dyaqua
INVISIBLE SOLAR



PHOTOVOLTAIC ROOFTILE

TECHNICAL DATASHEET

www.invisiblesolar.it

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IMPORTANT:

Read this dossier carefully and in its entirety before starting any design or installation work on the product.
Failure to comply with these instructions may invalidate the warranty provided by Dyaqua for Invisible Solar modules.

Installation techniques, handling and use of this product are not the responsibility of the Company. Therefore, Dyaqua assumes no liability for losses, damage or expenses resulting from improper installation, handling or use.

We reserve the right to change the data contained in this manual without prior notice.

Made in Italy.

INTRODUCTION

INVISIBLE SOLAR – WHAT IT IS AND HOW IT WORKS

What Invisible Solar photovoltaic modules are

Invisible Solar photovoltaic modules are active architectural elements made from a non-toxic polymer compound. They simultaneously perform the following functions:

- Photovoltaic module producing clean, renewable energy;
- Architectural element for covering and cladding various parts of a building;
- Self-cleaning material: rain and wind wash away dirt, so no cleaning or maintenance is needed.

Technology

Invisible Solar is a patented technology that makes it possible to create photovoltaic modules with the shape and appearance typical of the relevant building material. Each module is a monolithic, therefore indivisible, body in which monocrystalline silicon cells are embedded. It is therefore particularly important to create a special surface with a realistic appearance that is nevertheless transparent to sunlight.

This solution makes it possible to create an innovative type of module in which the photovoltaic element is completely indistinguishable within the built environment, making it ideal for historic centres and for all sites or buildings whose cultural and visual value must be protected.

How it works

Invisible Solar works on the principle of low molecular density. Each module is made of a non-toxic, recyclable polymer compound, processed through a specific production process designed to enhance photon absorption.

Monocrystalline silicon cells are embedded inside the module. Although opaque to the eye, the surface is transparent to sunlight and allows light to reach and power the cells.

Why choose Invisible Solar

Because of their distinctive appearance, Invisible Solar modules are designed to be installed on historic or protected buildings, or wherever it would otherwise not be possible to install a photovoltaic system.

The key features of Invisible Solar transform an apparently ordinary roof into an efficient, reliable, sustainable and, above all, invisible photovoltaic system.

Handcrafted products

We have chosen to maintain handcrafted production in order to ensure the highest aesthetic quality. This type of production allows us to create subtle differences between modules of the same model, giving them a slightly aged and natural appearance.

Quality

Invisible Solar modules and the connection system undergo quality checks to ensure safe and consistently functioning supplies.

Each individual module is tested three times before delivery:

- The internal electrical system is tested after soldering is completed and before it is inserted into the polymer compound;
- The completed module must pass a quality test;
- A final operating test is carried out before packaging.

Each connector is checked twice:

- Test of solder integrity;
- Test of the connection’s resistance to mechanical stress.

MAIN FEATURES

Integration

It blends into its installation setting, bringing technology and innovation without creating the slightest visual impact.

Sustainability

It produces clean energy from a renewable source, is made from non-toxic and recyclable materials and does not require cleaning.

Resistance

It withstands high static loads and is resistant to weathering agents and chemical solvents.

Sel-cleaning

Dirt does not adhere to the surface and is washed or blown away by rain and wind, so no cleaning or maintenance is required.

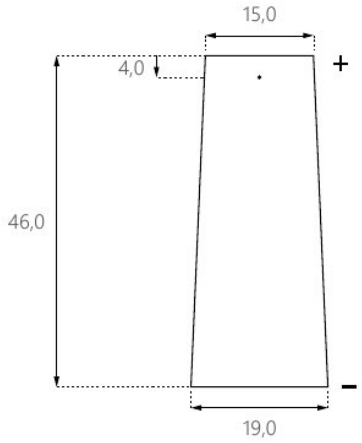
ADVANTAGES

- Photovoltaics in historic centres
- Renewable energy
- Energy independence
- Environmental respect
- Zero maintenance
- Discouragement of further land development
- Promotion of building reuse
- No detergents or polluting products are required to clean the modules

TECHNICAL DATA SHEET

Product version 2.1

Photovoltaic module in the form of an architectural element, made from a non-toxic and recyclable polymer compound in which monocrystalline silicon cells are embedded.



