Solar PV System Installation and Maintenance

NTQF Level IV

Learning Guide -12

Unit of Competence	Produce solar PV Installation drawings using Computer Aided Design Software
Module Title	Producing solar PV Installation drawings using Computer Aided Design Software
LG Code	EIS PIM3 M03 LO1 LG12
TTLM Code	EIS PIM4 TTLM 0120v1

LO 1:-Prepare to produce detailed solar PV installation drawings

Instruction Sheet	Learning Guide:-12

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

- Identifying, obtaining and understanding OHS procedures;
- Following established OHS risk control measures and procedures;
- Determining and discussing the extent of the work project;
- Consulting appropriate personnel on the work site;
- Obtaining software tools and equipment needed for the 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, obtain and understand OHS procedures;
- Follow established OHS risk control measures and procedures;
- Determine and discuss the extent of the work project;
- Consult appropriate personnel on the work site;
- Obtain software tools and equipment needed for the 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 Sheets
4. Accomplish the Self-checks

Information Sheet 1	Identifying, obtaining and understanding OHS procedures

1.1 Introduction

This chapter deals with occupational health and safety (OHS), which is also called occupational safety and health (OSH).The following paragraphs were adapted from (Osorio D.)The life cycle of small-scale solar installations includes the following stages:

- Design and planning,
- Fabrication,
- Transportation,
- Installation,
- Integration with the infrastructure,
- Operation and maintenance,
- Dismantling and
- Disposal/recycling.

These stages involve different worker's groups in various types of workplaces and sectors, for example industrial machinery mechanics, electrical engineers, welders, metal workers, electricians, installers of solar energy systems, construction workers, waste management workers, etc. The consideration of OSH aspects across these stages shows that the main hazards hazardous substances, working at height, slips, trips and falls, electric and fire hazards – may therefore have an impact on numerous workers in numerous workplaces. When designing a solar array, it is therefore important to consider OSH over the entire life cycle of the system and to design the system so as to minimise the OSH risks in later stages of the life cycle. Before putting the product on the market, OSH performance testing is also necessary to ensure that the product meet acceptable OSH standards.

The majority of the hazards related to small-scale solar systems are basically known from other industries and can be managed with existing OSH knowledge. However, novel combinations of skills are also required to meet new constellations of hazards and to deal with new products (e.g. PV tiles, meaning that tiles become a source of electrical hazard). The rising demand for small-scale, domestic solar installations may also lead to a skills gap that might be difficult to fill promptly; and may in turn result in workers handling new technologies, or technologies with which they are not familiar, while lacking the adequate training and skills to do so. There are currently no reliable data on work-related accidents linked to solar energy systems. As much of the work in relation to the installation of such systems is done

By self-employed or within the informal economy, collecting data on work-related accidents and diseases is challenging. The workplace risk assessment may also be hampered by a lack of safety and health data available, especially on the broad range of solar technologies and manufacturing processes of photovoltaic cells. The data available on fatal falls from height would indicate that rooftop solar power is several times more dangerous than wind power or nuclear power (0.44 deaths per terawatt hour each year compared with 0.15 and 0.04 deaths respectively).

As the demands for small-scale solar installations increase, the probability of health and safety-related accidents may also be rising. The expansion of the solar sector gives rise to a substantial up scaling of all stages of the technology's life cycle with potential risks for an increased number of people. Once the PV panels reach the end of their life cycle, they will create a huge amount of electronic waste (e-waste) with potential environmental and health impacts. Other life cycle phases of the solar technologies such as construction and maintenance are also affected by up scaling and must be closely monitored with regard to OSH aspects. The hazards of new solar PV technologies (solar cells with organic semiconductors, dye-sensitised cells, thin-film microcrystalline silicon carbide cells, and cells made of nano-materials) are difficult to evaluate since they are still at the laboratory stage of development.

1.2 Identifying OHS procedures

In most countries, there are well defined OHS rules and regulations in the form of OHS acts and is normally governed by the department that handles labour. It is quite important to identify the areas covered, obtaining and then understanding the procedures in order to effectively implement it. In terms of the installation of a system, the following OHS procedures may be applicable:

- Working at heights
  - ✓ Ladders
  - ✓ Scaffolding
  - ✓ Fall protection
- Electrical safety (AC and DC)
  - ✓ Electrical shock;
  - ✓ Electrical burns;
  - ✓ Fire risks
- Chemical safety (e.g. Acid based Batteries)
- PPE
  - ✓ Eye and ear protection
  - ✓ Headgear
  - ✓ Appropriate clothing and shoes
- Lifting of heavy objects
- First Aid

1.3 Obtaining OHS procedures

Before commencing any work, one should obtain the relevant OHS regulations from the local department dealing with labour issues. The regulations should be studied to identify which is applicable to the solar installation. A risk mitigation strategy should then be developed that is practical and understandable by all people involved.

1.3.1

Self-Check - 1	Written Test

Instruction: Follow the below selected instruction

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

N°	Questions and answers
1	**Working at heights includes** **A.** Ladders **B.** Scaffolding **C.** Fall protection **D.** all
	True or false:
2	**PV electricity is not dangerous as it is DC?**
	True or false:

Note: the satisfactory rating is as followed

Satisfactory	2 points
Unsatisfactory	Below 2 points

Information Sheet 2	Following established OHS risk control measures and procedures

2.1 Introduction

Solar power installations can be the source of a combination of risks throughout their life cycle. This may be influenced by the following main areas of hazards:

- Exposure to toxic chemicals and metals,
- Electric risks (PV)/burns,
- Working at height, and musculoskeletal disorders.

Psychosocial risks and work organisation issues are also relevant, particularly since a diverse workforce with widely different characteristics, skills and needs may be involved in work with small scale solar energy installations, including sub-contracted workers, migrant workers, illegal workers, new, unskilled entrants into the sector. All operations on small-scale solar power installations require training to recognise the various risks and to take the appropriate safety and health measures.

2.2 Risk Mitigation

In practice, a risk checklist covering relevant risks and mitigations can be a valuable tool on site. The following important issues should be addressed:

- Are managers and workers aware of the potential risks related to solar power installations and committed to their prevention?
- Has the organisation adopted a practical participative approach (worker involvement) to problem-solving?
- Has appropriately trained personnel undertaken comprehensive risk assessments?
- Are all reported cases of accidents and incidents being managed?
- How is the effectiveness of the measures taken to prevent risks caused by solar power installations across their life cycle being evaluated and monitored?

This following checklist is not intended to cover all the risks of every workplace but to help start the hazard identification process and identify and put relevant prevention measures into practice. A checklist is only a first step in carrying out a risk assessment. Further information or expert help may be needed to assess more complex risks. You should adapt the checklist to your particular sector or workplace and to the characteristics of the Workforce as specific workers' groups may have specific needs. Some extra items may need to be covered, or some points omitted as irrelevant. For practical and Analytical reasons, a checklist presents problems/hazards separately, but in workplaces they may be intertwined. Therefore, you have to take into account the interactions between the different problems or risk factors identified. At the same time, a preventive measure put in place to tackle a specific risk can also help to prevent the occurrence of another. It is equally important to check that any measure aimed at reducing exposure to one risk factor does not increase the risk of exposure to other factors. The proposed checklist is used by answering the following questions for each area:

- Does the hazard exist at the workplace?
- Are the hazards eliminated, and where not possible controlled to minimise negative influences on the safety and health of all people involved?

Answering 'NO' to one of the following questions indicates a need for improvements to be made in the workplace.

Table 1: Risk Checklist

Manual Handling		Yes	No
1	Is work arranged so that manual handling operations, such as lifting and carrying operations and repetitive manual handling of even lighter items are avoided and, where not possible, reduced to the minimum?		
2	Have workers been trained on safe manual handling techniques?		

Installation, maintenance, decommissioning		Yes	No
1	Is information on the solar system, the electrical installation and the building that is required to perform the work safely available to the workers?		
2	Is training provided on safe working procedures?		
3	Is there sufficient cooperation, communication and exchange of		

	information among the different actors involved (for example building owner, site manager and the workers) in order to allow the safe performance of the work, especially if different companies and sub-contractors are involved?		
4	Are workers involved in the workplace risk assessment?		

Working at height, slips and trips, falls		Yes	No
1	Can work at height in general, and in particular on slanting roofs be avoided?		
2	When work at height is necessary, are there mobile elevating work platforms (MEWPs) and scaffolding available if needed?		
3	When ladders are used to reach the place of work at height, has the appropriate ladder been chosen and is it used safely?		
4	When roof work is necessary, has the condition of the roof been assessed to ensure that the roof is dry and free from slipping and tripping hazards such as moss, snow, ice, vent pipes, equipment lying around, etc.?		
5	In the case of skylights or holes/cavities, are they safeguarded?		

Electricity-related risks (PV), burns/scalds		Yes	No
1	Are only qualified persons allowed to work on electrical equipment?		
2	Is a safe distance kept for workers, tools and materials from high voltage power lines during maintenance/repair activities?		
3	Is the work area at the power inverter dry?		
4	Are workers aware that low voltages can cause surprise shocks and thereby falls?		
5	Are workers aware that small amounts of sunlight can produce a voltage potential in the PV system and shock or arc-flash hazards?		
6	Are workers provided with suitable PPE when risk reduction measures at source are not sufficient?		

Hazards of musculoskeletal disorders (MSDs)		Yes	No
1	Is work arranged so that manual handling operations, such as lifting and carrying are avoided and, where not possible, reduced to the minimum?		
2	In case lifting or carrying operations are necessary, including lifting tools, equipment and material from the ground to the roof and vice-versa, are mechanical aids provided?		
3	Is the work area at the power inverter dry?		
4	In case a crane is used, are workers operating the crane properly trained?		
5	Are measures in place to avoid or, when not possible, to reduce to a minimum the need for workers to perform repetitive movements or to work in sustained postures?		
6	Are measures in place to avoid or, when not possible, reduced to a minimum the need for workers to work frequently or in prolonged kneeling or squatting positions?		

Electricity-related risks (PV)		Yes	No
1	Are only qualified persons allowed to integrate the system to the mains?		
2	Is the local electric power company contacted to turn the power off when connecting/separating the PV plant to/from the grid or working within a certain distance of high voltage power lines?		
3	Are workers accompanied always by at least one colleague when working on electrical systems, thereby eliminating lone working?		
4	Are workers aware of PV shingles bearing electric risks in case they are damaged e.g. during cleaning activities?		

1.4

Self-Check - 2	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	Are only qualified persons allowed to integrate the system to the mains?
	True or False
2	Are workers aware of PV shingles bearing electric risks in case they are damaged
	True or False
3	Are managers and workers aware of the potential risks related to solar power installations and committed to their prevention
	True or False

Note: the satisfactory rating is as followed

Satisfactory	3 points
Unsatisfactory	Below 2 points

Information Sheet 3	Determining and discussing the extent of the work project

3.1 Introduction

Before generating PV installation drawings, the extent of the work project needs to be determined. A good scope of work avoids some of the biggest project management traps, such as:

- Confusion, miscommunication, and disputes over scope
- Misinterpretations of expectations and needs
- Discrepancies between what was said and the need for expensive rework

3.2 Extent of the work

The idea with determining the extent or scope of the work is to ensure that everyone know exactly what they should be doing. It should include:

- Project objectives
- Schedule/Milestones
- Individual Tasks
- Deliverables
- Expected Outcomes
- Terms, conditions, and requirements

In terms of producing solar installation drawings, the requirements can be a simple single line diagram (SLD) or a much more comprehensive set of drawings including civil engineering work, construction drawings, architectural drawings, module layout and string layout drawings etc. It can also include shading analysis and system simulations.

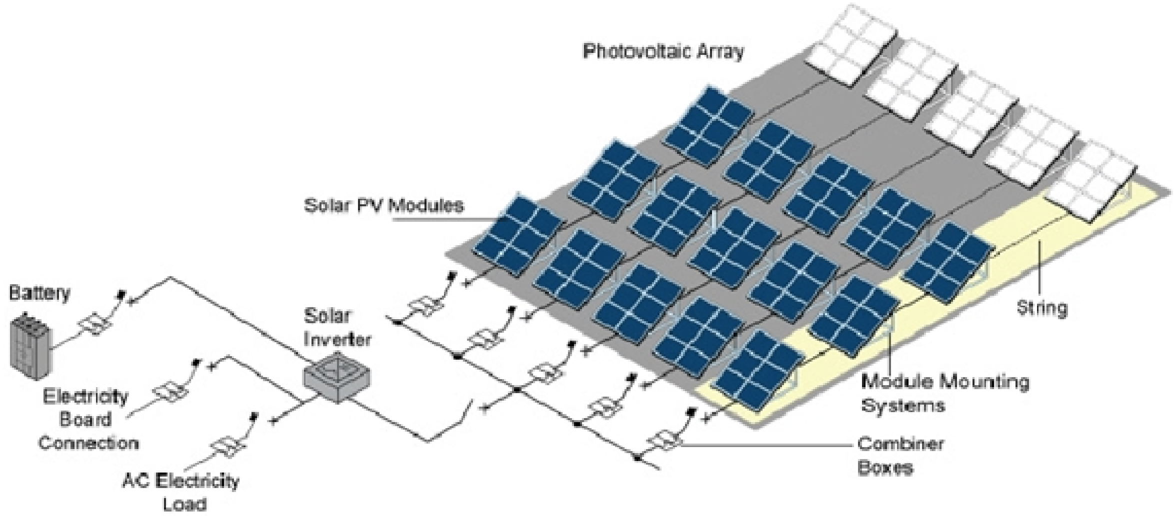


Figure 1: Site layout drawing (https://www.researchgate.net/)

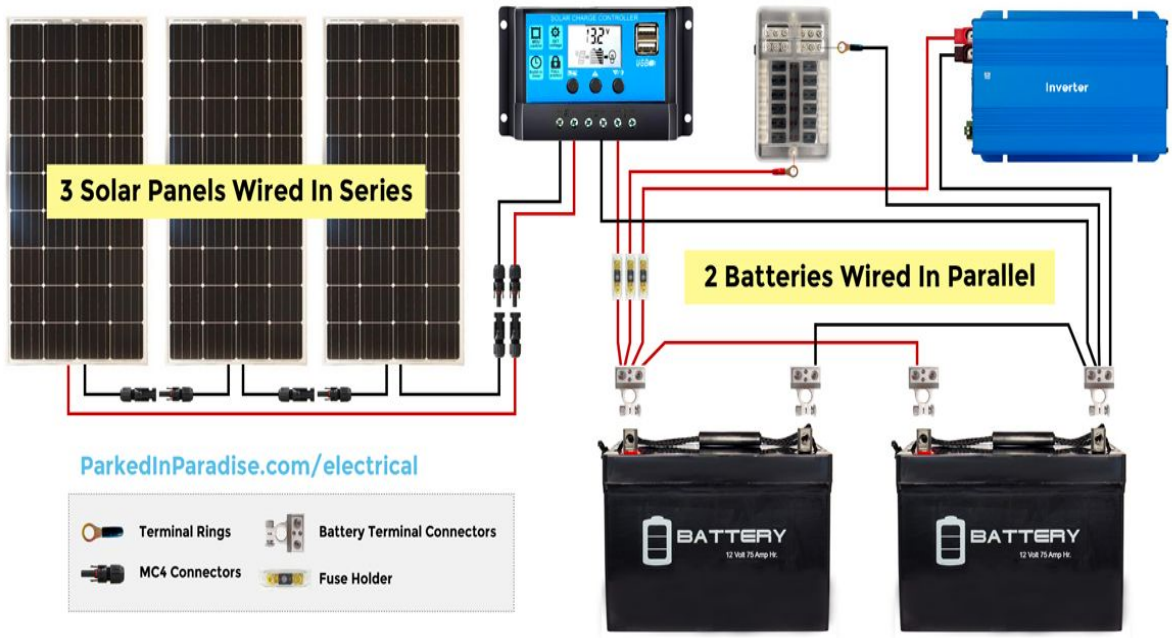


Figure 2: Wiring Connection diagram (pinterest)

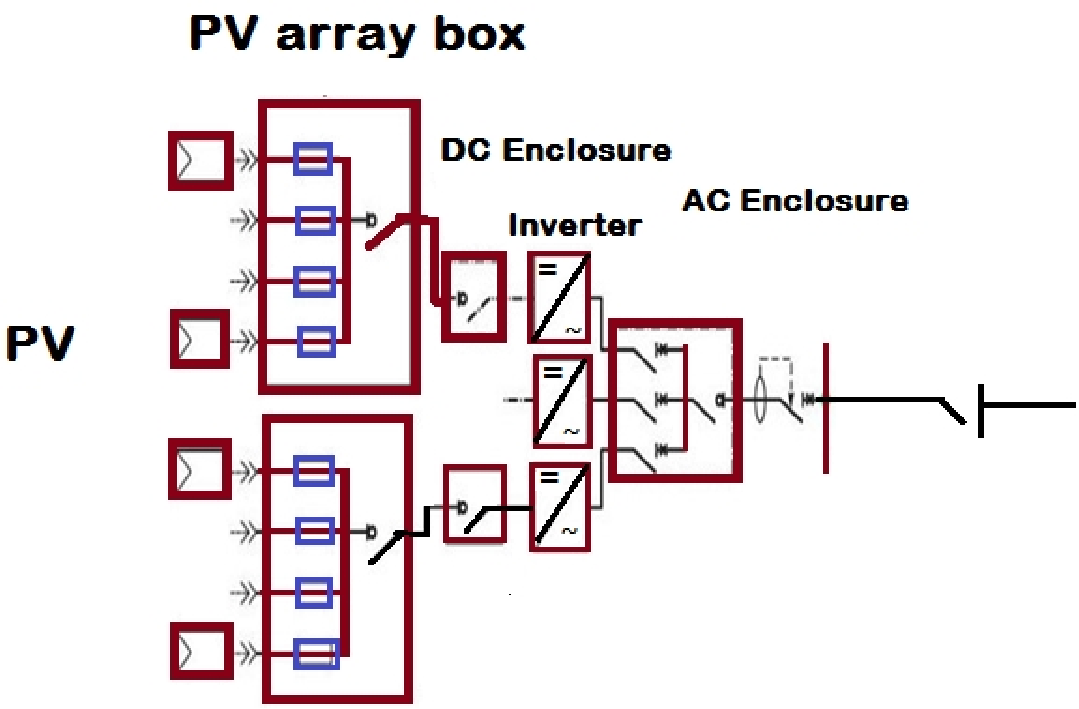


Figure 3: Single Line Diagram (https://www.indiamart.com/)

