



dyaqua

INVISIBLE SOLAR



PHOTOVOLTAIC ROOFTILE

TECHNICAL BOOKLET

www.invisiblesolar.it

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IMPORTANT:

Please carefully read this booklet, in its entirety, before to design the system and install the products. Warranty offered by Dyaqua for Invisible Solar modules may be invalidated if product use is not compliant to instructions included in this booklet.

The installation techniques, handling and use of this product are not the responsibility of Dyaqua. Our company therefore will not be responsible for any loss, damage or costs that are consequence of inappropriate installation, movement or use of the product.

Dyaqua reserves the right to modify the content of this booklet and without previous notice.

The original language of this booklet is Italian. English translation is only aimed to help understanding.

Product made in Italy.

INTRODUCTION

INVISIBLE SOLAR, WHAT IS IT AND HOW IT WORKS

What Invisible Solar modules are

The Invisible Solar modules are active architectural components made with non-toxic polymeric compound. At the same time, the modules perform these functions:

- as photovoltaic module, produce clean and renewable energy;
- as architectural part, are components for roof covering;
- as photocatalytic material, have a self-cleaning and depolluting surface.

Technology

Invisible Solar is a patented technology to create photovoltaic modules which are distinguished by typical shape and aesthetic of common building materials. Each module has a monolithic - indivisible - body in which are embedded monocrystalline silicon cells. Creation of the special surface that appears realistic while transparent for sun rays only is therefore very important.

This solution allows creation of innovative kind of modules, which photovoltaic component is absolutely indistinguishable from the building context; for this reason it is perfect for heritage town centres, buildings and sites where both cultural and visual values must be preserved.

How it works

Invisible Solar functioning is based on the low-molecular density principle. Each module is made with a non-toxic and recyclable polymeric compound that is specifically processed to encourage photons absorption.

Monocrystalline silicon cells are embedded inside the module. Surface is opaque at sight but transparent for sun rays, which therefore are allowed to enter the module and feed the cells.

Why to choose Invisible Solar

Invisible Solar modules are designed, by starting from their particular appearance, to be installed on historical and heritage buildings, that means where photovoltaic systems cannot otherwise be installed.

The Invisible Solar important features turns an apparently ordinary roof into a solar pv system which is efficient, reliable, sustainable and - especially - invisible.

Artisan-made products

We chose to maintain an artisan production line in order to guarantee the highest level of aesthetic quality. This kind of production allows us to create the light variations to modules of the same model, giving them a lightly aged and natural appearance.

Quality

Invisible Solar modules and their connection system undergo to quality tests to guarantee safe and working supplies.

Each single module is checked three times before delivery:

- internal electrical system is tested after cells welding is complete and before they are embedded in the polymeric compound;
- the completed module must pass a quality test;
- last test is run before packaging is done.

Each connector is inspected two times:

- welding's endurance test;
- connection's resistance to mechanical stress.

MAIN FEATURES

Integration

Invisible Solar is concealed in the installation site, in this way technology and innovation are brought in it without any visual impact.

Sustainability

Invisible Solar produces clean energy from renewable source, it is made of non-toxic and recyclable materials, purifies air from smog.

Resistance

Invisible Solar withstands to heavy static loads, atmospheric agents and chemical solvents.

Photocatalysis

Invisible Solar automatically starts a natural process of photocatalysis which cleans up module's surface and helps to depollute air.

BENEFITS

- Solar photovoltaic for heritage
- Renewable energy
- Energy independence
- Environmental respect
- No maintenance
- Discourage cementification
- Promote building reuse
- No need of cleanser or polluting products to clean modules.

TECHNICAL DATA SHEET

Product version 2.1

Photovoltaic module has architectural component shape and made of non-toxic and recyclable polymeric compound, in which are embedded monocrystalline silicon cells.

This document is valid for the following variations:

Item Code	Description
IS001-C01	Terracotta
IS001-C02	Yellow Clay
IS001-C03	Gray

System sizing example

Peak power	1 kWp
Quantity of module	91 Rooftiles
System area	6 sqm

Orientation and inclination

South	Optimal
East, West	Possible but with lower performance
North	Not recommended
Inclination	Recommended inclination 25°-30° relative to the horizontal plane. Performance could be reduced - also significantly - if a different inclination is applied.



