# The comparative study between UK and Spain in a energy autonomous housing

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# Summary

This study will compare the energy generation, consumption and the CO2 generated by a regular house between UK and Spain, more specifically Norther Ireland and Valencia. The main objective is to know how can we produce the average annual energy consumed for a regular house in each country using just clean energies, this technologies will be the Photovoltaic and the Wind power.
First of all we are going to take a look at the evolution of each technology and the CO2 ppm present in the atmosphere.
Afterwards we are going to define how are we going to calculate both installations showing the formulas, a sort manual to extract the data of the solar irradiation from the European application PVGIS and the average speed wind maps taked from the institute of energy in Spain (IDEA) and the NOABL in UK.
After calculate the installations for each country we are going to analyse how big it is the installation, and what is the cost of this installation concluding that at the Spanish location the wind installation will cost us 1,000€ after 30 years, the opposite of the British location that makes us saving around 24,000 €.
Suprisely the situation takes a change of 180º when we talk of solar production, where after 30 years the installation of Spain saves us 26,000 € and the installation of UK cost us around the 28,000 € giving, concluding that for the location from the south of Europe the only installation possible is the Photovoltaic one, and for the northen location the most efficient is the Wind Power one.

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## Chapter 1. Introduction

In this report, we are going to tackle the problem of the energy consumption, or better said, self-produced energy.

The global energy consumption has not stopped of growing up year after year, this was not a problem on the past year because our way of life was sustained by the petroleum and coal but this irresponsible thinking has left just the higher CO2 level in the history of the planet and an energetic dependency from foreign countries.

These problems just can be fixed with self energy production, and this can just be achieved by clean energies, energies that use our natural resources without harming our planet, but Which kind of clean energy is the most convenient for our placement? and most import, Is it possible with these technologies cover our annual energy consumption?

To answer these questions we need to establish the technology that we are going to use to produce our own energy. These technologies are going to be the Photovoltaic and Wind Power.

### 1.1 Photovoltaic Story

The history of this technology starts at the 1875 with William Grylls Adams and his student Richard Evans Day discovered that an electrical current could be started in selenium solely by exposing it to light, this discovery was a revolution, even Thomas Edison called the discovery as “scientifically of the most far-reaching importance.” This pioneering work portended quantum mechanics long before most chemists and physicist had accepted the reality of atoms.

Even though selenium solar cells failed to convert the sunlight to power electrical equipment, they proved that a material can create electric current without heat or moving parts.

In spring 1953, while the research of the use of silicon for electronic applications, Gerald Pearson, and empirical physicist at Bell Laboratories, create a solar cell more efficient than the ones made by selenium.

Two other Bell scientists, Daryl Chapin and Calvin Fuller manufactured the first silicon

solar cell capable to run electrical equipment.
This new solar cells generated up to five more times electricity than the selenium ones.
The efficiency was double during the next eighteen months but because of the cost per Watt, 300 $ per Watt in comparison with the cost of a contemporary power plant ( 50 cents ) the success of this new technology was a completely catastrophe.
The only demand of this technology was at the toy business, powering miniature of ships and airplanes.
But at the end of the 50s the USA Army and Air Force rescue the technology for national plan of earth orbiting satellites, but when the Navy was commended with the plan, the Navy rejected the silicon solar cells as the propeller of the satellites and decided to use a trusted technology as chemical batteries but Dr Hans Ziegler, as a leader of a crusade to change the mind of the Navy, believed that chemical batteries will run out of power in a few days after the release but with the solar cells the satellite will maintain the satellite with enough power to be communicated with Earth for years.

The production of the Solar cells for aerospace helped the production for terrestrial uses, Dr Elliot Berman helped with the financial support of Exxon Corporation designed a significantly less costly solar cell by using a poorer grade of silicon and packaging the cells with cheaper materials.
With this new manufacturing process the brought down the price from 100$ a Watt to 20$ per Watt, with this price the autonomous housing far away from power lines would be feasible for uses at oil rigs/fields.
The gas and oil industry gave the fledgling terrestrial Solar cell industry the needed capital to persevere and develop the industry for more common uses like powering buoys and in 1978 powering thirteen repeaters for telecommunications.