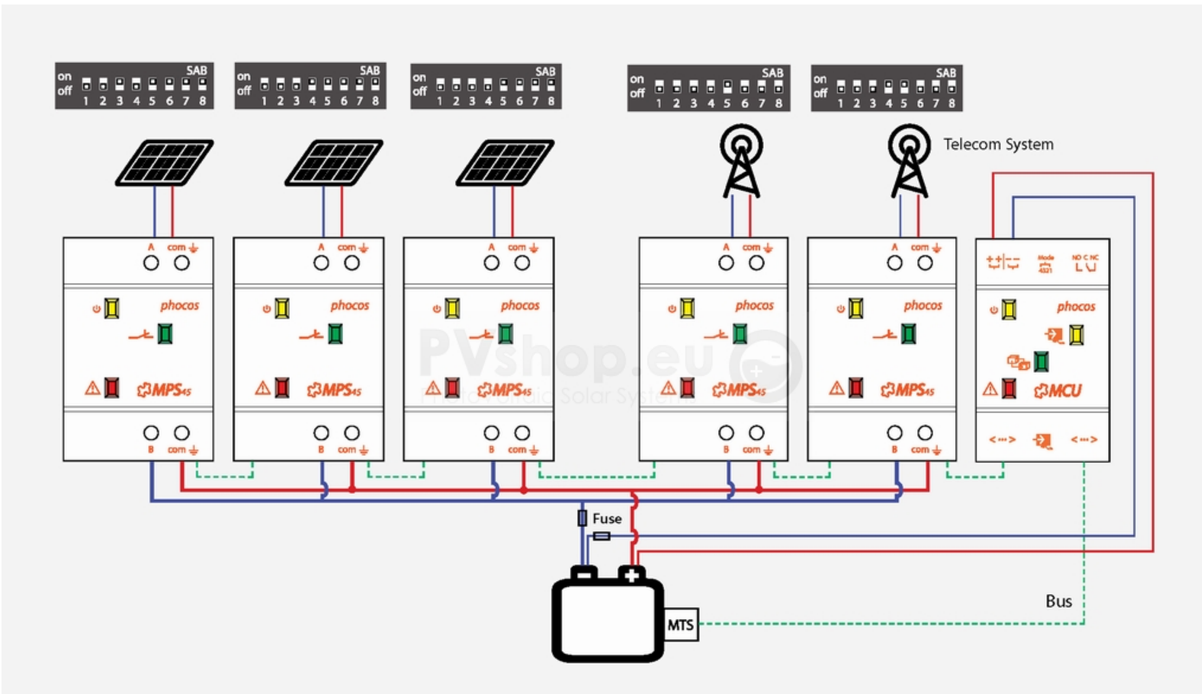


Figure 4: Off Grid Solar System Single Line Diagram

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	**A good scope of work avoids confusion, miscommunication, and disputes**
	True or false:
2	**The scope of work should include what types of drawings are required?**
	True or false:

Note: the satisfactory rating is as followed

Satisfactory	2 points
Unsatisfactory	Below 2 points

4.1 Introduction

A **consultant** (from Latin: *consultare* "to deliberate") is a professional who provides expert advice in a particular area such as business, education, law, regulatory compliance, human resources, marketing (and public relations), finance, health care, engineering, science, security (electronic or physical), or any of many other specialized fields. A consultant is usually an expert or an experienced professional in a specific field and has a wide knowledge of the subject matter. The role of consultant outside the medical sphere (where the term is used specifically for a grade of doctor) can fall under one of two general categories:

Figure 5: Consultation

- **Internal consultant**: someone who operates within an organization but is available to be consulted on areas of their specialization by other departments or individuals (acting as clients); or

- **External consultant**: someone who is employed externally to the client (either by a consulting firm or some other agency) whose expertise is provided on a temporary basis, usually for a fee. Consulting firms range in size from sole proprietorships consisting of a single consultant, small businesses consisting of a small number of consultants, to mid- to large consulting firms, which in some cases are multinational corporations. This type of consultant generally engages with multiple and changing clients, which are typically companies, non-profit organizations, or governments.

By hiring a consultant, clients have access to deeper levels of expertise than would be financially feasible for them to retain in-house on a long-term basis. Moreover, clients can control their expenditures on consulting services by only purchasing as much services from the outside consultant as desired. Consultants provide their advice to their clients in a variety of forms. Reports and presentations are often used. However, in some specialized fields, the consultant may develop customized software or other products for the client. Depending on the nature of the consulting services and the wishes of the client, the advice from the consultant may be made public, by placing the report or presentation online, or the advice may be kept confidential, and only given to the senior executives of the organization paying for the consulting services.

Figure 6: Internal versus External Consult

4.2 Common types

In the business, and as of recently the private sphere, the most commonly found consultants are:

- **3D consultants** who are specialists in the field of 3D scanning, printing, modelling, designing, engineering, building, and everything that has to do with the three dimensions.

- **Business transformation consultants** are specialists in assisting business stakeholders to align the strategy and objectives to their business operations. This may include assisting in the identification of business change opportunities and capability gaps, defining solutions to enable required business capability (this may include technology, organisational, or process solutions) and supporting the implementation of these changes across the business.

- **Engineering consultants** provide engineering-related services such as design, supervision, execution, repair, operation, maintenance, technology, creation of drawings and specifications, and make recommendations to public, companies, firms and industries.
- **Educational consultants** assist students or parents in making educational decisions and giving advice in various issues, such as tuition, fees, visas, and enrolling in higher education.
- **Human resources (HR) consultants** who provide expertise around employment practice and people management.
- **Immigration consultants** help with the legal procedures of immigration from one country to another.
- **Internet consultants** who are specialists in business use of the internet and keep themselves up-to-date with new and changed capabilities offered by the web. Ideally internet consultants also have practical experience and expertise in management skills such as strategic planning, change, projects, processes, training, team-working and customer satisfaction.
- **Information-technology (IT) consultants** in many disciplines such as computer hardware, software engineering, or networks.
- **Interim managers** as mentioned above may be independent consultants who act as interim executives with decision-making power under corporate

policies or statutes. They may sit on specially constituted boards or committees.

- **Marketing consultants** who are generally called upon to advise around areas of product development and related marketing matters including marketing strategy.

- **Process consultants** who are specialists in the design or improvement of operational processes and can be specific to the industry or sector.

- **Public-relations (PR) consultants** deal specifically with public relations matters external to a client organization and are often engaged on a semi-permanent basis by larger organizations to provide input and guidance.

- **Performance consultants** who focus on the execution of an initiative or overall performance of their client.

- **Property consultant** advises property investors, buyers or sellers about pros and cons while investing in a property.

- **Sales consultants** who focus on all levels of sales and marketing for the improvement of sales ROI and moving share from competition.

- **Strategy consultants** (also known as management consultants) working on the development of an improvement to organizational strategy alongside senior management in many industries.

4.3 Personnel to consult

The following personnel can assist in getting the final set of drawings as accurate as possible:

- Construction team
  - ✓ Site layout
  - ✓ Trenches
  - ✓ Panel mounting structures

- Electrical installation team
  - ✓ Module and string layouts
  - ✓ Wiring
  - ✓ Safety devices
  - ✓ Equipment layouts
- Commissioning team
  - ✓ Final connections

Once all aspects of the installation have been discussed, the final as-build drawings can be created.

Self-Check - 4	Written Test

Instruction: Follow the below selected instruction

No	A		B
1.	3D consultants	A.	specialists in assisting business stakeholders
2.	Business transformation consultants	B.	specialists in the field of scanning, printing, modelling, designing,
3.	Engineering consultants	C.	assist students or parents in making educational decisions
4.	Educational consultant	D.	provide engineering-related services
5.	Immigration consultants	E.	specialists in business use of the internet and keep
6.	Internet consultants	F.	help with the legal procedures

Note: the satisfactory rating is as followed

Satisfactory	4 points
Unsatisfactory	Below 3 points

Information Sheet- 5	Obtaining software tools and equipment needed for the work

5.1 Introduction

Fundamentally, computer-assisted drafting is the use of computer technology for design, in effect replacing manually drafted work with an automated program. Solar drafting includes a wide range of professional disciplines as viewed from an engineering perspective, including: Electrical, Mechanical, Structural, and Architectural as some of the key players. Drafting services provide detailed diagrams and drawings of designs that span more simple systems to those which are highly complex.

Solar array layouts, detailed roof diagrams, residential roof mounts, commercial ground mounts, carports, and solar farms are all part of the designs we draft into two and three dimensional information. As simple as it may sound, in order to create an effective solar powered system, the direction of the sun is a key consideration that must also be accounted for. A powerful tool that solar drafting offers is 3D shading analysis and Sol metric calculations which allow for the proper positioning of solar panels, adding one more time-saving benefit to the long list of CAD functionality.

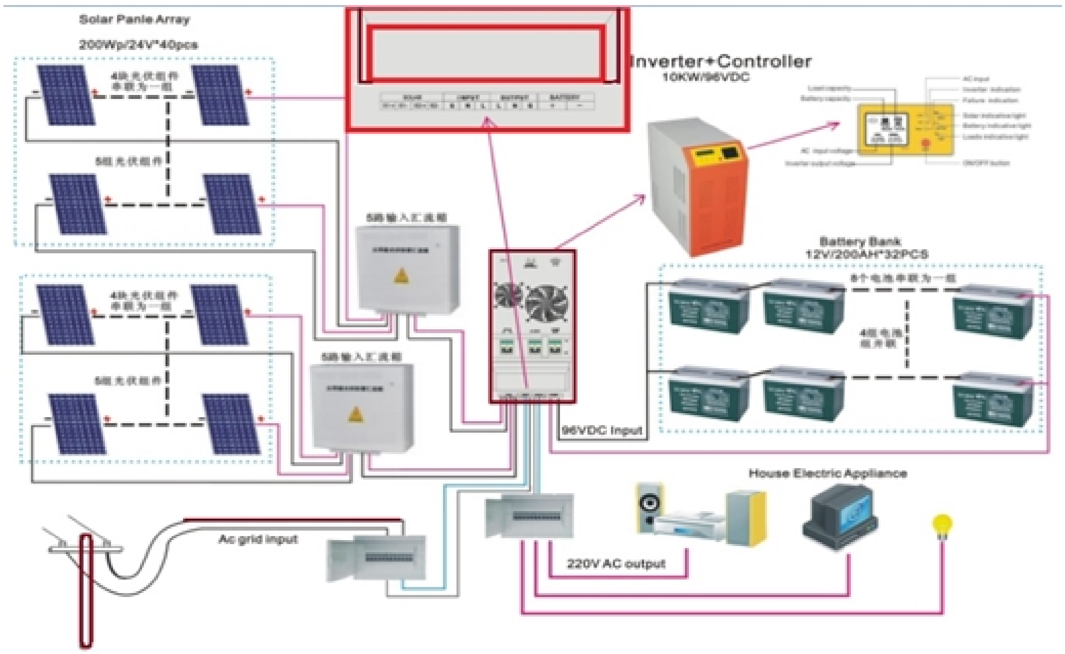
The ultimate goal of CAD is to enable efficient installation for our clients, making their customers' experience easy and smooth. Installers benefit greatly from having solar CAD because they can approach a project with an idea about how the solar array will be laid out, while also having access to dimensions. A critical component of computerized drafting is a quick turnaround for measuring energy output of a particular solar project thanks to the speed upon which a project may be simulated. This critical information can add precious value to your proposal for your clients.

5.2 Types of Drawings

There are many software tools that can be used in the production of drawings. These tools also vary in price from free to very expensive. There are in essence the following types of drawings that generally can be produced for a small off-grid PV system:

5.2.1 Single Line Diagrams (SLD's) for the electrical layout;

These diagrams indicate the main components and their connection to each other using single lines. A SLD is a simple way to represent the whole system and is used to get a good understanding of how everything fits together. A SLD does not indicate the actual connections e.g. + and – wires etc.



System simplified wiring diagram

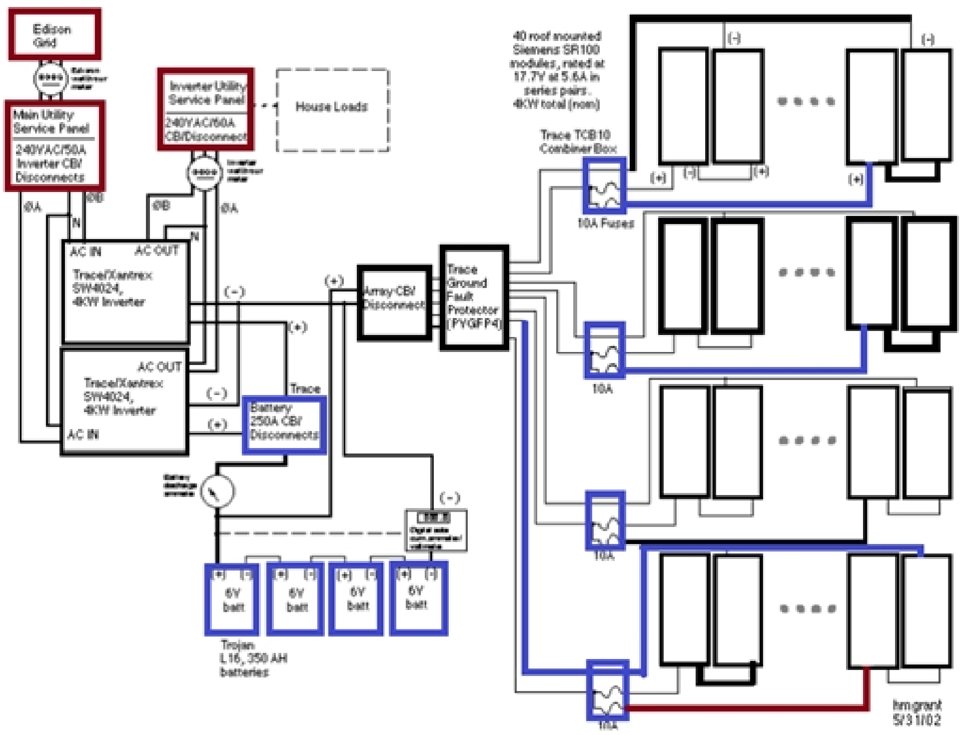


Figure 7: SLD example

The SDL above was prepared for a 14.31 KWp off-grid solar system installed in Karanda, Zimbabwe. One can read the following information in this diagram:

Inverter/battery

3 x 5kW/48Volt inverters are connected to a 1000Ah (C5), 2Volt x 24 cell lead acid battery bank. The inverters connect on AC separately to a source and to a load. Each inverter will be given one phase from the building's main electrical supply system. The theatres are supplied via their individual DB-boards from the inverters AC output. A change over switch in the Distribution board allows for the reconnection to the mains supply in case of an inverter/battery system failure.

Solar MPPT

The inverter has an integrated MPPT that controls the solar panels output to the Batteries.

Figure 8:MPPT

Solar array

The 14.31kWp off-grid solar system consists of 54 x 265Wp solar modules split up on two generators: 18 x 265Watt solar panels on the West roof and 36 x 265Watt solar panels on the East facing roof. Each inverter's MPPT connects to an individual array of 16 x 265Watt solar panels.

The 54 solar panels are connected in strings of 3 x 265Watt solar panels. Two strings are paralleled with y-Connectors directly on the roof. Therefore 6 panels are connected together on the roof and connect to a 32A fuse holder with a 25A fuse within the PV/DC combiner box. The combiner box connects via the surge protection device and the DC disconnect switch to the DC/MPPT input terminal of the inverter.

5.2.2 Wiring diagrams

A wiring diagram is a more comprehensive diagram showing all the wiring connections. These diagrams are used as a guide for the physical wiring of the equipment. Wiring diagrams often use images of the actual equipment to indicate the exact wiring positions.

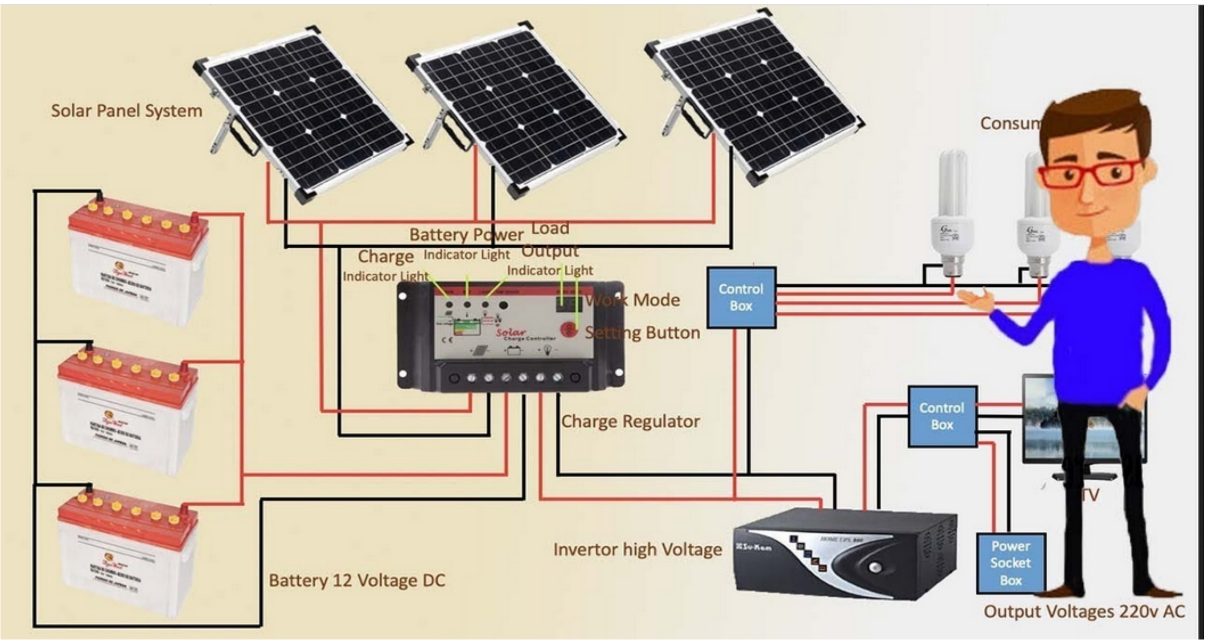


Figure 9: Wiring diagram example (https://paintingvalley.com/)

5.2.3 String layout diagrams

A string layout diagram shows the physical string layout and how modules are connected. This diagram is a layout drawing on which a length of string is utilized to record the extent as well as the pattern of movement of operators, materials and machines working in a limited area during a certain period of time It is a special type of flow diagram generally drawn when the paths are many and repetitive and a flow diagram becomes congested and it is neither easy to trace it nor to understand. The example in fig 8 was created with PVSOL software and shows two strings of 7 modules all going into the roof at the same point.

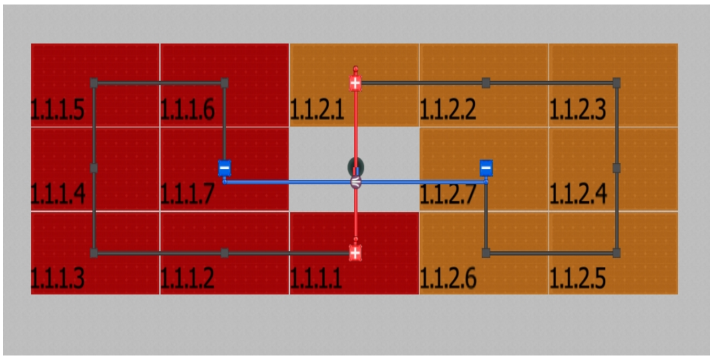


Figure 10: String layout example (PVSoL software)

5.2.4 Roof dimension diagrams

These roof dimension diagrams show the actual mounting position and sizes of the modules. It can be used by the installation team to position the modules correctly.

