Photovoltaic Installation Guidelines

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Preface

General preface

Since the beginning, man's life, or rather its survival has been guaranteed by the amount of energy he has managed to obtain, energy that allowed him to feed, warm and protect himself. Thanks to scientific discoveries and technological innovations, scientists have made since centuries of mankind history, it is impossible to compare the amount of energy that man used to produce and exploit in the past with the one he normally uses nowadays, in fact we cannot simply say that it has grown but it has reached huge values . Such values are destined to grow at an urgent pace due to Far East countries industrial development. However if on one hand having available energy means well-being and improvement in ma's living conditions, on the other hand we are also realizing that the negative impacts on environment have been dramatically getting worse and worse.

Earth's overheating, tropospheric ozone hole extension water and soil, pollution and increase of respiratory diseases, are only some consequences of today's intense human activity and the exploitation of energy sources.

The greenhouse effect

The greenhouse effect is a natural process that warms the Earth's surface. When the Sun's energy reaches the Earth's atmosphere, part of is reflected back to space and the rest is absorbed and re-radiated by greenhouse gases.

Greenhouse gases include water vapour, carbon dioxide, methane, nitrous oxide, ozone and some artificial chemicals such as chlorofluorocarbons (CFCs).

The absorbed energy warms the atmosphere and the surface of the Earth. This process maintains the Earth's temperature at around 33 degrees Celsius warmer than it would otherwise be, allowing life on Earth to exist.

Indeed It occurs because of the combustion of fossil sources (oil, coal, methane gas) and released Gas after which the thermal energy is transformed into mechanical and electrical energy at the end of this process CO_2, NO_x, SO_x.residues are released directly into the atmosphere.

CO_2 (carbon dioxide), water vapor, methane (CH_4), nitrous oxide (N_2O), hydrofluorocarbons (HFC), perfluorocarbons (PFC) and sulfur hexafluoride (SF_6) ,derived from human activities, are the main gas that are responsible of the anthropogenic greenhouse effect.

In fact, greenhouse effect represents a natural phenomenon produced by water vapor, natural CO_2, ozone (O_3) and other gases which are present in the earth's atmosphere.As a matter of fact these gases retain a large part of the infrared radiation (heat) reflected from the earth's surface without giving it to the universe. This causes an increase in the average temperature (temporal and geographical) of the Earth's surface, by settling it at around 16 ° C instead of at -15 ° C which would occur in the absence of this effect, thus guaranteeing life to all living species.

However if a portion of CO_2, which is released into the air by humans, is naturally disposed of by the plants through chlorophyll photosynthesis, the increase of it, caused by industrial activities and the simultaneous deforestation, is rising both concentration of gas, carbon dioxide and other greenhouse ones. Because of this, the earth's crust average temperature is destined to increase, bringing catastrophic consequences for living beings (plants and animals).

From Kyoto to photovoltaics

At the beginning of the nineties, some scientists starting from the observation of the climate changes launched a campain aimed to raise awaireness about the risks associated with the greenhouse effect and the problems deriving from pollution. The Kyoto Protocol is an international agreement linked to the United Nations Framework Convention on Climate Change, which commits its Parties by setting internationally binding emission reduction targets.

It was adopted in Kyoto, Japan, on 11 December 1997 and entered into force on 16 February 2005. The detailed rules for the implementation of the Protocol were adopted at COP 7 in Marrakesh, Morocco, in 2001, and are referred to as the "Marrakesh Accords." Its first commitment period started in 2008 and ended in 2012.

Recognizing that developed countries are principally responsible for the current high levels of GHG emissions in the atmosphere as a result of more than 150 years of industrial activity, the Protocol places a heavier burden on developed nations under the principle of "common but differentiated responsibilities.

The European Union approved the Protocol on 25 April 2002 with Directive 2002/358 / EC, committing itself to reduce CO_2 emissions by 8%, a quota that sees the different member countries engaged differently. Italy ratified the directive with the law n.120 of 1 June 2002, from which the "National plan for the reduction of greenhouse gas emissions responsible for the greenhouse effect 2003-2010" then emerged.

During the first commitment period, 37 industrialized countries and the European Community committed to reduce GHG emissions to an average of five percent against 1990 levels. During the second commitment period, Parties committed to reduce GHG emissions by at least 18 percent below 1990 levels in the eight-year period from 2013 to 2020; however, the composition of Parties in the second commitment period is different from the first one.