Unità misura: cm

Document valid for the following product variants

Item code	*Description*
IS001-C01	Red terracotta
IS001-C02	Yelloe terracotta
IS001-C03	Grey

Example of system sizing

Peak power	1 kWp
Number of modules	91 Rooftiles
System area	6 m²

Orientation and inclination

South	Optimal
East, West	Possible, but with yield losses
North	Not recommended
Inclination	Recommended 25°–30° relative to the horizontal plane. A different tilt may significantly reduce yield.

TECHNICAL DATA

Module

Dimensions	47 x 20 x 15 x H8 cm
Weight	1.00 kg
Operating temperature	-40°C / +85°C
Flammability	BROOF (t1) with fire sheath
Number of Invisible Solar modules per m²	15 pieces/m²
Net absorbing surface (total cells)	0.0468 m²
NOCT operating temperature	43.5°C
Type of photovoltaic cell	Monocrystalline silicon
Module efficiency	22.17%

Invisible Solar photovoltaic modules have been tested to BROOF(t1) and are classified as Class E for reaction to fire. Since it is not possible to certify the entire roof system to achieve BROOF(t3) and BROOF(t4) classifications, the use of Invisible Solar modules requires the installation of a fire-resistant membrane.

Electrical performance

Isc – Short-circuit current	6.47 A
Voc – Open-circuit voltage	2.20 V
Pp – Peak power	11.10 W
Imp – Optimal operating current	6.00 A
Vmp – Optimal operating voltage	1.85 V
Maximum system voltage	1000 V
General temperature coefficient	-0.5%/°C

Mechanical properties

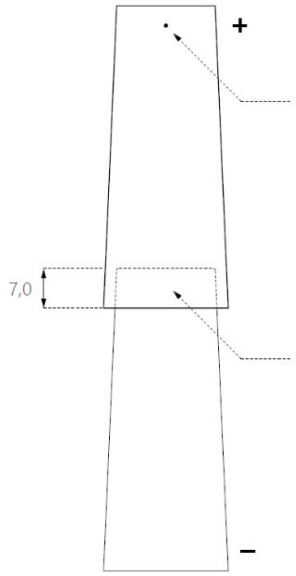
Bending and tension	Module	Stress	Elongation at break	EN ISO standard
Bending	2490 MPa	39.8 MPa	1.2%	527-4
Tension		20.5 MPa	4.8%	178
Viscous tension temperature	56.0°C			11357
Impact resistance (test by dropping a 500 g steel ball)				1.464 newtons
Maximum static load (test using a hydraulic press)				500.00 kg

The tests were carried out on modules selected at random. The modules withstand any expansion and contraction caused by atmospheric conditions, hail, and can be walked on.

Other features

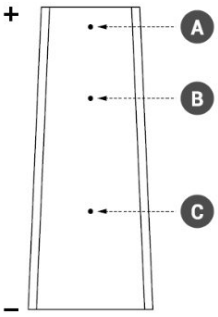
Entirely handcrafted product	Water-repellent
Non-toxic and recyclable material	Thermal retardant (approx. -32°C)
Photocatalytic surface	Resistance to strong acids and their bases
Walkable	Solvent resistance

INVISIBLE SOLAR CONNECTION SYSTEM



Fixing hole
Where the screw will be inserted to fix the module to the roof structure.

Overlap area
Overlapping space between two connected modules. Not modifiable.



Back of the module

A - Fixing hole
Exit hole of the fixing screw inserted on the front side.

B - Positive connection hole
Application point for the screw-in fitting of the Red Connector.

C - Negative connection hole
Application point for the screw-in fitting of the Black Connector.