TECHNICAL DATA

Module

Dimensions	46 x 19 x 15 x H8 cm
Weight	1,00 kg
Working temperature	-40°C / +85°C
Flammability	EN 13501-5, EN13501-1, CEN/TS 1187-1, EN/ISO 11925-2
Quantity of Invisible Solar modules per m ²	15 pcs/m ²
Net absorbent surface (total cells)	0,0468 sqm
Operative temperature NOCT	43,5°C
Type of solar cell	Monocrystalline silicon
Module efficiency	22,17 %

Electrical performances

Isc - Short circuit current	6,47 A
Voc - Open circuit voltage	2,20 V
Pp - Peak power	11,10 W
Imp - Maximum power current	6,00 A
Vmp - Maximum power voltage	1,85 V
Maximum system voltage	1000 V
General temperature coefficient	-0,5%/°C

Mechanical properties

Bend and traction	Module	Strain	Elongation at break	EN ISO
Bend	2490 MPa	39,8 MPa	1,2%	527-4
Traction		20,5 MPa	4,8%	178
Viscous traction temperature	56,0°C			11357
Impact resistance (fall of a 500gr steel ball)				1,464 newton
Maximum static load (hydraulic press)				500,00 kg

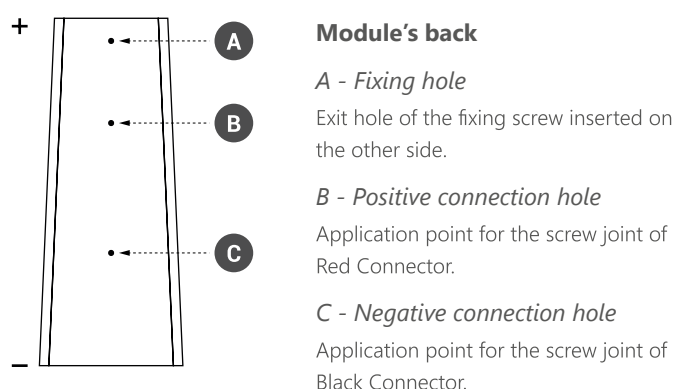
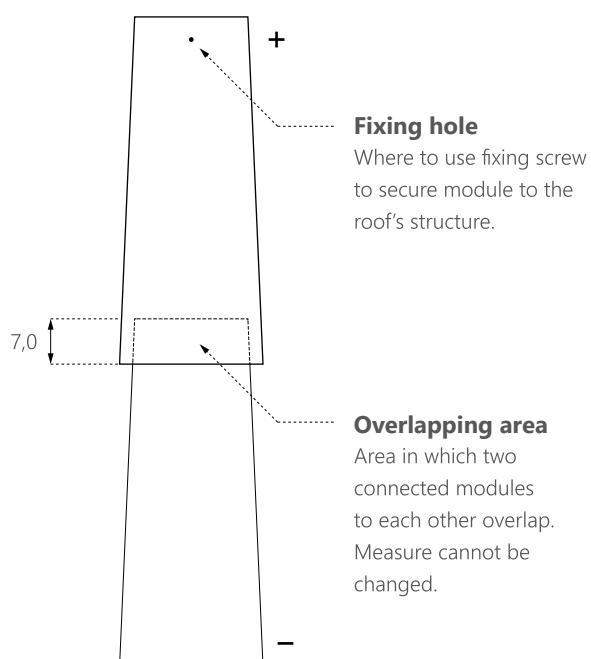
Test made on randomly chosen modules.

Modules withstand to any expansion, decrease due to atmospheric conditions, hail and walk-over.

Further features

Entirely artisan-made product	Waterproof
Non-toxic and recyclable material	Thermal retarder (about -32%)
Photocatalysis	Hard acids and their bases resistant
Walk-over	Resistant to solvent

INVISIBLE SOLAR CONNECTION SYSTEM



Black Connector

Screw graft with photovoltaic cable and MC4 female connector, it shall be applied to negative connection hole (C) of the module.