A a matter of fact it is an important commitment for the protection of the planet, which involves questioning the traditional energy supply systems and production processes. Not only that, but it is a matter of reviewing and resizing consumption to move towards a more sustainable development, aware of the importance of energy saving and the use of renewable energy sources.

In order to stimulate the States to a greater awareness of the energy problem, the European Community intervened by publishing the Green Paper on the security of energy supply adopted in 2000, which reaffirms the need to resort to renewable sources both to comply with the Kyoto Protocol , increasing the share of electrical and thermal energy produced with these, both to reduce the continent's dependence on fossil fuels, in particular oil, purchased from non-EU OPEC countries.

As a first step towards a strategy for renewable energy the Commission adopted a Green Paper on 20 November 19969 A broad public debate took place during the early part of 1997 focusing on the type and nature of priority measures that could be undertaken at Community and Member States' levels. The Green Paper has elicited many reactions from the Community institutions, Member States' governments and agencies, and numerous companies and associations interested in renewables. The Commission organised two conferences during this consultation period many issues were extensively discussed.

History of photovoltaics

The discovery of the photovoltaic effect dates back to 1839 when a nineteen-year-old Edmund Becquerel, a French experimental physicist, discovered the photovoltaic effect while experimenting with an electrolytic cell made up of two metal electrodes.

- 1873: Willoughby Smith discovered the photoconductivity of selenium.
- 1883, Charles Fritts built the first selenium photovoltaic cell: he had a yield of 1%.
- 1987, Heinrich Hertz discovered that ultraviolet light altered the lowest voltage capable of causing a spark to jump between two metal electrodes.
- 1904, Hallwachs discovered that a combination of copper and cuprous oxide was photosensitive. Einstein published his paper on the photoelectric effect.
- 1914, The existence of a barrier layer in PV devices was reported.
- 1916, Millikan provided experimental proof of the photoelectric effect.
- 1918, the Polish scientist Czochralski developed a way to grow single-crystal silicon.
- 1954, The PV effect in Cd was reported; primary work was performed by Rappaport, Loferski, and Jenny at RCA. Bell Labs researchers Pearson, Chapin, and Fuller reported their discovery of 4.5% efficient silicon solar cells; this was raised to 6% only a few months later (by a work team including Mort Prince). Chapin, Fuller, Pearson (AT&T) submitted their results to the Journal of Applied Physics. AT&T demonstrated solar cells in Murray Hill, New Jersey, then at the National Academy of Science Meeting in Washington, DC.

These were the most representative years in which there were several photovoltaic cells improvements in both use and technology. Since then, this new way of producing energy has passed through many steps, exploiting different improvements of the electronics and microelectronics industry, with whom it shares the principles of operation.

Recently, experimental studies have been focusing on the research and development of new photosensitive materials able to evade the problems related to the retrieval and processing of raw materials (silicon) and to further reduce the costs of this technology.

Why should we use solar energy?

The Sun is the main source of energy for life on Earth.

Its influence is such that it is a direct or indirect cause of all climatic and meteorological phenomena. Sun's energy greatly exceeds man's requirements in fact in less than an hour we receive from the sun an amount of energy equal to the world annual requirements.

- It is free and unlimited resource of energy, it still comes whether exploited or not;

- Because of our planet's spherical shape incoming solar radiation is not equally distributed over the planet. At each instant, only the sun lights only half of the planet's surface, with maximum radiation coming in at local noon and less in other times of the day.

- It is the main inexhaustible energy source: Sun has been alive for about 4.5 billion years, and it is estimated to live another 5-6 billion years, before it "dies".

- The potential environmental impacts associated with solar power — land use and habitat loss, water use, and the use of hazardous materials in manufacturing — can vary greatly depending on the technology, which includes two broad categories: photovoltaic (PV) solar cells or concentrating solar thermal plants (CSP

Main disadvantages:

- Solar power is a variable energy source, with energy production dependent on the sun. Solar facilities may produce no power at all some of the time, which could lead to an energy shortage if too much of a region's power comes from solar power.

- Availability does not coincide with needs (night)

- Solar energy is somewhat more expensive to produce than conventional sources of energy due in part to the cost of manufacturing PV devices and in part to the conversion efficiencies of the equipment. As the conversion efficiencies continue to increase and the manufacturing costs continue to come down, PV will become increasingly cost competitive with conventional fuels.