During the decade of 80s to electrify at rural zones countries like Mexico run their televisions sets, with solar electricity, besides of these successes Swiss engineer Marcus Real proved the economic advantages of the micro approach by selling 333 rooftop solar systems to homeowners in Zurich Switzerland neglected the idea of centralized solar-cell plants.

At 90s the use of Solar cells grown caused by the down of the price per Watt because of the new manufacturing methods to somehow either grow the silicon into a shape that eliminates most of the slicing or merely deposit solar cell material onto an inexpensive but rigid support structure such as ceramic glass, plastic or steel.

Nowadays, the power installed of Photovoltaic Panels exceed the 100 GigaWatts.

## 1.2 Wind Power History

The history of the Wind Power energy starts with the vertical axis windmills found at the Persian-Afghan borders around 200 BC.
Much later (1300-1875 AD) came the horizontal-axis windmills from the Netherlands and Mediterranean. Further evolution and the perfection of these systems was performed in the USA during the 19th, the first large wind machine to generate electricity (12 kW) was installed in Cleveland, Ohio, in 1888, while during the late stages of Word War I, use of 25 kW machines throughout Denmarkt was widespread.
The development of wind generators in the USA was inspired by the design of airplane propellers and monoplane wings, while the efforts in Denmark, France, Germany and UK showed that large-scale Wind Turbines could work.
After World War II the Gedser mill 200 kW three-bladed upwind rotor Wind Turbine operated successfully in Denmark until the early 1960s.
One of the most important milestone in the wind energy production history became with the oil crisis of 1973 and the USA government involvement in the wind energy research and development.
In the years between 1973 and 1986 the commercial Wind Turbines market evolved from domestic and agricultural (from 1 to 25 kW) to utility interconnected wind farm applications (from 50 to 600 kW). In this context, the first large-scale wind energy penetration outbreak was encountered in California, where over 16,000 machines, ranging from 20 to 350 kW ( a total of 1.7 GW) were installed between 1981 and 1990, as a result of the incentives as a federal investment or energy credits.

In northern Europe on the other hand, wind farm installations increased steadily through the 80s and 90s, with the higher cost of electricity and excellent wind resources leading to the creation of a small but stable market. After 1990 most of the market activity shifted to Europe, with the last twenty years bringing wind energy at the front line of the global scene with major players from all world regions.

Nowadays the global production using Wind energy is 63,013 MW.

## 1.3 The problem of the CO2

CO2 on the atmosphere was present since the beginning of the times but from the 1950 the CO2 ppm leves have been increasing from the 180 ppm up to the 404 ppm on March of 2016, this increase has been related with the increase of the Earth temperature anomaly has increase up to 0.87 ºC.

If the CO2 ppm increase up to 550 ppm the temperature anomaly will be 3 ºC higher, temperature that for the European Union is an extremely temperature, that will change the life on Earth, increasing the sea levels and the animal life will change dramatically.

## Chapter 2. Aims & Objectives

The aim of this project is the design of an "energy island" in Courtyard Residence (Jordanstown Campus , Northern Ireland) and Aldaia (Valencia, Spain).

These energy islands will consist of on the necessary Solar Panels or Wind Turbines to supply all the energy consumption per year required at these houses.

With both energy islands designed we will see the kilograms of CO2 saved and the cost of kiloWatt installed and the room required for the Solar panels and Wind Turbines, find out the optimum slope for the Solar Panels, finally the savings in the Electricity Bill in the next 30 years.

With all of these we can observe the difference between the installation requirements, CO2 emissions, and the savings differences between both countries.

## Chapter 3. Literature Review

This dissertation talks about the energy comparassion between UK and Spain, this kind of study is not as common as some studies in each country to develop a Solar Plant (e.g. Alan Bartlett & Sons Solar Plant) to supply the consumption of a factory, or the build of an Off-Shore Wind Farm (e.g London Array) and in this studies you can know the amount of Panels/Turbines required to generate a certain amount of energy, and we can know which is the amount of CO2 saved in this production, but we can not know what is the amount saved by our own house per year, or how much time it will be the payback.