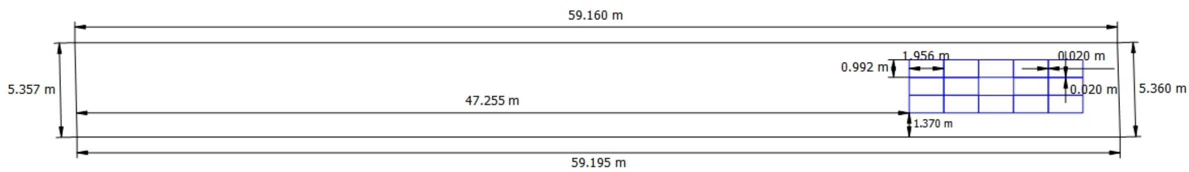


Figure 11: Roof layout diagram (PV SoL Software)

5.2.5 Architectural drawings

Architectural drawings are mainly used to visualise the end result for the client. It generally shown the appearance of the modules on the client's roof and may show trees and other objects. The example in Figure 12 shows an architectural drawing created using PVSOL software.

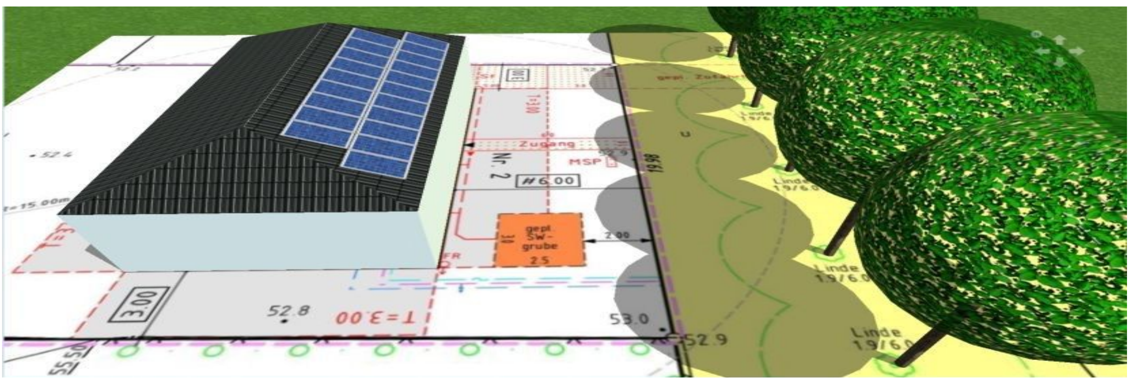


Figure 12: Architectural drawing (PVSoL)

5.2.6 Shading Analysis

Shading analysis drawings can assist in the correct placing of modules to minimise shading losses. The example in Figure 13 shows a shading analysis done using PVSOL software. It shows the percentage loss due to shading per year for each module. One can then move the modules to find a position less affected by shading or alternatively remove shading objects.

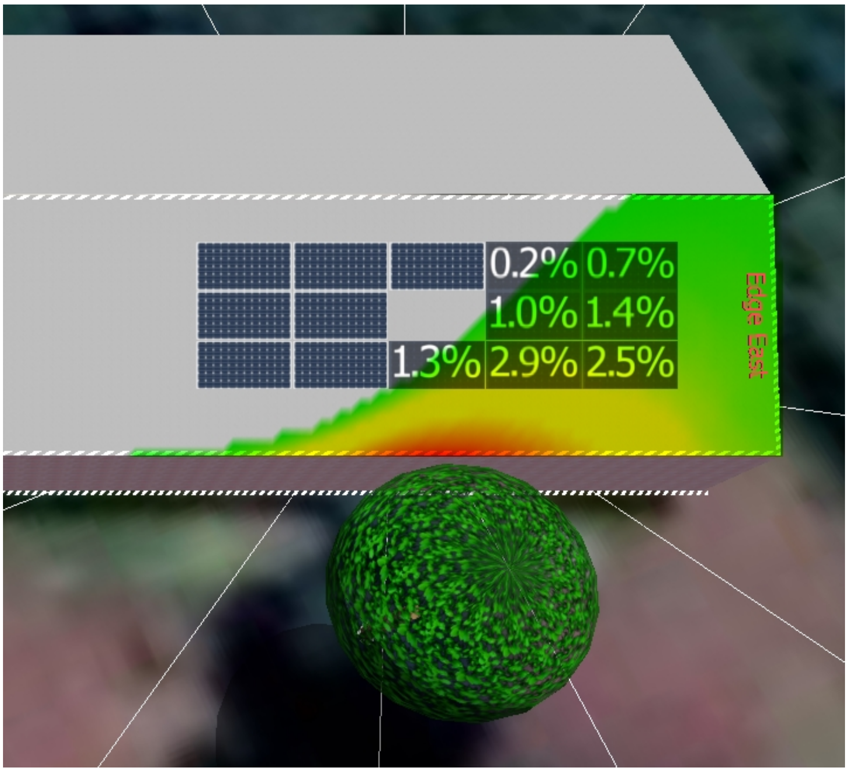


Figure 13: Shading Loss (PVSoL software)

5.2.7 Site layout diagrams

These diagrams show the physical site layout. It can be a simple diagram as shown in Figure 14 or a much more complex one shown in Figure 15. A site diagram shows the position of the main equipment like modules, inverters and batteries, DB boards etc. It can also show the path of the AC and DC cables.

Site Drawings

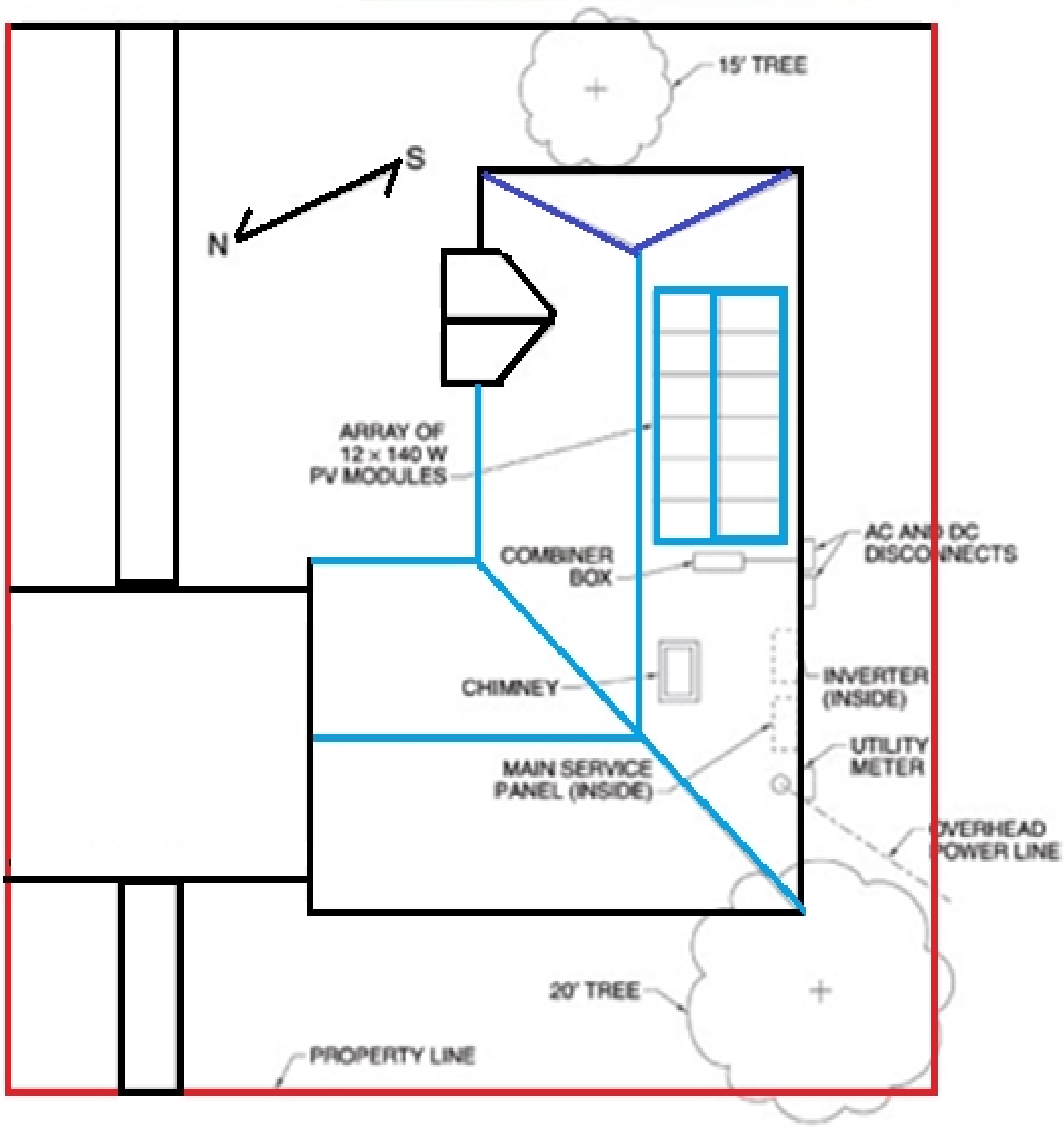


Figure 14: Simple site layout diagram (https://www.thesolarplanner.com/)

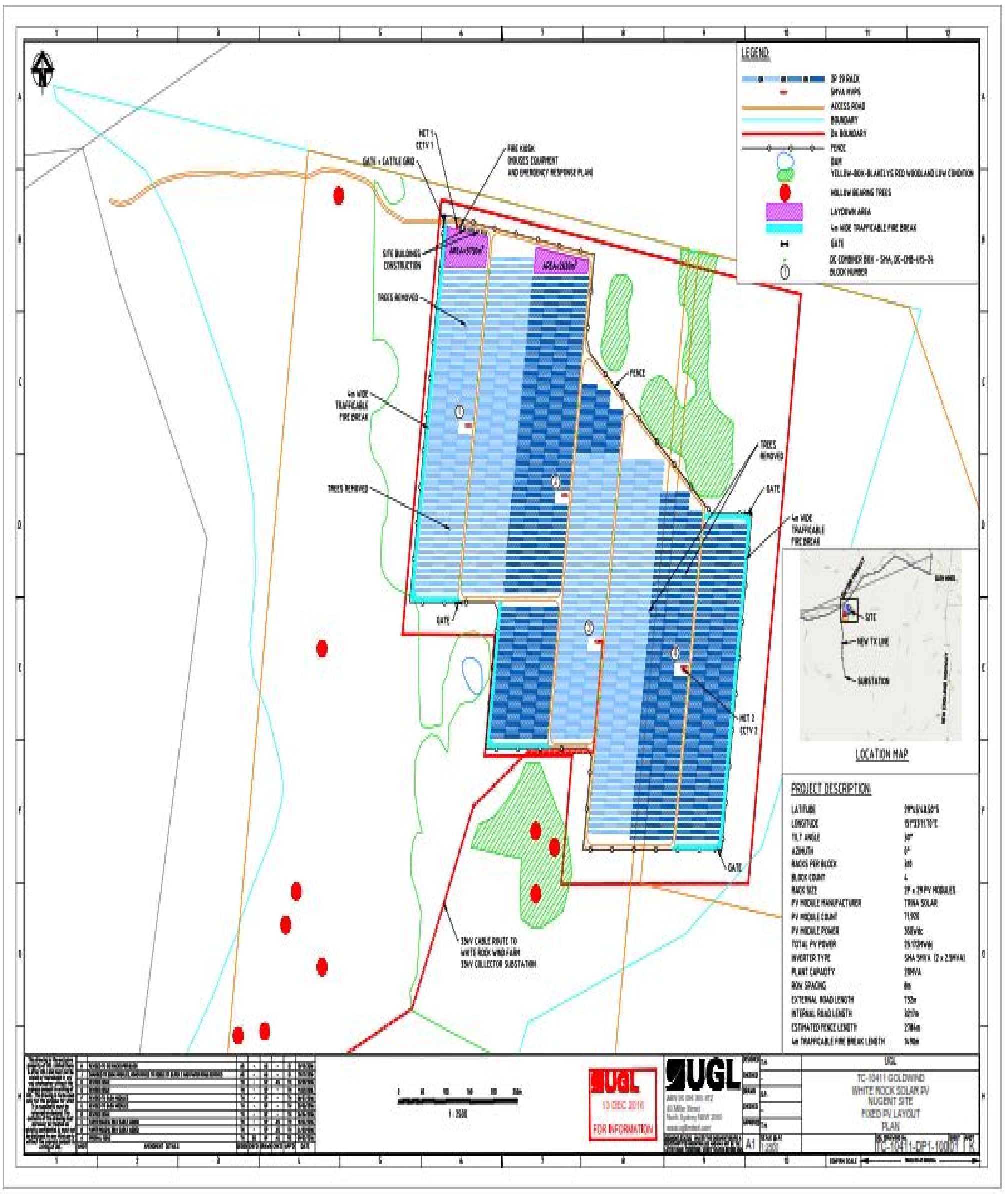


Figure 15: More complex site layout (http://whiterocksolarfarm.com/)

5.3 PV Design and CAD Software

There are many different pieces of software available to perform the functions mentioned in the previous section. Selecting the right software package can be a daunting task as they differ significantly in functionality, ease of use and price. Broadly speaking, the following types of software are available (the examples are not extensive and not meant as recommendations):

- General CAD software to create 2D and/or 3D drawings, often with solar and electrical libraries or extensions;
  - ✓ Schetchup, Corel draw, Visio, Smart draw, Profi cad etc.
- Dedicated electrical design software

- ✓ Auto cad Electrical, ETAB, Solid works electrical etc.
- PV design and simulation software with extensive libraries of PV equipment
  - ✓ PVSyst, PVSoL, Helio scope, SAM etc.
- Supplier specific software, often limited to the supplier’s range of equipment
  - ✓ SMA Sunny Design, Solar Edge Designer, PV Manager and many more
  - ✓ K2 base roof mounting design software
- Geographical Information Systems
  - ✓ PVGIS and NASA’s Power Data Access Viewer (previously RETSCREEN)

5.4 Selecting Software

For small off-grid systems, it is generally not required to do extensive CAD drawings. Often a string layout, roof layout and SLD or wiring diagram will be sufficient. For larger systems, more comprehensive drawings may be required. Often, more than one package may be required to get full required functionality. The software selected is probably a personal choice based on the functionality required, the price and the ease of use. It can be beneficial to spend some time and try out software before buying. Most software suppliers have trial versions of their software that can be used free for a period of time, albeit with some limitations.

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Self-Check - 5	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	The ultimate goal of CAD is to enable efficient installation for our clients
	True or false:
2	Solar MPPT inverter has an integrated that controls the solar panels output to the Batteries.
	True or false:
3	Single Line Diagrams (SLD's) These diagrams indicate the main components and their connection to each other using single lines.
	True or false:

Note: the satisfactory rating is as followed

Satisfactory	5 points
Unsatisfactory	Below 5 points

Solar PV System Installation and Maintenance

NTQF Level IV

Learning Guide -13

Unit of Competence	Produce solar PV Installation drawings using Computer Aided Design Software
Module Title	Producing solar PV Installation drawings using Computer Aided Design Software
LG Code	EIS PIM3 M03 LO2 LG13
TTLM Code	EIS PIM4 TTLM 0920v1

LO 2:- Produce detailed solar PV installation drawings

Instruction Sheet	Learning Guide:-13

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

- Following OHS risk control measures and procedures;
- Determining the types of design detail for solar installation drawings and layouts;
- Interpreting technical data of system components;
- Using software tools for producing detailed drawings;
- Checking detail drawings for accuracy;
- Selecting methods for dealing with unexpected situations.

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

- Follow OHS risk control measures and procedures;
- Determine the types of design detail for solar installation drawings and layouts;
- Interpret technical data of system components;
- Use software tools for producing detailed drawings;
- Check detail drawings for accuracy;
- Select methods for dealing with unexpected situations.

Learning Instructions:

1. Read the specific objectives of this Learning Guide.
2. Follow the instructions described below.
3. Read the information written in the information Sheets
4. Accomplish the Self-checks

Information Sheet 1	Following OHS risk control measures and procedures

1.1. Introduction

Before working on site, it is important to do a risk assessment and define a mitigation strategy for all the risks. See LO1.

- **Risk Assessment**

  The following risks are associated with working on a solar installation site:

  - ✓ Fall risk
  - ✓ Electrical shock risk;
  - ✓ Electrical burn risk;
  - ✓ Chemical burn risk;
  - ✓ Eye and ear risks due to e.g. tile grinding.
  - ✓ Lifting of heavy equipment.

1.2. Risk Mitigation

Risk mitigation can be defined as taking steps to reduce adverse effects. There are four types of risk mitigation strategies that hold unique to Business Continuity and Disaster Recovery.The risks mentioned in LO1 can be mitigated as follows:

- **Fall risk**
  - ✓ Use fall protection equipment e.g. harnesses
  - ✓ Make sure ladders are secure and in good working condition
  - ✓ Ladders should be able to carry the weight of a person
  - ✓ Make sure that no work is done on wet roofs

- **Electrical shock risk**
  - ✓ Only qualified personnel to work on the electrical installation
  - ✓ Follow tag and lockout procedures
  - ✓ Remember PV modules are producing power when the sun shines.
  - ✓ Wear the correct PPE
  - ✓ Use appropriate, insulated tools
  - ✓ Use eye protection and electrical gloves

- **Electrical burn risk**
  - ✓ The same principles to electrical shock apply

- **Chemical burn risk**
  - ✓ Wear appropriate PPE
  - ✓ Never use equipment that can create a spark close to batteries
  - ✓ Make sure the area is well ventilated
  - ✓ Make sure there is running water available

- Eye and ear risks due to e.g. tile grinding
  - ✓ Wear appropriate eye and ear protection

- Lifting of heavy equipment
  - ✓ Do not attempt to lift heavy equipment alone
  - ✓ Use forklifts etc.
  - ✓ Make sure the surface is stable and not slippery before lifting
  - ✓ Do not lift equipment in heavy winds

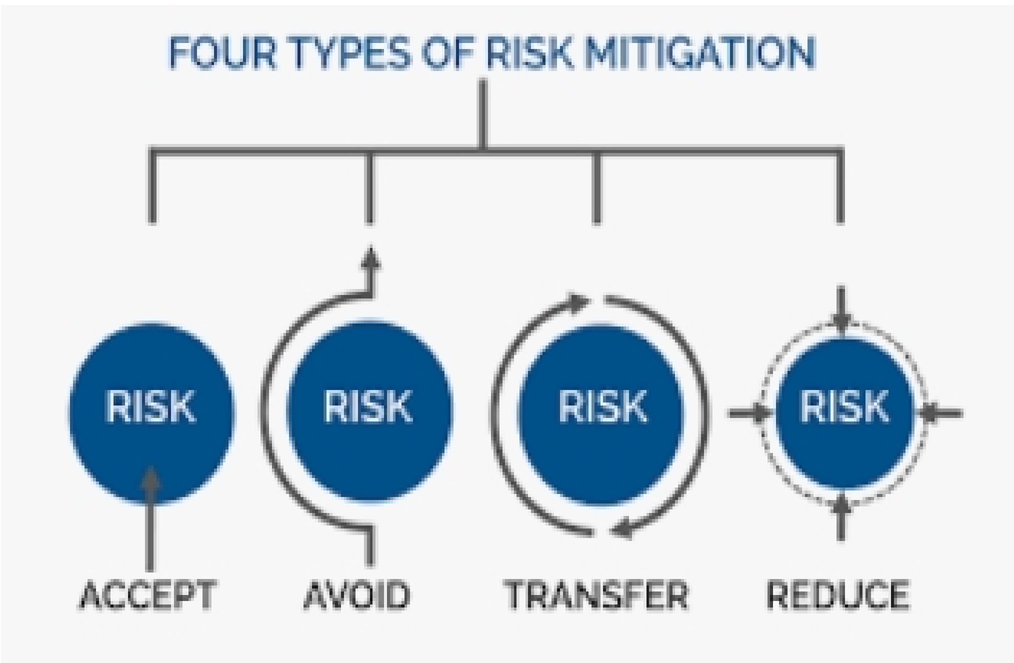


Figure 16: Risk Compliance

Figure 17: Risk management Process

Self-Check - 1	Written Test

Instruction: Follow the below selected instruction

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

N°	**Question and Answer**
1	Make sure the surface is stable and not slippery before lifting
	True or false
2	Do not attempt to lift heavy equipment alone
	True or false
3	Before working on site, it is important to do a risk assessment and define a mitigation strategy for all the risks
	True or false

Note: the satisfactory rating is as followed

Satisfactory	2 points
Unsatisfactory	Below 2 points

Information Sheet 2	Determining the types of design detail for solar installation drawings and layouts

2.1 Introduction

Before any drawings can be made, it is important to determine the level of detail required. In general, there should be enough detail in drawings for the installation team to clearly understand what needs to be done.