Black Connector
Screw-in fitting with photovoltaic cable and female MC4 connector to be applied to the negative connection hole (C) of the module.



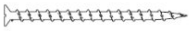
Red Connector
Screw-in fitting with photovoltaic cable and male MC4 connector to be applied to the positive connection hole (B) of the module.



MC4 Diode
MC4 connector with built-in 10A diode, to be used on the end-of-string Red Connector.



Fixing screw
Screw to be inserted from the front into the fixing hole (A), to fix the module to the roof structure.



SPECIFICATIONS

Technical characteristics

The product's technical characteristics were determined through the following tests, conducted by Dyaqua in its own laboratory using instruments calibrated according to Dyaqua standards:

- 50 thermal-cycle tests at a rate of 100°C/h in a climatic chamber, with temperature control from -40°C to +95°C;
- 96 hours of salt-mist corrosion testing;
- 40 humidity and freezing cycles, with temperature variation from -40°C to +95°C and relative humidity from 0% to 90%, in a climatic chamber.

Dyaqua periodically repeats all the tests listed in this document on Invisible Solar modules sampled from production batches.

Precautions

Do not pierce the product.
Do not tamper with and/or modify the product in any way.
Do not tamper with the components of the connection system.
Use MC4 connectors to connect the strings to the rest of the system.

Electrical performance

Electrical performance is determined in Dyaqua laboratories by carrying out tests according to the STC standard, namely with: irradiance of 1000 W/m², junction temperature of 25°C and solar irradiance spectral distribution AM=1.5.

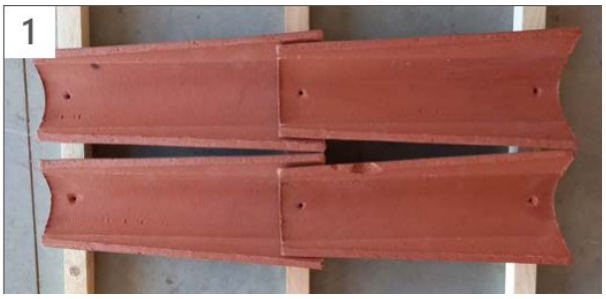
Data not provided here are missing because the standard detection and calculation system is based on traditional photovoltaic panels and is therefore not applicable to innovative, non-conventional products such as Invisible Solar.

The module's electrical performance data represent an average.

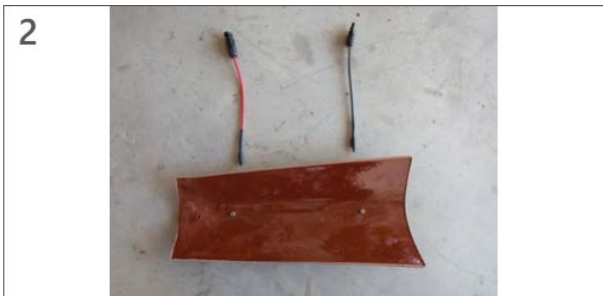
Certifications

Invisible Solar modules represent an innovative and non-conventional technological solution. For this reason, they cannot be certified under the standards applicable to transparent photovoltaic panels, as they are not suitable for the test procedures and test configurations applicable to such devices.

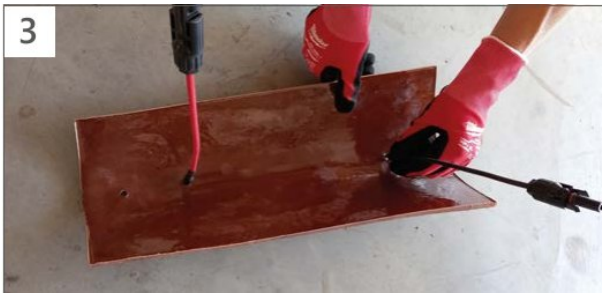
INSTALLATION GUIDE



First, check that the installation conditions are suitable before starting the assembly procedure for the Photovoltaic Coppo tiles. The modules can be installed on: channel tiles (under-tiles), pantiles, plastic or metal corrugated sheets.