- It has a power density (in terms of W / m^2), which translates into the need to have large capturing surfaces

- Its exploitation is linked to the use of "expensive" technologies

• Non-standardized design: because of irradiation conditions vary with latitude, any plant optimization characteristics have to be adapted to the place;

Photovoltaic cells

The photovoltaic effect

The operating principle of a photovoltaic cell is based on the so-called photoelectric effect. This phenomenon consists in the transfer of energy from the photons making up the incident solar radiation to the atomic electrons of the solid material used (Silicon or others). The energy transferred to the electrons can be conveniently exploited to generate an electric voltage from which to obtain a direct current electric current, in this case it is referred to as a photovoltaic effect.

Specifically, the photovoltaic effect allows electrons, energy receptors, to move from the atomic region in which they routinely orbit, called the valence band, to a peripheral region, called conduction band, from which they can migrate to other atoms composing the material. If the material consists of a junction of two oppositely doped materials (p-n), atomic migration can generate a potential difference between the opposite ends of the junction from which an electrical voltage can be obtained and consequently an electric current.

In case of silicon cells, a surface doping treatment is used on a support already doped at the start. The doping consists in the deposition in the atomic lattice of the silicon of chemical elements such as boron, phosphorus, arsenic that leads the material to have an excess or a defect of free electrons.

Production of photovoltaic cells

Special materials are used for the construction of photovoltaic cells. These materials are called semiconductors. The most commonly used semiconductor material for the construction of photovoltaic cells is silicon. Several forms of silicon are used for the construction; they are single-crystalline, multi-crystalline and amorphous. Other materials used for the construction of photovoltaic cells are polycrystalline thin films such as copper indium diselenide, cadmium telluride and gallium arsenide.

Crystalline silicon cells

Silicon is a widely diffused material on the earth's crust (in terms of weight it is the second component for 25.7%) even if present mainly in the form of compound with oxygen as the common silica (SiO2) present in many rocks.

By means of a sequence of chemical and metallurgical processes, which employ a considerable amount of energy, a cylindrical or parallelepiped ingot is generally obtained which will then be cut into very thin slices.

The typical silicon photovoltaic cell is a thin slice usually called wafer, with a thickness of 0.2 -0.3 mm and square or otherwise squared as much as possible (the circular sections are now in disuse) to cover the largest surface area on the panels where they will be assembled. Typical dimensions of the sides are 10, 12.5 up to a maximum of 15 cm.

Technically, monocrystalline silicon provides superior performance in terms of efficiency and allows for having a smaller surface area in applications with the same installed power but with a higher cost than polycrystalline silicon..

Cells (film) in amorphous silicon

Specifically, when we talk about such kinds of cells we do not refear to real silicon cells but to amorphous silicon films.

As a matter of fact it is used a specific different type of silicon characterized by variable atomic bonds without the typical crystalline regularity. Indeed it is not used pure silicon but its compounds with hydrogen such as silane (SiH4) or disilane (Si2H6), deposited (or if we want to spray) in the form of very thin films (1 µm) on specific substrates.

From the point of view of efficiency, the theoretical values are of the order of 20% but the practical achievements are under 10%. They are widely used for low-power electronic devices such as calculators and gadgets.

Photovoltaic plants

Plant components

In a PV system there are five sets, each one of them consists of different elements, which are characterized on the base of their different configurations.

The main distinction is related to the presence or absence of an electric network. In this case, we respectively refear to grid connected systems (connected in the network) and stand-alone systems (isolated users), the first one is commonly used in houses served by electricity and the second one is mainly used in remote mountain huts.

However, in a medium-sized PV system, there must be these three important elements: a photovoltaic field, a power conditioning system and an electrical load. Large plants (approximately above 50 kW), used to produce electricity, are directly connected to an electricity grid but placed far from electrical loads.

Stand-alone systems need accumulation batteries in order to, first, store the produced energy and secondly supply it to the electrical loads. In this case, a connection to an electric network or to an auxiliary generator, such as diesel-fueled diesel engine, may be useful.

Systems without battery storage must necessarily be network connected to both guarantee electricity supply to electrical loads and feed the grid with the excess energy produced by the PV generator.