2.2 Detail Required

The detail required can be broken into the following categories:

- Overview of the system e.g. a SLD
- Mounting detail e.g. roof layout, size and position.
- Stringing detail e.g. how modules are stringed together (in series and/or parallel)
- Connection detail e.g. how all the equipment connects together.
- Shade analysis detail (can be done with shading analysis software)
- Roof static detail (to determine wind loads etc.)
- Site layout detail (layout of the site indicating arrays, buildings and trenches.

Often, for smaller systems it is not cost and time effective to do extensive drawings. In cases like that, only the bare minimum is done. The most important diagrams are the single line diagram and the site layout detail, as these two documents give a clear indication where and how the system has to be installed. A third important document is the string plan, but this plan could also easily be prepared as a hand drawing.

Self-Check - 2	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	Before any drawings can be made, it is important to determine the level of detail required.
	True and false

Note: the satisfactory rating is as followed

Satisfactory	1points
Unsatisfactory	Below 1 points

3.1 Introduction

In order to make accurate drawings, it is very important to analyse the datasheets and specifically the installation manuals of the equipment to be used. These manuals contain critical sizing, connection and safety information.

3.2 Using technical data

The following sections explain the type of technical data that can be found in the technical manuals of the equipment that will be used. It is important to read the data sheet and installation manual carefully and to ensure that this installation is done according to the specifications in the data sheets and manual. Installations which not follow the specifications will lose warranty!

3.2.1 Mounting Structure

The mounting structure manuals define a number of critical factors that should be taken into account when designing and drawing the system:

- Roof or ground connection type e.g. roof hooks for tile roofs, hanger bolts for corrugated roofs, roof clips for non-penetrating systems etc.
  - ✓ The manuals define how the various mounting systems should be installed e.g. the size of screws, how deep it should penetrate etc.
  - ✓ Torque settings

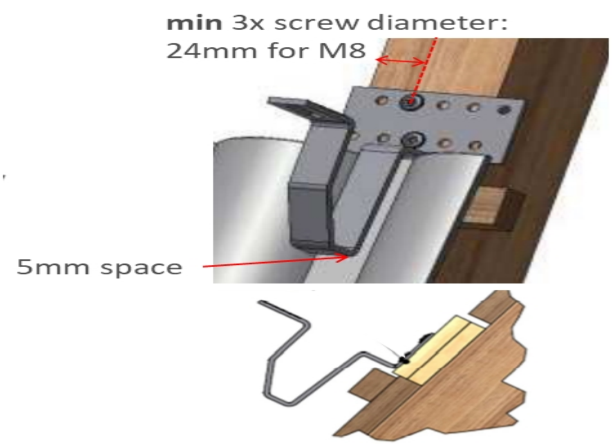


Figure 18: Roof hook mounting

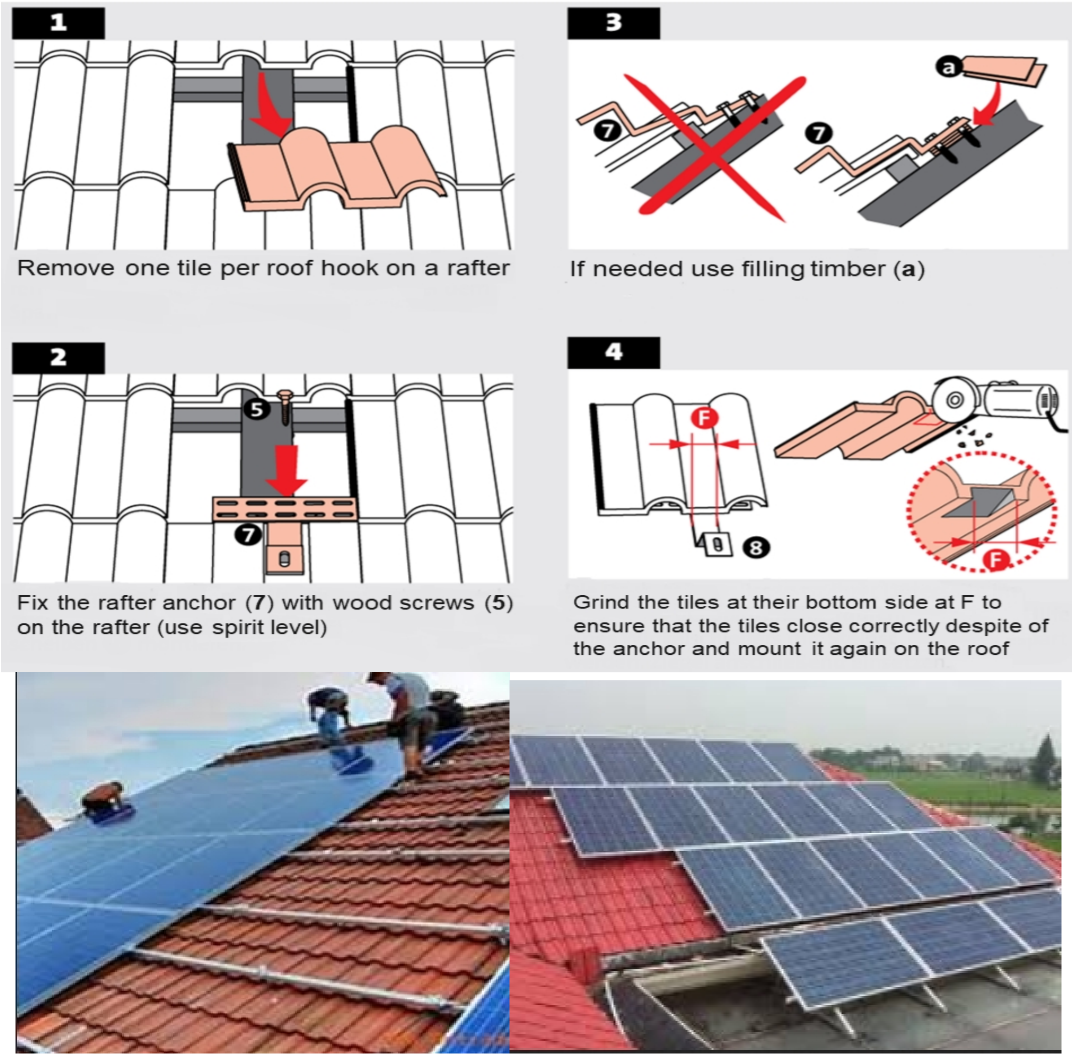


Figure 19: Installing roof hooks instructions

(https://www.solarmango.com/scp/mounting-structure-supporting-the-solar-panels-on-the-ground/)

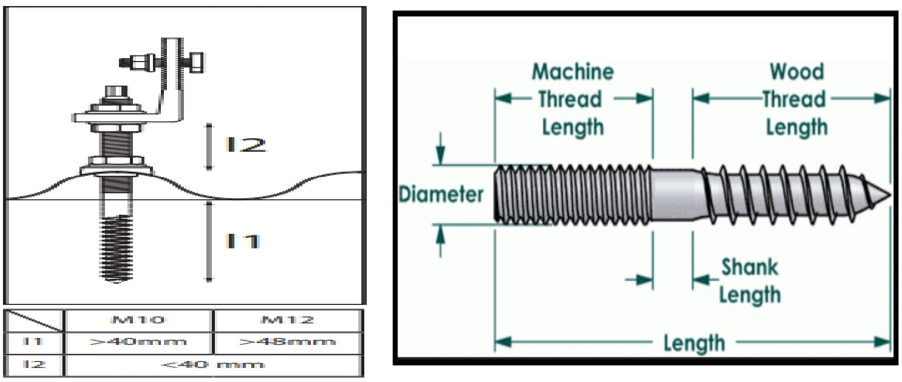


Figure 20: Hanger bolt depth (renusol)

- Rails
  - ✓ Specify the maximum span between roof anchors
  - ✓ Specify the maximum overhang

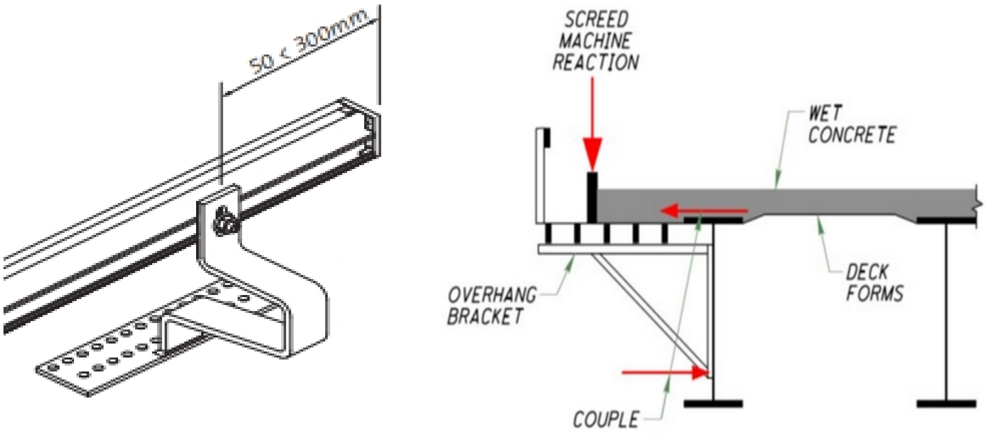


Figure 21: Rail overhangs (Renusol)

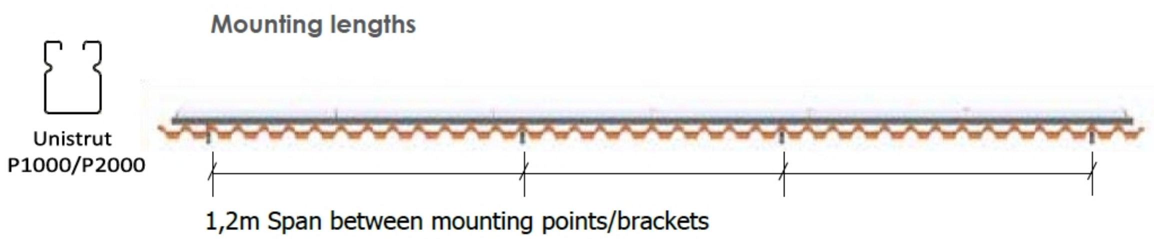
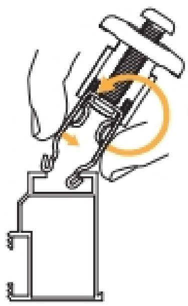
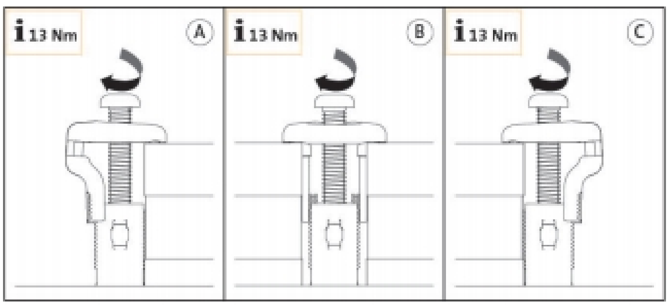


Figure 22: Rail span (Sun mount)

- Clamps
  - ✓ Clamp torque settings





3.2.2 PV Modules

The PV module installation manual typically defines the following:

- Safety measures
- sizes
- Permissible clamping zones, often for different loads
- Grounding
- Maintenance
- Transport and storage

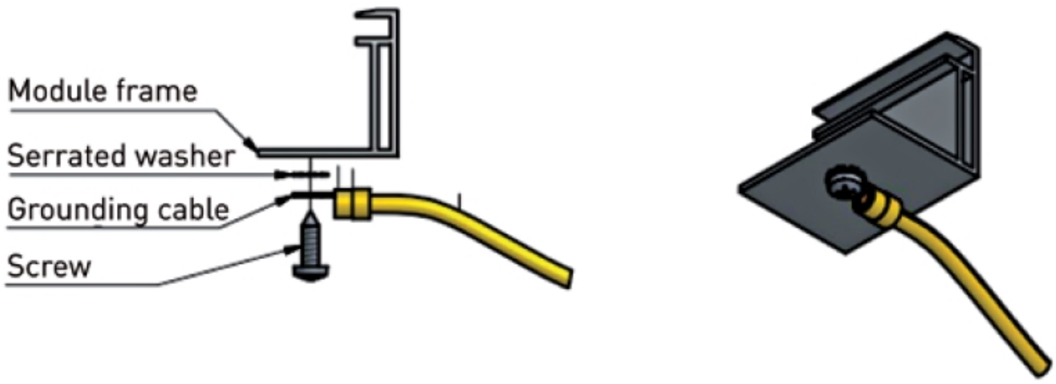
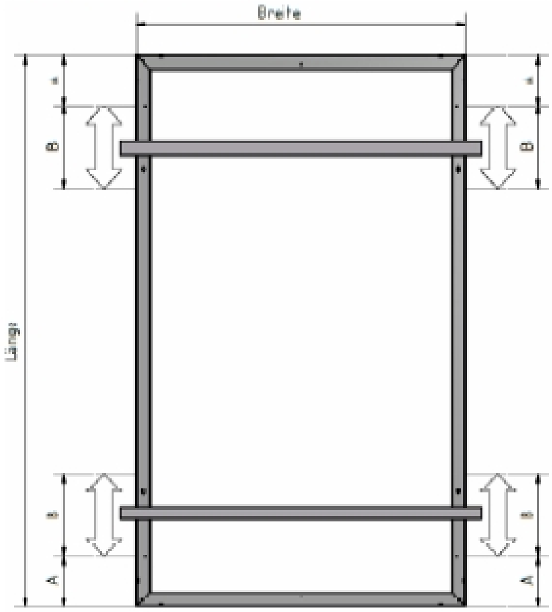
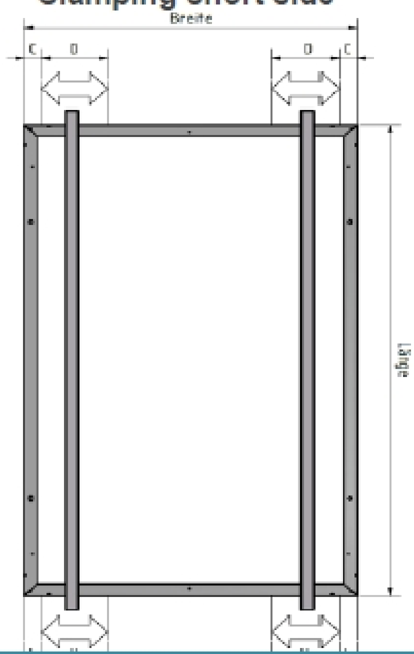


Figure 23: Module grounding (IBC)

Clamping long side



Clamping short side



Module type	A	B	C	D
PolySol ZL/ZX 1639x983x40	210 mm (max 5400Pa)	330 mm (max 5400Pa)	50 mm (max 2400Pa)	190 mm (max 2400Pa)
PolySol GX 1654x989x40	215 mm (max 5400Pa)	200 mm (max 5400Pa)	0 mm (max 2400Pa)	247 mm (max 2400Pa)
	115 mm (max 4200Pa)	350 mm (max 4200Pa)		
	0 mm (max 2400Pa)	465 mm (max 2400Pa)		
PolySol CS4 1956x992x40	250 mm (max 5400Pa)	350 mm (max 5400Pa)	50 mm (max 2400Pa)	190 mm (max 2400Pa)
PolySol VL4 1650x992x45	150 mm (max 5400Pa)	330 mm (max 5400Pa)	50 mm (max 2400Pa)	190 mm (max 2400Pa)
PolySol CS4 1640x992x40	210 mm (max 5400Pa)	330 mm (max 5400Pa)	50 mm (max 2400Pa)	190 mm (max 2400Pa)
MonoSol ZX/ZX4/ZX4 Black 1639x983x40	210 mm (max 5400Pa)	330 mm (max 5400Pa)	50 mm (max 2400Pa)	190 mm (max 2400Pa)
MonoSol CS4 Smart 1640x992x40	210 mm (max 5400Pa)	330 mm (max 5400Pa)	50 mm (max 2400Pa)	190 mm (max 2400Pa)
MonoSol VL4 1640x992x40	150 mm (max 5400Pa)	330 mm (max 5400Pa)	50 mm (max 2400Pa)	190 mm (max 2400Pa)

Figure 24: IBC clamping zones

3.2.3 Cables and connectors

The cable datasheet defines the voltage and temperature range for the cable. It is important to adhere to it as excessive voltages may cause arching through the cable insulation and excessive temperatures can cause cable degradation. It is also important to follow the connector crimping instructions thoroughly as wrong crimping can cause fires due to arching.

