ENERGY 4 FARMING

MODULE 2
Photovoltaic Solar energy

2020-1-ES01-KA202-082440

lowcarbon economy®

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SOLAR ENERGY

INTRODUCTION

The sun. Energy Source

This closest star to Earth is characterized by:

- Equatorial radius: 695,000 km
- Mean surface temperature: 6000ºC
- Surface gravity: 274 m/s^2

Inside are nuclear fusion constantly produces reactions that release energy. The hydrogen atoms, the most abundant element, combine to form helium atoms and energy flows from the interior to the solar surface and from there is radiated into space in all directions.

Part of the radiated energy is transported in the form of electromagnetic waves (photons), which moves in a vacuum at 300,000 km/s, taking about eight minutes to travel the 150 million km that separate the Earth from the sun.

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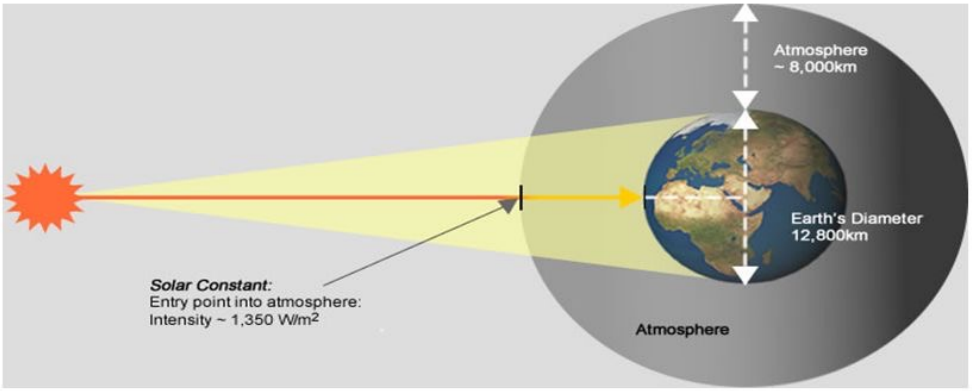
INTRODUCTION

The sun. Energy Source

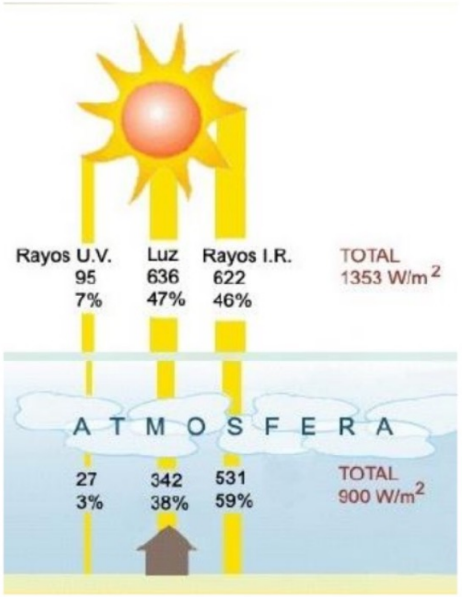
The **Solar constant** Is the flow of energy per m^2 that arrives to the outside of the atmosphere per second, and its value is **1366 W/m²**

Of this radiation only a small part reaches the Earth, the rest of the energy is reflected by the atmosphere, or emitted into space in the form of infrared radiation.

Constante solar = 1366 [Watt/m2] ±3% .



Energía Solar útil = 1000 [Watt/m2] (en promedio)



1 year of solar radiation ≈ 20 x world´s fossil reserves

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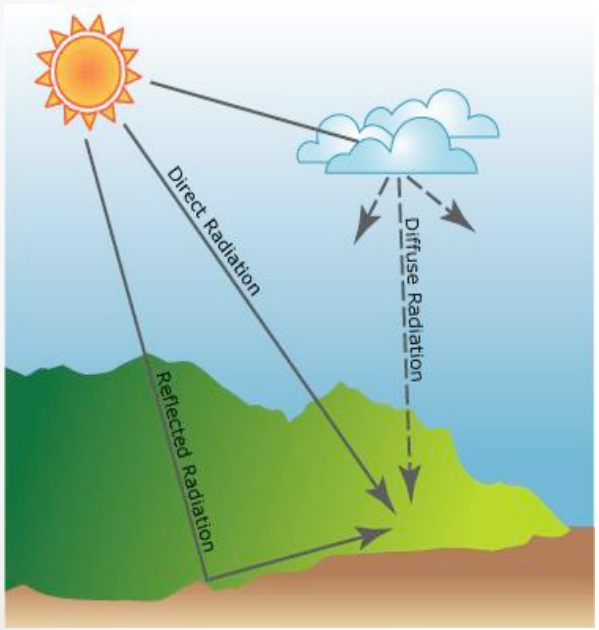
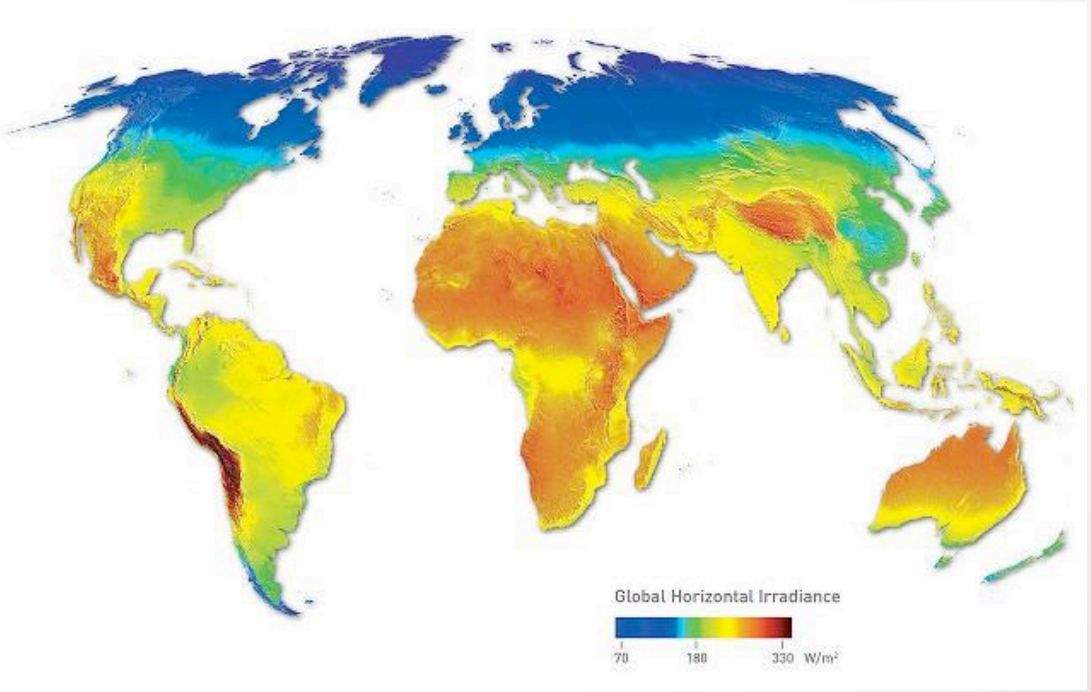
INTRODUCTION

SOLAR ENERGY ON THE EARTH'S SURFACE

- Only a part of the solar radiation index reaches the Earth´s surface.
- The direct radiation that reaches the earth's surface is affected by the composition of the atmosphere, as parts of the global radiation are reflected or diffused.





