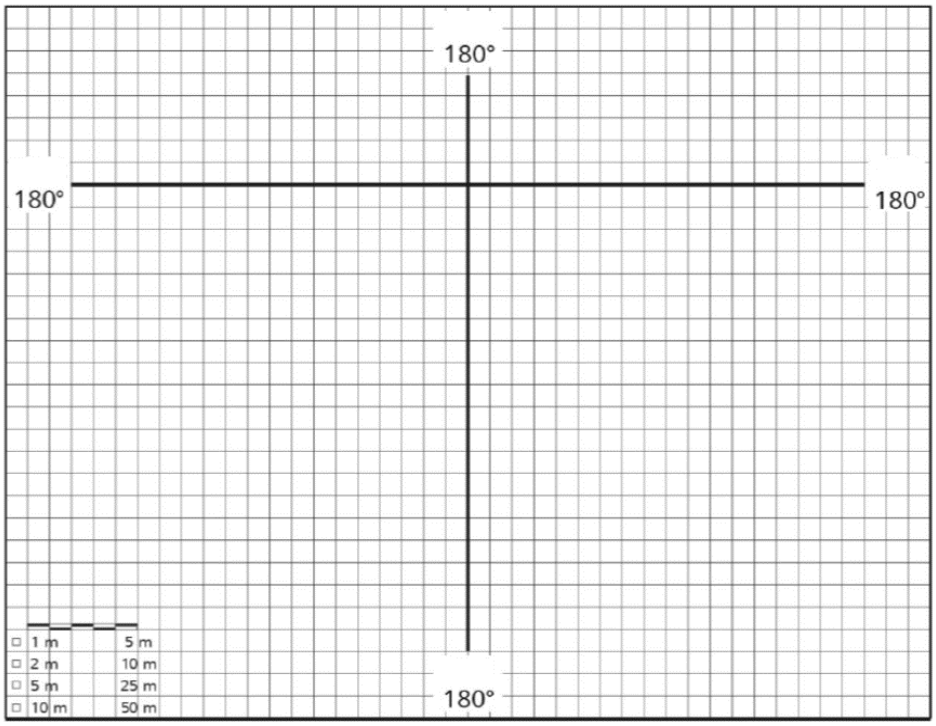


Table 3: Template to draw site

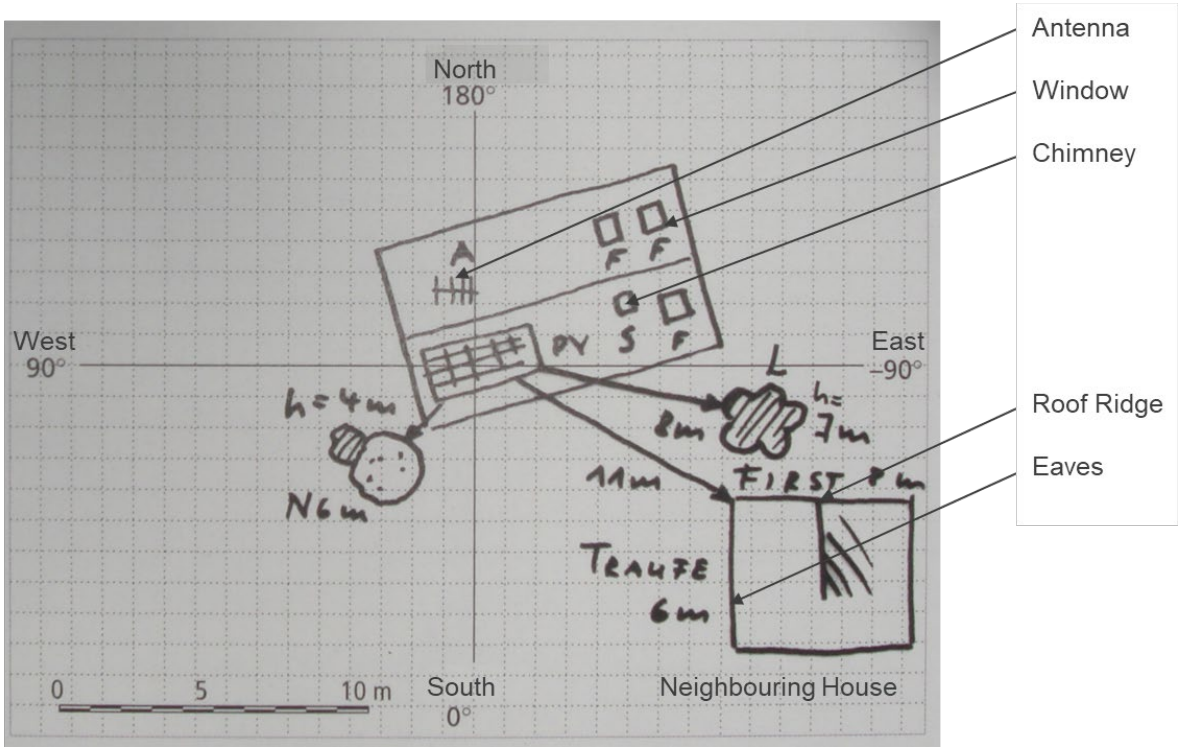


Table 4: Example for a site drawing

Additionally, the following information has to be documented in the site survey form:

- Mounting area (pitched roof, flat roof, open space, other)
- Describe if there is an existing mounting frame
- Describe if there is a roof area available for the PV system
- Describe the Shading (Is there any other building, tries, etc. which shades the roof area?)
- Describe any further information relevant information.

2.3.4 Roof structure, Roof Covering and Roof Waterproofing

When you can mount the PV system on the roof you need a detailed description of the roof, as you need to plan how to mount the PV array on the roof.

The following paragraphs give you more background information on why and what is important to document. They are taken from [Mayfield, 2010, chapter 5, page 85] and adapted for Africa by the authors.

How much physical space is available for the installation? Typically, PV systems are installed on the roofs of buildings or on free land space. Your task during the site survey is to make sure the space available will suffice for the client's desired PV system. Your client may have an idea of where he wants the array to go, but it's your job to make sure a better alternative doesn't exist.