Take one Black Connector for the negative pole and one Red Connector for the positive pole. Start working on the back of the Coppo tile.



Apply the screw-on fittings of the connectors to the respective holes and tighten them by hand. The Black Connector, negative pole, must be applied to the large end of the module, while the Red Connector, positive pole, must be applied to the small end.



Seal the joint at the points where the connectors fit into the module to ensure perfect insulation of the connections.



Starting from the lower part of the roof slope, place the newly prepared Photovoltaic Coppo tile onto the installation layer in its covering position, with the small end facing the top of the roof. We recommend connecting a cable long enough to reach the end of the string to the Black Connector of the first module installed, even when the string consists of several rows, in order to check its electrical continuity after each module is installed using a tester between the module's positive connector and the cable connected to the negative pole of the string. Once the string is complete, remove the cable used for the check.

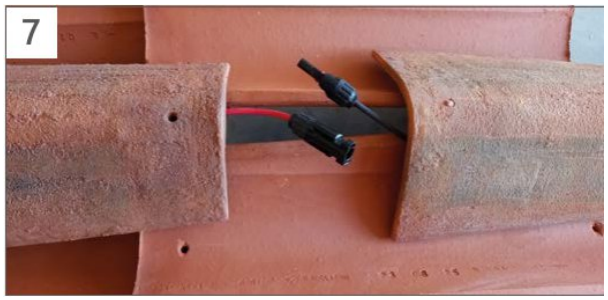


Insert the fixing screw into the dedicated hole in the module and tighten it into the underlying batten without forcing it, in order to secure it to the roof structure. If using an electric screwdriver, stop slightly earlier and complete the procedure manually.

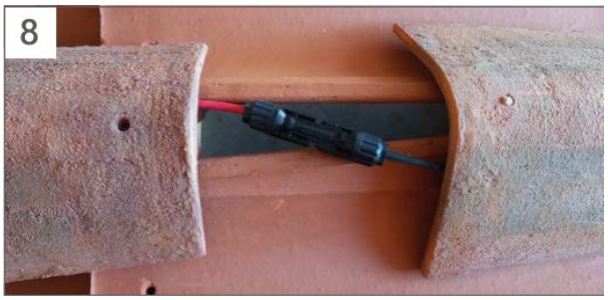
If the installation layer consists of corrugated sheets, check the most suitable fixing method so as not to damage their integrity.

The screws can also be fixed to metal supports if the structure does not have wooden battens.

All modules must always be secured to the structure to prevent dangerous situations such as the sliding and/or displacement of part or all of the system.



Prepare a second module by applying the connectors following the same instructions as in points 2, 3 and 4.



Connect the Red Connector of the first module to the Black Connector of the second module. Then secure the second module to the roof structure as described in point 6.



Repeat the procedure until the row is complete and connect an MC4 Diode to the Red Connector of the last module in the string.

If a string consists of more than one row, the MC4 Diode must be applied only to the last module of the entire string and NOT at the end of each individual row.

Repeat the entire procedure for each string in the system.

CONNECTION CONFIGURATION

Below are some suggestions and examples to help configure the strings and system optimally with our products. Specific technical assessments must nevertheless be carried out by an experienced technician.

Row
A sequence of Rooftiles arranged vertically, running from the bottom to the top of a roof slope.

String
A sequence of Rooftiles connected to one another in series.

The string runs from the bottom (beginning) to the top (end) and may consist of one or more rows, even of different lengths.

The minimum length of a string is 5 Rooftiles, even if divided into several rows, so as to exceed the resistance imposed by the MC4 Diode. The maximum length must be calculated on the basis of the maximum system voltage stated in the product technical data sheet. Generally, excessively long strings are not recommended in order to:

- prevent temporary shading and/or any malfunction of one or more modules from significantly affecting the system's yield;
- make it easier, in the event of a malfunction, to identify the module(s) that may have interrupted the continuity of the string.