Radiación solar global = Directa + Difusa + Reflejada ≈ 1.000 W/m² · día

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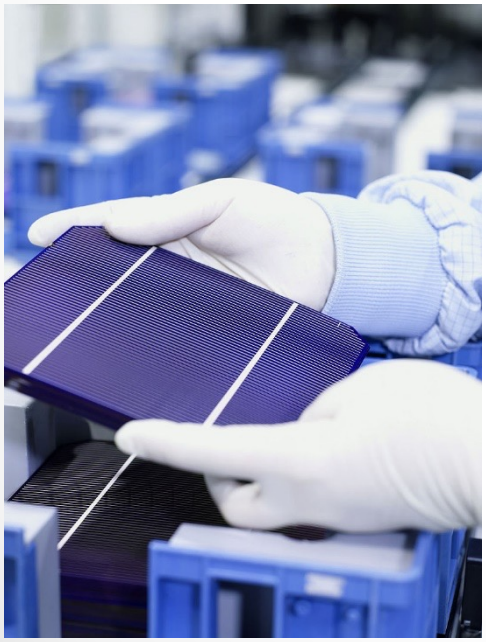
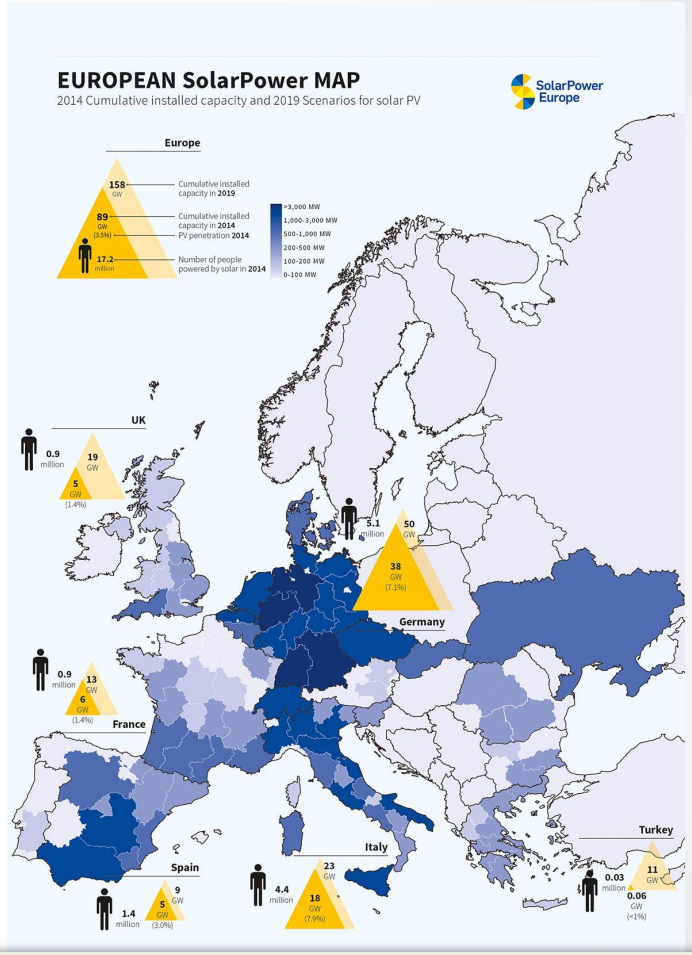
Photovoltaic Solar Energy

Photovoltaic solar capture

- It consists of the direct conversion of light energy into electrical energy.
- The so-called ***Photovoltaic cells***, Formed by very thin sheets of semiconductor materials (for example, silicon), transform solar light energy (photons) into electricity through the stimulation of the electrons in the semiconductor material.





Photovoltaic systems have reduced their costs by 75% over the last 10 years

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Photovoltaic Solar Energy

Photovoltaic System Components

- Solar Photovoltaic Modules

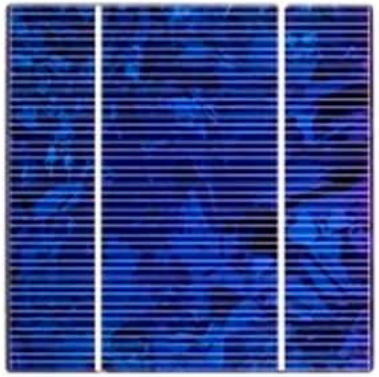
Monocrystalline Silicon

Performance: 17 - 22%

Polycrystalline silicon

Performance: 16-18%

Dark Blue



Amorphous Silicon

Performance: 6-10%

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Photovoltaic Solar Energy

Photovoltaic System Components

- Solar Photovoltaic Modules

Monocrystalline Silicon

The most common sizes:

60 Cells
1650x990x40mm
300 - 340 Wp
Performance: 18.44 - 21%
Vmp: 33 V
Imp: 9 A

72 Cells
1956x990x40mm
360 - 460 Wp
Performance: 18.55 - 21.08%
Vmp: 39 V
Imp: 9 A

Polycrystalline Silicon

The most common sizes:

60 Cells
1650x990x40mm
265 - 280 Wp
Performance: 16.2 - 17.2%
Vmp: 31 V
Imp: 8.8 A

72 Cells
1956x990x40mm
325 - 335 Wp
Performance: 16.7 - 17.2%
Vmp: 37 V
Imp: 8.8 A

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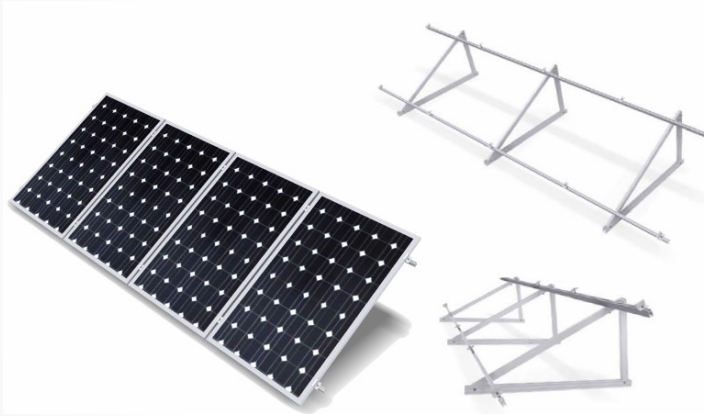
Photovoltaic Solar Energy

Photovoltaic System Components

- Support Structure

Fixed structure

Flat roof or floor



Pitched Roof

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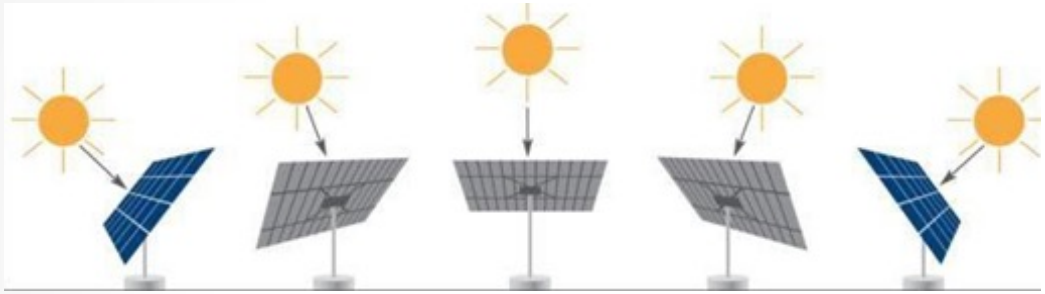
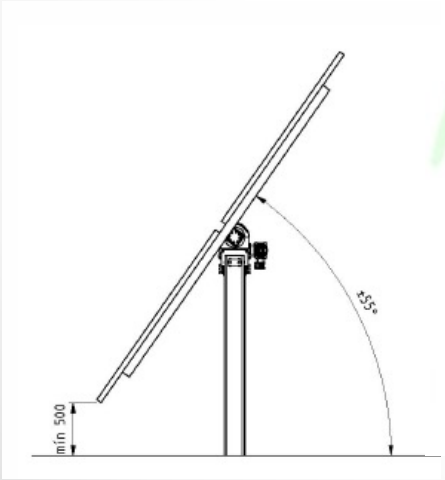
Photovoltaic Solar Energy

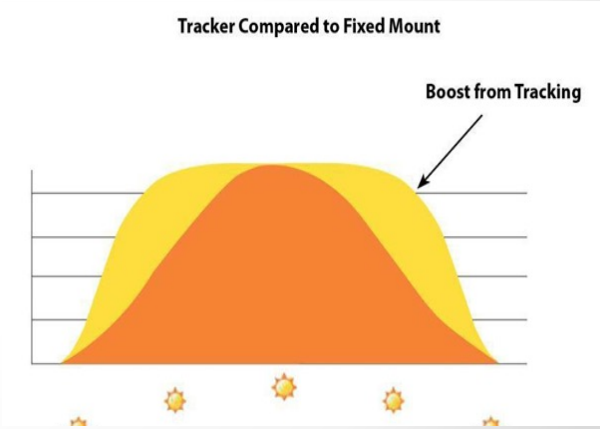
Photovoltaic System Components

- Support Structure

Structure with a follower







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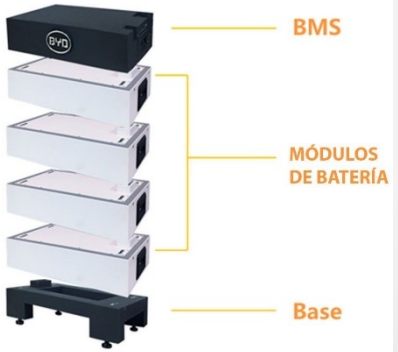
Photovoltaic Solar Energy

Photovoltaic System Components

- Maximizer regulator /

  Electronic equipment that controls the charging of the batteries.