Figure 25: cable and connectors

3.2.4 Charge Controllers

The charge controller manual specifies:

- Safety instructions
- Installation and mounting
- Connecting and grounding
- Operation
- Size
- Troubleshooting

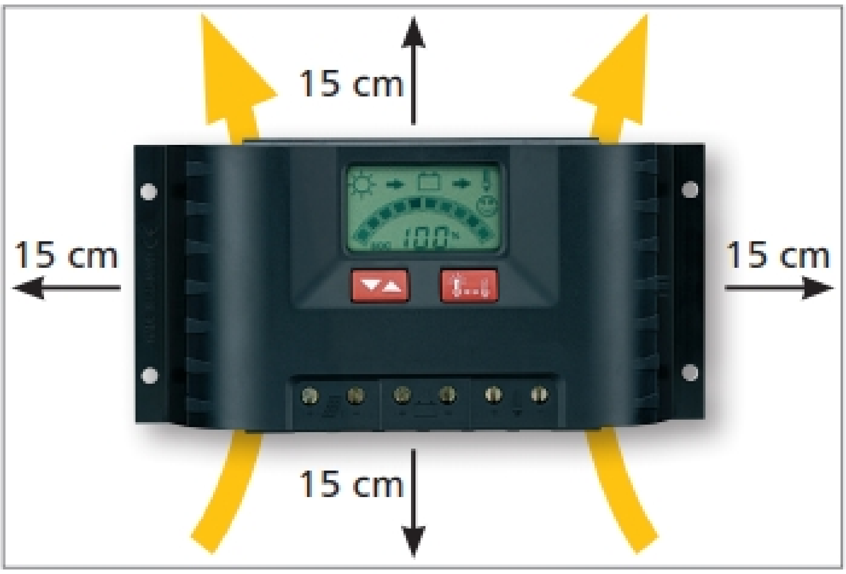


Figure 26: Steca CC mounting

Caution
Danger of damage to the controller. Make sure that no common connection exists for the *Module Minus*, *Battery Minus* and *Load Minus* connections, e.g. via a ground connection.

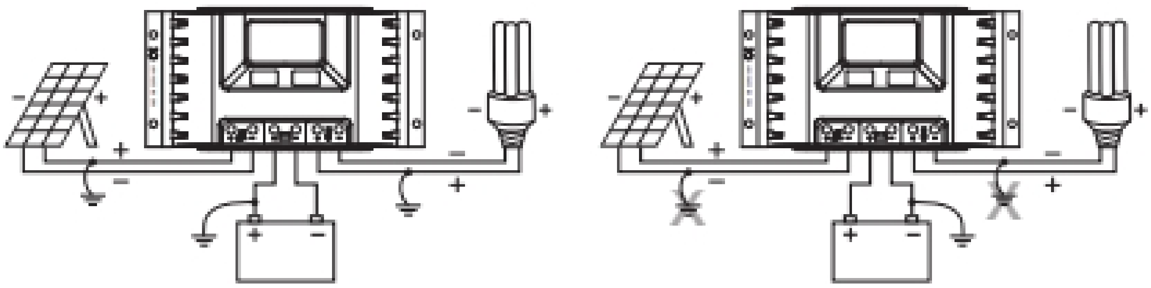


Figure 27: Steca grounding

3.2.5 Inverters

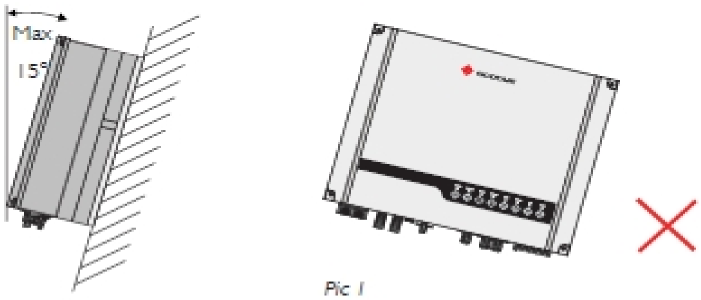
The inverter installation manual specifies:

- Safety instructions
- Installation and mounting
- Connecting and grounding
- Operation
- Size
- Troubleshooting

For inverter's protection and convenient maintenance, mounting location for inverter should be selected carefully based on the following rules:

Rule 1. Inverter should be installed on a solid surface, where is suitable for inverter's dimensions and weight.

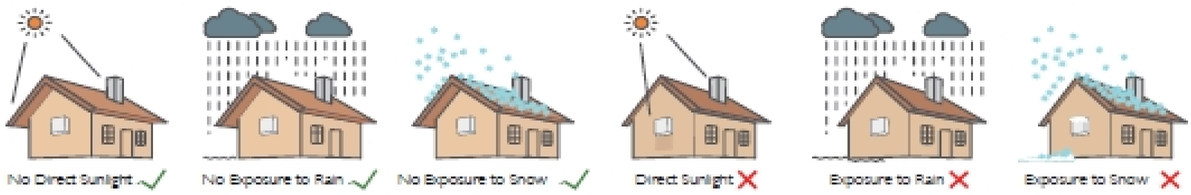
Rule 2. Inverter installation should stand vertically or lie on a slop by max 15° (Pic 1)



Pic 1

Rule 3. Ambient temperature should be lower than 45℃

Rule 4. The installation of inverter should be protected under shelter from direct sunlight or bad weather like snow, rain, lightning etc. (Pic 2)

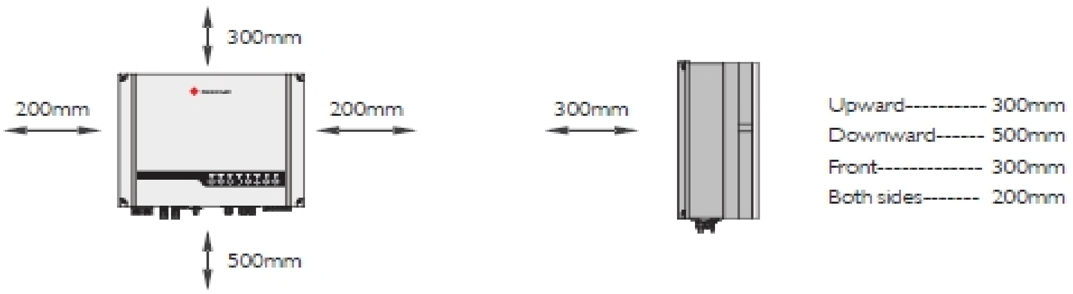


Pic 2

Rule 5. Inverter should be installed at eye level for convenient maintenance.

Rule 6. Product label on inverter should be clearly visible after installation.

Rule 7. Leave enough space around inverter following the values on pic 3.



Pic 3

Figure 28: Inverter mounting (Good we ES)

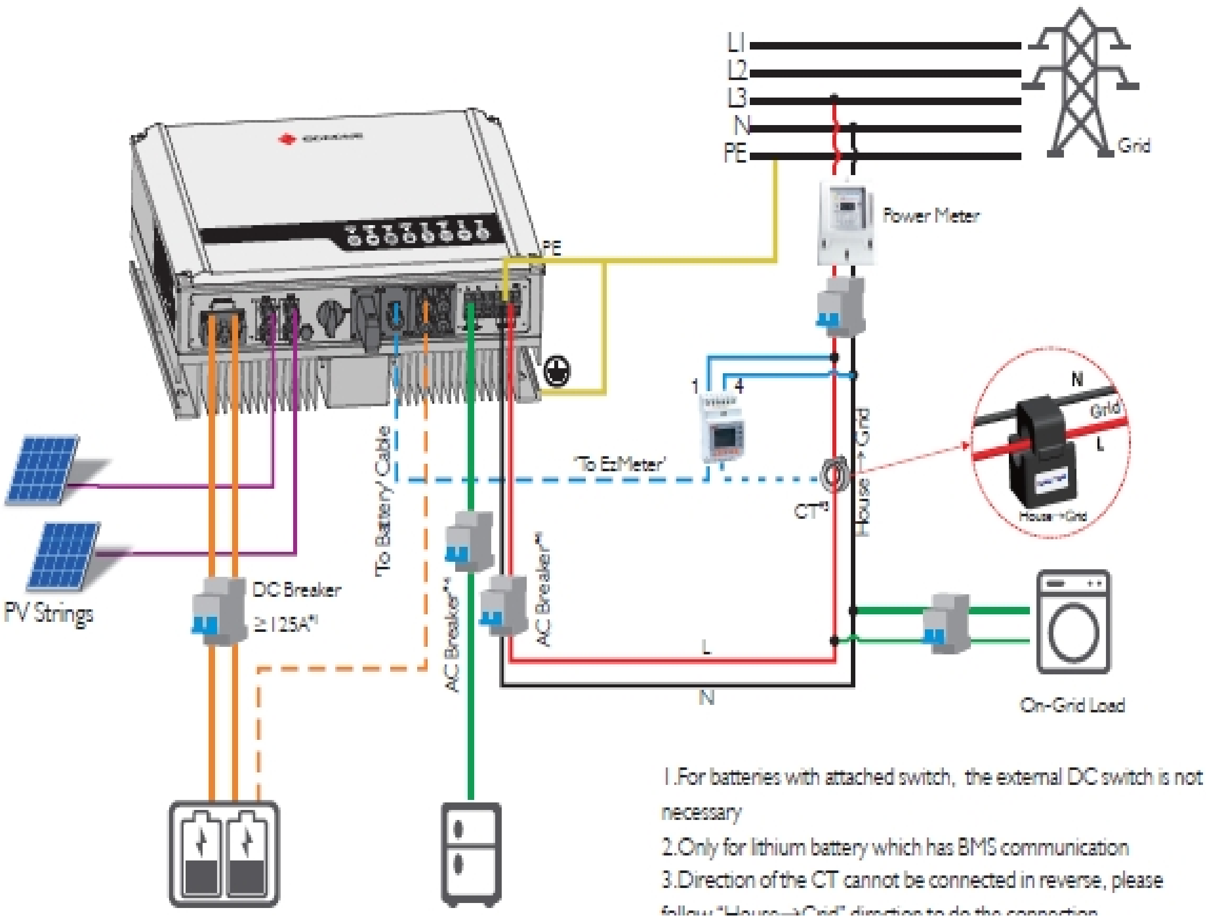


Figure 29: Good we ES Wiring

3.2.6 Batteries

The battery datasheets and maintenance manuals specify:

- Battery Size and weight
- Installation
- Safety measures
- Maintenance methods

Figure 30: Hoppecke battery racks

Requirement	Our recommendation
Ventilation source	Danger! Sufficient room ventilation is absolutely required in order to limit the hydrogen concentration (H_2 concentration) in the ambient air of the battery room to a value of < 2 % by volume. Hydrogen is lighter than air. Make sure that hydrogen does not accumulate (e. g. in the ceiling area). Ventilation and deaeration openings should be placed near the ceiling (see also *Chap. 5.2.1.1* and *Chap. 5.2.1.2*).
Environment	The ambience has to clean and dry. Water, oil and dirt must be kept away from the cell surface.
Passageway width in front of and between the battery racks (and cabinets)	Europe: Passageway width = 1.5 x cell width (installation depth), at least 500 mm (see also IEC 62485-2). USA: 36" or 915 mm HOPPECKE recommendation: If possible at the installation location: 1 m. Otherwise: In accordance with local regulations.
Minimum distances	
Rack to wall	50 mm
Battery to wall	100 mm
Conductive parts to ground	1500 mm for U_{nom} or U_{part} > 120 V DC between non-insulated and grounded parts (e. g. water lines)
Battery ent terminals	1500 mm for U_{nom} > 120 V DC
Battery to sources of ignition	See calculation of safety distance in *Chap. 5.1.1.*
Upper surface of battery to next tier of rack or bottom of the next cabinet	250 mm It must be possible to measure the voltage and density and to add water.
Access door	Lockable and fire retardant (T90).
Lighting	Recommend: at least 100 lx.
Labeling	Warning signs in accordance with IEC 62485-2. Warning sign depicting risk of electrical voltage only necessary if battery voltage exceeds 60 V DC.
Risk of explosion	No sources of ignition (e. g. open flame, glowing objects, electrical switches, sparks) near to the cell openings.
Ambient temperature	The application temperature is 20 °C, which is based on IEC60896. Higher temperatures shorten the service life of the battery. All technical data is valid for the nominal temperature of 20 °C. Lower temperatures decrease battery capacity. Exceeding the limit temperature of 55 °C is not permissible. Avoid operating at temperatures in excess of 45 °C for long periods of time. It is not permitted to expose the batteries to the direct sun light or beeing near to heat sources.
Ambient air	The air in the battery room must be free of impurities, e. g. suspended matter, metal particles or flammable gases. The humidity should be at a maximum of 85 %.
Earthing	If you ground the racks or battery cabinets, make sure that you use a connection to a reliable grounding point.
Battery installation	We recommend that batteries are properly installed in HOPPECKE battery racks or cabinets. The use of other operator-specific solutions may render the warranty for the batteries null and void.
Country-specific regulations	Some countries require batteries and racks to be installed in collection tanks. Please observe all local regulations and contact your local HOPPECKE representative if necessary.

Figure 31: Hoppecke installation site requirements

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	In order to make accurate drawings, it is very important to analyse the datasheets and specifically the installation manuals of the equipment to be used
	True and False
2	technical data that can be found in the technical manuals of the equipment that will be used
	True and False
3	The mounting structure manuals define a number of critical factors that should be taken into account when designing and drawing the system
	True and False
4	The cable datasheet defines the voltage and temperature range for the cable
	True and False

Note: the satisfactory rating is as followed

Satisfactory	3 points
Unsatisfactory	Below 2 points

Information Sheet 4	Using software tools for producing detailed drawings

4.1 Introduction

As mentioned in LO1, there are many software tools available and it would be impossible to discuss all of them. In this section, we will look at a practical example of using software tools to generate drawings. It will be done using the 5kW installation at the Adama polytechnic college as example.

4.2 Adama Installation

The details were the following:

- Located in Adama, Ethiopia
- Customer wants an off-grid system to supply certain loads only
- Used throughout the year
- PV system can be installed on one building with a metal sheet roof
- Roof 1: East-South-East: 20° slope the following diagrams will be created in the process:

Table 2: Adama Diagrams

Diagram (reference to LO1)	**Reference**	**Created With**
Site Layout Diagram (5.2.75.2.1)	 **Figure 32**	PVSOL+MS Power point

Shade Analysis Diagram (5.2.6)	Figure 42	PVSOL
String layout Diagram (5.2.3)	Figure 44	PVSOL
Single Line Diagram (SLD) (5.2.1)	Figure 48	PVSOL
Roof dimensioning Diagram (5.2.4)	Figure 49	PVSOL
String layout Diagram (5.2.3)	Figure 50	PVSOL
Wiring Diagram (5.2.2)	Figure 54	Visio

After doing a site survey, a site layout diagram was created as depicted in Figure 32

.

Figure 32: Site Layout Diagram

The Adama installation consists of the following material:

Table 3: Bill of Materials

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	16	Pcs
6		End Clamp included in 4	24	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

See EIS PIM4 M01 0120_Calculating_System_Components for the details of calculating all the system components. The design was then also simulated in PVSoL design and simulation software. The following steps were taken:

- Define customer details
- Define system type
- Define climate data
- Define AC Data
- Enter the consumption details
- 3D visualisation including:
  - ✓ Building extrusion from Google data
  - ✓ Module mounting

- ✓ Inverter connection
- ✓ String design
- ✓ Wiring
- ✓ Shade simulation

- Battery and Charger specifications
- Wiring and protection devices
- SLD
- Simulation
- Reporting

PV Sol is simulation software for PV systems. An online version of the software is available here: **http://pvsol-online.valentin-software.com/#/ .** PV Sol is a dynamic simulation program with 3D visualization and detailed shading analysis for the calculation of photovoltaic systems. The software produces detailed reports for every design including all relevant system drawings. PV Sol is thus a great tool for as it generates both, the design, and the drawings. Following the step by step use of PV Sol for an exemplary project is demonstrated and the design and the export of drawing are explained.

4.2.1 Defining customer details

The first step (in most software) is to define the customer details:

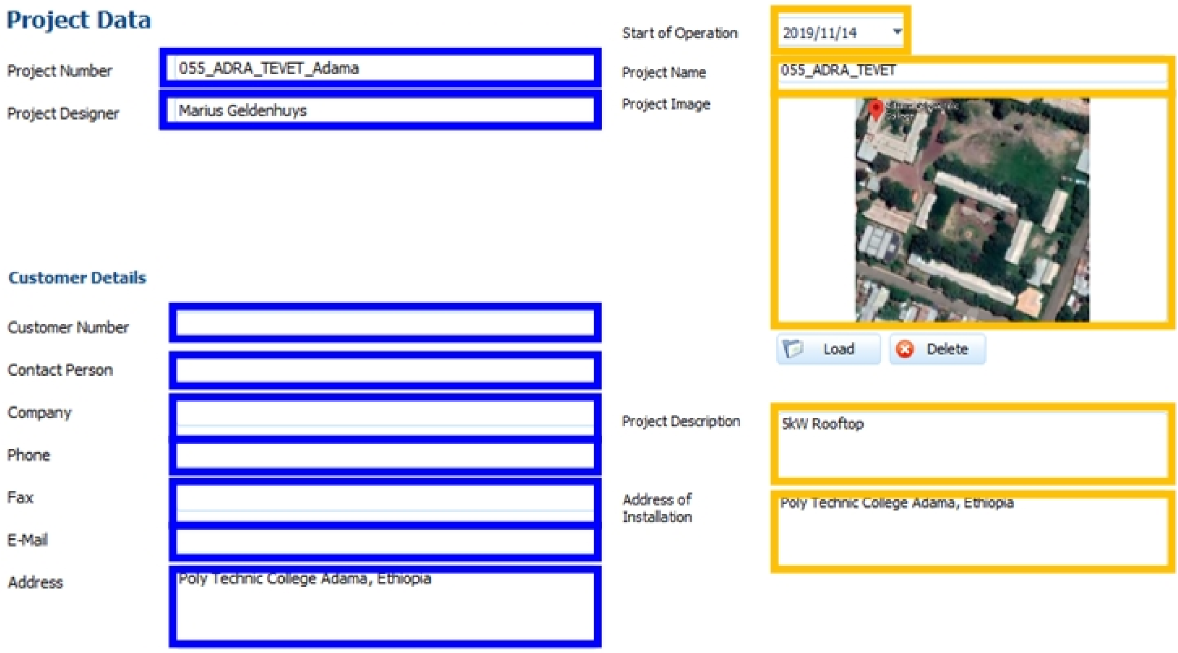


Figure 33: Define customer detail

4.2.2 Define system type

The next step was to define the type of system. In this case, it was a Grid-connected PV system with Electrical appliances and battery system. Although the system can be grid-connected, it will run as an off-grid system.