MC4 Diode

MC4 connector with 10A diode embedded, it shall be applied to Red Connector at the string's end.



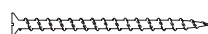
Red Connector

Scw graft with photovoltaic cable and MC4 male connector, it shall be applied to positive connection hole (B) of the module.



Fixing Screw

This screw must be inserted in fixing hole (A) from the module's front-side to secure it to the roof structure.



SPECIFICATIONS

Technical features

Product's technical features were determined through the following tests, that were performed by Dyaqua in its laboratory by using equipments calibrated on Dyaqua's standards:

- 50 cycles of 100°C/h thermal variations with controlled temperature from -40°C to +95°C;
- 96 hours of salt spray corrosion test;
- 40 cycle of humidity and freezing in a controlled temperature chamber, with thermal variation from -40°C to +95°C and humidity from 0% a 90%. Dyaqua periodically repeats all tests on Invisible Solar modules, which are randomly selected from manufacturing batches.

Caution

- Do not pierce the product.
- Do not in any way alter and/or modify the product.
- Do not alter components of the connection system.
- Use MC4 connectors to join strings to the rest of the system.

Electrical performances

Electrical performances are determined at Dyaqua's laboratory by performing tests according to STC standard, that means with 1000W/m² irradiance, 25°C connection temperature and spectral distribution of irradiance AM=1,5.

Lack of some data depends by the standard detection system, which is based on traditional solar panels and cannot be applied on innovative and non-conventional product like Invisible Solar ones.

Electrical performances data of the module represent an average value.

INSTALLATION GUIDE



1 Check if the laying conditions are suitable to start the installation procedure of Invisible Sola Rooftiles. Rooftiles can be installed on reversed curved tiles, tuscan roman flat tiles, plastic or metal roofing sheets.



2 Take a Black Connector for the negative pole and a Red Connector for the positive pole. Start to work on the backside of Rooftile.



3 Insert the scaw grafts of both connectors in the respective holes, and fasten them manually. Black Connector - negative pole - shall be applied to specific hole towards the module's large head while Red Connector - positive pole - shall be applied to specific hole towards the module's small head.



4 Seal the junction points of connectors with silicon sealant to assure a perfect isolation of connections.



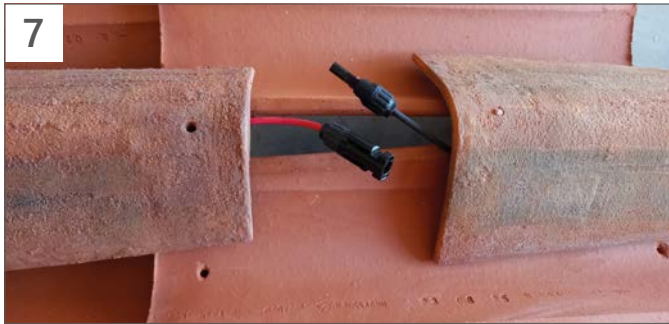
5 Start from the lower side of the roof to lay the Rooftile that was previously prepared on the laying layer. The small head shall be oriented to the roof top edge.

We recommend to check string's electrical continuity while installation process is in progress. For an easier check, connect an additional cable - long enough to reach the opposit string end, even if it is made of different rows - to Black Connector of the first module of the string. Apply a tester and connect it to both additional cable and Red Connector of the last module that has laid; then, check data. Repeat the check on each laid module, until the string is completed.



6 Insert fixing screw in the specific hole, and tighten it - without force - to the batten, so that the module is secured to the roof structure. If using an electric screwdriver, stop before the screw is completely in and finish by using a hand screwdriver. If laying layer is made by roof sheets, use a fixing method that will not damage them. Fixing screws can be used also with metal supports when roof structure is not made with wooden battens.

All modules must be secured to roof structure to avoid dangerous situations, for example the slip and/or move of installed modules.