The area you have your eyes on may be the same as someone else. Always verify that other plans don't exist for the space you want to use, such as plans for solar

thermal collectors or skylights. Here are some additional structural and mechanical questions that you should ask if the array will likely be mounted to a roof:

What are the dimensions and shape of the roof area available?

Taking the dimensions of the roof area you plan to install on will help you sketch out the roof later when you're ready to plan how the array will be arranged on the roof. During the site-survey process, you also need to identify obstructions (such as plumbing vents, chimneys, and attic vents) on the roof as well as their locations.

What condition is the roof material in, and how old is the roof covering?

Placing an array on a roof that will need to be replaced in a few years doesn't make a lot of sense. If a reroof is in order, suggest it be done now and be sure to work closely with the client and the roofer to coordinate phases of the project so you can continue with the PV system design and installation in a timely fashion.

What's the roof framing like?

The roof's framing plays an important role. Most modern homes and commercial buildings tend to have roof framing that's adequate for a PV array mounted parallel to the roof so long as a single layer of lightweight roofing material (such as composition cement fiber shingles or wood shake) is used as the roof covering. Why? Because the roofs of modern homes are designed to handle multiple lightweight roof layers. As long as only one layer is present, adding the weight of a PV array will be less than the structure's limitations.

It is always recommended to involve a structural engineer to evaluate the roof for you and outline any changes you need to make to safely support the array. Make sure this consultation happens as early as possible in the system design process.

Note: Simple huts in unformal settlements or rural areas are often not suitable to carry any extra load. In this case pole or ground mounting is the only way to install a PV array.

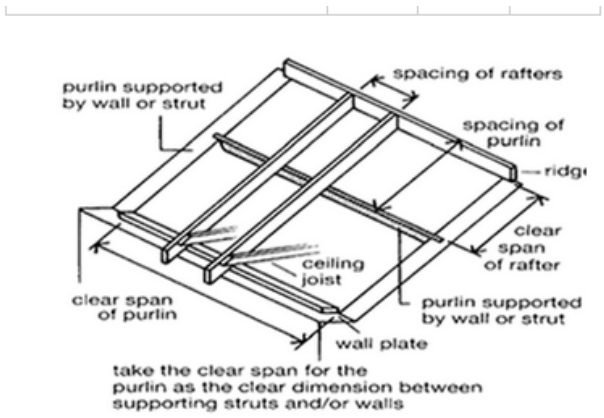
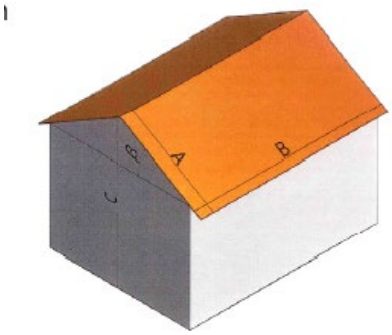
What are the dimensions and spacing of the roof framing?

Some buildings have lumber, similar to residential roofs; others use very large wood support members; and some use steel supports. Consequently, you should take the time to verify the roof structure in order to properly attach the array in any system that's being installed on a commercial roof. You have to identify the roof type, used material and dimensioning. Always do your best to verify the roof framing composition and orientation when conducting your site survey. Be sure to carefully evaluate rafters that are over spanned — a situation where the rafter has too much space between vertical support members.

Different spans are allowed based on lumber type and roof-loading restrictions, but as a general rule, if the rafters have a span of more than 2 meters between supports, you should investigate the need for adding support by consulting a structural engineer. After roofs, ground mounts are the most popular type of racking system. Unless your client's site has unusually loose soil (like sand), you can work with a racking company (and maybe an engineer, if necessary) to determine the best possible mounting

solution for the array. Of course, before you start talking to a racking company, you need to make sure the location is suitable for mounting an array.

The site survey form will help you to collect all information as described by Mayfield above.

	
Roof height A:	
Roof width B:	
Height Attica D (if existing):	
Building height C:	
Slope of the roof β:	
Roof orientation: 0° (North), 90° (East), 180 (South), 270° (West)	
Roof inclination β: 0° (Horizontal) to 90° (Vertical)	
Rafter size:	
Rafter cm wide / high/length in cm	
Spacing of rafters in cm:	
Amount of rafters:	
Tile/Brick material*:	
Tile/ Brick size in cm:	
Roof age in years: Please indicate if correct figure or estimated	

* clay, concrete, fibre cement, concrete, roofing paper, reinforce concrete, fibre cement, Hollow concrete blocks, gravel, Reed, bitumen, others

Please note all information you can get in the form an ask if there are any drawings available.

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	**What Should one Take with when going to a site assessment?**
2	**Why it is important that the client signs the site assessment?**
2	**What should be included in a drawing of the area dedicated for the PV system?**

Note: the satisfactory rating is as followed

Satisfactory	15 points
Unsatisfactory	Below 10 points

Answer Sheet

Score = _____

Rating: _____

Name

Date

Information Sheet 3	Accomplishing forms load assessment

3 Accomplishing forms load assessment

Typical customers of small off-grid systems, also known as Solar Home Systems (SHS) are:

- Households without electricity.
- Households or commercial customers who use any off-grid electricity source, typically those are diesel generators or batteries, but sometimes also wind or water turbines.
- Households or commercial customers with unreliable grid-connection who want to go off the grid.

The load assessment will give us an insight in the present and planned electricity use of the customer. It is crucial to get a realistic picture of the future demand. It is always easier to collect information when the customer already uses electricity as in this case you can survey the electricity consumption and document all loads. Loads are electricity consuming appliances, such as lamps, fridges, computers and so on. In order to dimension the system according to the needs of the customer it is important to know the power of every load and the usage time.

You have to cross-check if all the loads the customer wants to operate. You have to understand when the customer uses the loads, every day, once a week, in the morning, in the night and so on. The design will then be made based on the daily consumption. If you have a consumer you only use e.g. once a week you do not have to consider it in the calculation or if you want to be 100% sure just take a fractional part of the amount of energy it requires. In most cases the dimensioning of a SHS only considers daily requirements and during the daily use, the users find out how much more consumers they can connect additionally without running out of electricity.