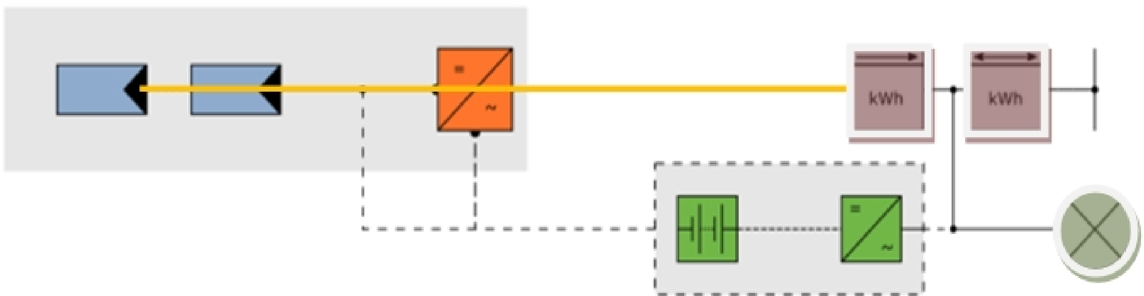


Figure 34: System with appliances and battery system

4.2.3 Define climate data

It is very important to define the location of the site accurately as this software (and most others of the type) extracts climate information based on the site location.

Climate data		
No	Country	Angle direction
	Ethiopia	
1.	Latitude	8^{0}30’57”(8,52°)
2.	Longitude	39^{0}15’34”(39,26°)
3.	Time zone	UTC+3
4.	Time period	1981-1990
5.	Resolution	Hourly

No	Location	
Adama		
1.	Annual sum of global Irradiation	2146kwh/m^2
2.	Annual Average Temperature	17.3C°

Figure 35: Location and climate data

4.2.4 Define AC Data

The next step is to define the AC side – in this case single phase, 230V:

AC Mains	
Enter	
Voltage (N-L1)	230 V
Number of Phases	1-phase
cos φ	1
Maximum Feed-in Power Clipping	No

Figure 36: AC definition

4.2.5 Enter the consumption details

In this case, a load table was used to define the power and consumption of the system. This data was then transferred into PVSoL

Table 4: Load Table

	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	Lights - inside	18 W	20	4	N	1440.00	360.00
2	Lights - outside	18 W	9	12	N	1944.00	162.00
3	Computer	250 W	3	8	D/N	6000.00	750.00
4	Printer	700 W	1	1	D/N	700.00	700.00
5	Projector	300 W	1	6	D/N	1800.00	300.00
6	Internet	15 W	1	24	D/N	360.00	15.00
7	Router	15 W	2	24	D/N	720.00	30.00
	Total:					**12964 Wh/d**	**2317 W**

The resulting profile is shown below in Figure 37

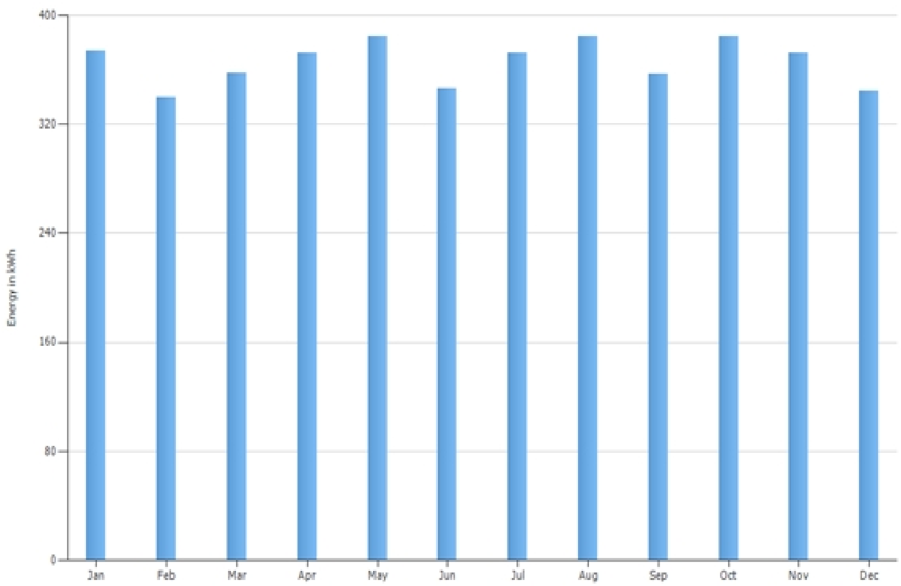


Figure 37: Load profile

4.2.6 3D visualisation

The next step was to make a 3D model of the site.

- Building extrusion from Google data
  - ✓ The first step is to select the building in the map section using Google or Bing satellite images.

Figure 38: Google satellite image within PVSoL

Then polygons are drawn over the roof areas of interest.

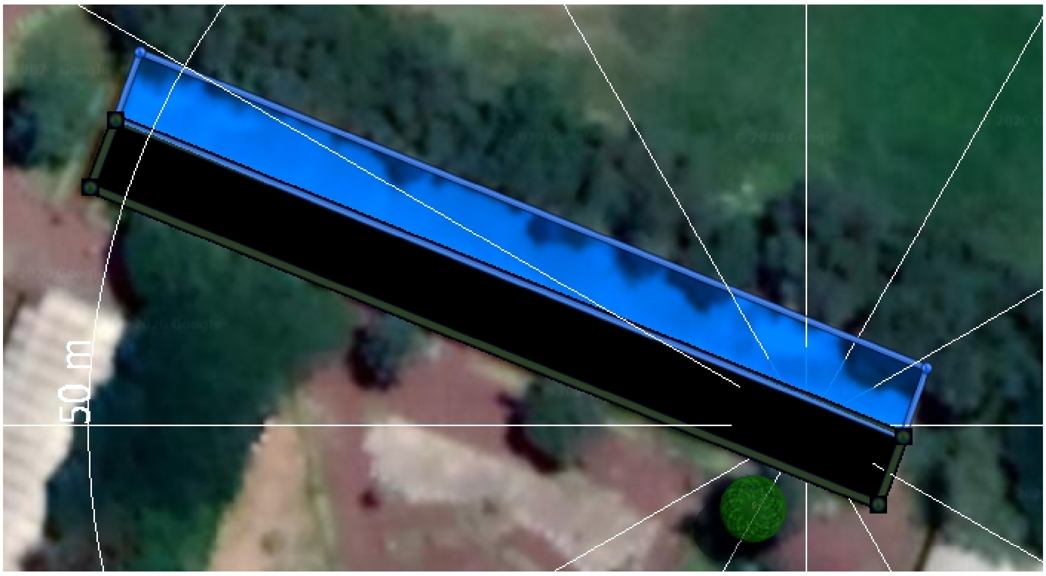


Figure 39: Polygons define the roof areas

- ✓ The next step is to extrude the polygons specifying the angle and height. This creates a 3D rendition of the building. Other objects like trees etc. can also be added.

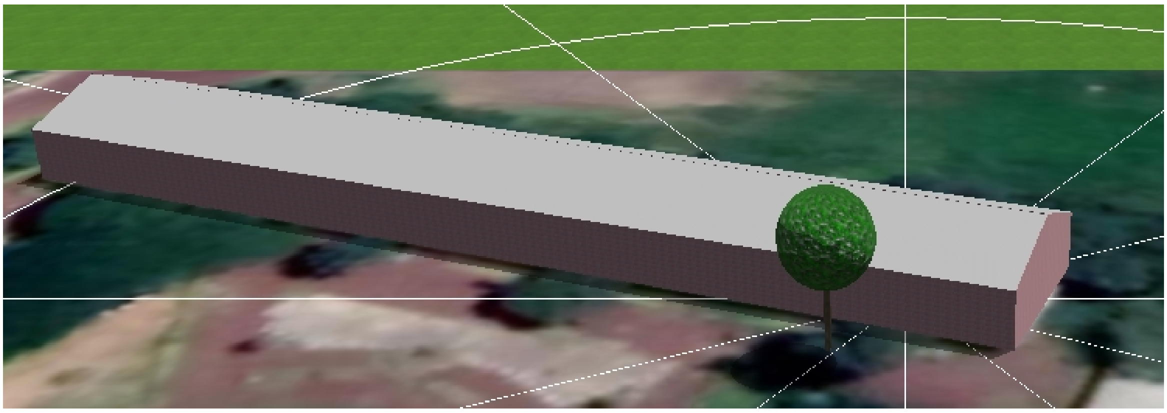


Figure 40: 3D rendition of building and other objects

- The next step is to define the modules to be used. PVSoL have a vast database of modules that are updated regularly. Modules can also be entered manually.

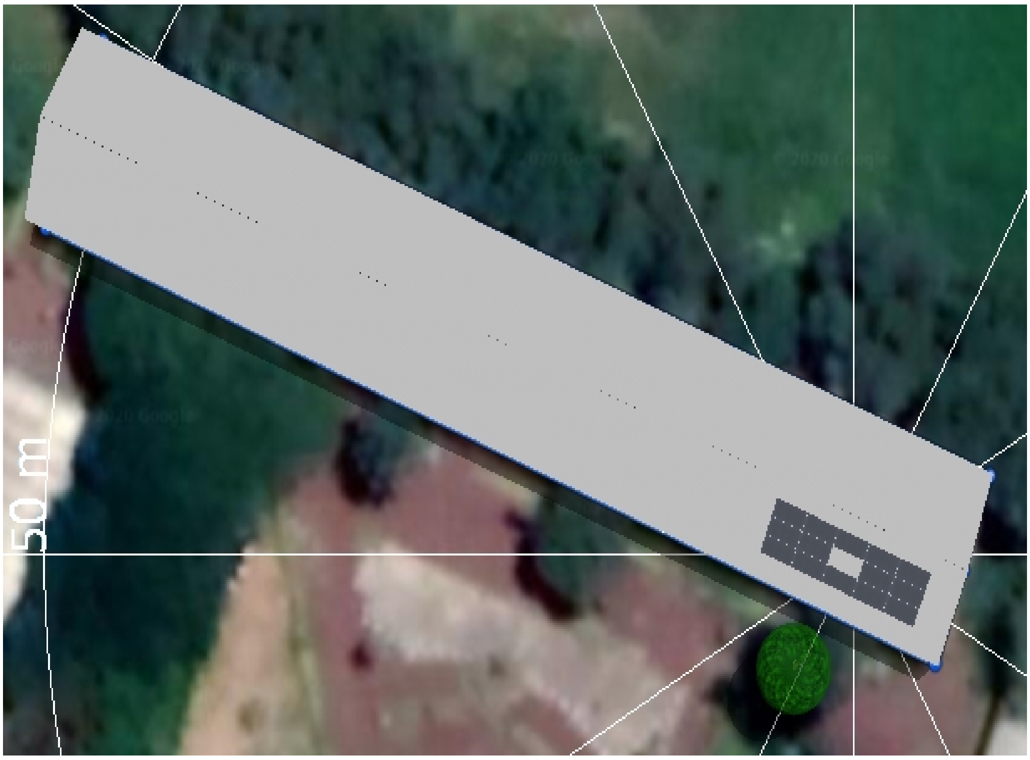


Figure 41: Module mounting

- At this stage a shade simulation is handy as it can help with the placement of the modules.
- As can be seen in Figure 42, the tree cause a maximum of 2.9% loss on the worst affected panel over a period of a year. The modules can now be shifted to a better location or the tree can be removed. In this case, it was decided to remove the tree.

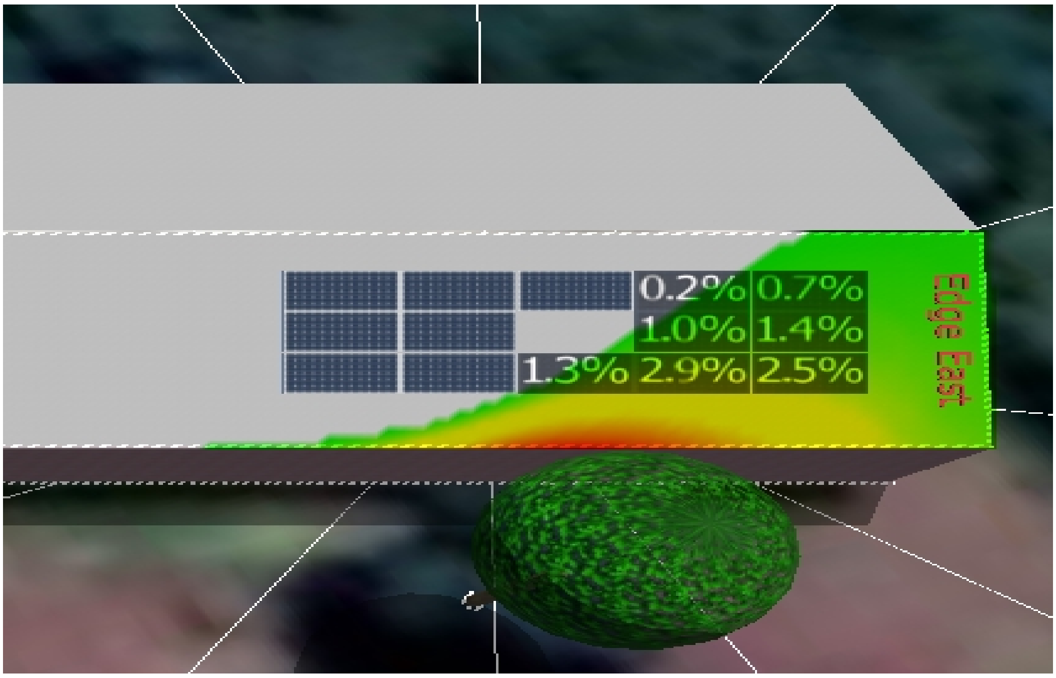


Figure 42: Shade simulation drawing

- The next step is to connect the modules to an inverter. In this case, two strings of 7 modules connected to the single MPPT tracker of the Phocos hybrid inverter. PVSoL will indicate if there are critical errors like over current or over voltage and will prevent further configuration before it is corrected.

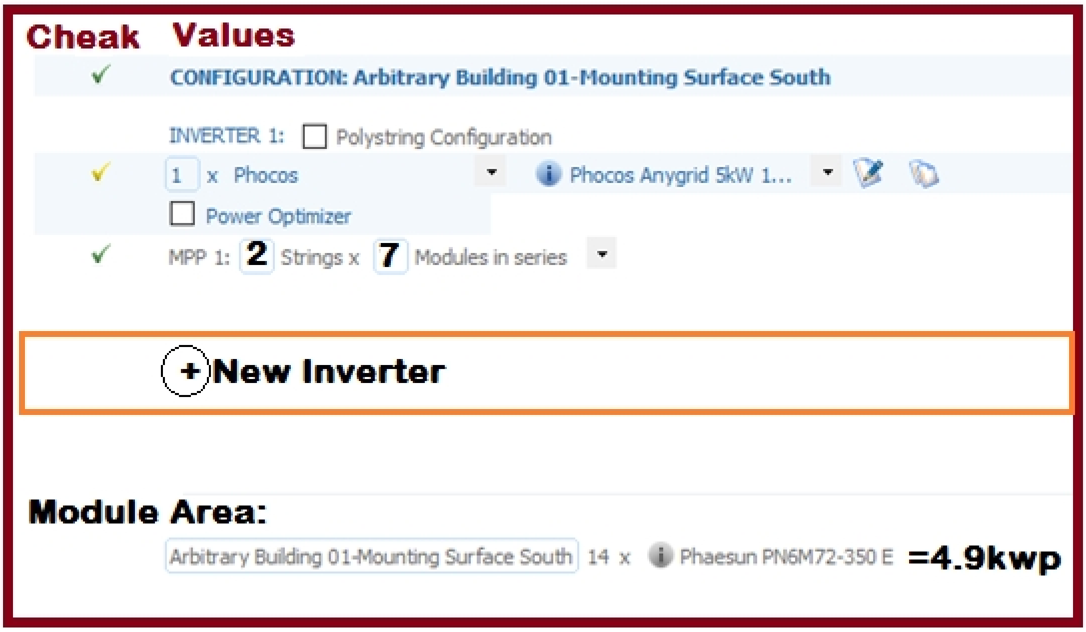


Figure 43: Inverter selection

- After the inverter is selected, the strings can be laid out. PVSoL makes use of a 4 number numbering system to identify a module:
- The numbering system defines**: Inverter. MPPT. String. Module**

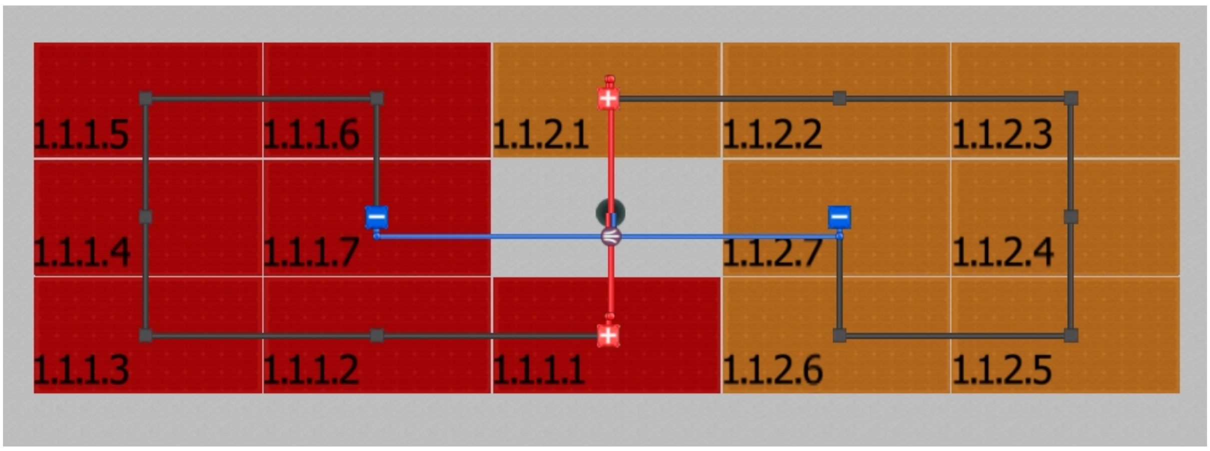


Figure 44: String Design Drawing

- A roof entry point can be selected and the strings wired to it. The system then calculates the total wire required up to the entry point:

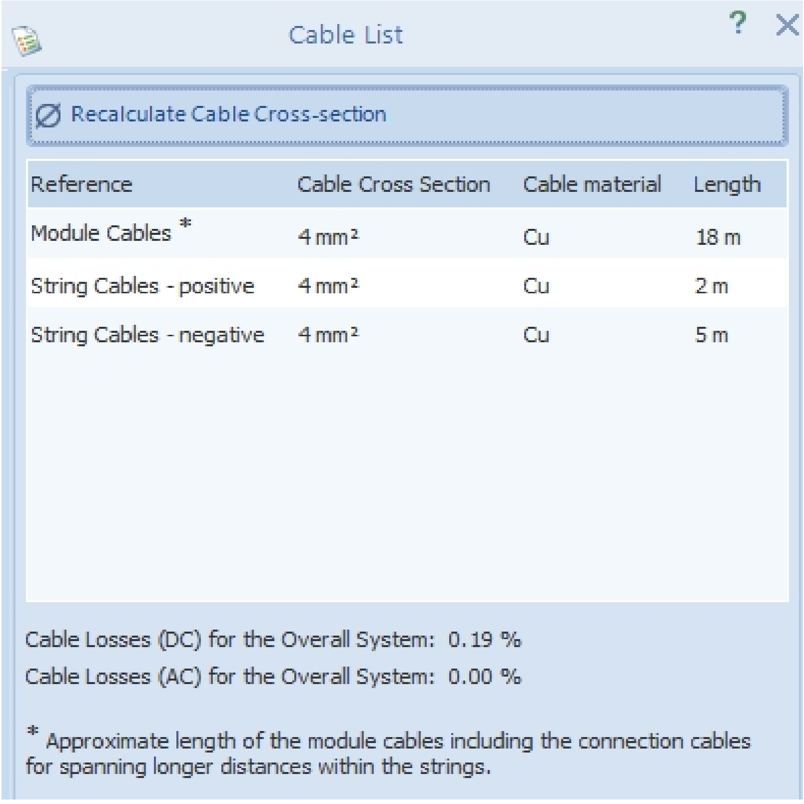


Figure 45: Cable calculation

Also calculated are the cable losses.