7 Prepare a second module following the previous instruction at points 2, 3, and 4 .



8 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 done at point 6.



9 Repeat the process until the row is completed, and connect an MC4 Diode at Red Connector of the last module of the string. If string is made of more than one rows, the MC4 Diode shall be applied to the last module of the entire string only - NOT at the end of each row. Repeat the entire process per each string of the system.

CONNECTIONS CONFIGURATION

Here below some recommendations and useful examples on how to best configure strings and systems made with this module. Specific evaluations must be done by a skilled technician in any case.

Row

A sequence of modules connected to form a vertical line across the roof slope, from the bottom to the top.

String

A sequence of modules connected to each others in series.
String crosses roof slope from bottom to the top, and it can be made by one or more rows, which can have same or different lengths.
Minimum length is 5 modules, to overtake resistance made by the MC4 Diode. Minimum length must be observed even when the string is divided in several rows. Maximum length must be calculated in accordance with the maximum value of system voltage, which is specified in the product's technical data sheet.
Usually we recommend to avoid creation of very long strings in order to:

- prevent system performance to be strongly reduced by temporary shadings and/or any malfunctions;
- simplify, if any malfunctioning occurs, the process to find modules that interrupt the string's continuity.

Groups

Group is made by one or more strings connected in series or in parallel. Similarly, it is possible to connect two or more groups in series or in parallel. This means that a system can be made by one or more string's groups.
Connection type (series or parallel) used in a group or set of groups must be decided in accordance with functioning requirements of complementary components. If components require a greater tension, series connection should be preferred; otherwise, if greater current is required, parallel connection should be preferred.
Strings and groups must be adequately designed in order to observe specific installation conditions of the single project.

Key:

	Invisible Solar Rooftile		MC4 Diode
	MC4 Black Connector - negative pole		Black photovoltaic cable - negative
	MC4 Red Connector - positive pole		Red photovoltaic cable - positive
	Switch		

Diagram n. 1

Single row string
(minimum 5 Rooftiles).

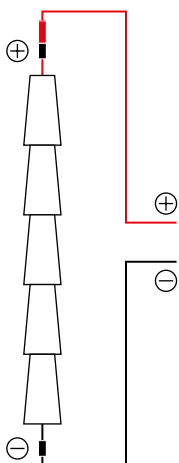


Diagram n. 2

String of multiple rows with
same length.

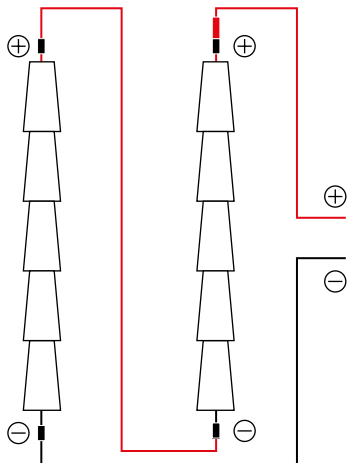


Diagram n.3

String of multiple rows with
different length.

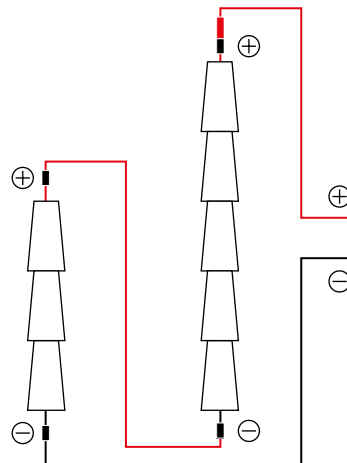


Diagram n. 4

Single group of same-length strings.

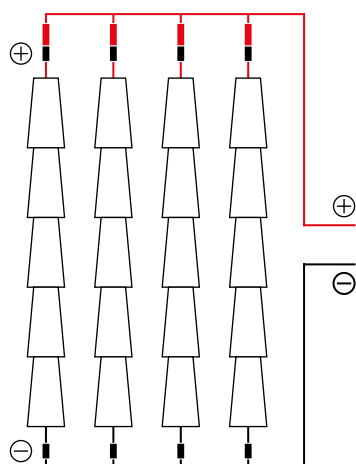


Diagram n. 5

Single group of different-length strings.