# Chapter 4. Theory

To design or “energy island” we are going to use to different technologies, Solar and Wind.

For the design of the Solar installation we are going to need the next knowledge:

A regular solar installation consist of the next components:

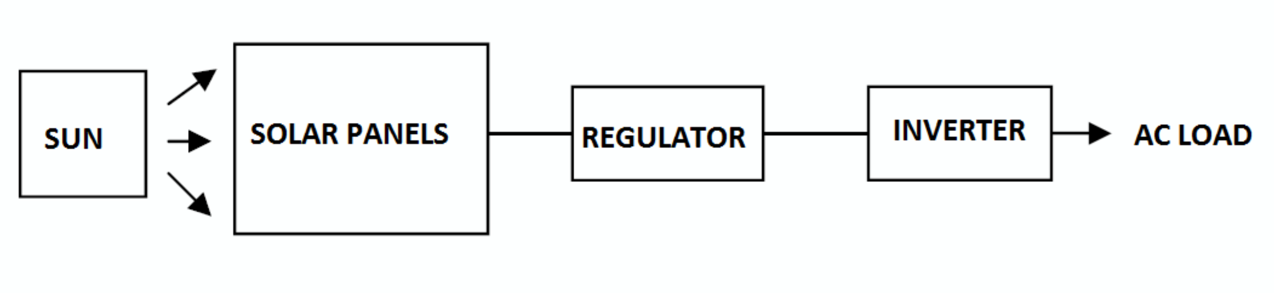


Figure 1: Sketch of a Solar Installation.

## 4.1 Solar Panels

First of all are the Solar Panels, they are the responsible of the generation of the energy, they are made of solar cells that could be made of three different types of technologies: Mono-crystalline, Polycrystalline and amorphous.

The cells are connected in series or parallels between them to achieve the voltage and current desired. The average voltage for the Mono-crystalline and Polycrystalline panels is between 17.5 and 29.5 Volts as Peak Working Voltage.

The characteristics of the panels depends of each manufacturer and the power varies between the 50 Watts and the 310 Watts

The performance of the panels it is defined be its I-V curve, given by the manufacturer, the draw of this curve is done under an standardized conditions of radiation (1000 W/m2) and temperature (25º).

The I-V curve of our panel is the next one:

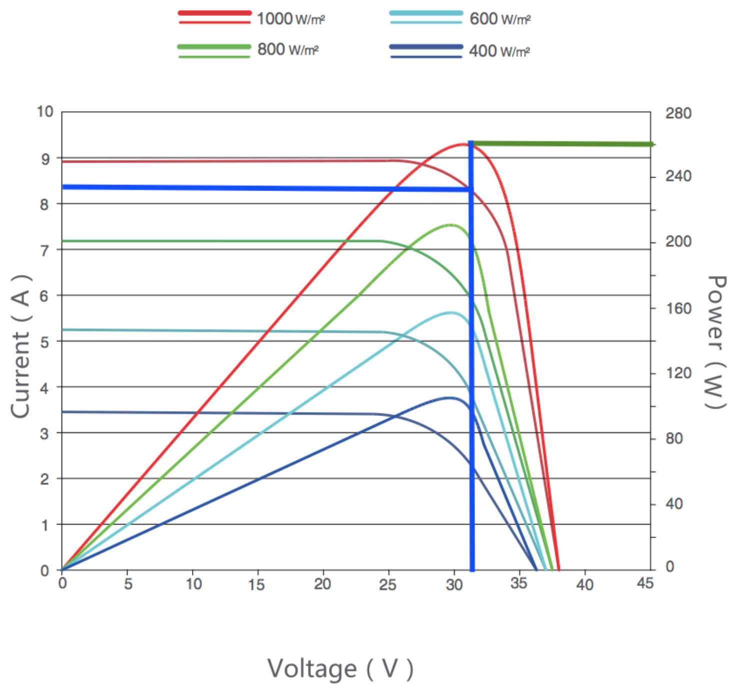


Figure 1.2: I-V graph extracted from the technical data sheet of the solar panel used for the calculations.