Here are the steps on how to check the customer's energy consumption:

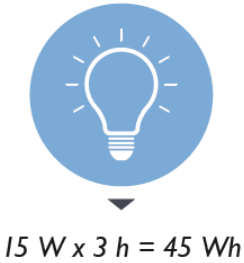
1) How much power does the device consume? Look at the number of Watts (W) on the packing or the description directly on the device.

2) How many hours do the customer want to use the consumer?

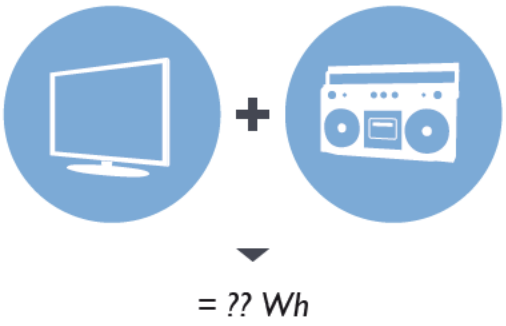
3h	1h	2h
15 W	60W	60W

3) How much energy would the customer need per day?

Multiply the power by the time of usage that means the Watt by the hours. The result is the amount of energy and has the unit Wh.



4) Repeat this calculation for every consumer you want to use.



5) Sum up all the results to get the total amount.

3hx15W+1hx60W+2hx60W=225Wh

6)Calculate the total Power

15W+60W+60W=135W

In case the customer already uses electricity, you can survey the electricity consumption with electricity meters, simple tables to document meter readings or fuel consumption. But this will not replace the evaluation of the devices.

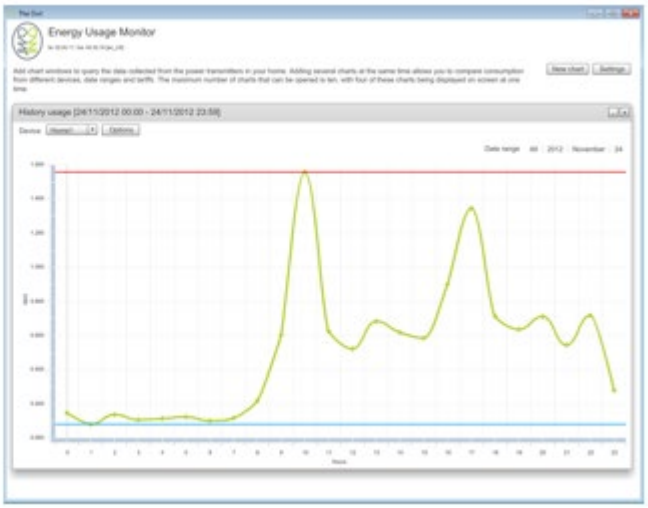


Table 5: Electricity meter (OWL) to monitor the electricity consumption

maxx-solar energy PTY Ltd. consumption monitoring template

Client: Dominican-Grimley Meter number: 319756

Week: 9 - 15 November

Please write the kWh from the display of your meter every full our in the table

Sunday		Monday		Tuesday		Wednesday		Thursday		Friday		Saterday	
1:00 AM		1:00 AM		1:00 AM		1:00 AM		1:00 AM		1:00 AM		1:00 AM	
2:00 AM		2:00 AM		2:00 AM		2:00 AM		2:00 AM		2:00 AM		2:00 AM	
3:00 AM		3:00 AM		3:00 AM		3:00 AM		3:00 AM		3:00 AM		3:00 AM	
4:00 AM		4:00 AM		4:00 AM		4:00 AM		4:00 AM		4:00 AM		4:00 AM	
5:00 AM		5:00 AM		5:00 AM		5:00 AM		5:00 AM		5:00 AM		5:00 AM	
6:00 AM	19246	**6:00 AM**	19211	**6:00 AM**	19216	**6:00 AM**	19223	**6:00 AM**	19227	**6:00 AM**	19235	**6:00 AM**	19240
7:00 AM		7:00 AM		7:00 AM		7:00 AM		7:00 AM		7:00 AM		7:00 AM	
8:00 AM		8:00 AM		8:00 AM		8:00 AM		8:00 AM		8:00 AM		8:00 AM	
9:00 AM		9:00 AM		9:00 AM		9:00 AM		9:00 AM		9:00 AM		9:00 AM	
10:00 AM	19247	10:00 AM	19213	10:00 AM	19219	10:00 AM	19224	10:00 AM	19230	10:00 AM	19237	10:00 AM	NOT READ
11:00 AM		11:00 AM		11:00 AM		11:00 AM		11:00 AM		11:00 AM		11:00 AM	
12:00 PM		12:00 PM		12:00 PM		12:00 PM		12:00 PM		12:00 PM		12:00 PM	
1:00 PM		1:00 PM		1:00 PM		1:00 PM		1:00 PM		1:00 PM		1:00 PM	
2:00 PM	19247	2:00 PM	19213	2:00 PM	19219	2:00 PM	19225	2:00 PM	19232	2:00 PM	19237	2:00 PM	19242
3:00 PM		3:00 PM		3:00 PM		3:00 PM		3:00 PM		3:00 PM		3:00 PM	
4:00 PM		4:00 PM		4:00 PM		4:00 PM		4:00 PM		4:00 PM		4:00 PM	
5:00 PM		5:00 PM		5:00 PM		5:00 PM		5:00 PM		5:00 PM		5:00 PM	
6:00 PM	19248	**6:00 PM**	19214	**6:00 PM**	19221	**6:00 PM**	NOT READ	**6:00 PM**	19232	**6:00 PM**	19238	**6:00 PM**	19243
7:00 PM		7:00 PM		7:00 PM		7:00 PM		7:00 PM		7:00 PM		7:00 PM	
8:00 PM		8:00 PM		8:00 PM		8:00 PM		8:00 PM		8:00 PM		8:00 PM	
9:00 PM		9:00 PM		9:00 PM		9:00 PM		9:00 PM		9:00 PM		9:00 PM	
10:00 PM		10:00 PM		10:00 PM		10:00 PM		10:00 PM		10:00 PM		10:00 PM	
11:00 PM		11:00 PM		11:00 PM		11:00 PM		11:00 PM		11:00 PM		11:00 PM	
12:00 AM		12:00 AM		12:00 AM		12:00 AM		12:00 AM		12:00 AM		12:00 AM	

* NOTE: We began on Monday 9 NOVEMBER.