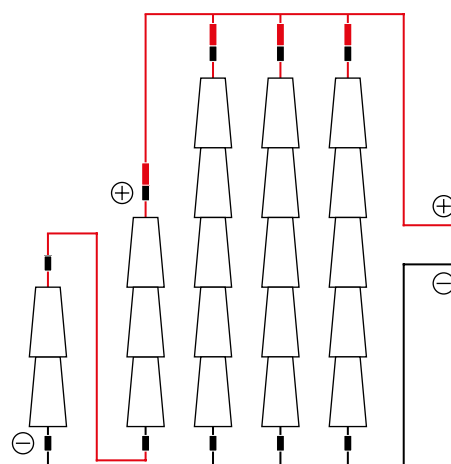


Diagram n. 6

Multiple groups of same-length strings connected in parallel.

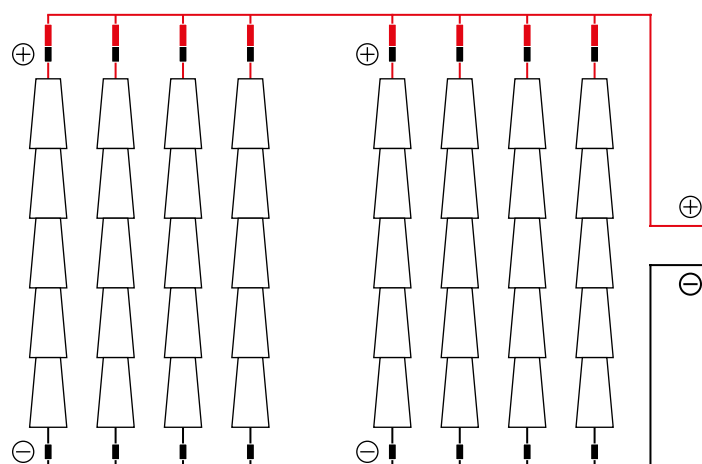


Diagram n. 7

Multiple groups of same-length strings connected in series.

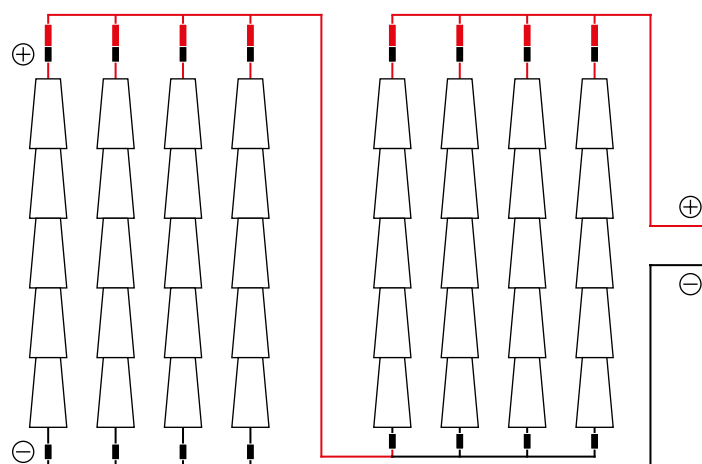


Diagram n. 8

Multiple groups with different-length strings connected in parallel.