Groups
Strings can be connected to one another in series or parallel to form groups. Likewise, several groups of strings can be connected to one another in series or parallel. A system may therefore consist of one or more groups of strings.

The choice of connection type (series or parallel) for each group and for the set of groups must be calculated according to the values required for the operation of the various system components: if the components require higher voltage, a series connection is preferable; where higher current is required, a parallel connection is preferable.

Strings and groups must be properly sized during the design stage, taking into account the specific installation conditions.

Legend

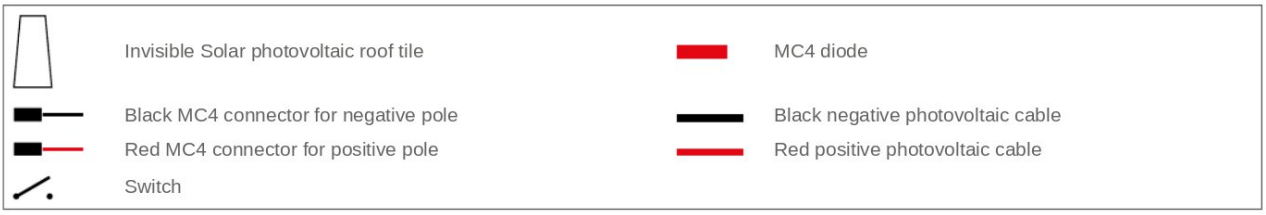


Diagram No. 1

Single-row string (minimum 5 pairs).

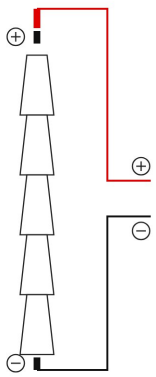


Diagram No. 2

Multi-row string with equal lengths.

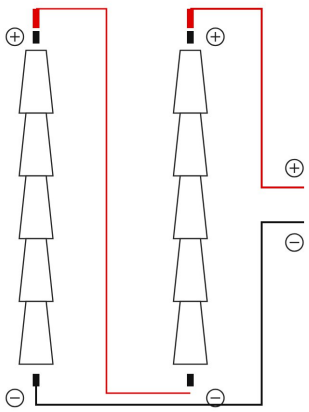


Diagram No. 3

Multi-row string with different lengths.

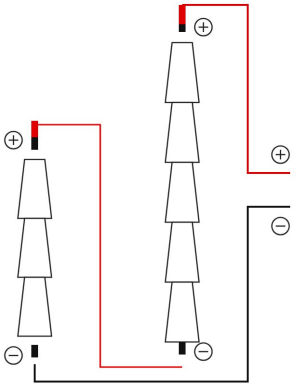


Diagram No. 4

Single group with multi-row strings of equal length.

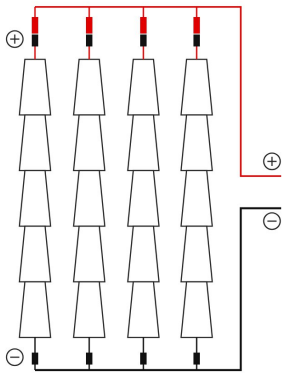


Diagram No. 5

Single group with multi-row strings of different lengths.

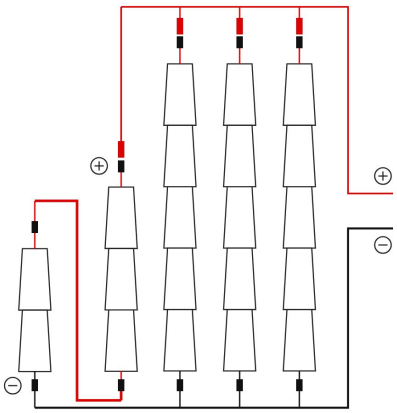


Diagram No. 6

Groups of equal strings connected to each other in parallel.