Table 6: Meter reading and documentation in a table

The two important questions to answer are:

- How much electricity (Wh) consumes the customer?
- What is the sum of the power (W) of the loads to be used at the same time?

The electricity consumption is important for the sizing of the PV generator and the battery and the power of the loads is important for the sizing of the inverter.

Wrong assumptions will lead to failure of the system!

3.1 Power Consumption

During the site survey you have to complete the power consumption table and collect general information like: The building is used as residence or office or for other purposes.

And you have to document all loads, also called appliances or technical devices in order to understand the daily load energy demand, which is the amount of energy required each day to power all loads. The paragraph below describes the use of the table and the definitions where prepared based on the definitions given by Hankins, 2010.

Column 1: Number of the entries from 1 to n.

Column 2: Individual load description. List all the lamps and appliances to be powered by the system here. When listing appliances, you should consider all the appliances to be powered by the system, even those that will be purchased in the future.

Column 3: Note if it is an AC or DC appliance. DC appliances are those that run e.g. at 12V DC or the system voltage and AC appliances are those that will run through an inverter. AC appliances are standard appliances used everywhere, where we have a grid, whereby DC appliances are typically used in boots, camping, trucks and PV systems. In case you install the system for a customer who has no electricity so far and no appliances the use of DC appliances and the use of a pure DC system should be considered.

Column 4: Number of same appliances, appliances with the same characteristics. 15 and 20 W lamps e.g. can't be mixed.

Column 5: Individual lamp and appliance power. List the power in watts for each appliance and lamp. Usually, the manufacturer indicates the power rating on the appliance itself. With better information about your appliance, you can accurately predict your demand. Try to get actual ratings of the power use of appliances from labels or manufacturers' data. Table 21: Performance of typical 12V lamps (Hankins, 2010) and Table 22: Approximate power and energy requirements for common off-grid appliances (Hankins, 2010) (LO2) list the power ratings of common lamps and appliances – if you do not have information about your appliances, use these when making calculations. Better yet, measure the actual DC current consumption of your lights and appliances using a multimeter or a clamp-on amp-meter. Do not guess! (The actual power consumption of AC appliances can be measured quite accurately using plug-in watt-meters, but it is best to use them on the mains – the wave form of an inverter may interfere with an accurate reading. Remember that in an off-grid PV system the appliance will consume more electricity because of inverter inefficiency.)

Column 6: Individual lamp and appliance use (hours per day). Estimate the number of hours per day that each lamp and appliance is used. If the appliance is only to be used a few times per week (e.g. a sewing machine might only be used on weekends), estimate the number of hours it is used per week, divide by 7 and write the number of hours per day in Column 6.

Column 7: Discuss with the customer if he uses the appliance only during the day or only during the night or both. This information will help you to understand the usage pattern better and to estimate the max power in total, but also during the day and the night. Lamps e.g. are only used during the night, whereby Computers are often used both, night and day.

Table 7: Table to document the Technical devices used by a customer

1	2	3	4	5	6	7
No.	Technical device	AC or DC	Quantity	Power [W]	Operation time [h]	Operation hours a day or night, please describe the usage patterns
1						
2						

1	2	3	4	5	6	7
No.	Technical device	AC or DC	Quantity	Power [W]	Operation time [h]	Operation hours a day or night, please describe the usage patterns
3						
4						
5						
6						
7						
8						
9						
10						
11						
12						
13						

It is important to not only document existing devices but also discuss in detail with the client which devices he wants to use/operate with the PV system.

3.2 Loads/consumptions

For a detailed planning it is not only important to know the power and energy demand but also to know when the energy is used and if there are differences in summer and winter or day and night. Weekend houses e.g. are usually only used in Summer, telecommunication towers have the same electricity consumption 24/7 and families usually need more electricity in the evening.

To get this figures we can either ask the customers or we could evaluate the data collected with a meter, see Table 5: Electricity meter (OWL) to monitor the electricity consumption or manual reading, see Table 6: Meter reading and documentation in a table. The load curves show us when the loads are used and thus when which amount of power and electricity is needed.

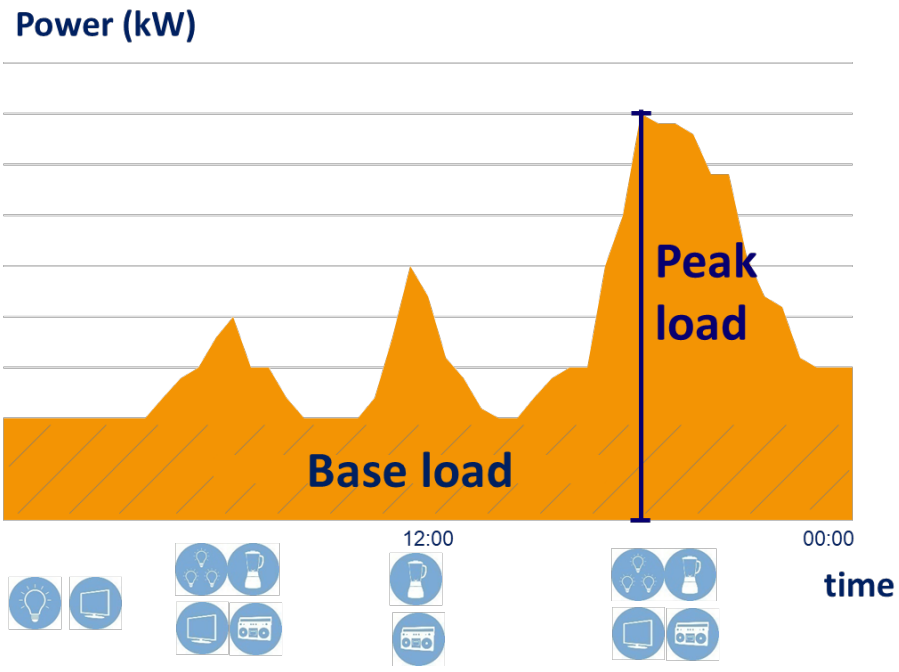


Table 8: Load curve of a rural household

For the planning we need to understand when we can use electricity directly and how much electricity has to be stored in the batteries to be used in the night or during days without sunshine. The figure below shows the load curve of a customer with an overall energy consumption of 42 kWh per day. The load curve or load profiles is a graph of the variation in the electrical load versus time. The figure below compares the load curve with a typical solar profile and thus shows us which electricity can be used directly.