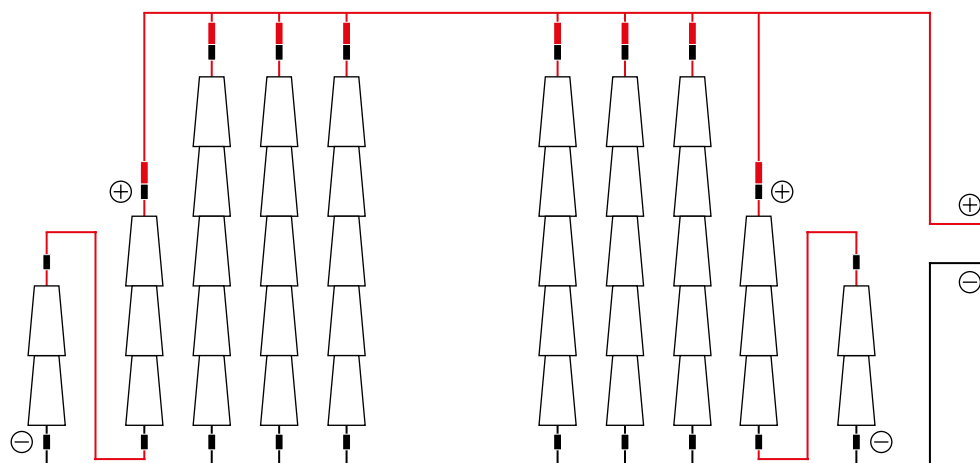
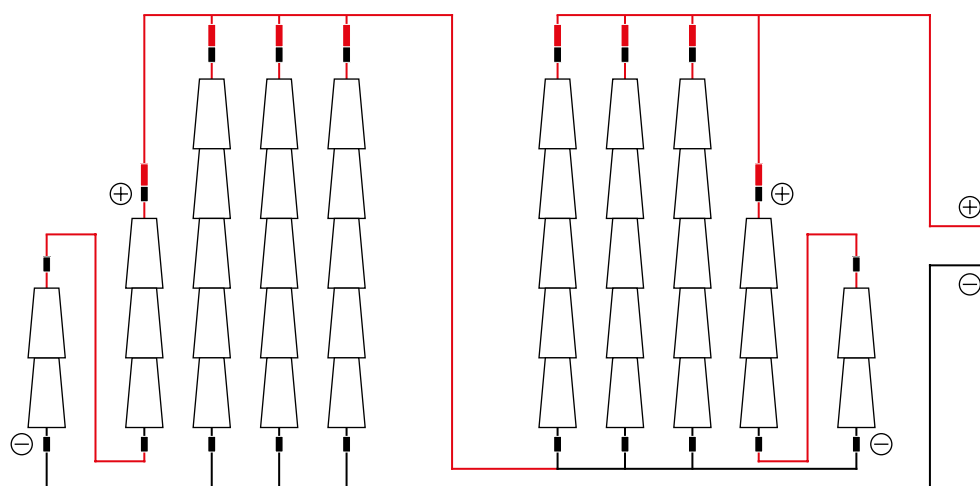


Diagram n. 9

Multiple groups with different-length strings connected in series.



GENERAL INFORMATION

These instructions are meant to provide a more complete help to best use the product.

These instructions are not meant to substitute specific evaluations made by experts.

PRODUCT

General

Invisible Solar modules are manufactured by using artisanal process. Shapes, dimensions and colors could have differences due to the production type.

The architectural component is entirely reproduced by using non-toxic compound, and formed as monolithic body that cannot be divided.

Sizes and colors of the modules are designed to reproduce the typical aspect of reference materials.

Colors

Colors are entirely artisan-made.

Same color modules from the same supply can have slightly different shades. Their appearance can be similar to each other but not identical. Color is not expected - and it is not possible - to exactly imitate of a specific material.

Color offered by modules represents an "average color" which suits as many situations as possible.

Color does not change in time, not even in presence of rain or humidity. Its appearance is light aged to provide realistic aesthetic even when

installation context has aging signs.

Color cannot be modified. Any attempt to modify color reduces, if not zeroes, energy production and - above all - revokes access to product's warranty.

Aim of Invisible Solar modules is to aesthetically assimilate photovoltaic technology to installation sites; this feature is offered even when color combination does not perfectly match.

Modifies, customizations and alterations

Modules and connection system shall not be modified and/or altered.

Any variation and/or alteration can irreparably damage the functioning.

Warranty is not applied to modified and/or altered products.

Customizations are not available.

DESIGN

Samples

It is suggested to always acquire one product samples to do, at least, proper evaluations about color, measures, etc.

Inactive complementary roof tiles

Usually the area occupied by a system of Invisible Solar modules does cover one or more roof sections, but not all the roof. On the roof sections free from the system, traditional tiles (new or existing) must be used to complete the covering.