- Batteries

MONOBLOCK	AGM	Stationary	Lithium-ion
			
6 - 12V Small Installations Economic Less useful life	6 - 12V Small Installations Higher performance Maintenance-free	2V Long service life 50% 3000 cycles (DoD)	48-51V Download High depth Long service life Maintenance-free 6000 Cycles (80%DoD)

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Photovoltaic Solar Energy

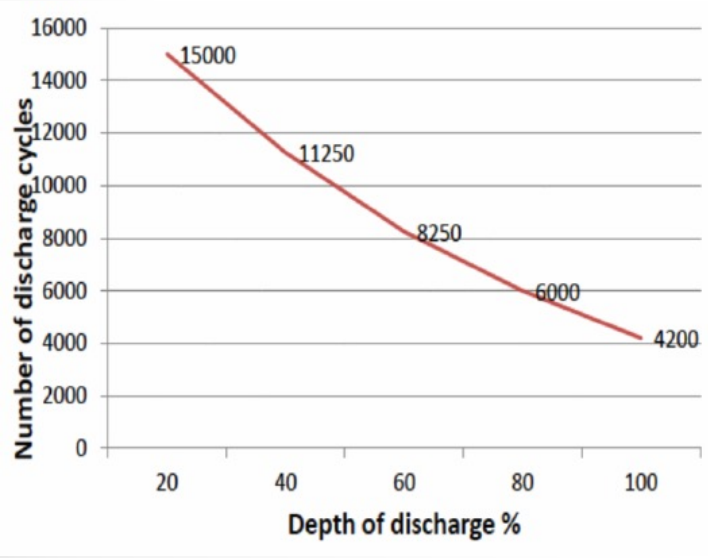
Photovoltaic System Components

- Batteries

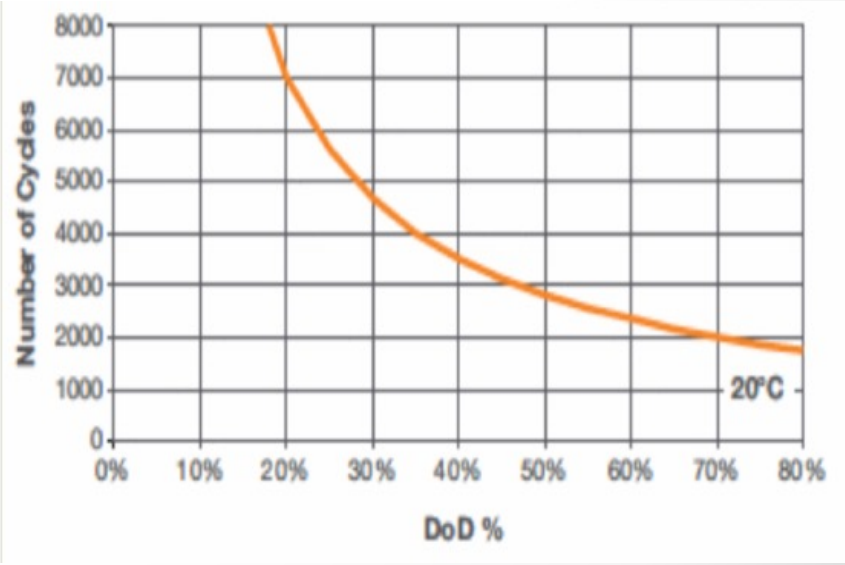
  Main features to take into account:

  - Voltage (V): 2, 4, 6, 12 V
  - Capacity (Ah)
  - Depth of Discharge
  - Life Cycles:

Lithium-ion battery



Stationary OPzS



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Photovoltaic Solar Energy

Photovoltaic System Components

- Inverter

  The DC/AC inverters are electronic devices that allow you to convert the direct current produced by the photovoltaic modules into alternating current.

Grid-tie inverter

Requires the presence of an electrical network to transform energy to the same characteristics of the network

Up to 1000 kW

Off-grid inverter installation

For isolated facilities in which the equipment generates the network switches suitable for use itself

Up to 15kW

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Photovoltaic Solar Energy

Types of photovoltaic installations

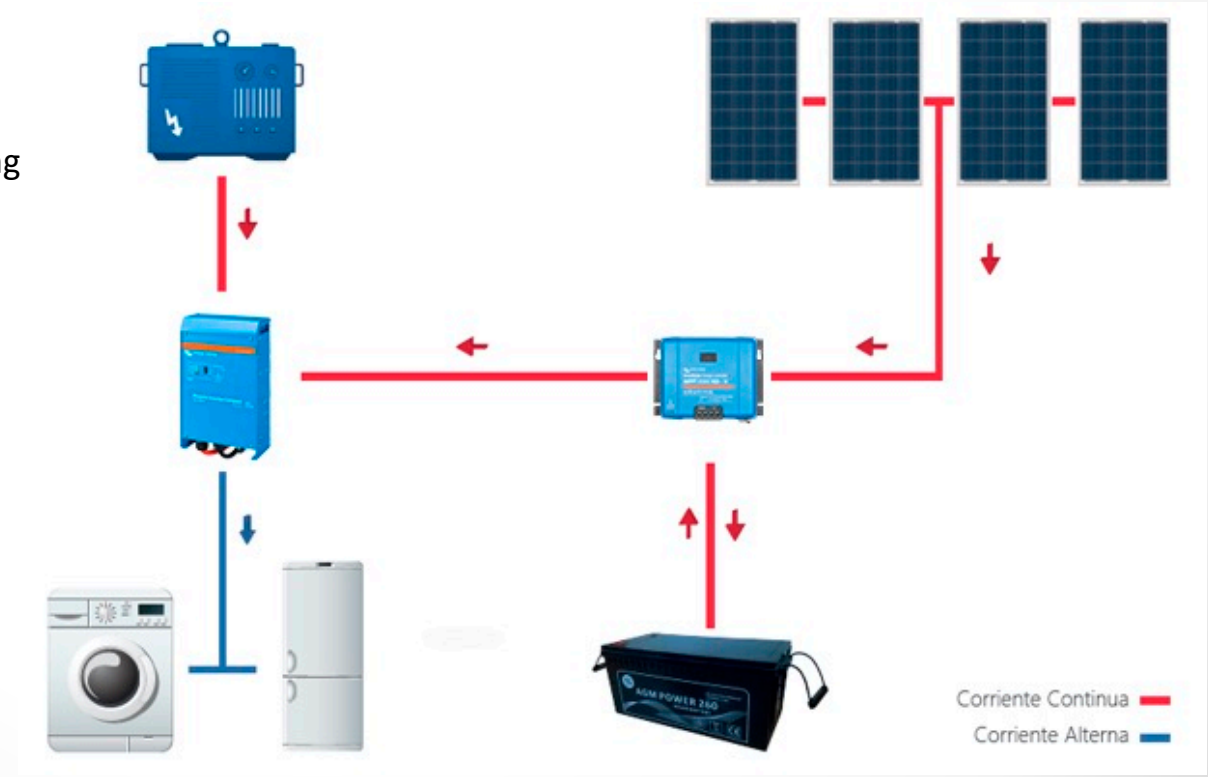
- Isolated installation

  Photovoltaic installation without a network connection. The installation generates and stores energy for later use.