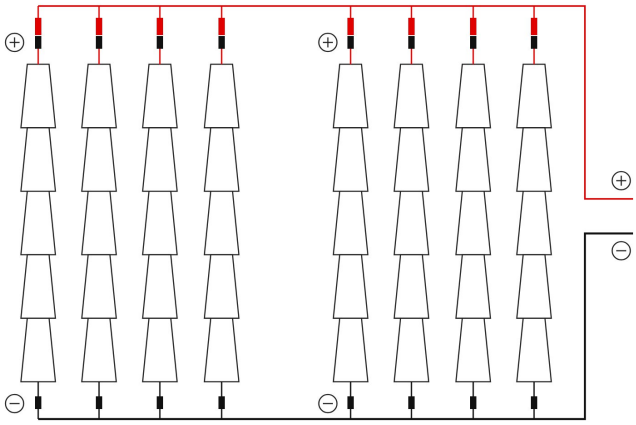


Diagram No. 7

Groups of equal strings connected to each other in series.

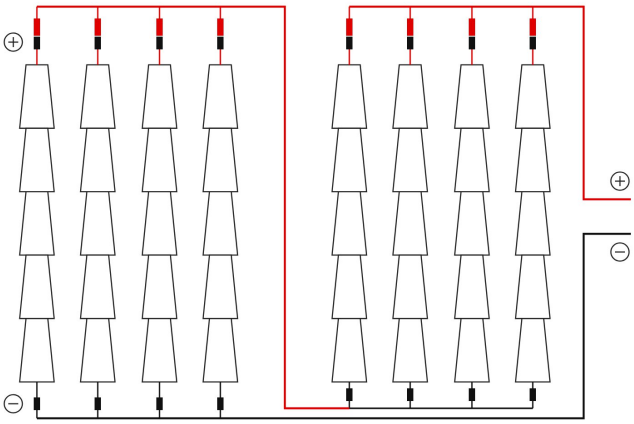


Diagram No. 8

Groups of strings with different row lengths connected to each other in parallel.

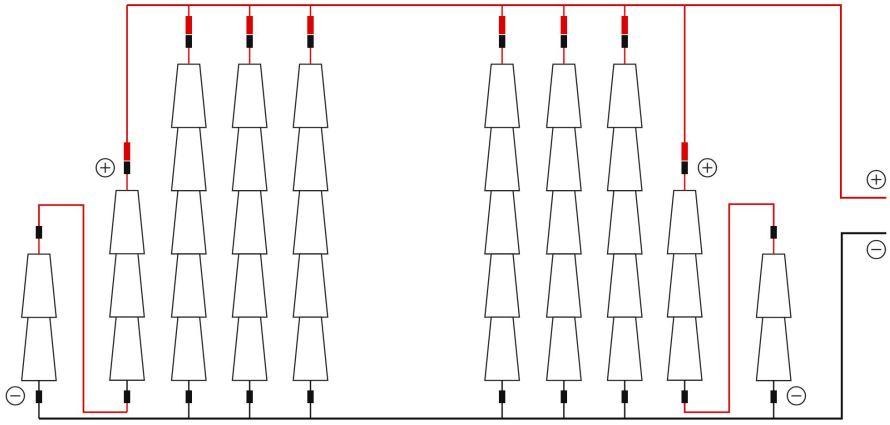
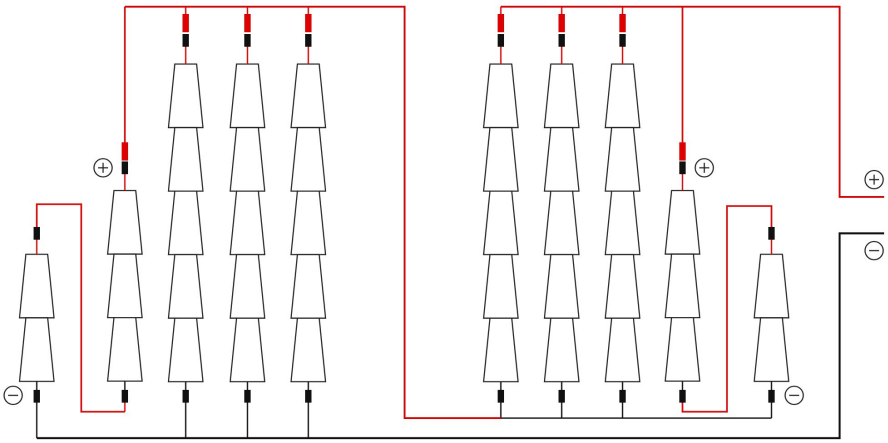