As we can see the maximum power it is given at 8.37 A and 31.1 V same number as the specifications table:

## SPECIFICATIONS

| Module Type | JKM255P | | JKM260P | | JKM265P | | JKM270P | |
|---|---|---|---|---|---|---|---|---|
| | STC | NOCT | STC | NOCT | STC | NOCT | STC | NOCT |
| Maximum Power (Pmax) | 255Wp | 189 Wp | 260Wp | 193Wp | 265Wp | 197Wp | 270Wp | 200Wp |
| Maximum Power Voltage (Vmp) | 30.8V | 28.5V | 31.1V | 28.7V | 31.4V | 29.0V | 31.7V | 29.4V |
| Maximum Power Current (Imp) | 8.28A | 6.63A | 8.37A | 6.71A | 8.44A | 6.78A | 8.52A | 6.80A |
| Open-circuit Voltage (Voc) | 38.0V | 35.2V | 38.1V | 35.2V | 38.6V | 35.3V | 38.8V | 35.4V |
| Short-circuit Current (Isc) | 8.92A | 7.26A | 8.98A | 7.31A | 9.03A | 7.36A | 9.09A | 7.38A |
| Module Efficiency STC (%) | 15.57% | | 15.88% | | 16.19% | | 16.50% | |
| Operating Temperature(℃) | -40℃~+85℃ | | | | | | | |
| Maximum system voltage | 1000VDC (IEC) | | | | | | | |
| Maximum series fuse rating | 15A | | | | | | | |
| Power tolerance | 0~+3% | | | | | | | |
| Temperature coefficients of Pmax | -0.41%/℃ | | | | | | | |
| Temperature coefficients of Voc | -0.31%/℃ | | | | | | | |
| Temperature coefficients of Isc | 0.06%/℃ | | | | | | | |
| Nominal operating cell temperature (NOCT) | 45±2℃ | | | | | | | |

Figure 1.3: Technical specifications of our solar panel.

Knowing how to read the curve and extract the Peak current and Voltage, we can design our system following the next steps:

First of all we need to know the Monthly Consumption (**MC**) in Amperes per hour (**Ah**)

**MC = MonthlyConsumption in Watts / (Vinstallation × ŋinverter)**

once we have this figure we are going to need the solar irradiation at our place expressed in kWh/m2 or as we are going to name it SPH (Solar Peak Hours).
With the MC and the SPH we can calculate the Cmd, this coefficient will be higher as our needs of production will be higher

**Cmd = MC / SPH**

After calculate this coefficient for every month , we will take the highest one to know the Number of Parallel Lines that we will have at our installation.

**Npl = Cmd x Ks / Ip**

Where:

Npl = Number of Parallel Lines

Cmd = Consumption Coefficient

Ks = Oversize Coefficient

Ip = Peak current of our panel
Finally we will need to know the Number of Series Panels ( **Nsp**) of our installation:

**Nsp = Vinst / Vp**

Where:

Nsp = Number of Series Panels

Vinst = Voltage of the installation

Vp = Voltage of the panel

**Batteries:**

For the design of the batteries system is as simple as knowing our Amperes per hour that we will need and choose from the manufacturer how many hours are we going to be without the energy produced from the Solar panels, and put as many as we need to achieve the Voltage of the installation in series.

**Regulator:**

Known the Amperes per hour that the PV installation will produce, we need to buy as many regulators as we need to reach this Amperes, is so important to be close to this amount because the performance of the regulator varies significantly if it does not work at full load.

**Inverter:**

For the installation of the inverter the most important thing that we need to know is to install one with able to work with our Power output, remembering that every inverter can work at a higher power momentarily.