The PV field

Since from an electrical point of view a PV field is similar to a generator, it is correct to consider it as a device able to produce electricity whose main components are:

• PV modules (PV field)

• supporting structures and fixing materials

• bypass diodes, blocking diodes

• fuses, overload protection systems (lightning protection)

• switches, cables and junction box

Conditioning system power and control

It is the set of components suitable to DC / AC electrical conversion, to charge batteries- if these are present- and to introduce the produced energy into the grid. An inverter converts the DC voltage to an AC voltage. In most cases, the input DC voltage is usually lower while the output AC is equal to the grid supply voltage of either 120 volts, or 240 Volts depending on the country.

The electric load consists of the whole loads used in the building using a PV system and in cases of remote users; it can consist of 12V or 24 V direct voltage devices.

Solar Module Selection

Analysis of Characteristic Parameters of Photovoltaic Modules

These are the main factiors should be considered to ensure you are choosing the right quality of Module, which best meets, your needs:

- Understand that cost and efficiency alone are not the sole factors dictating module quality;
- Learn how build quality and component selection affects both solar module lifespan and power production – thus affecting your monetary investment;
- Establish how to ensure a life span of 20 years plus, along with a reliable and high output every day.

Cells.

Whether you use a technology or another one (monocrystalline, polycrystalline, amorphous) which certainly affects both electrical characteristics and costs, the aesthetic factor can mostly influence the choice (color and form).

Electrical, design and implementation characteristics

The main feature of a module is represented by the power it is able to supply, in fact in the model acronym is very often contained the indication of this value (for example: Helios Technology H1540, BP 4160 S, Shell SQ160-C with 154, 160 and 160 WP respectively). The value is always referred to its peak power at STC.

In order to formulate the worst hypothesis of productivity of a PV system it is useful to consider the value of tolerance on the Wp one. However, efficiency is an important parameter since it demonstrates, considering similar modules, the high engineering quality made by the manufacturer. Obviously, the designer should evaluate the parameter in the plant definition phase from both points of view economic and technical one.

From a practical point of view it can be used in specific situations in which it is necessary to optimize the energy that can be produced and at the same time minimize the surface on which the photovoltaic system is placed.

Support structures

From a mechanical point of view, the structure have to be able to bear its weight and two of its main predictable stresses, that is, the load derived by both wind action and weight of snow.

Since producers have to face more and more challenges represented by users' requirements asking for modules with different and specific characteristics, today, from a commercial point of view manufactures offer a considerable quantity of usable products.

The main distinction regarding fixed structures without inclination adjustment stands between using them directly on roof pitches with a given inclination or on a flat surface.

The first one is a solution direved by aesthetic reasons or by the impossibility of having alternative surfaces exposed to the sun and which is often used in installations for private houses.

Inverters

We will have an energy output with determined values of voltage and direct current depending on the installed photovoltaic system, ie the characteristics of the modules, their number, their arrangement and the series / parallel connections. For systems connected to the network, it is necessary to convert this current from continuous to alternating. Likewise, for stand-alone systems, the passage from direct to alternating current is necessary for the operation of the users, as well as for the system for regulating the charge of the accumulators.

A solar inverter represents a suitable static power converter since it is able to perform these functions. Starting from a continuous current input date, the inverter is able to generate a desired alternating voltage of amplitude and frequency. Not just this, but it is able to meet the specific needs of the photovoltaic system in such a way to interface with downstream systems, in case of whether a national electricity grid or direct users.

The market offers a wide variety of inverters: they are essentially distinguished by the type of installation, grid-connected or stand-alone, having different constructional and functional characteristics, and by the power that can supply (100 W applicable to domestic outlets, up to a few one hundred kW for large systems)

Place of installation

They can be placed outside, near the system (eg under the supporting structures of the modules) or inside, for example on an attic, which must always be well ventilated. If outside, we have to pay attention to place them in a shady place (roofs) inside metal enclosures (enclosures) to contain metal ponds provided with an appropriate air circulation system to avoid condensation and to allow electronic components cooling .

In any case, both maximum and minimum temperatures of the acceptable installation location (operating temperature range) are always indicated in order to avoid any sort of damages.

If several inverters are installed near each other, it always must be ensured that enough space is left between them in order to allow cooling air to pass through, preventing them from interfering each other. Indeed, it is always advisable to check the indications and constraints manufacturers always specify.