Diagram No. 9

Groups of strings with different row lengths connected to each other in series.



GENERAL INFORMATION

The following information is intended to provide further support for better use of the product. It is not intended to replace the specific assessments of professionals.

PRODUCT

General
Invisible Solar modules are products made through an entirely handcrafted process. Shapes, dimensions and colours may differ due to the type of production.

The architectural element is reproduced in its entirety using a non-toxic polymer compound and appears as a monolithic, indivisible body.

The dimensions and colours of the modules are designed to recreate the typical appearance of the original material.

Colours
The colours are entirely handcrafted.

Within the same supply, modules of the same colour may have different shades. They will therefore be similar to one another but never identical. Likewise, it is neither intended nor possible for the colour of the modules to reproduce the exact colour of a specific original element.

The colour offered by the modules represents an “average colour” that can suit as many situations as possible.

The colour does not change over time, nor in the presence of rain or humidity. It is given a “slightly aged” appearance in order to provide a realistic look even when the surrounding context shows signs of ageing.

The colour cannot be changed. Attempts to change the colour of the modules may reduce, or even eliminate, energy production and, above all, invalidate the product for warranty purposes.

The aim of Invisible Solar modules is to integrate photovoltaic technology, and this feature is provided even if the colour match is not a perfect match with the surrounding context.

Modifications, customisations and tampering
The modules and connection system must not be modified and/or tampered with in any way. Modifying and/or tampering with them may irreparably damage their operation.

The warranty does not apply to modified and/or tampered products.

No customisations are carried out.

DESIGN

Sampling
We always recommend obtaining at least one product sample in order to carry out the appropriate checks on colour, dimensions, etc.

Inert complementary elements
Generally, an Invisible Solar module system occupies only one or more portions of the roof, not all of it. Terracotta covering tiles (new or existing) must be used in the areas not occupied by the system.

Sometimes it may be difficult to find the right colour match between Invisible Solar modules and complementary terracotta elements. To find the right match, it is first advisable to obtain at least one Invisible Solar sample to use as a reference.

Installation sites with special requirements

The standard installation process for the product involves the use of fixing screws to secure each module to the roof structure. This solution is generally also suitable for areas exposed to strong winds, earthquakes and other events that could cause the modules to move and/or fall.

If the installation site is subject to heavy snowfall or particularly high/low temperatures, please check the operating parameters stated in the technical data sheet to assess whether such conditions are suitable for installing the product.

If the solutions provided here are not sufficient for the specific case, you may contact us to assess possible alternatives.

Fire protection design

Fire protection design is the responsibility of the designer responsible for developing the system, who must assess the possible use of panels or insulating membranes suitable for the roof structure in accordance with the Fire Brigade Guidelines.

The various certifications, including the fire-safety certification, are stated in the product technical data sheet; please consult the document and contact us if you have any doubts.

North-facing system

Invisible Solar modules must not be installed facing north, i.e. on all roof slopes between east and west that face north.

Although a north-facing roof slope may appear illuminated at certain times of day, the sun's rays strike at the wrong angle and only a very small proportion of them reaches the cells. Energy production is therefore reduced to almost zero.

Furthermore, unlit Invisible Solar modules risk absorbing the energy produced by the illuminated ones, thereby being detrimental to the yield of the entire system.