Generic isolated

They are formed by:

- Photovoltaic modules
- Cruise control/Maximizing
- Battery Bank
- Inverter/Charger
- Auxiliary generator



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Photovoltaic Solar Energy

Types of photovoltaic installations

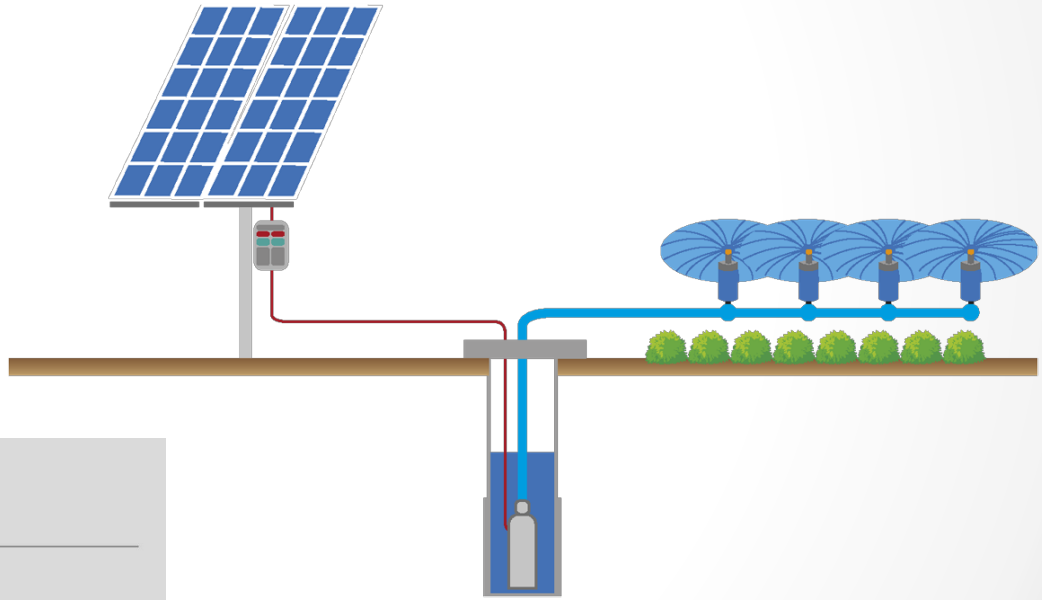
- **Isolated installation**

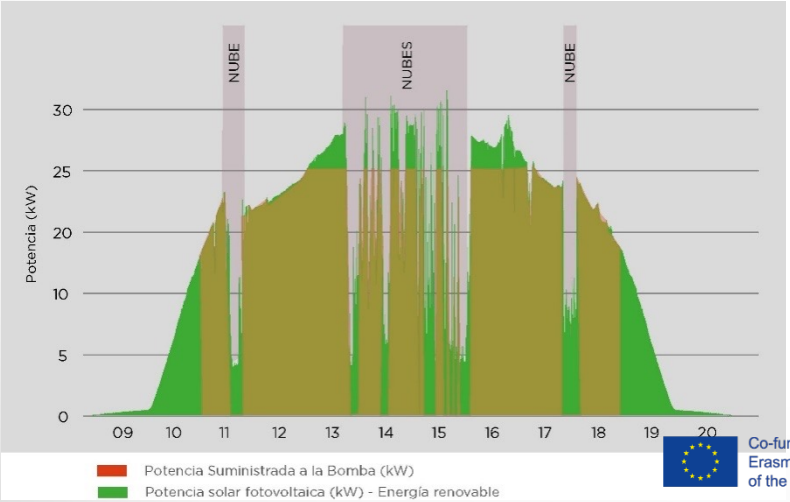
  Photovoltaic installation without a network connection. The installation generates the energy for direct use in a water pump.

SOLAR pumping

They are formed by:

- Photovoltaic modules
- Variable Frequency Drive/controller
- Water Pump





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Photovoltaic Solar Energy

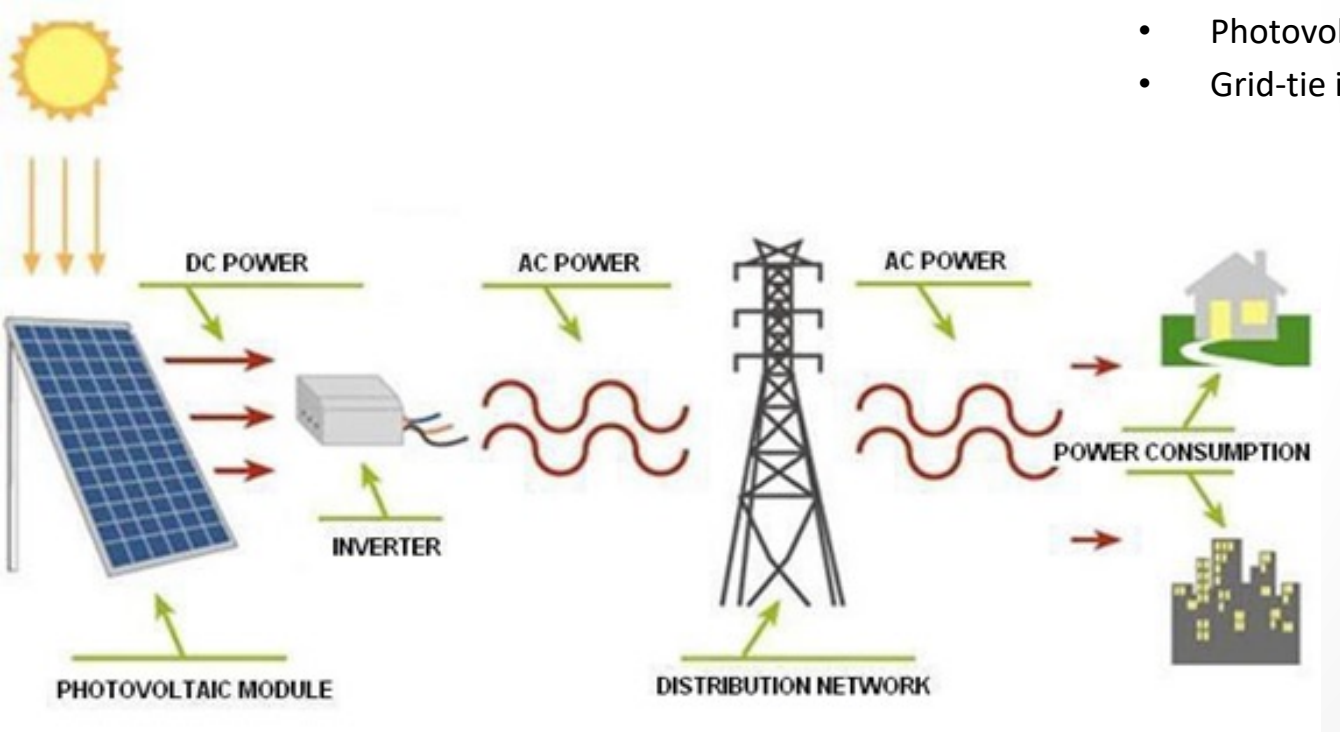
Types of photovoltaic installations

- Installation with a network connection

  Photovoltaic installation which injects all the energy generated to the electricity distribution grid.