Moreover remember that inverters are electronic devices whose components are particularly sensitive and their sensitivity is higly affected by polluted environments: if this danger exists, it is necessary to chose inverters with greater resistance to damaging agents (eg: condensation, powders, salts ... - IP standard ...). However also in this case it is important to take into consideration the limits provided by the manufacturer.

In addition, inverters may be equipped with displays on which you can read the main system quantities (voltage, current, frequency ...) and, in case of malfunctioning; it is also possible to read error messages thanks to which you can immediately realize what is not working. For this reason, it is important that inverters are located in easily accessible places to ensure rapid monitoring and appropriate interventions.

Switchboards

The number and arrangement of the panels for a PV system varies depending on both their size and the specific design choice.

However, panels can be divided according to the voltage to which they are subjected:

- direct current
- alternating current

All cabinet enclosures for electrical panels must be suitable to installation site conditions, especially when some of them are placed outdoors.

In the latter case, however, the picture must always be protected from atmospheric agents by constructing small shelters or, if it is possible, exploiting the cover offered by the panel.

PHOTOVOLTAIC PLANT

Installation

General recommendations

Make sure that the components and all materials are in compliance with the reference standards which are always specified in the project and in the notices.

Components have to be selected, all provided services being equal, on the basis of our photovoltaic plant installation and maintenance ease and speed, rather than on the basis of its initial purchase cost.

Materials

All the materials used must be suitable to prolonged exposure to UV rays and to solar radiation in general.

All materials must be choosen considering any temperature conditions of the installation place.

Any metal materials (such as aluminum and steel), if they are placed in contact, they must be suitably insulated by interposing an insulating material.

Aluminum structures must not be placed in direct contact with cementitious materials.

Only high quality connectors should be used.

Components and criteria

Rely on providers with great experience in this field able to provide you with both great support and right product warranty. Remember that all electrical components you are going to use must be suitable to either currents or voltages foreseen in your system.

All components must be installed in accordance with both requirements and specifications provided by manufacturers. A good practice is to read carefully (at least the first time you use it) components use and maintenance manuals in order to become familiar with them.

All component identification labels and safety labels must be clearly visible and positioned according to the project

All electrical safety devices (SPD, LPS, blocking diodes and related stringboards) must be easily accessible in order to both check and monitor and must be positioned as far as possible in a sheltered place.

All electrical connections must be well insulated and no cables must be removed.

Equipment

Most of the tools needed for a PV install are commonly used and easily found being the ones used in construction and electrical field. Despite the fact that there are some few highly specialized tools the only one special equipment are Crimping tools which are also called wire crimping pliers because these simple crimping tools that somewhat resemble the common pliers. A crimper is used to joint two metallic ends, e.g., a connector to end of a cable, or a cable to another cable..

Operational phases

The installation operations must necessarily be organized in successive stages linked together and it is fundamental to follow a list of phases well distinguished one another.

Here there is a possible list of steps for dividing the set of activities to be performed to construct a PV system. Of course, it must be considered an indication of method rather than a precise prescription of how to carry out your installation work.

Phases of installation

- Site Survey- Analysis of the project and check compatibility with characteristics of the site;
- Leveling of the site- Marking the exact places -Drilling holes for foundations-Pier foundations (all at the same height);
- List of equipment and components to be used;
- Components supply;
- Work plan drawing up;

- Support structures mounting;
- Wiring (channels) Arrangement ;
- Panels laying;
- Wiring / Connections;
- Installation of inverters;
- BOS and accumulators (if any) positioning;
- Connections to the network / user;
- Design and test checks;
- Final test;
- Design report on "how to build" and requirements on maintenance and use;

Perform a Site Survey

A correct inspection of the site where the installation is planned represents an important step, which significantly may affect your installation work. This is because the sooner you become aware of the problems that may arise during assembly, the better you can do to limit any unespected consequence.

It is important to scrupulously evaluate the building since not every roof can accommodate an array. A house built before1980, for instance, may not be strong enough to hold the extra weight without bracing, blocking or other support for the underlying structure. On the other hand, in newer houses, if you find a roof surface in poor condition, it must be repaired or replaced before a solar array is mounted. Moreover, remember you can never be too careful so go and "touch" with your hands the structure you are working on. Being scrupulous in this initial phase will help you install a safe plant from the structural point of view without making your job grind to a screeching halt. So get organized, do your homework, ask a lot of questions, devise a game plan, create a To-Do list, and (at the very least) have an experienced installer oversee your work.