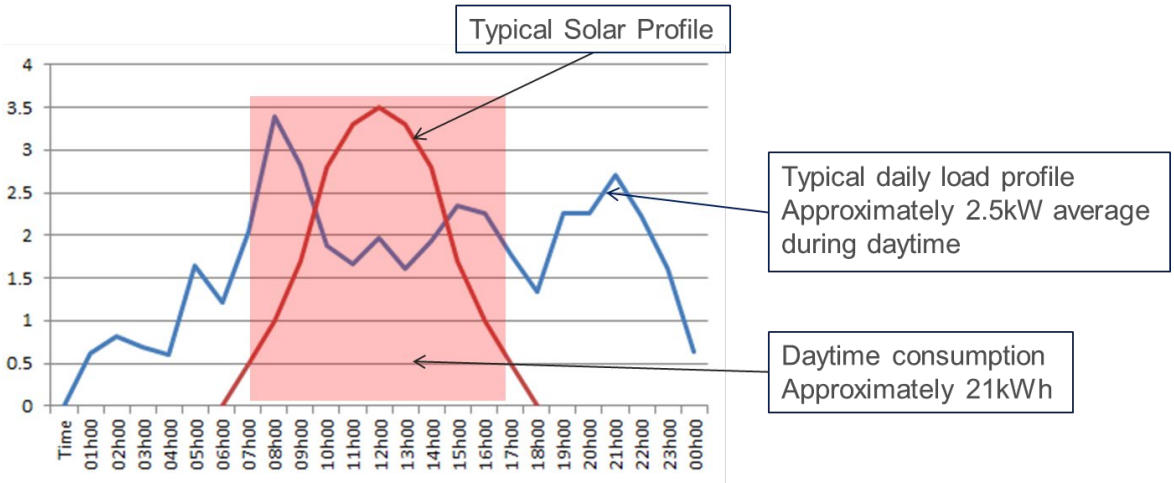


Table 9: Solar profile vs load profile of a customer with 42kWh/day consumption

One needs to understand the usage patterns to design the system, but especially the batteries. The table below will help to collect the needed information.

Table 10:Table to document seasonal usage patterns

	Daily	Summer	Winter	Yearly

Energy consumption in kWh/d				
Nominal total load in kW				
Maximum load in kW				
Minimum load in kW				
Please provide more information on load peaks or consumers with high starting currents if available				

	Please tick if you attach load curves		Please tick if you attach electricity bills

3.3 Customer Requirements

It is also important to discuss with the customer the type of PV system he has in mind. One has to discuss the different option with the client and note the requirements in the site survey from.

- Type of plant
  - Off-grid
  - On-grid
  - combined
  - hybrid
  - Other:
- Type of mounting
  - Roof-top installation
  - In-roof installation
  - Erected-mounting
  - Facade-mounted
  - Portable
  - Other:
- System design constraints
  - Design for max. income
  - Design with max. investment costs of:
  - Design for max. use of area
  - Design for self-consumption
  - Other

3.4 Given Electrical Conditions on Site

In case the customer already uses electricity, you have to analyse the sources to understand how to connect or integrate the PV system. You must evaluate the conditions on site. Once you collected all data you can come up with strategic decision:

- Should the PV system replace the existing systems, e.g. old diesel generators or batteries?
- Can the PV system be used additionally?

- How should integration work?
- Which source should be the main source?

One can only answer all those questions if one has a clear picture on the existing electricity sources. Thus, it is very important to collect as much information as soon as possible.

3.4.1 Electricity Grid

The description below is taken from [Mayfield, 2010, chapter 5, page 86] and adapted for Africa by the authors.

For utility-interactive systems (whether grid-direct or battery-based), you have a number of items to review while you're on-site because you either want to connect the PV system to the utility or you want to replace this connection and use the existing cabling and DB board.

What are the specifications for the main distribution panel (MDP) or distribution board (DB) and the main circuit breaker protecting the panel?

The ratings on the DB and the main circuit breaker play a major role in determining a PV system's maximum size. When looking at the existing electrical service, you need to document the specifics on the DB and any subpanels you want or need to use, including their physical locations. The standard voltage is 220 V and the standard frequency is 50 Hz. Usually small houses use one phase systems.

Busbars are the pieces of metal in the back of the DB that connect the circuit breakers in the panel to the wires coming from the utility (you can't see them when the cover of the DB is on). Every DB has a rating for its busbars on the label attached to the inside of its cover. This rating is a value for the amount of current that can flow on the busbars inside the panel without causing any problems.

The other specification for the MDP (and any subpanel used) is the rating of the main circuit breaker protecting the panel. For the MDP, this is often the same size as the busbar rating. The ratings for circuit breakers in subpanels vary based on the loads located in the subpanels.

Are there any open breaker spaces on the main electrical panel?

Look in the MDP or subpanels to check for available space to put a breaker, as the electrician need to connect the inverter's output wires to one of these panels by placing a breaker in the panel and wiring the inverter to it. (This process is similar to putting a breaker in the panel for a new set of outlets or a new load except that the electrons are running in the opposite direction.) If the panel is full, you need to either make room or replace the existing panel with a larger panel.

Take as much pictures as needed and add all needed information in the site survey from:

- Document the electricity costs price per kWh and ask for an electricity bill to be able to evaluate all involved costs.
- Ask if the client wants to connect its system to the grid

  - Evaluate the type of grid:
  - Voltage in V:
  - Frequency in Hz
  - Phases:
  - Other relevant information, such as load shedding schedules and power failures.
- Meter specifications:
  - Type of meter
  - Can the meter count in 2 directions?
  - Is grid feeding allowed
- Lightning protection and grounding
  - Availability and location of lightning protection
  - Where can the PV array be grounded?