4.2.7 Battery and Charger specifications

The Battery and chargers are then specified.

Battery Inverter		
No	Types of coupling	DC intermediate or cut coupling
1.	Connected to inverter	Inverter1()phocos anygrid 5kw 1MPPT
2.	Nominal output	5kw
3.	Charge power	5kw
4.	Discharge power	6.72kw
5.	Minimum SOC	50%
6.	Maximum SOC	90%

Battery Inverter		
1.	Name	HOPPECKE,7OPzS Solar, power 730
2.	Nom. Voltage	2V
3.	Type	Lead Acid-Vented Type(liquid)
4.	Number of Battery	24
5.	Battery voltage	48v
6.	Battery capacity C10	546Ah

Figure 46: Battery System

4.2.8 Wiring and protection devices

The next step is to define all the cable lengths, protective devices and other equipment. Cable lengths can be specified. PVSOL will calculate appropriate cable sizes and breaker sizes. Also calculated are cable losses.

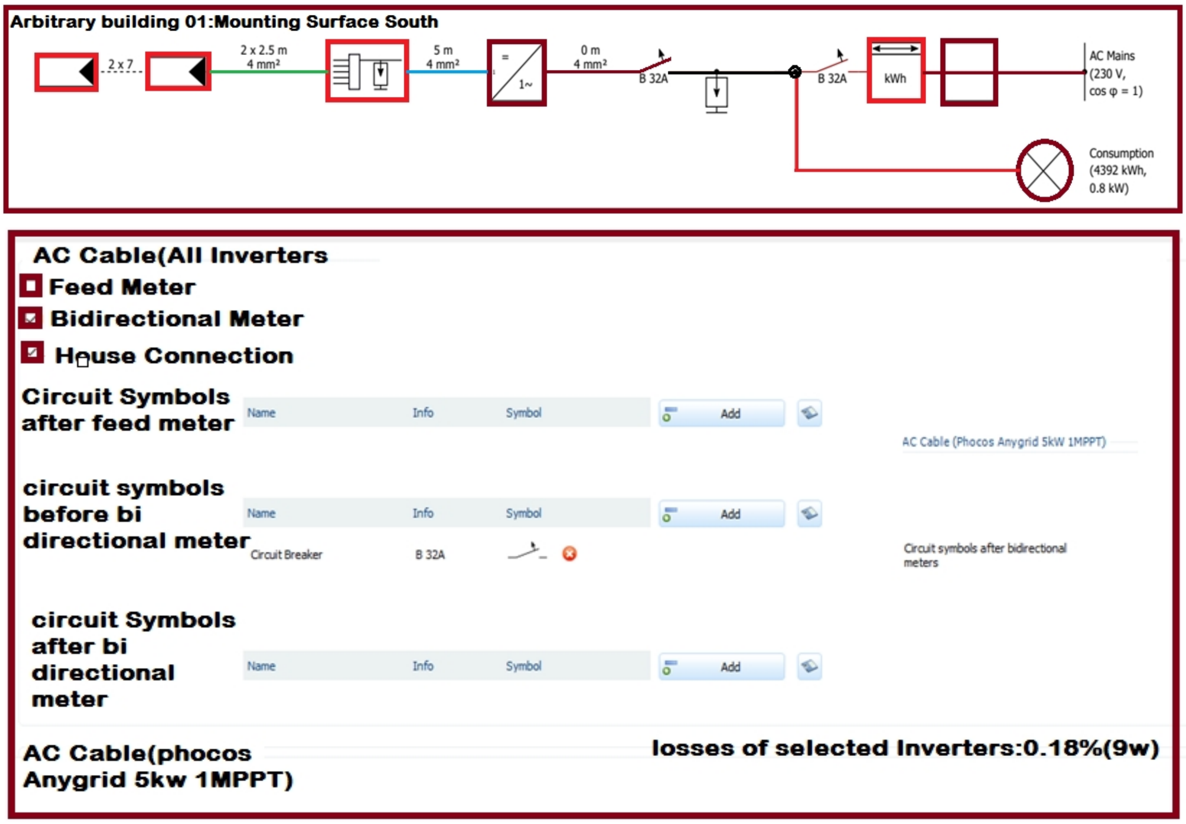


Figure 47: Defining cable and protective devices

4.2.9 SLD

PV Sol generates a SLD which can be printed or exported to other software.

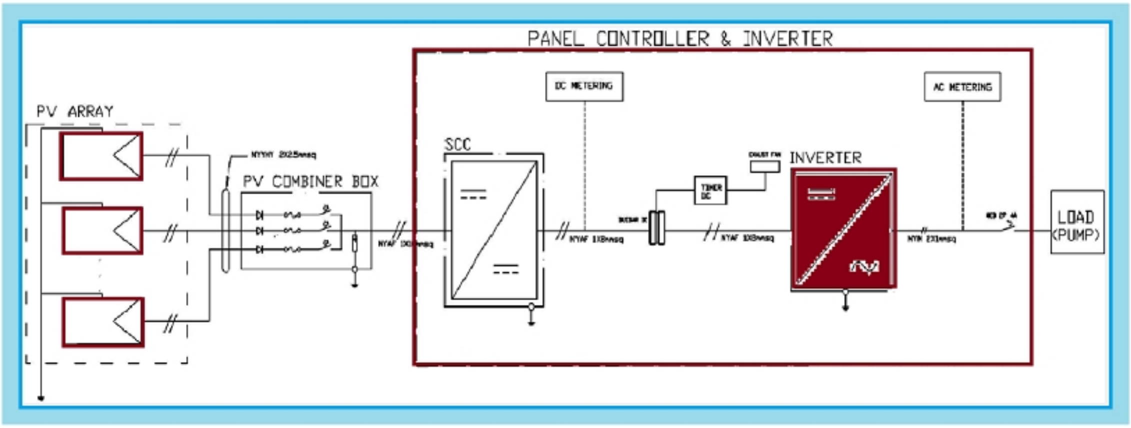


Figure 48: SLD

Also created is a roof layout diagram and string diagram:

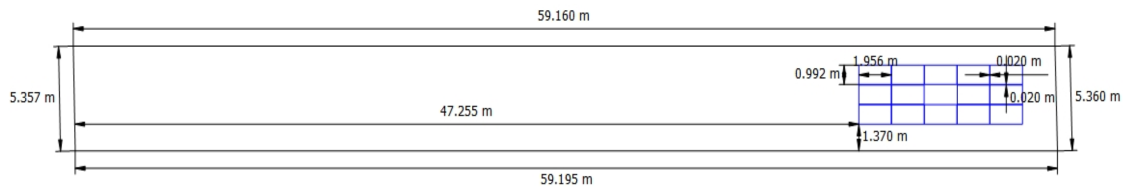


Figure 49: Roof Layout Diagram

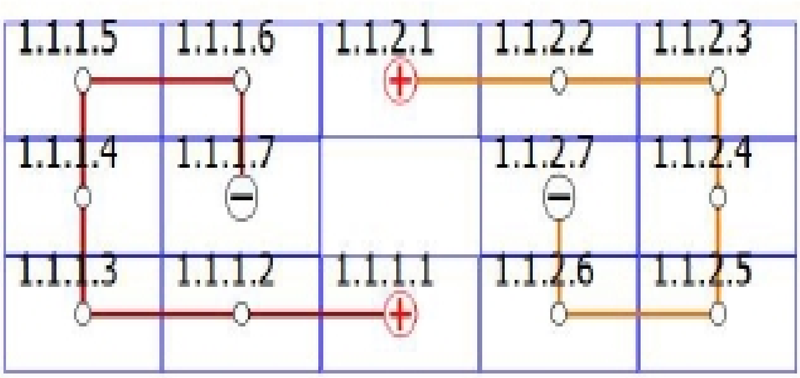


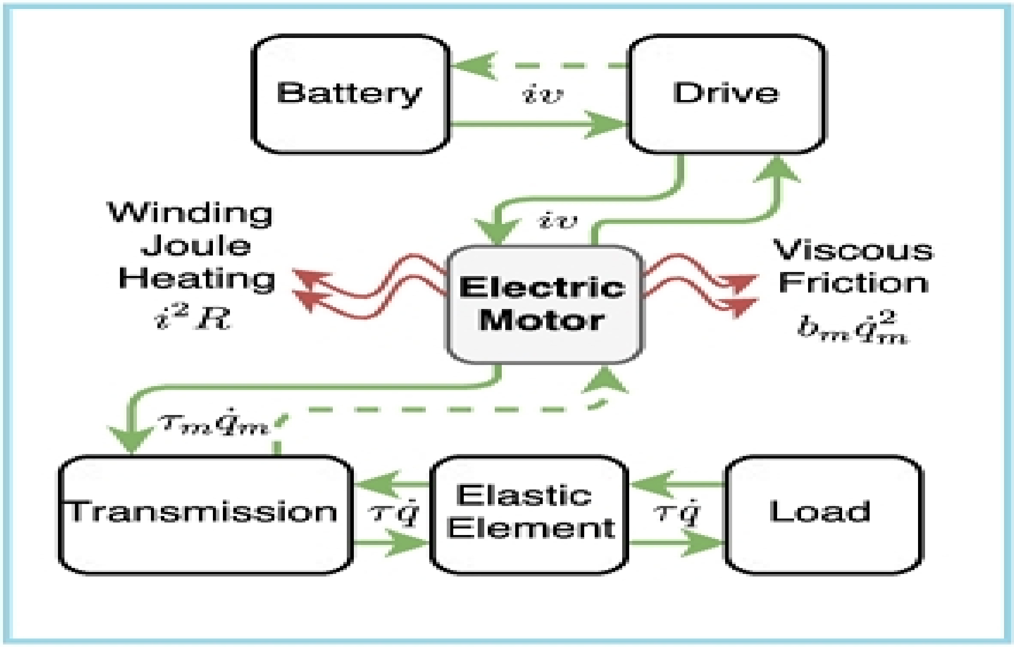
Figure 50: String Diagram

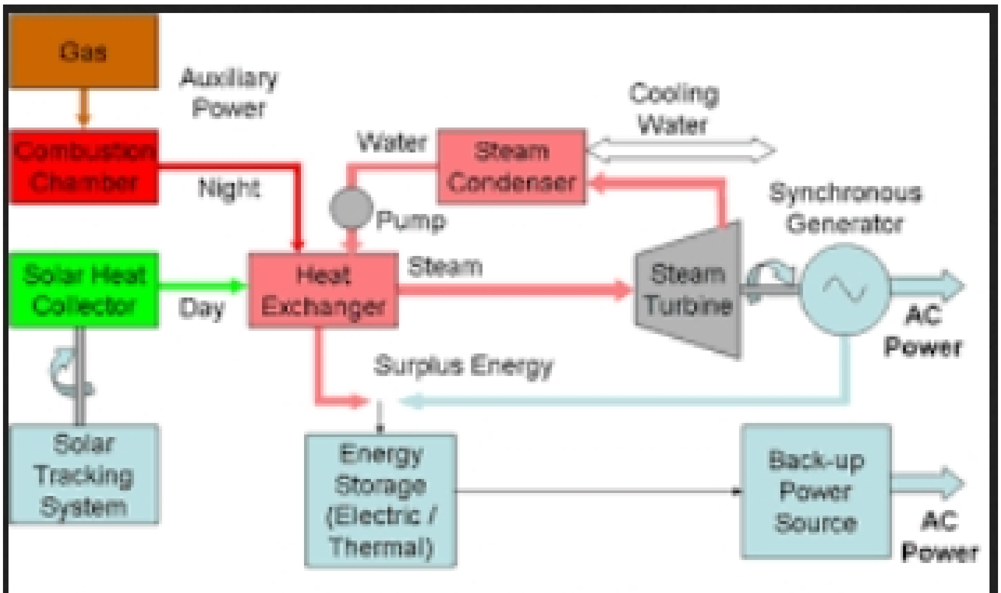
4.2.10 Financial analysis

Although not part of the scope of this module, PVSoL also have comprehensive financial analysis capabilities taking into consideration electricity tariffs, loans, taxes and depreciation.

4.2.11 Simulation

PVSoL have powerful simulation capabilities like energy flow graphs, graph capabilities of many different parameters, energy balance of the system etc.





Large Scale Electric Power from Solar Thermal Energy

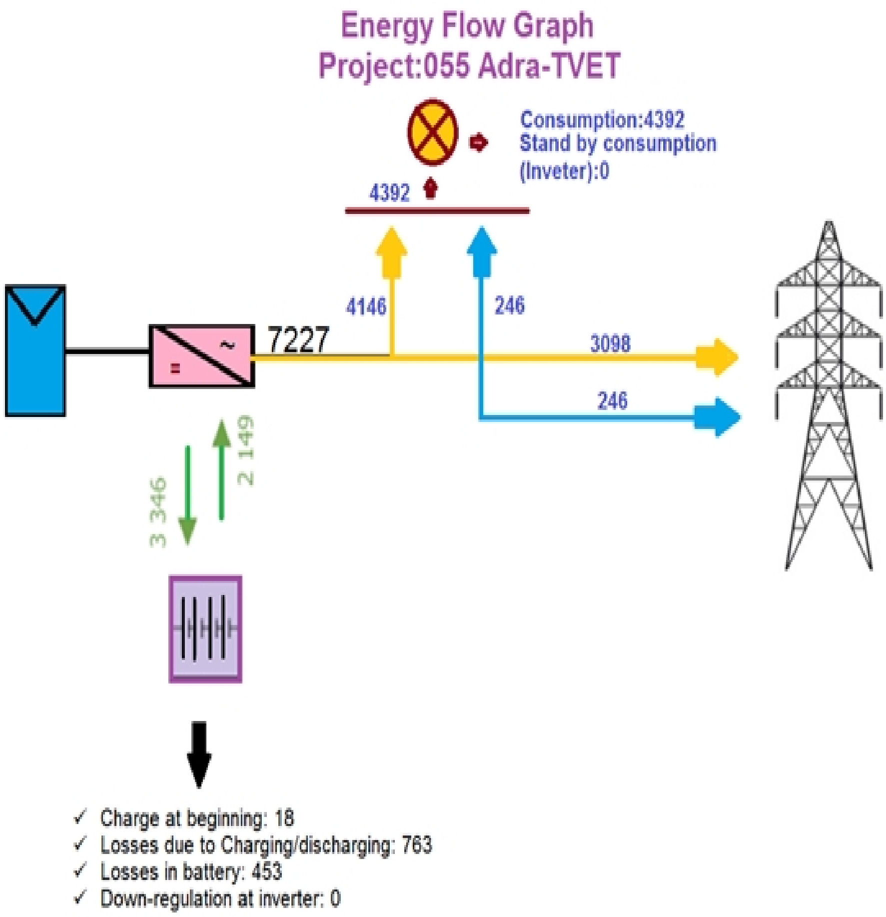
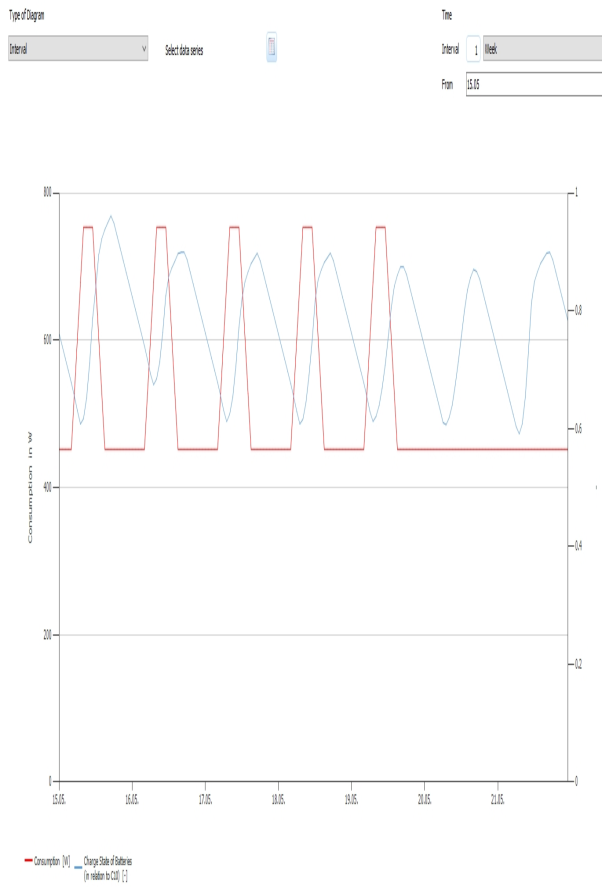


Figure 51: Energy flow graphs



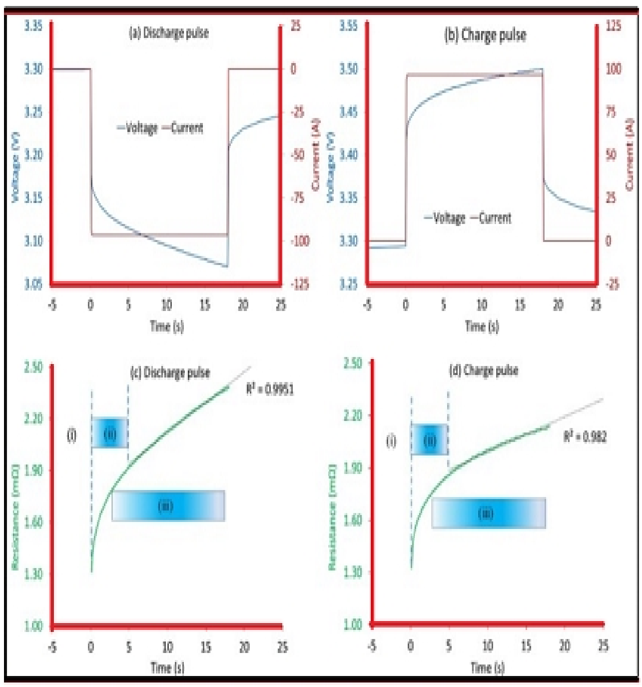


Figure 52: Plotting of battery state of charge - note That the state of charge do not go below 50%

4.2.12 Reporting

The resulting report can be customised to include selected results or all of the results, drawings, datasheets, and financial calculations.