Another aspect to be observed carefully is the existence of visual obstacles around the building that can partially shade the PV modules. Indeed, we often talk about how installing a solar energy system can have the same effect on the environment as planting trees. Ironically, maximizing those solar benefits may involve cutting down a tree or two. It's a difficult truth, but solar power and trees do not always get along. Branches and leaves can block sunlight from hitting your roof, which means your solar panels aren't maximizing their electricity production.

To perform a correct site survey it may be useful to use a camera, better if digital, it will help you to highlight the most relevant details of the site itself.

Being scrupulous in this initial phase will help you install a safe plant from the structural point of view without making your job grind to a screeching halt. So get organized, do your homework, ask many questions, devise a game plan, create a To-Do list, and (at the very least) have an experienced installer oversee your work.

Analysis of the project

Together with the survey site, it is profitable to check if your design hypothesis matches the found conditions. It is important to understand the risks beforehand. Although it is often touted as a wholly positive endeavor, not every solar power project survives – and this is why every investor should take time to complete a solar power study on the feasibility of a project before they begin. It just makes good sense to do a fully analysis of the project. If you carefully analyse the project you will not demonstate distrust but you will be considered professional in approaching your work. Indeed even a small design error could compromise the final resul so it is important to spend more time in analyzing the project than grinding days and day of hard work by halting the execution to readjust some unconsidered important factors.

It is certainly true that the best evaluation tool is the experience acquired over time.

All projects of photovoltaic systems must be drawn up in compliance with the specific technical regulations mentioned in the appropriate section.

The guide defining the design documentation of the electrical systems states that design phases can be divided into three stages, each one of them is provided with its different documents.

They are the following:

- General project, also called Preliminary project
- Definitive project
- Executive project

For public installations, the project phase distinction is mandatory, while it is not necessary for private ones but it can be very adopted.

Supply of components

Despite the fact that producers have been offering a wide range of these products for many years nowadays such kind of components are still consistently under-estimated in the sense that they are not so greatly diffused.However in Italy solar pannels market is developing year by year.

The best advice for choosing the supply of components, especially if you are a beginner, is to rely on experienced suppliers in salling PV devices,who has to able to provide you with support and at the same time he has to guarantee the products reliability. Moreover, we want to remind you, once again that costs must not represent the main parameter of your evaluation. Only if you have familiarity with the PV components and your previous experience with certain brands or product models has been positive, then you can easily decide on the basis of their purchase price.

It's important to take into account that in some periods the demand for PV panels can have peaks and delivery times can be dilated, so it is better to schedule the working time after checking both the availability of materials and delivery times.

Mounting of support structures

In terms of time, MOUNTING represents the longest phase, especially if you are going to operate in difficult access places and / or critical safety or if construction works must be carried out at the same time.

To be sure that the installed system safety holds, the laying phase must be given great carefulness.

You have to be sure about the PV module supports final arrangment in order to avoid having to dismantle and reposition the structures during the work, which make you waste time and money!

We want to to point out again that it is essential to choose components which are either ease to assembly or very flexible in order to reduce execution time.

Laying the panels

Check the delivery on arrival to ensure that all items are complete and undamaged. The sending manufacturer will only recognise transit damage if it has been recorded on the driver's delivery note and reported immediately in writing. Leave the modules in their packaging until you intend to install them. Pallets should always be placed on solid and levelled ground. DO NOT stack one pallet on top of another.

The installation consists in fixing the panels on the support structures depending on the different cases and in accordance with the panels connection series to finally realize strings according to the project.

The panels are protected by the protective wrapping (frame and tempered glass) so they do not need to be stored and handled with particular precautions and they can be carried even by a single person since its weight is not considerable. However their overall dimentions may represent a problem particularly if you have to work in raised building, in that case you will need hoists.

Wiring / Connections

The wiring operations are not subject to particular precautions, nevertheless we want to point out the need to put maximum care in the physical cables connection of the and terminal blocks to ensure minimum dispersions.

Installation of inverters

If it is the first time you are installing an inverter, it is necessary to carefully read the warnings and precautions reported by the manufacturer, both for safety reasons and to avoid damaging the product.

Make sure the product is certified.