Table 11: Pictures from distribution board and meter

3.4.2 Existing power generators

Some customers already use generators or other renewable energy sources. During the site survey you have to document those generators and discuss with the customers how they want to use the systems in the future. Should a diesel generator e.g. only be a backup for the solar system or should solar be used during the day and diesel during the night.

Please use the table below to collect as much information as possible from the existing generator and take pictures of the name plates and the complete system.

	Existing generators	Power in kW	Voltage in V	Frequency in Hz	phases	Manufacturer	Model
	Diesel						

	generator						
	PV						
	Wind						
	Others:						

Please provide any further information on Existing Power Generators, Grid Power cuts, usage patterns.

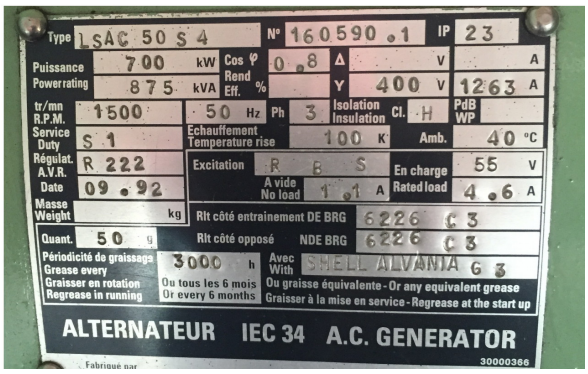
Generator 1	Generator 3
	

Table 12: Typical pictures from a site survey

3.5 Technical Planning (Batteries and Inverter)

The final question to be answered is the location where to install the batteries and the inverter. Please take into consideration, that the batteries perform best at 25°C. Ambient temperatures above 20°C have an influence on the lifetime of the batteries. The corrosion rate of the electrodes doubles every 10°C increase (Arrhenius-equation).

Inverters produce not only electricity but also heat but this heat influences the performance of the inverter. Thus, one must make sure that the inverter is placed in a location where cooling or at least the escape of the produced heat is possible.

Another important point is the distance to the PV modules. A long distance means more cable, which increases the costs, but also thicker cable as the cable diameter is direct proportional to the cable length.

Use the table below to collect information about possible locations for the batteries and the inverters.

9. Technical Planning (Batteries)

Is there a room for batteries?		yes
		no
Where is the room?		
Distance to the PV modules in m		
Distance to the inverters in m		
How is the ventilation of the room, windows?		

Picture of the room:

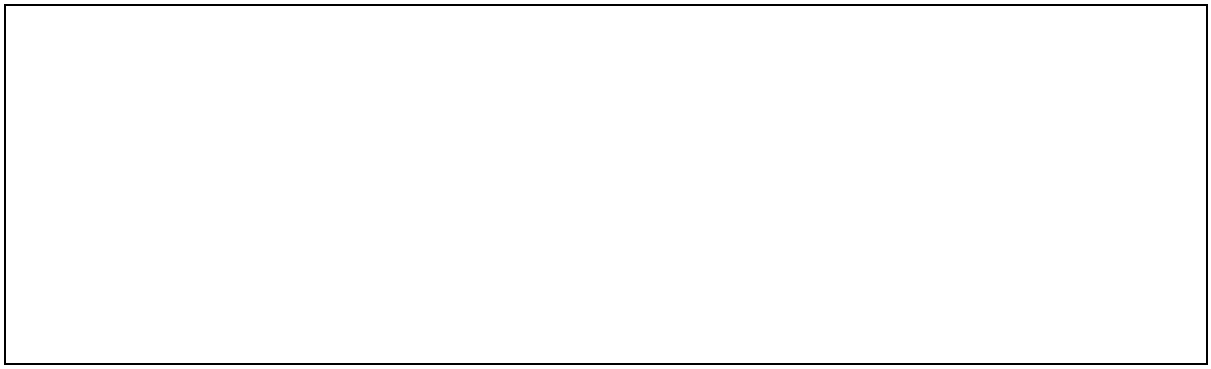
10. Technical Planning inverter

Can the inverter be installed in the battery room?

☐ yes ☐ no

If no, where can they be installed?	
Distance to the PV modules in m	
Distance to the batteries in m	
How is the ventilation of the location? (windows, air-conditioning, ...)	

Picture of the room:



Self-Check - 3	Written Test

Instruction: Follow the below selected instruction

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

N°	Questions and answers
1	**What is a load? Describe a load in a PV system and name**
	True or false:
2	**Question**
	True or false:

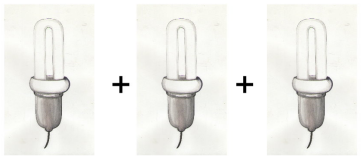
B)

N°	Questions and answers	
1	**What is a load in PV system?**	
	A – Answer A	B – Answer A
	C – Answer C	D – Answer D
1	**Question**	
	A – Answer A	B – Answer A
	C – Answer C	D – Answer D

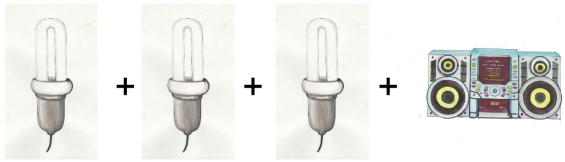
C)

N°	Questions and answers
1	**Please calculate the total power of the following loads using the below given power per load:**

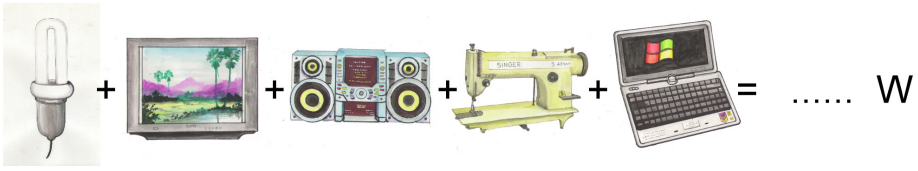
7 W 10 W 5 W 35 W



..... W



..... W



..... W

2 **Convert the following values:**

1 W = ... kW;	100 W=..... kW	1000 W=..... kW
1kW=..... W	10 kW=..... W	0.1 kW=.....W
1500 W= ..... kW	15 W=.....kW	1240 W=..... kW
1.05 kW=..... W	11.5 kW=..... W	0.005 kW=..... W