4.3 Wiring Diagram

Although the PVSoL software can produce most of the information required for a small system, there are areas where other software may be required. One example is if a full wiring diagram will be required. In Figure 53 below a wiring diagram created with Microsoft Visio is shown. There are libraries with electrical symbols to use. It is fairly inexpensive way to create wiring diagrams for smaller systems. Alternatively, specialised electrical wiring software like ETAP, Solid works electrical or Auto cad Electrical can be used.

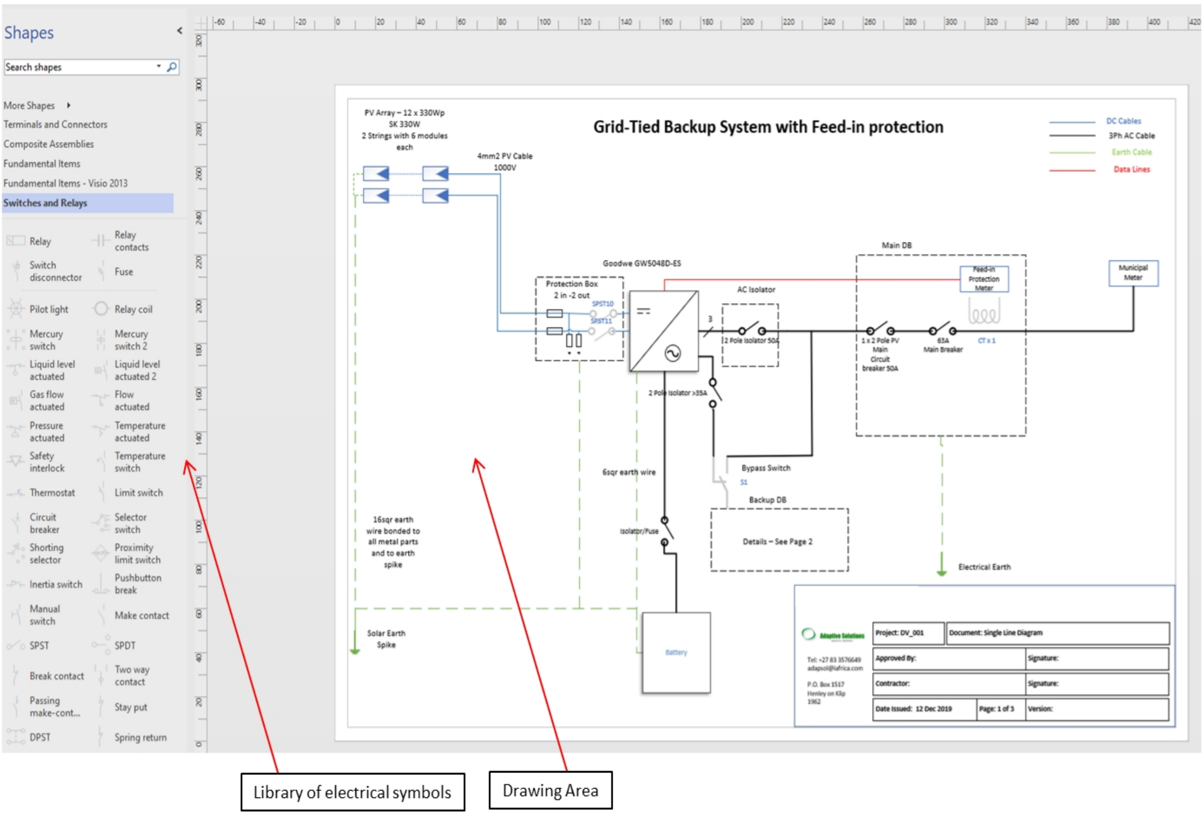
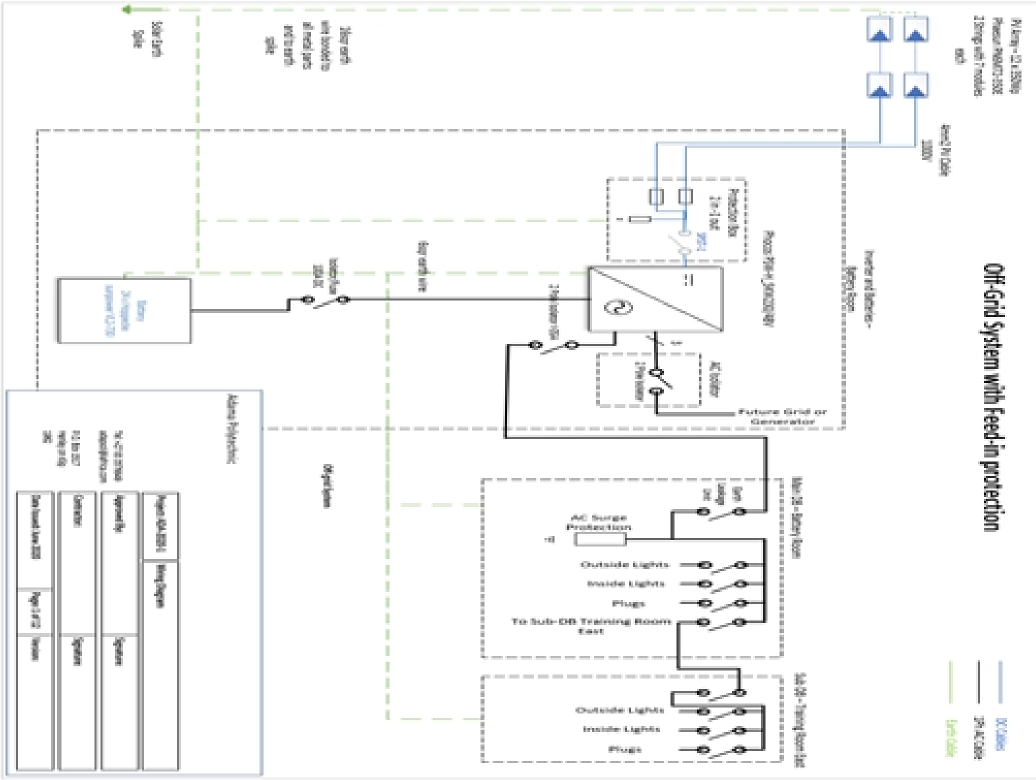


Figure 53: Visio diagram



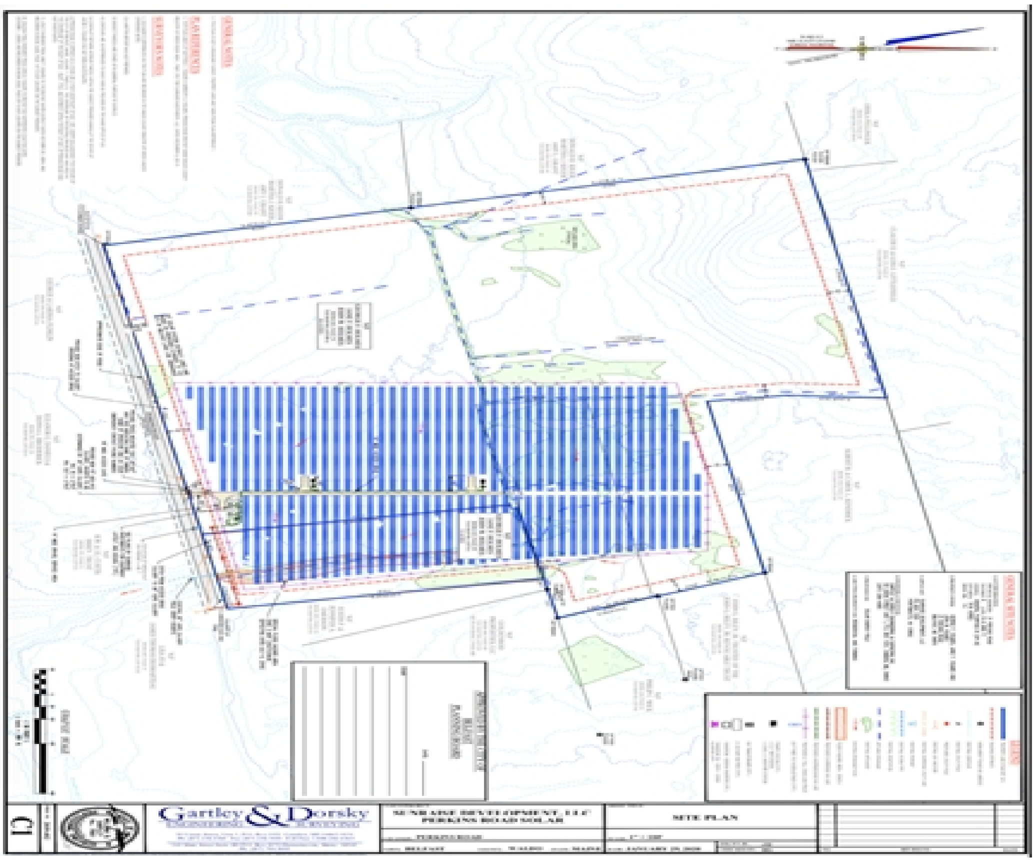


Figure 54: Adama Wiring Diagram Site Layout using dedicated CAD software

4.4 Site Layout Diagrams

Once again, simple site layout diagrams can be created using Visio (see

Figure 32). If more complex diagrams are required, dedicated CAD software will be required (See **Error! Reference source not found.**).

Self-Check - 4	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	software can produce most of the information required for a small system
	True or False
2	climate data It is very important to define the location of the site accurately as this software
	True or False

Note: the satisfactory rating is as followed

Satisfactory	2points
Unsatisfactory	Below 2 points

Information Sheet 5	Checking detail drawings for accuracy

5.1 Introduction

As drawings are normally created off-site, it is important to check them for accuracy before installation. A process should be followed to review drawings in order to get accurate drawings that fulfil all the customers' specifications.

5.2 Reviewing Drawings

In many cases, there may be a conflict between the drawings and the specifications or regulations, e.g.an electrical diagram that calls for one grade of wire while the specifications call for another grade of wiring.

Generally, drawings will supersede the specifications about quantity and location, while the specification will supersede the drawings on material type, performance, and quality. The following was adapted from (Zerrip)

5.3 Why reviewing drawings?

The following could be reasons why drawings should be reviewed:

- Design shortcomings can easily be corrected at the design stage
- It is only "paper" at the design stage
- Minimal cost when discovered early
- Reduces risk across the board
- There are indications of mistakes being made at the design stage

Not doing reviews:

- Yields construction by design and not by intent
- Errors that exist might be corrected in the field
- There could be the long term results on
  - ✓ Safety
  - ✓ Efficiency
  - ✓ Cost

The goals for doing reviews should be:

- Increase Quality and Safety
- Reduce Risk
- Minimize Change Orders
- Increase Reliability, MTBF
- Decrease MTTR
- Check Drawings Against Project Objectives

5.3.1 Who should review?

The reviewer:

- Should have significant design and hands-on experience in installation and maintenance of PV equipment.
- Provides another set of experienced eyes reviewing drawings for feasibility, consistency, and completeness.

Self-Check-5	**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	A process should be followed to review drawings in order to get accurate drawings that fulfil all the customers' specifications.
	True or False
2	In many cases, there may be a conflict between the drawings and the specifications or regulations, e.g.an electrical diagram that calls for one grade of wire while the specifications call for another grade of wiring.
	True or False

Note: the satisfactory rating is as followed

Satisfactory	2 points
Unsatisfactory	Below 2 points

6.1 Introduction

There is always the possibility of encountering unexpected situations when installing systems in the field. Situations and conditions in the field may change or was not considered during initial site inspection. This can render some of the installation drawings inaccurate. A process needs to be followed to capture changes and corrections in the field in order to get accurate as-built drawings.

6.2 Change Management Process

In order to deal with unexpected situations that will require changes to the installation, a formal process should be followed to ensure that no changes are made on site that can affect the overall system negatively. Figure 55 shows a typical change management process.

Figure 55: Change Management Process (dreamstime.com)

- **Request for Change**

If a change in the plans is required, a formal request should be made to the person in charge to make the change. No changes should be implemented haphazardly.

- **Impact Analysis**

The impact of the change should be analysed to ensure that it will not cause unintended consequences and that the initial objective will be met. The cost impact of the change should also be considered as well as possible alternatives.

- **Approve or Deny**
- **Once the impact of the change has been analysed, the change should be approved or denied. If denied, an alternative solution should be found.**
- **Implement Change**

Once approved, the change should be implemented.

- **Review and Reporting**

Once implemented, the change should be reviewed to ensure that the end-goal was reached. All documentation and plans should be updated accordingly.

Self-Check - 6	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	If a change in the plans is required, a formal request should be made to the person in charge to make the change.
	True or False
2	Once implemented, the change should be reviewed to ensure that the Start --goal was reached.
	True or False
3	There is always the possibility of encountering unexpected situations when installing systems in the field.
	True or False

Note: the satisfactory rating is as followed

Satisfactory	2 points
Unsatisfactory	Below 2 points

Solar PV System Installation and Maintenance

NTQF Level IV

Learning Guide -14

Unit of Competence	Produce solar PV Installation drawings using Computer Aided Design Software
Module Title	Producing solar PV Installation drawings using Computer Aided Design Software
LG Code	EIS PIM4 M03 LO3 LG14
TTLM Code	EIS PIM4 TTLM 0920v1

LO 3:- Complete detailed solar PV installation drawings

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:

- Submitting completed detail solar installation drawings;
- Following any alterations, additions or correction instructions and re-submitting detailed solar drawings for final approval;
- Filing copies of completed detail solar drawings securely.

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:-

- Submit completed detail solar installation drawings;
- Follow any alterations, additions or correction instructions and re-submitting detailed solar drawings for final approval;
- File copies of completed detail solar drawings securely.

Learning Instructions:

1. Read the specific objectives of this Learning Guide.
2. Follow the instructions described below.
3. Read the information written in the information Sheets
4. Accomplish the Self-checks

Information Sheet 1	Submitting completed detail solar installation drawings

1.1. Introduction

Once the solar installation drawings have been completed, it should be submitted to the head of the design team for review.

1.2. Submitting Drawings

Completed solar installation drawings should be reviewed by the head of the design team (see LO2 Information Sheet 5). This is to ensure that they are accurate, complete and that all the customers' specifications have been met. After reviewing, the drawings must be submitted to the installation team where the person(s) in charge of installation should also review them to ensure there are no ambiguities and that it is practical implementable.

Self-Check - 1	Written Test

Instruction: Follow the below selected instruction

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

N°	Questions and answers
1	Drawings should be submitted to the head of the design team to check for accuracy?
	True or false:
2	The installation team should review drawings before installation?
	True or false:

Note: the satisfactory rating is as followed

Satisfactory	2 points
Unsatisfactory	Below 2 points

Information Sheet-2	Following any alterations, additions or correction instructions and re-submitting detailed solar drawings for final approval

2.1 Drawing Alterations

Following the review of drawings mentioned in information sheet 1, any changes, additions or corrections should be made and resubmitted. Any changes required while installing the system should follow the change management process mentioned in LO2, information Sheet 6. The goal should be to have accurate as-built drawings that reflect the current installation as handed over to the customer. This is very important as future maintenance of the system relies heavily on accurate drawings.

Self-Check - 2	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	Any system changes required while installing the system should follow the change management process?
	True or false:

Note: the satisfactory rating is as followed

Satisfactory	1 points
Unsatisfactory	Below 1 points

Information Sheet 3	Filing copies of completed detail solar drawings securely

3.1 Introduction

Once the project is complete, all installation drawings (and other documentation) related to the installation should be stored securely.

3.2 Document Management System

The following were adapted from (Ward) Document management is the process of handling documents in such a way that information can be created, shared, organized, and stored efficiently and appropriately. As such, learning how to create a document management system is critical for businesses. For many businesses, the focus of a document management system is on the organization and storage of documents. They want to be able to store documents in an organized and secure way that still allows documents to be found easily. The problem is that many small businesses have to deal with a mixture of old-fashioned data on paper and electronic files and, in some cases, the proportion of paper data is much larger.

One solution to the problem of a mixed data environment would be to use a document imaging system to convert all of your business's documents to electronic form. Setting up a document management system involves three steps:

- Create a document management plan
- Implement the document management plan
- Follow through

3.3 Create a document management plan

A document management plan should cover:

- The creation of documents
  - ✓ Templates and style guides
  - ✓ Naming conventions
  - ✓ Sharing procedures
- Storing of documents
  - ✓ Local storage (on a local computer or server)

- ✓ Cloud-based storage (One Drive, Drop box etc.)
- ✓ Version control measures

- Retrieving of documents
  - ✓ Finding the document
  - ✓ Good filing practice scan go a long way toward solving the problem. If you do things such as consistently follow strict naming conventions, for example, documents will be much easier to find.
- **Security**
  - ✓ Physical security of the premises where documents are kept
  - ✓ Regular backups or automated backups, preferably stored off-site
  - ✓ Restricting user access

3.4 Implementation

Once you have created your document management, you're ready to implement it. Make sure everyone knows the details of your business's document management system and that everyone follows appropriate procedures when creating, storing, and retrieving documents.

You'll also have to be sure that everyone who accesses and uses documents within your organization follows through by consistently naming and storing documents appropriately. Spot check on a regular basis to test whether particular files can be easily found and to guard against misfiling. Even occasional carelessness can throw off the entire system.

Self-Check - 3	Written Test

Instruction: Follow the below selected instruction

There is always the possibility of encountering unexpected situations when installing systems in the field.

N°	Questions and answers
1	Make sure everyone knows the details of your business's document management system and that everyone follows appropriate procedures when creating, storing, and retrieving documents.
	True or False
2	They want to be able to store documents in an organized and secure way that still allows documents to be found easily.
	True or False

Note: the satisfactory rating is as followed

Satisfactory	2 points
Unsatisfactory	Below 2points

Reference

1. adsourcing.com. (n.d.). what-are-solar-drafting-services-from-cadsourcing/. Retrieved from https://cadsourcing.com: https://cadsourcing.com/what-are-solar-drafting-services-from-cadsourcing/

2. Osorio,D.(n.d.).*e-fact-68-osh-and-small-scale-solar-energy-applications*. Retrieved from https://osha.europa.eu/en/publications/efacts/: https:// osha. europa.eu/en/publications/e-facts/e-fact-68-osh-and-small-scale-solar-energy -applications

3. Osorio, D. T. (n.d.). *e-fact-69-hazard-identification-checklist-osh-risks-associated-with-small-scale -solar-energy-applications*. Retrieved from https://osha.europa.eu/en/publications/e-facts/:https://osha. europa. eu/en/ publications/e-facts/e-fact-69-hazard-identification-checklist-osh-risks-associa ted-with-small-scale-solar-energy-applications

4. Ward, S. (n.d.). *creating-a-document-management-system-2948084*. Retrieved from https://www.thebalancesmb.com/: https://www. The balancesmb.com/creating-a-document-management-system-2948084

5. Zerrip, D. (n.d.). *ncbc-2010-review_electrical_systems-zerrip.pdf*. Retrieved from https://www.bcxa.org/: https://www. bcxa.org/ ncbc/2010/ documents/ presentations/ncbc-2010-review_electrical_systems-zerrip.pdf