Sometimes, it can be difficult to find the best color combination between the Invisible Solar modules and traditional roof tiles. In such cases, to ease finding of the best color combination, it is suggested to have at least one Invisible Solar sample as reference.

Installation sites with particular requirements

Standard installation process involves use of fixing screws to secure the product to the roof structure. In general, this solution is also adapted to locations subjected to strong winds, earthquakes, and other events that would move and/or fall the modules.

If installation site is subjected to snowfalls or very high/low temperatures, check functioning parameters on technical data sheet, to evaluate if such site does offer adequate conditions for the product's use.

If the above solutions are not enough for your specific case, please contact us to find possible alternatives.

Fire safety design

Technician who plans the system is responsible for fire safety design, and has to evaluate the possible use of insulating panels or sheaths which are suitable for roof structure, in accordance with guidelines of the local Fire Brigade.

Product technical data sheet contains reference about all necessary certifications. Please consult the document and contact us if you need

any further question.

North oriented installation

Invisible Solar module shall not oriented to North, North-East and North-West.

Even if a North oriented roof has a good exposure during the day, solar rays reach the module with a wrong inclination, and then only very few solar rays are able to reach the cells. For this reason, performance of a north-oriented module is almost zeroed.

Strings setting up

It is important to pay attention on designing strings, their set up can in fact produce positive or negative influence to entire system performance. We remind to:

- 1) calculate voltage by adding up Volts (V) from each module of the string;
- 2) calculate current by adding up Amperes (A) of each string;
- 3) obtain Watts (W) by multiplying Volts (V) and Amperes (A) that were previously calculated.

Different inclination and/or orientation in the same system

If the system is made by groups that are differently oriented and/or inclined, it could be necessary to prevent any current returns towards the groups that have lower performance than others, which are due for example to less advantageous installation conditions.

Unit of measure

Product's nominal power is expressed as Watt-peak (Wp), this value is detected in accordance with STC standard. However, such value is conditioned by environmental conditions of the installation site, for example: solar irradiation in a specific month, inclination and position of the roof slope, any shadings thrown on the system.

Starting from Watt-peak (Wp), it is possible to calculate Kilowatt-peak (kWp) which is equivalent to Kilowatt-hour (kWh).

System sizing

System size is the amount of modules, the area they cover, and the power they produce. System size must be defined by a technician, in accordance with specific features of installation site and, therefore, deducing real performance the system can achieve.

System's components

Dyaqua supplies modules and their connection system; that is all necessary items to install modules inside a specifically sized system - which is made with other components as inverter, battery, etc.

The decision of which components shall be used to complete the system is not competence of Dyaqua, and therefore it exclusively pertains the designer.

Invisible Solar modules do not require the use of components of specific brands and/or model.

It could be appropriate to install modules for a higher power than the actually needed, this solution allows the battery to maintain a reserve accumulation.

Basic electrical scheme

We suggest to place the accumulation battery before the inverter. In this way all energy produced by the system will be accumulated during the day, and transferred toward the inverter constantly. On the contrary, energy produced when irradiance is low would be lost because it is insufficient to activate the inverter.

INSTALLATION

Who can do the installation

Installation of Invisible Solar modules can be done by any installer skilled in photovoltaic systems.

Walkability

Invisible Solar modules are walkable both during installation and later. If system is properly installed, there are not electrical risks and then it is possible to walk on modules.

Functioning check

We suggest to verifying the electrical continuity module-by-module while installation is in progress, and to not wait until it is completed.

In fact, if any electrical discontinuity would be detected after installation is completed, it could be necessary to remove installed modules partially or entirely to solve the problem.

The electrical continuity check during installation is easy. Connect a photovoltaic cable to the Black Connector of the first module of the string - it shall be long enough to reach the opposite end of the string. Connect a voltmeter to both the added cable and the Red Connector of the just installed module, then repeat on each module until the string is completed.