### 4.2 Wind Generation

For the design of the Wind installation we need to know how many hours at one speed we will have at our location, and with this data calculate the annual energy production, just multiplying the hours with the Power output at this speed, but further as we can not obtain the data from the British and Spanish government in a easy way, ( the only way is paying for the data of the last 25 years), we are going to based our annual energy production on the next equation:

**Annual energy production(kWh) = Annual Hours(h) x Output Power at annual average speed (kW) x ŋinstallation x ŋinverter**

Where:

Annual Hours = 365 x 24 = 8760 hours

ŋinstallation = 0.9

ŋinverter = 0.9

The performance curve of our Turbine is the next one:

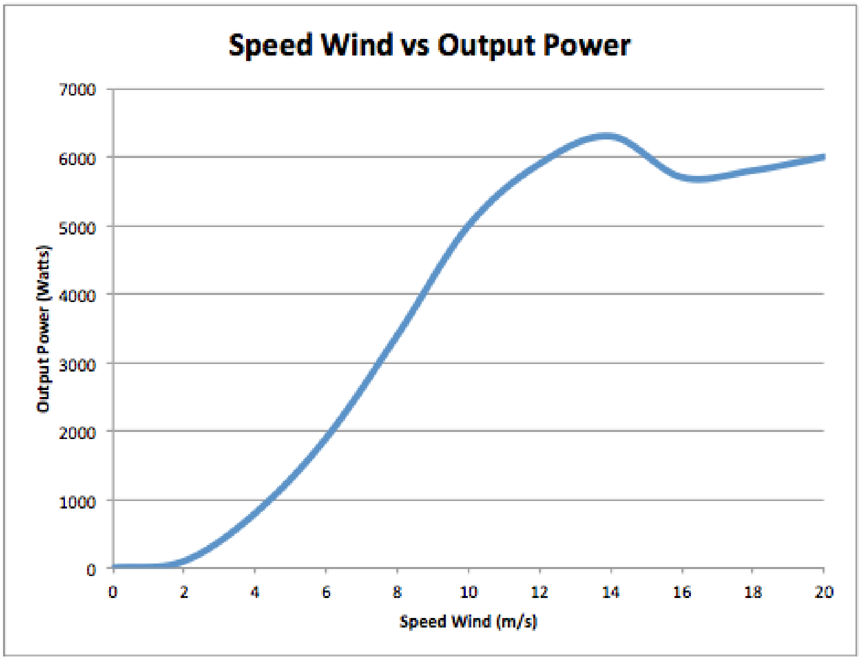


Figure 1.4: Output power curve of the wind turbine studied.

# Chapter 5. Implementation

## 5.1 Annual consumption

To achieve our main objective of being completely "energy autonomous" with the use of Solar Panels or Wind Turbine, first of all we are going to need the average consumption at each location, this is just possible in two different ways:

· Make an annual study of our consumption and achieve a final amount of energy.
· Trust in the national studies about average consumption.

For the case of the UK location, we have used a mix of both, considering that our energy consumption data comes from a national study realize in the midlands (England).
This study was ordered by the UK's Government to Intertek, to know the amount of energy required by a different types of house, with a different types of appliances, this study was based on an annual measurement of energy requirements over 160 houses in the Midlands.
From this study we can acknowledge that for a full electrified heated house the average daily consumption curve is:

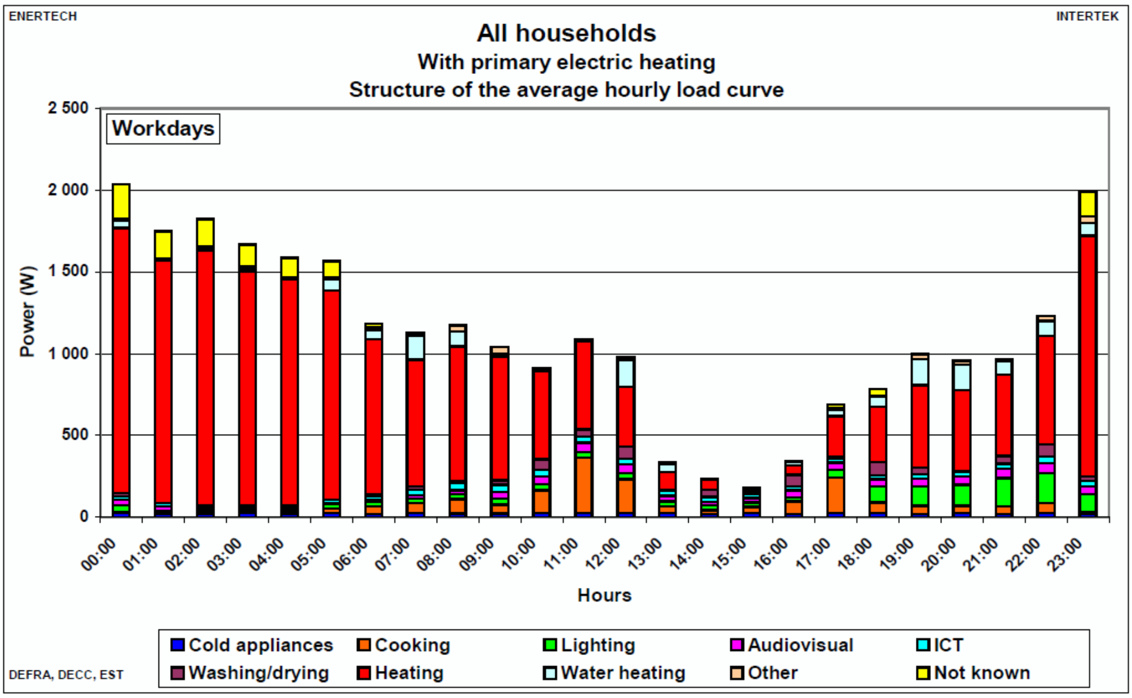


Figure 2.1: Average daily consumption for a fully electrified house in UK extracted from the study of cunsumption of *Intertek Testing & Certification Ltd*

From this graph we can extract that the daily consumption is : 25.515 kWh

Finally the year consumption is:  25.515 x 365 = 9,312.975 kWh ≃ **9,313 kWh**

This consumption refers to a regular house with heating, freezer, fridge, Tv, Lighting, and all the appliances required for a flat of 120 m2 or a bungalow of 157 m2.

For the average annual consumption in the Spanish location we have used a national study from the  Energy Institute (IDAE) with the help of the department of  industry, energy and tourism.

In this report we can see a similar analysis about the energy consumption, showing the average consumption in Spanish house depending on which part of Spain is the house or which kind of house is analyzed.

In addition this report, as the british one, show us how this energy is used in our houses, giving figures of the percentage of energy it requires the heating, appliances, or even the Standby of the appliances.

Finally from this report we can extract a average consumption in Spain of 9,922 kWh.

Being finally our consumptions the next ones:

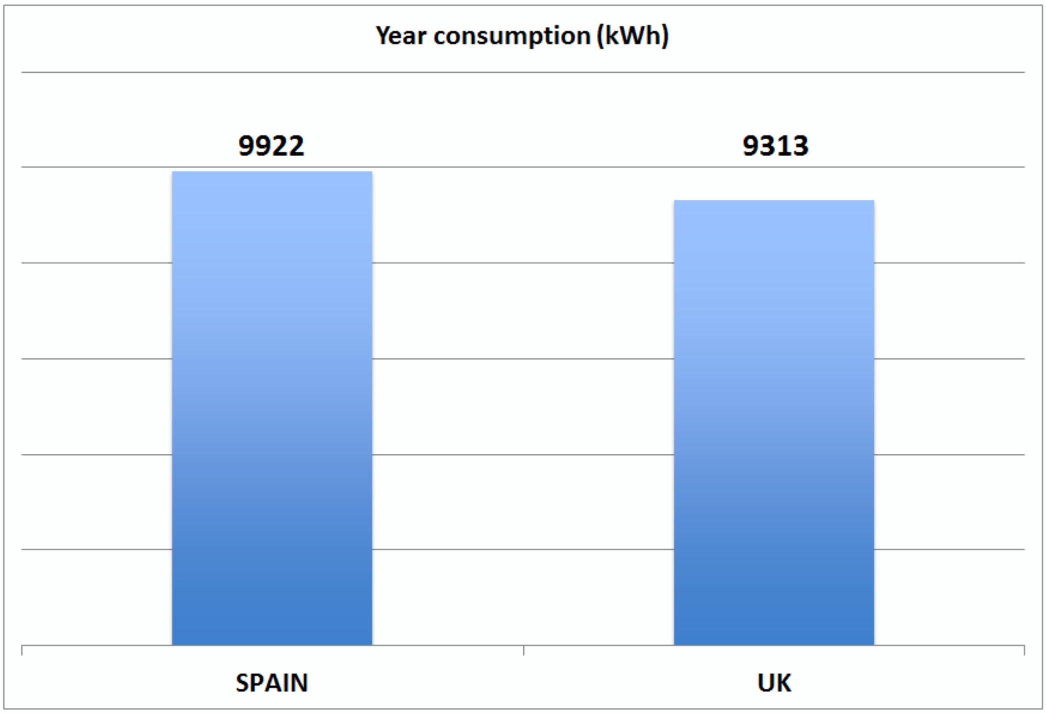


Figure 2.2: Average annual consumption in Spain and UK

## 5.2 Photovoltaic Geographical Information System (PVGIS)

The next step to achieve our objective is to know what is the amount of solar irradiation in our locations.

To know this the easiest way is to use the European application: **Photovoltaic Geographical Information System (PVGIS).**

**As we can read at the web page (**http://re.jrc.ec.europa.eu/pvgis/index.htm**) :**
**"**Photovoltaic Geographical Information System (PVGIS) provides a map-based inventory of **solar energy resource** and assessment of the **electricity generation from photovoltaic systems** in Europe, Africa, and South-West Asia. It is a part of the SOLAREC action that contributes to the implementation of renewable energy in the European Union as a sustainable and long-term energy supply by undertaking new S&T developments in fields where harmonization is required and requested by customers."
PVGIS can provide us the Solar irradiation in our location, beside that , PVGIS can give us an approximately daily and monthly electricity production of our system, the optimum slope for the system in our location, the outline of horizon with sun path for winter and summer solstice.

How can we use this application?

First of all we need to go to the web page: http://re.jrc.ec.europa.eu/pvgis/ and select at **Interactive access to solar resource and photovoltaic potential** the **Europe** maps.