There are many ways of positioning an inverter; however, the first thing you have to do is to check if the wall or the support structure is suitable to support its weight. As for the connections, the inverter must be connected to the photovoltaic generator on one side and to the grid, or to the loads if it is an island, on the other side.

However we need to distinguish two cases:

1. presence of external contacts to the inverter: it can be Multicontact connectors to facilitate installation;
2. connections to be made from the terminal blocks of the inverter by opening the enclosure.

For connections, follow the manufacturer's instructions who will have to set up terminals for connection to the grid and to the PV generator.

The network will have the three connections to the line (L), to the neutral (N) and to the ground protection (EP) (three-phase system).

We want to remind you that a protection device must be interposed between the inverter and the power grid, it must meet the grid operator's requirements. (!!!!! REFERENCE STANDARDS)

The connection to the strings of the photovoltaic field consists in connecting the two polarities ("+" and "-") to the inverter (be careful to respect the indications).

The connection modes between the strings and the inverter depend on the maximum voltage values accepted by the inverter and the characteristics of the field (number of strings, power generated ...). Also, in this case, check the manufacturer's specifications contained in the instrument technical data.

Maintenance

Generally, the maintenance operations of a PV system are minimal and mostly limited to visual inspections of the state of the various components and the verification of their correct functioning.

However In the whole system the most sensitive and critical components are the static converters (inverters) and the accumulation batteries.

The number of complex and delicate electronic elements present into inverters may affect these devises and provoke faults. However if they break it is generally more advisable to replace the entire device rather than repair the damaged part, this because of their intrinsic complexity. Neverthless in a time span of 20 years (this is the time they should keep in good conditions) it is predictable, at least, the substitution of one inverter. So in light of their impact on the cost of the whole plant, it is advisable to choose inverters able to guarantee both durability and reliability.

As far as maintenance activities are concerned, it is recommended to always follow the specific instructions contained in the use and maintenance manual provided by the inverter manufacturer.

Accumulators are the component with a lower useful life compared to the entire system and are usually programmed to be replaced at a rate which is calculated on the basis of the type of used battery and the use of the device itself. Since they contain acid, they are components which need to be treated with expertise and care specially when handled they need great attention.

A correct planning of the PV plant (which goes farther the scope of this guide) must take into account the possible alternatives both in terms of the choice of components and their positioning so that minimize the overall cost over the useful life of the plant,as well as reducing the number of maintenance operations and possible faults.

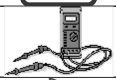
The following table shows the main periodic checks we consider very useful for the correct maintenance of the system.

The list is to be considered a set of useful indications and not a list of prescriptions to be scrupulously observed, both because each plant has specific characteristics and because it is not always easy to carry out all the operations in detail.

Since there is not a check predictable specific periodicity, it is advisable to carry out all the checks in a single annual day in order to minimize the maintenance time (and the cost too!).

It should be remembered that if prescribed it is however mandatory to deliver to the customer a use and maintenance manual that describes, in a summary manner, which are the main operations to be followed to ensure the operation of the plant.

Maintenance Chart:

SYMBOL.	Type of operation
	VISUAL
	MEASURE
	BY HAND

Maintenance table

Component	Detail	TYPE	Description	periodicity	Possible intervent
Surrounding environment	Vegetation		Verification of the size of the foliage of trees near the panels to avoid shading	Annual (useful to use historical photos)	Pruning
Plant	Performance		Verification of the production capacity of the plant directly orthrough remote data acquisition	Annual with fixed deadlines	

Component	Detail	TYPE	Description	periodicity	Possible intervent
	fouling		Depending on the specific atmospheric conditions, the transparency of the covering surface must be checked	At least yearly	*Generally manual cleaning is not recommended*

Panels	Integrity		Presence of evident damage, formations of superficial bubbles in the		Replacement
	Termination boxes		(A sample) accumulations of water, damage to cables, status of		*Replacing cables, siliconing the cassettes*
Support structures	Integrity		Clamping of bolts, presence of small deformations of the support frame, galvanization status of the clamping	*Annual or following particular meteorological events (snow / wind)*	
Strings	Voltage		Under the same conditions, check that the no-load voltage (V ..) of all is uniform with a maximum		Control of connections and panels
Switchboards	Integrity		Correct indication of measuring instruments ()		
	Switches - disconnect		correct operation		

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