They are formed by:

- Photovoltaic modules
- Grid-tie inverters



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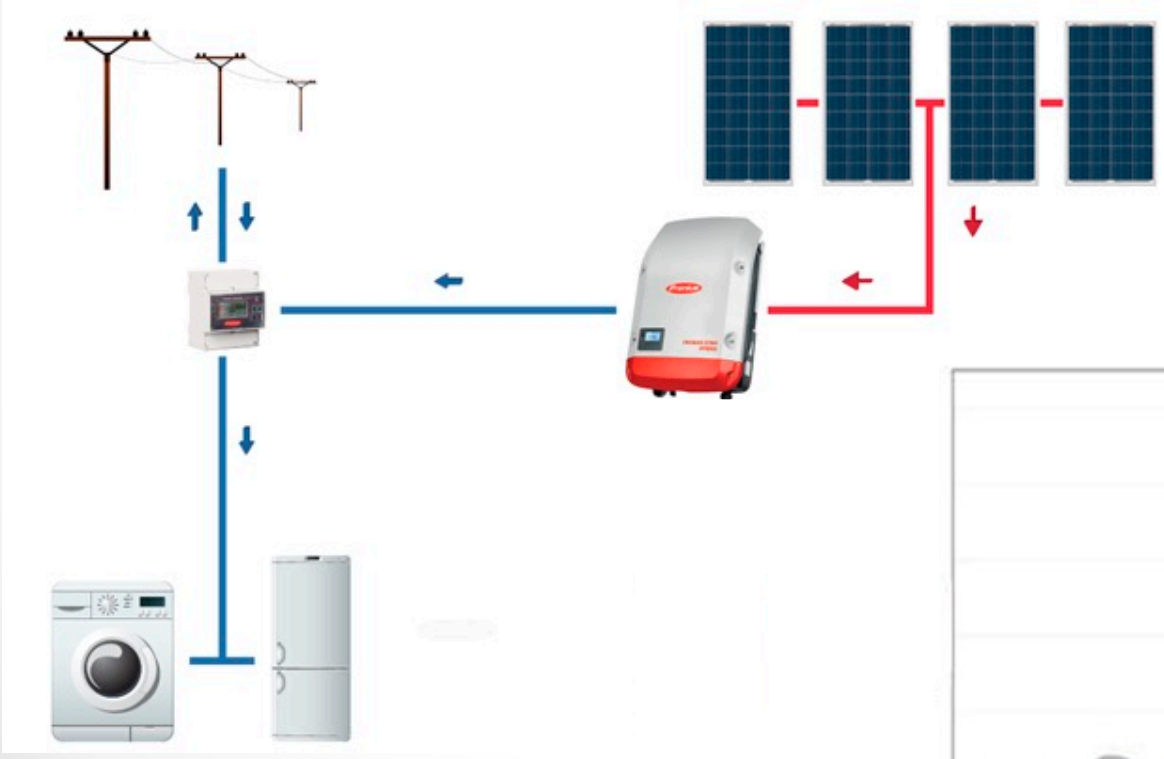
Photovoltaic Solar Energy

Types of photovoltaic installations

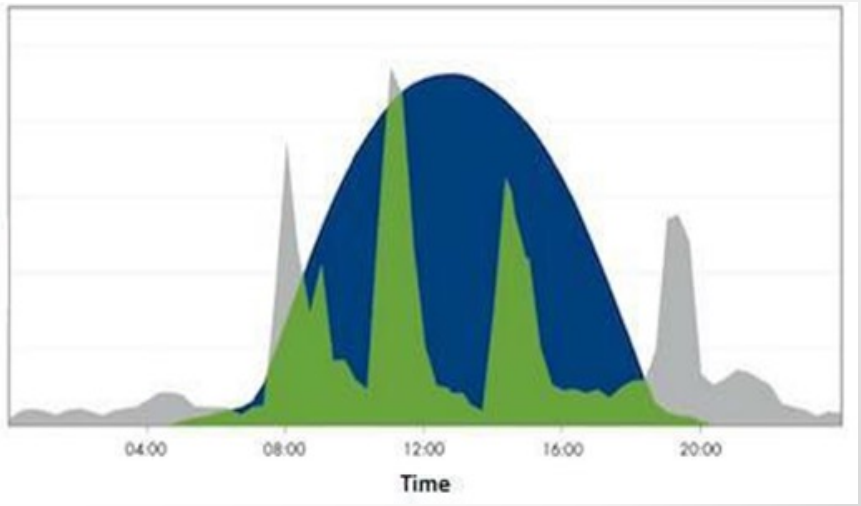
- Installation for self-consumption

  Self-consumption without accumulation



They are formed by:

- Photovoltaic modules
- Grid-tie inverters
- Power Meter
- (Power Limiter)



Configurations:

- Instantaneous consumption
- Activation of consumption
- Power limitation

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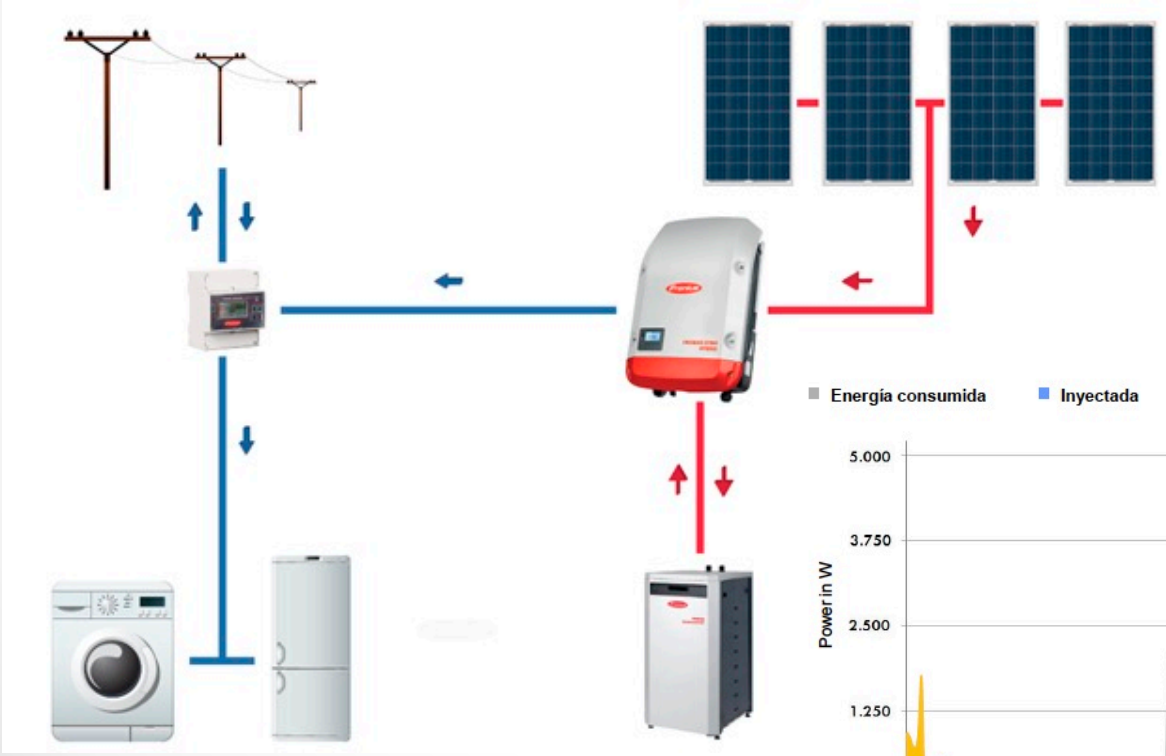
Photovoltaic Solar Energy

Types of photovoltaic installations

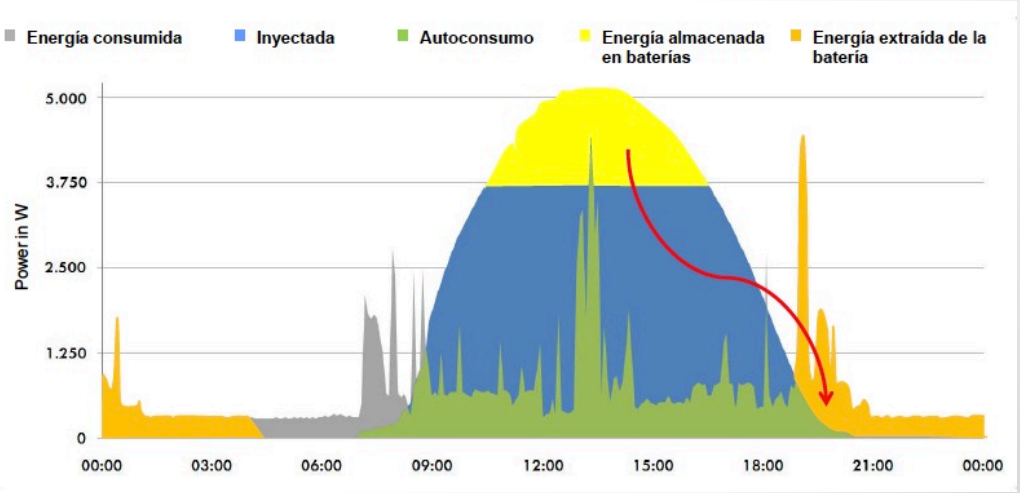
- Installation for self-consumption

  Self-consumption with accumulation



They are formed by:

- Photovoltaic modules
- Grid-tie inverter
- Batteries
- Power Meter
- (Power Limiter)



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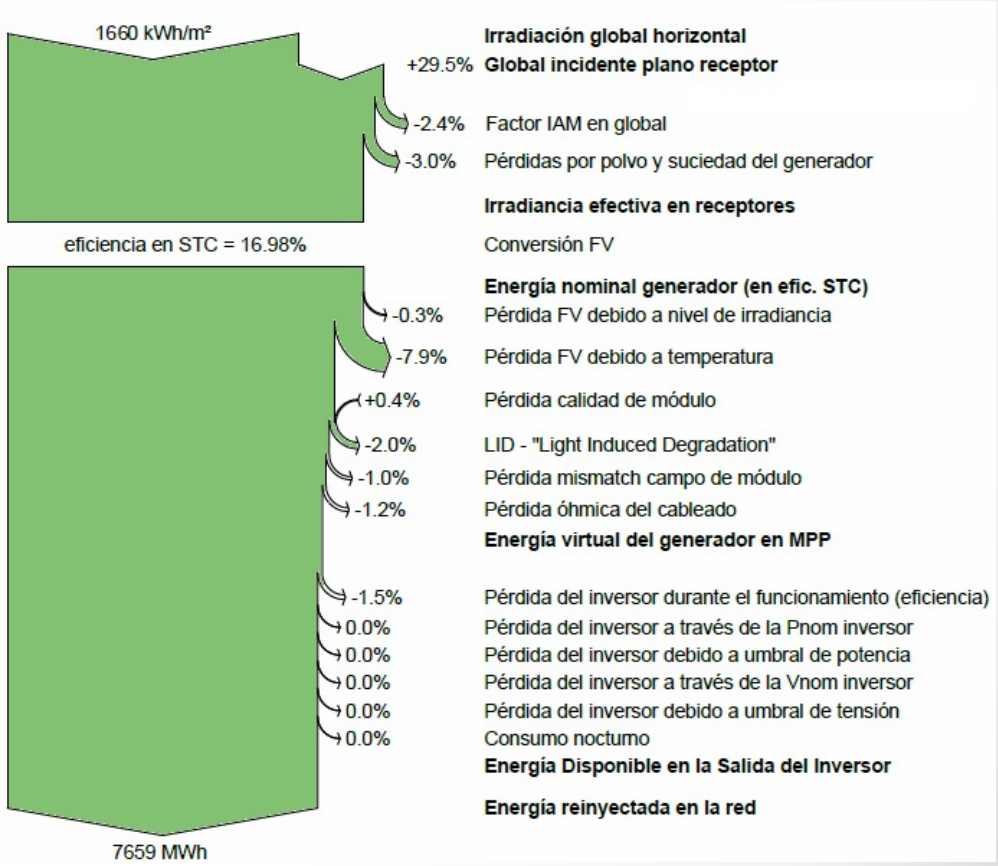
Photovoltaic Solar Energy

General considerations SIZING AND INSTALLATION

- For optimum operation of the installation must take into account the following factors:

  - Radiation
  - Tilt and orientation
  - Loss by shade
  - Loss due to dirt.
  - Temperature of the cell
  - Efficiency of the equipment
  - Deterioration of solar panels



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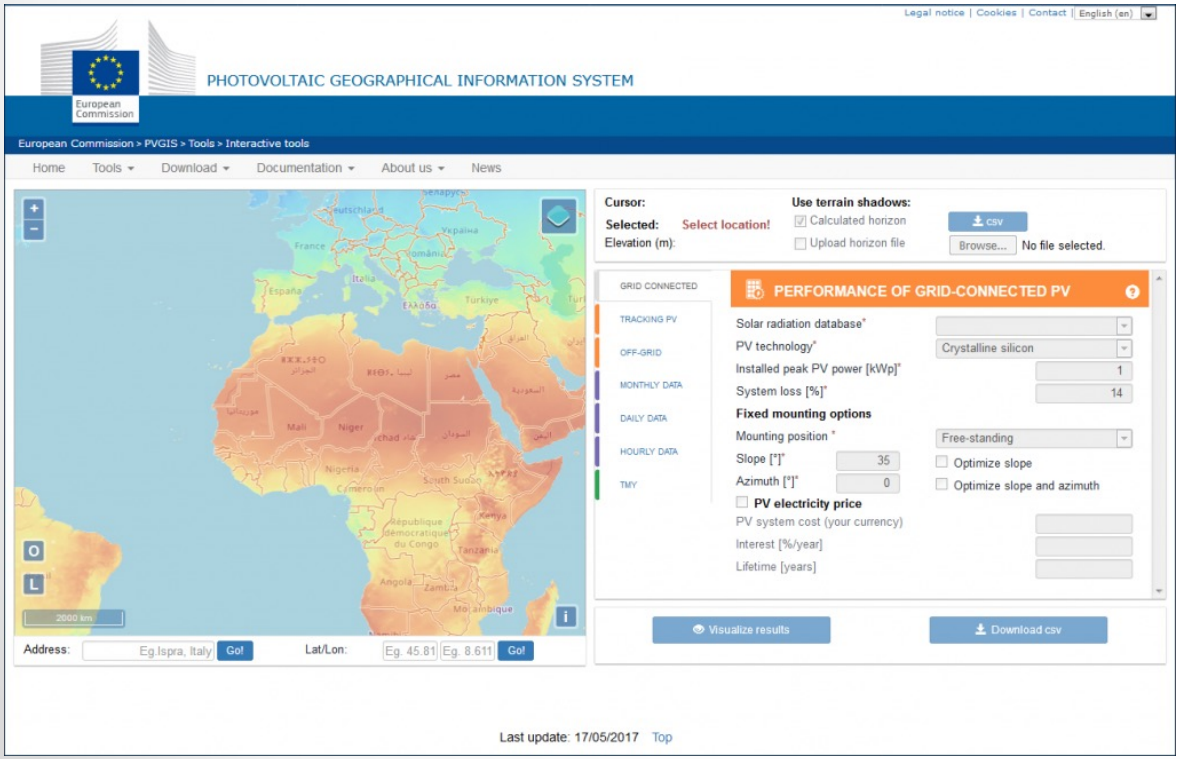
Photovoltaic Solar Energy

General considerations SIZING AND INSTALLATION

- Radiation

Radiation databases

PVGIS - European Commission



PVGIS-5 base de datos de irradiación geoespacial

Datos proporcionados

Latitud/Longitud:	39.823, -0.249
Horizonte:	Calculado
Base de datos	PVGIS-CMSAF
Año inicial:	2007
Año final:	2007
Variables incluidas en este informe:	
Irradiación global horizontal:	Si
Irradiación directa normal:	Si
Irradiación global con el ángulo óptimo:	Si
Irradiación global con el ángulo °	No
Ratio difusa/global	Si
Temperatura media	Si

Irradiación solar mensual

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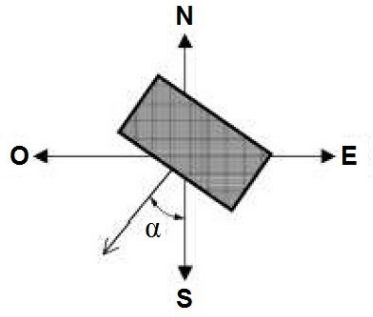
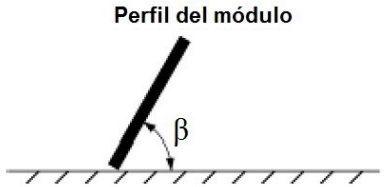
Photovoltaic Solar Energy