String configuration

It is important to pay attention when designing the strings, as their configuration can have a positive or negative effect on the system's performance.

Please remember that:

1) to calculate the system voltage, add the volts (V) of each module in the string;

2) to calculate the system current, add the amperes (A) produced by each string;

3) to calculate the system power in watts (W), multiply the volts by the amperes obtained above.

Units of measurement

The product's power is expressed in peak watts (Wp), i.e. measured in accordance with the STC standard. However, it should be noted that this figure is affected by the environmental conditions at the installation site, such as solar irradiation in a given month, the actual tilt and position of the roof slope, and any shading cast on the system.

From peak watts (Wp), it is possible to calculate peak kilowatts (kWp), i.e. the peak equivalent of kilowatt-hours (kWh).

System sizing

System size refers to the number of modules, the area they occupy and the power they produce. It is the responsibility of the system designer to determine the size of the system based on the specific characteristics of the installation site and, accordingly, to estimate the system's actual expected yield.

System components

Dyaqua supplies modules and the related connection system for connecting them into strings.

The system will consist of strings and other complementary components such as an inverter, battery, etc. Determining which complementary components to use is the responsibility of the system designer, based on the specific characteristics of each project. The use of components of a specific brand and/or model is not required.

It may be advisable to install modules with a power output higher than actually required, so as to allow the battery to maintain a reserve charge.

Different tilts and/or orientations within the same system
If the system includes groups of strings with different orientations and/or tilts, it may be necessary to prevent current from flowing back into the groups whose yield, due to less favourable installation conditions, is lower than that of the other groups.

Basic electrical scheme
We recommend positioning the storage battery before the inverter. This solution allows all the energy produced by the system throughout the day to be stored and supplied steadily to the inverter. Otherwise, the energy produced during periods of lower sunlight would be wasted because it is insufficient to activate the inverter.

INSTALLATION

Who can carry out the installation
Invisible Solar modules can be installed by any photovoltaic system installer.

Walkability
Invisible Solar modules can be walked on both during and after installation. If the system has been properly installed, there are no electrical hazards and it is therefore possible to walk on the modules.

Operational check
We recommend not waiting until installation is complete to check the operation of the modules and their connection system, but rather checking the electrical continuity of the strings as installation progresses. Identifying any discontinuities once installation is complete is more complex and may require partial removal of the newly installed system.

To check continuity during installation, all that is needed is a photovoltaic cable long enough to reach the end of the string and a tester. One end of the cable is connected to the Black Connector of the first module in the string, while the other is connected to a tester. By applying the tester to the Red Connector of each newly installed module, it is possible to check the electrical continuity of the string step by step throughout the installation procedure.

Temporary impairment of operation
La produzione elettrica dell'impianto è temporaneamente compromessa quando:

1) the system is covered in snow;
2) during night-time hours;
3) when it rains and/or the sky is particularly cloudy;
4) the installation site is subject to shading.

Permanent impairment of operation
The system's electricity production is permanently impaired when:

1) the installation conditions are incorrect or particularly unfavourable;
2) one or more connectors have been tampered with;
3) one or more connectors have not been inserted correctly;
4) the MC4 Diode has been used incorrectly within the system;
5) one or more modules have been damaged due to excessive force used when tightening the fixing screws into the underlying structure — particularly if an electric screwdriver is used;
6) the system has not been properly designed and the strings and various components have not been appropriately managed;
7) the storage battery has not been positioned before the inverter.

Problem detection and replacement of installed modules
If it becomes necessary to identify a faulty module, we recommend the following procedure:

1) if the system consists of several groups, check the yield of each group and identify the one with an unusually low yield;
2) check the yield of all the strings belonging to the selected group and identify the one with an unusually low yield;
3) check the yield of the modules belonging to the selected string, identify those with problems and remove them;
4) replace the faulty modules with working ones and restore the string connections.

Find out more: www.invisiblesolar.it

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