2 **Calculate the Consumption and the total Watt for a customer with the following loads?**

N°	Existing Consumers	Power in Watt	Amount	Operation Hours per day	Usage Time	Consumption [Energy]	Total Power in Watt
		[W]	[qty.]	[h/d]		[Wh/d]	[W]
1	Illumination	15	2	3.0	night		
2	55" led tv	60	1	3.0	night		
3	decoder	45	1	3.0	night		
4	Laptop	65	1	2.0	day		

5	Charge Controller	0.15	1	4.0	Day/night		
6	Inverter standby	0.5	1	20.0	Day/night		
7	Inverter ON	6	1	4.0	Day/night		
8							
9							
10							
11							
Total:						Wh/d	W

A3	Energy Consumption [E]	Wh/d
A4	Total Power in Watt [W]	W
A5	Total Power per Day in Watt [W]	W
A6	Total Power per Night in Watt [W]	W

Note: the satisfactory rating is as followed

Satisfactory	26 points
Unsatisfactory	Below 13 points

Answer Sheet

Score = _____

Rating: _____

Name

Date

Solutions for Question 3

N°	Estimated Consumption of the Costumers						
	Existing Consumers	Power in Watt	Amount	Operation Hours per day	Usage Time	Consumption [Energy]	Total Power in Watt
		[W]	[qty.]	[h/d]		[Wh/d]	[W]
1	Illumination	15	2	3.0	night	90.00	30.00
2	55" led tv	60	1	3.0	night	180.00	60.00
3	decoder	45	1	3.0	night	135.00	45.00
4	Laptop	65	1	2.0	day	130.00	65.00
5	Charge Controller	0.15	1	4.0	Day/night	0.60	0.15
6	Inverter standby	0.5	1	20.0	Day/night	10.00	0.50
7	Inverter ON	6	1	4.0	Day/night	24.00	6.00
8						0.00	0.00
9						0.00	0.00
10						0.00	0.00
11						0.00	0.00
Total:						569.60 Wh/d	206.65 W

A3	Energy Consumption [E]	569.60 Wh/d
A4	Total Power in Watt [W]	206.65 W
A5	Total Power per Day in Watt [W]	71.65 W
A6	Total Power per Night in Watt [W]	141.65 W

LAP Test	Practical Demonstration

Name:		Date:	
Time started:		Time finished:	

Instructions: Given necessary materials, tools and measuring instruments you are required to perform the following tasks within 2 hour.

Task 1:

Your instructor will give you a site survey form and tell you for which building of the school you have to prepare a site survey. Complete the form and collect all needed information to plan a PV system for the selected building.

Information Sheet 4	Conducting interviews

4 Conducting interviews

The paragraphs below are taken from [Mayfield, 2010, chapter 5, page 79].

One of, if not the most exciting portions, of the overall system installation process is the site survey. Why? Because you get to work with a blank slate (after all, the client shouldn't have another PV system anywhere on his building or property) and create a PV system from the ground (or roof) up.

As the person who performs the site survey, you need to be able to identify any potential trouble spots and the best ways to address the issues they pose from the beginning of the project.

The site survey is generally your one chance to obtain all the required information about the site to create a proposal that works for both you and the client. It's also the only time you can really work with your client to establish his goals and expectations for his PV system before you're too far along in the process.

When you're at a client's house or business to perform a site survey, you must be diligent about collecting the information you need. You don't want to leave out any information that may prove critical for you to provide an estimate and a quality design for your installation crew. Return trips to gather information that should've been collected the first time around do nothing but waste your time and risk making you look less than professional.

The planning and construction of a PV system is generally initiated by a customer's enquiry. As well as the quotation, consultation with the customer is an important and essential step before commissioning the construction of a PV system. In discussion with the customer, the tradesmen should find out about the customer's expectation and wishes.

Competent advice to the customers is vital, as tradesmen are often the first point of contact for questions on solar energy use. As well as technical knowledge concerning structure, function, sizing and the installation of PV systems, they should also possess knowledge about costs/subsidies and the global significance of solar energy use.

The aim is to win the customers as active dialog partners and to answer their questions in a way that is comprehensible for the non-expert. Here it is helpful to use diagrams as explanatory aids.

Four side model

The paragraphs below are taken from www.skepticalscience.com/The-four-sides-model-for-improving-climate-communication.html and adapted from the authors.

A classical way to analyse communication is by the "four sides model" by the German psychology professor and expert on inter personal communication Friedman Schulz von Thun. Let me explain the model in a few words. For simplicity, let's talk about a

'sender' saying something and a 'receiver' who is listening. Schulz von Thun postulates that there are four channels that we communicate on simultaneously, namely:

- **Fact channel:** the facts communicated
- **Self-revealing channel:** what the sender says about him or herself
- **Relationship channel:** what is being said about the relationship
- **Appeal channel:** what the sender wants the receiver to think or do