General considerations SIZING AND INSTALLATION

- Tilt and Orientation



Representación del ángulo azimut



Inclinación del módulo fotovoltaico

Annual demand: βOpt = ϕ - 10

Summer demand: βOpt = ϕ - 20

Demand for winter: βOpt = ϕ + 10

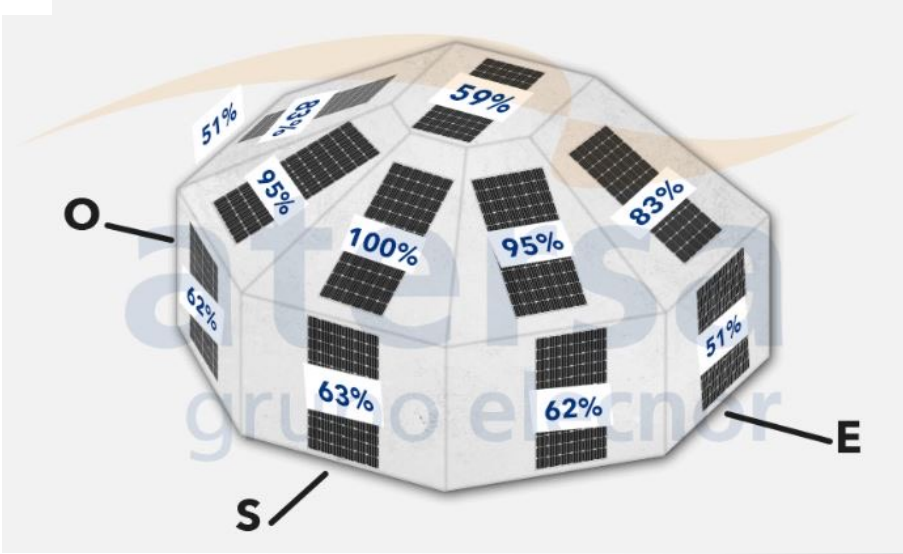
BOpt It is the optimum tilt angle and ϕ is the latitude of the location.

Optimal Orientation

South orientation (Azimuth: 0º)

Optimum inclination Castellón

30º



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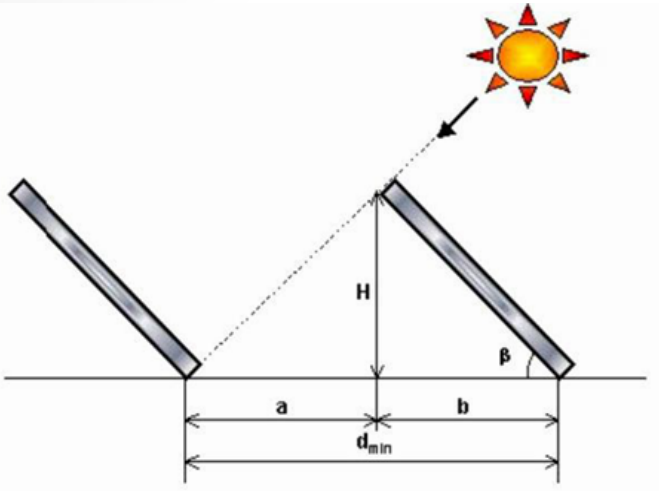
Photovoltaic Solar Energy

General considerations SIZING AND INSTALLATION

- Losses by shadows

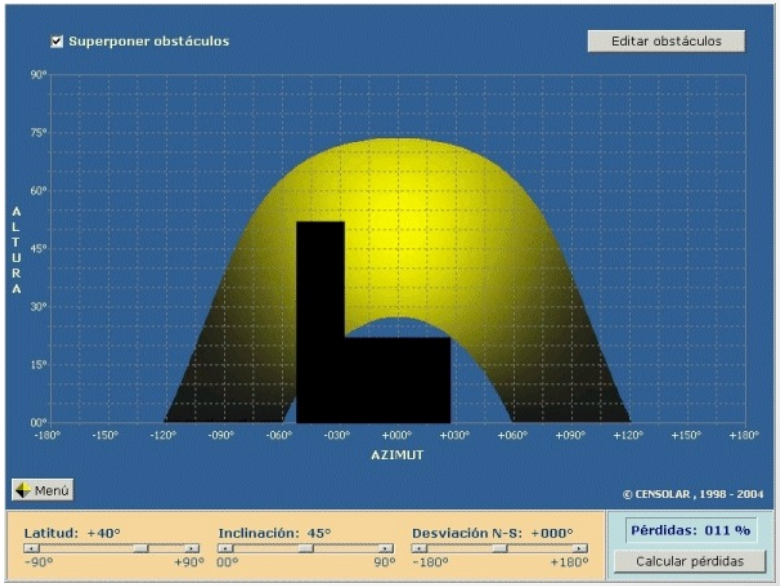


A = H / Tg (61º - altitude of the place)

December 21

Solar day with lowest height of the Year

4 central hours without shadows



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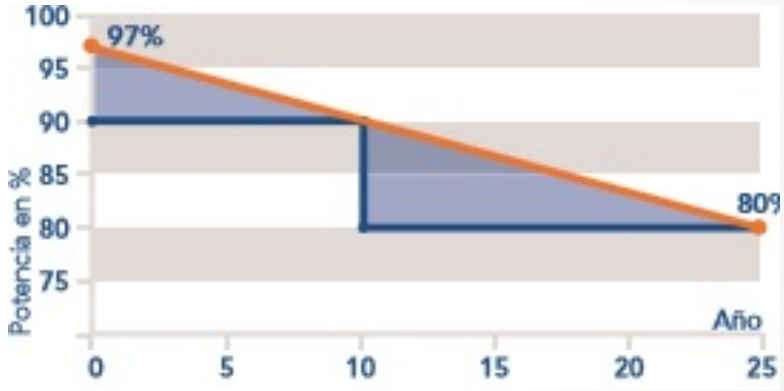
Photovoltaic Solar Energy

General considerations SIZING AND INSTALLATION

- Other losses

- Loss due to dirt.	~3 %. You can reach 30%. Six-monthly cleaning is recommended
- Temperature of the cell	~8 %
- Efficiency of the equipment	~8 %
- Wiring losses	~1,2 %
- Deterioration of solar panels	