Temporary compromising of functioning

Energy production of the system is temporarily compromised:

- 1) if system is covered with snow,
- 2) at nighttime (lack of sun rays),
- 3) when it rains and/or the sky is very cloudy,
- 4) installation site undergoes to shading events.

Permanent compromising of functioning

Electrical performance of the system is permanently compromised in case of:

- 1) incorrect or particularly disadvantageous installation conditions;
- 2) one or more connectors were manipulated;
- 3) one or more connectors were not correctly plugged in;
- 4) incorrect use of MC4 diode in the system;
- 5) one or more modules were damaged by using exceeding force to fasten the fixing screws to roof structure - in particular if operation was done by using an electric screwdriver;
- 6) incorrect system design, with strings and components were not adequately managed;
- 7) accumulation battery is not placed before inverter.

Issues detection and replacement of installed modules

The recommended method to detect and replace any possible interrupted modules:

- 1) if system is made by several groups, check performance of each group and identify which one has an unusually low performance;
- 2) check performance of all strings in the identified group, and find the string that has an unusually low performance;
- 3) check performance of all modules in the identified string, find the interrupted ones and remove them;
- 4) replace interrupted modules with functioning ones, then restore connections of the string.

ENVIRONMENTAL MEASUREMENTS

The following tables show data obtained by environmental measurements we done on Invisible Solar Rooftile, sample "G2", product version 2.0 power 7,57 Wp, during 2023 at our operative headquarter. We selected data collected on the month's day with the best irradiation. These tables are meant to give an overview of the product's environmental performances, beside laboratory measurements.

Month	Orientation						Inclination - South oriented					
	South			North			Horizontal			Vertical		
	Volt (V)	Ampere (A)	Watt (W)	Volt (V)	Ampere (A)	Watt (W)	Volt (V)	Ampere (A)	Watt (W)	Volt (V)	Ampere (A)	Watt (W)
January	2,05	2,45	5,02	1,85	0,25	0,46	2,03	1,31	2,66	2,12	3,06	6,48
February	2,14	2,89	6,18	1,86	0,29	0,55	2,09	1,70	3,55	2,14	3,01	6,44
March	2,12	3,05	6,47	1,96	0,68	1,33	2,07	2,01	4,16	2,09	2,92	6,10
April	2,10	3,10	6,51	1,97	1,18	2,32	2,07	2,48	5,06	2,07	2,32	4,80
May	2,09	2,99	6,25	1,96	1,28	2,50	2,06	2,55	5,25	2,02	1,68	3,39
June	2,03	3,30	6,70	1,94	1,82	3,53	2,01	2,95	5,93	1,95	1,72	3,35
July	2,00	3,04	6,08	1,94	1,97	3,82	2,00	2,53	5,06	1,90	1,45	2,75
August	1,99	2,83	5,63	1,88	0,68	1,28	1,96	2,01	3,94	1,88	2,20	4,29
September	2,02	2,94	5,94	1,79	0,83	1,49	1,98	2,16	4,28	1,97	2,08	4,10
October	2,14	2,90	6,20	1,92	0,40	0,77	2,07	1,93	3,99	2,12	2,63	5,57
November	2,04	2,70	5,50	1,79	0,35	0,63	1,95	1,97	3,85	2,04	2,64	5,38
December	2,05	2,31	4,54	1,75	0,16	0,27	1,96	1,08	2,12	2,08	2,77	5,76

Detection of 17th November 2023

Measurement carried on Invisible Solar Rooftile exposed to the sun on 17th November 2023, on roof at Camisano Vicentino (Vicenza, Italy).
Nominal power: 7,57 Wp

	South	East	West	North	Vertical	Horizontal
Volt (V)	2,03	1,98	1,98	1,76	2,02	1,91
Ampere (A)	2,60	1,69	1,69	0,29	2,68	1,15
Watt (W)	5,28	3,35	3,35	0,51	5,41	2,20

Performances variation based on South on several orientations.

South (base)	Loss, East	Loss, West	Loss, North	Loss, Vertical	Loss, Horizontal
W 5,28	- 36%~	- 36%~	- 90%~	+ 2%~	- 59%~



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