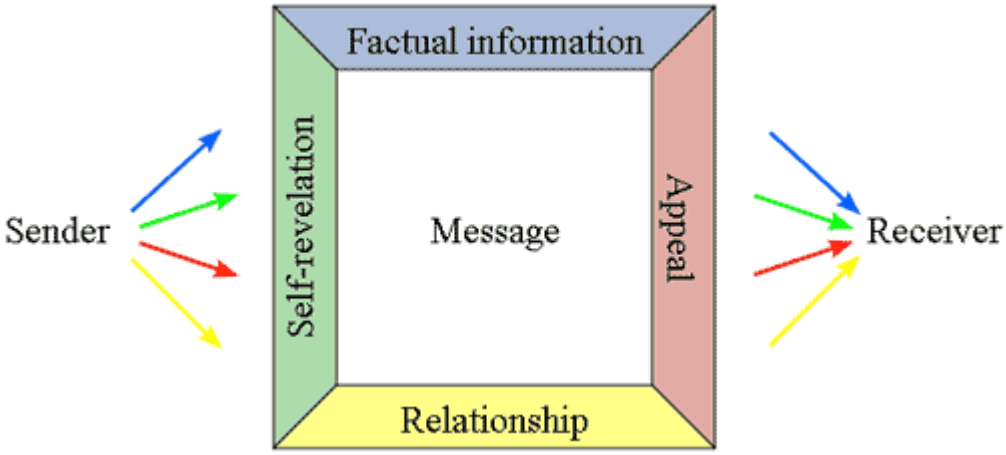


Table 13: Fours side model communication model

Simply speaking, in good communication, we neither have a mix of channels (sender said something on channel A, but receiver listened on channel B), nor a misunderstanding of the content communicated in each channel. Of course, the channels have two ends: four mouths and four ears! That means that the sender speaks in all four channels simultaneously and the receiver hears with all four ears at the same time.

Let's look at an example from debating about sceptic arguments. Imagine you're saying: "The earth is dramatically heating, that's obvious." Depending on how you're saying this and the context, the listener may be hearing very different things. Maybe you are trying to communicate the Fact channel and would like to quote all the different studies on the earth's heat in the last 100 years. But what if the listener hears "You shouldn't fly!" (Appeal channel) or "I think you are stupid not to know this by now!" (Self-revealing channel). I hope you are getting the point of the model.

Now, how can we avoid this type of miscommunication? A good start is to keep this model in the back of your head and try to communicate clearly in all those channels and follow the following advices:

- Focus on the fact channel and formulate the messages as such (e.g. do not use rhetorical elements like "that's obvious!" or “as you know”). Sceptical Science is a very good role model for this. If you don't know an answer to an argument immediately, defer answering and take your time to research, instead of inadvertently switching to other channels.
- Use "I" sentences, when communicating on the Self-revealing channel. I find this channel less problematic. Let people know when you are concerned about the earth, the future or your children.

- The appeal channel is more complicated. I think that a lot of miscommunication happens on this channel, as the receiver's bad conscience is very likely to hear a lot of things on this channel that were not really said. Maybe you would really love to see the other person immediately starting to be proactive in protecting the climate ASAP, but you can't expect for people to change in a second. My personal feeling is that the facts are so clear that your appeal will come if you succeed communicating the facts.
- Most dangerous is the relationship channel. You should ensure that you do not make any difference in your relationship to your communication partner, whatever the reactions to your arguments are. This is especially important for very close people. If you are soft on the person, you can be hard about the facts. So keep on listening, don't raise your voice unnecessarily, watch your face expressions, fit in a joke at times, and don't mix up other things with the debate (like indicating not going to lunch with a co-worker, because he or she didn't accept what you said about a sceptic argument).

It is difficult to follow the advice given above, because the channels are never so clearly defined and it's complicated to focus on all of these things at once, while discussing the complex matters.

The most important information out of the communication model is only because you (as sender) say something this does not mean that the client (as receiver) understand exactly the same and vice versa. You have to double check facts with questions, and you can use the side survey form to document all details.

Another very important point is that the client and only the clients knows what he wants, and he will tell it to you. Do not make the mistake to move him in another direction, focus on listening. You are the subject matter expert; thus, you can explain to the client what a PV system is and how it works and which one could be suitable for him, but the client makes the decision at the end. Do not try to sell him your idea, understand his idea and develop a concept for him from his idea.

Self-Check - 4	Written Test

Instruction: Follow the below selected instruction

B	For each of the following question choose the best answer and circle the letter of your choice.

N°	Questions and answers	
1	**The four channels of communication according to Schulz von Thun are?**	
	A: Fact channel Self-revealing channel Relationship channel Appeal channel:	B: Telefon Mobil Internet E-Mail
	C: Wifi 3G LTE Modem	D: TV Radio YouTube Netflix

Note: the satisfactory rating is as followed

Satisfactory	1 point
Unsatisfactory	Below 1 point

Answer Sheet

Score = _____

Rating: _____

Name

Date

Information Sheet 5	Conducting assessment within the prescribed time

5 Conducting assessment within the prescribed time

The paragraph below is taken from [Mayfield, 2010, chapter 5, page 79/80] and adapted for Africa by the authors.

You can't conduct a solid site survey without allowing yourself ample time and staying focused. If through preliminary phone or in-person conversations with the client you get a feeling that he'll require extra time, then schedule yourself enough time to answer his questions while leaving enough time to collect the information you need. Speaking of questions, the one you'll hear most often (aside from "What's the average cost?") is "Can I run my fridge/computer/lamps/AC?" Although this can be a difficult question to answer without knowing a number of specifics, you should have an answer for it. You have to be familiar with what a 1 kW PV array can produce in the client's area and how many days a battery bank has to last without sunshine. Figuring out what a 1 kW system can produce means you can easily do the math to adjust the values for your client's site. You even can look for tools, such as the SMA app or the PV Solar online calculator: http://pvsol-online.valentin-software.com. One of the best features of this tool is the ability to vary input factors such as the direction you want your array to point or what tilt angle you want it to have. With just a few mouse clicks, you can run some scenarios and be able to determine the best solution for your site

Normally, we start with a short phone conversation or discussion by email where we can get some general information about the goals of the customer, the site and the current energy requirements. A site visit by the assessor is arranged for at this time.

The site visit takes two to four hours during which you have to make site and usage observations, measurements, and can further discuss goals and options with the client.

Make sure that you complete all questions of the site survey form and that the client gave you all needed information. To understand the wish of the client is crucial, however you should limit the site assessment to max 4 hours.

Self-Check - 5	Written Test

For each of the following question choose the best answer and circle the letter of your choice.

N°	Questions and answers	
1	**How long should a site assessment take?**	
	A – 30 Minutes	B – 2 to 4 hours
	C – 5-6 hours	D – 1 day

Note: the satisfactory rating is as followed

Satisfactory	1 point
Unsatisfactory	Below 1 point

Answer Sheet

Score = _____

Rating: _____

Name

Date