Average yield of ~78%

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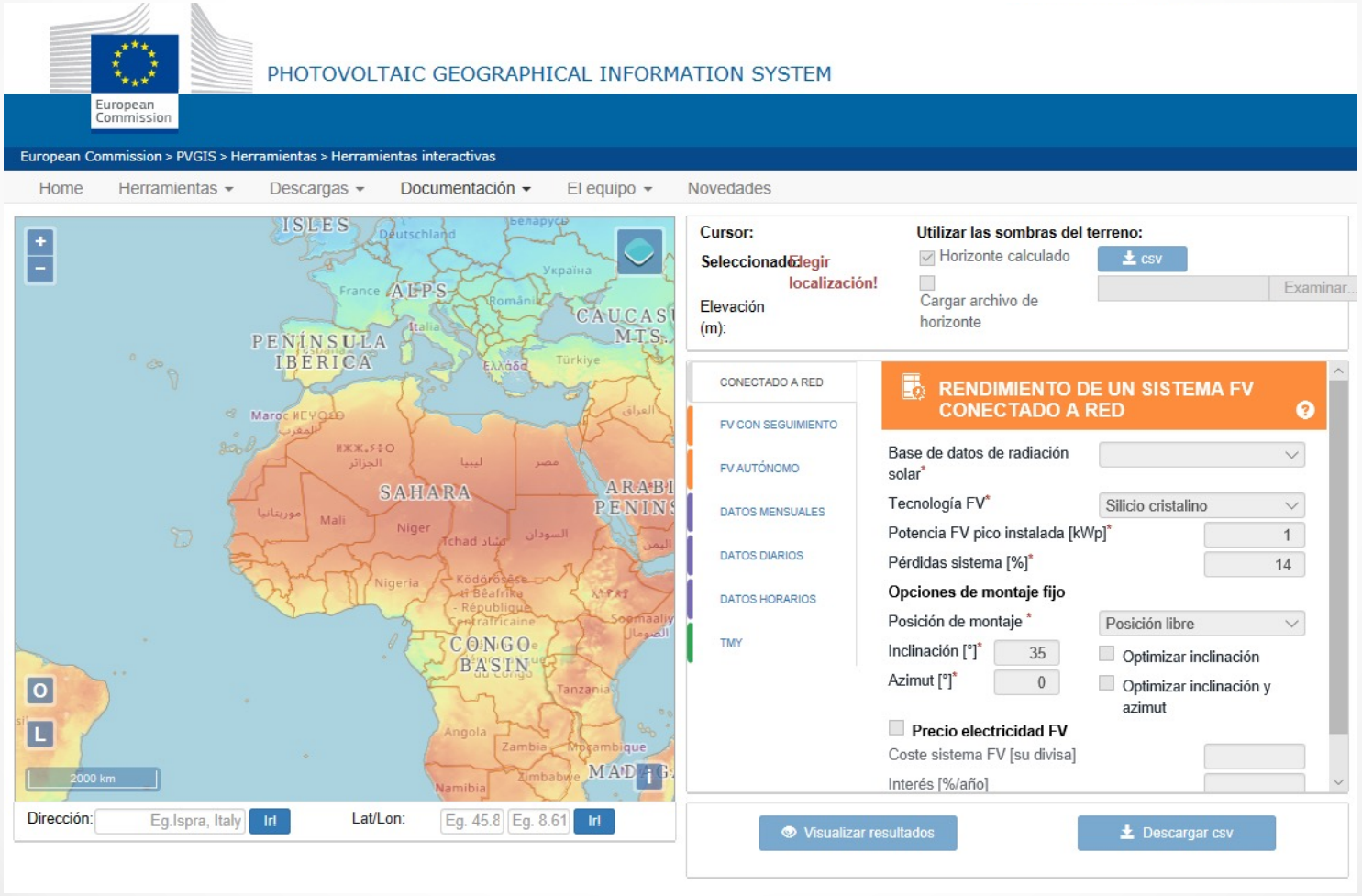
Photovoltaic Solar Energy

Calculation of production

- PVGIS



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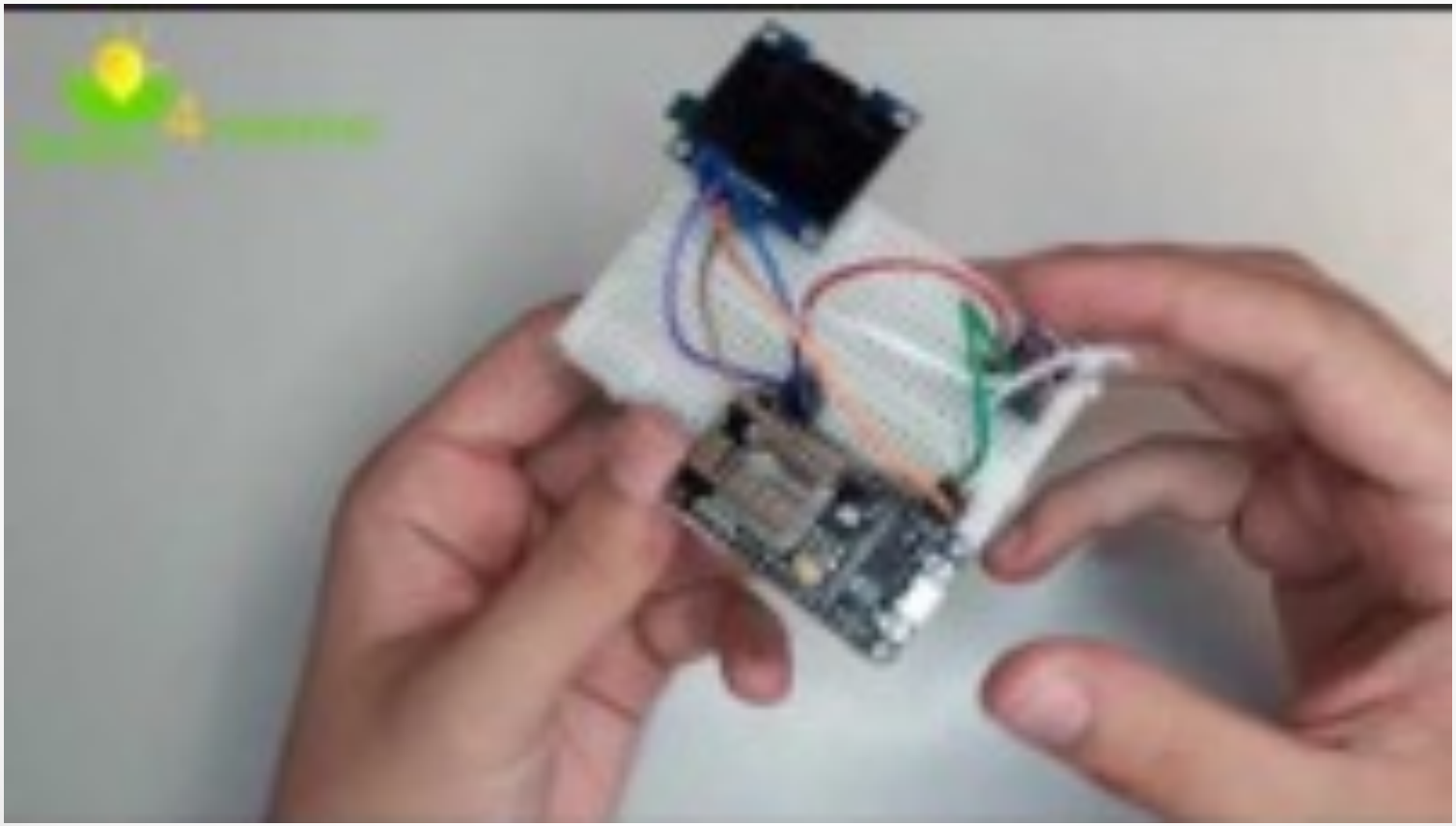
Prototype demo

Arduino System

- A system that measures the humidity and temperature of the air and soil to control agricultural farms or greenhouses.



Prototype demo

Arduino System

- Calculation of photovoltaic solar system to suply the Energy requirements of the Arduino system.

CONSUMPTION OF ARDUINO SYSTEM:
Arduino System has an energy consumption of 70 mA with 3.3V. This mean a consumption energy of:

$$0.070\ (A) \times 3.3\ (V) = 0.231\ Wh$$

For one day, the consumption calculated of the arduino system is 1680 mAh with 3.3V, which mean a consumption energy of:

$$1.68\ (Ah) \times 3.3\ (V) = 5.55\ Wh$$

BATTERY: 2000 mAh (powerbank selected, higher than 1680 mAh), which gives a minimum autonomy of 1,2 days without sun energy.

PHOTOVOLTAIC SOLAR CELL: It is needed to generate a minimum of 5.55 Wh per day.

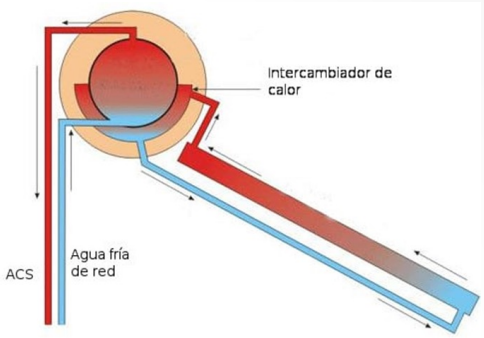
JRC Photovoltaic Geographical Information System (PVGIS) - European Commission (europa.eu)

In December, the worst month of irradiation, is produced by a 5 W PV cell an energy of 520 Wh per month. This mean a daily energy produced of 16.8 Wh. Higher than 5.55 Wh per day required by the system.

Prototype demo

Solar thermosiphon system

- Prototype of thermosiphon system to heat water from the sun Energy.



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