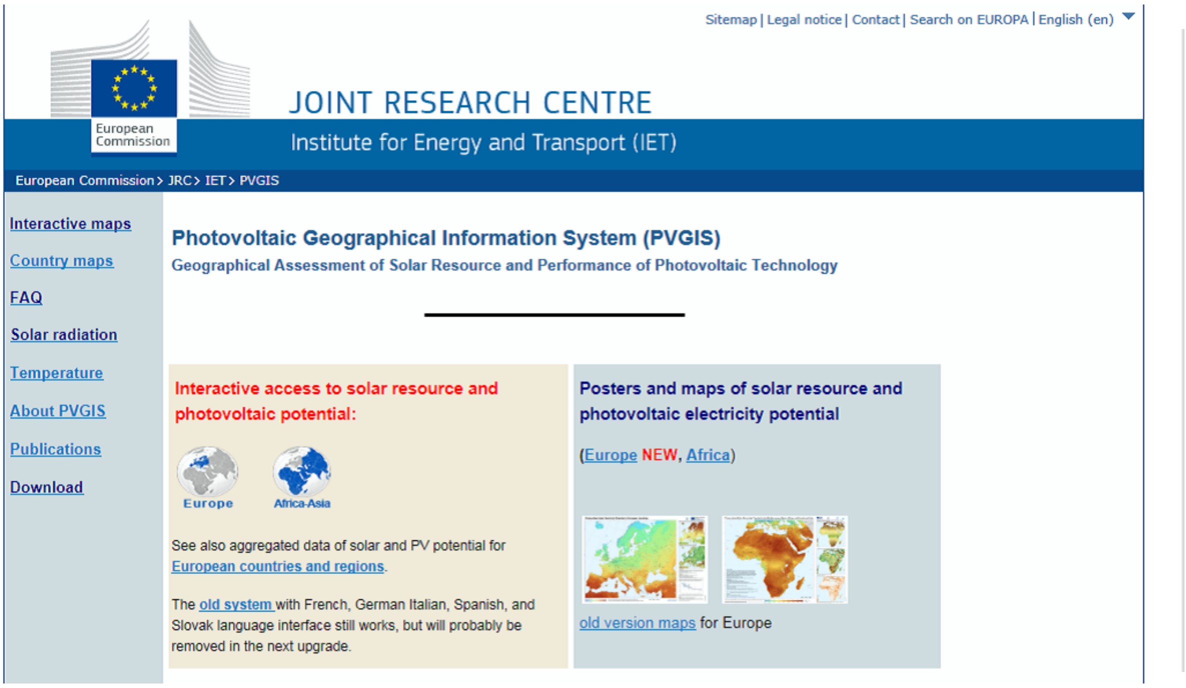


Figure 2.3: Website of the PVGIS application.

After this, we will enter into the application, and we will see the next:

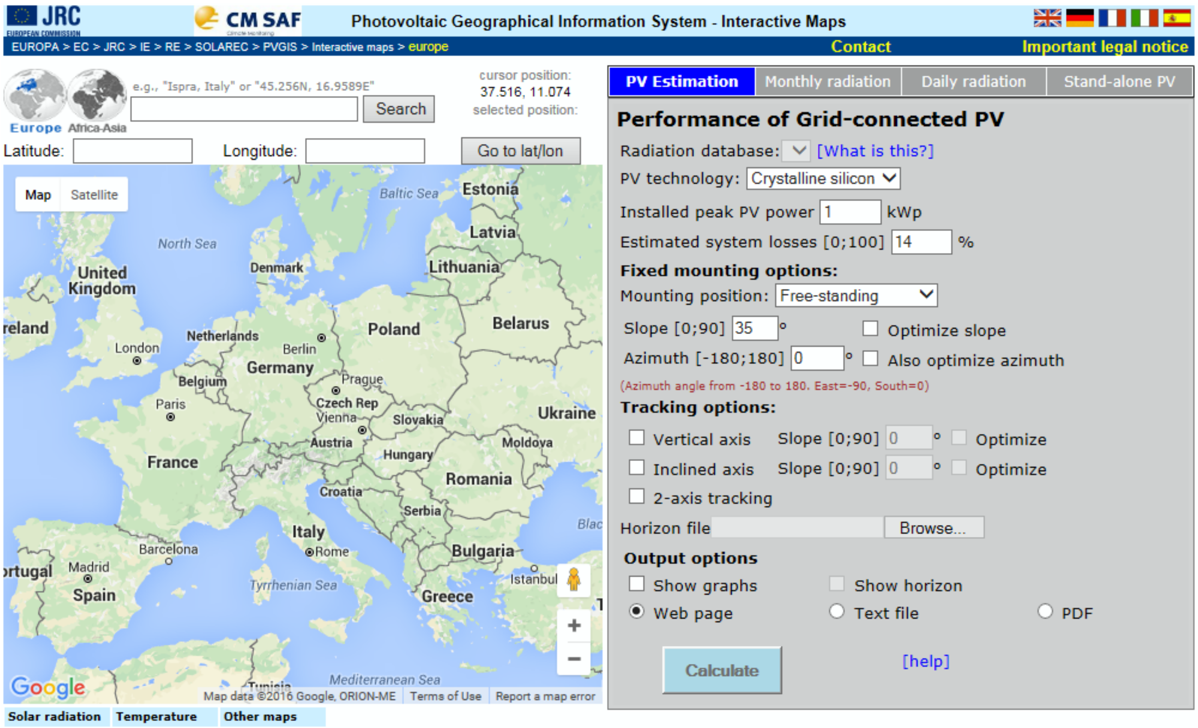


Figure 2.4: PVGIS application.

In this page we will put all the information about our system,

1- Location: We can input the location of our system like if we would be using Google Maps, you just need to put the name of the street, Zip Code, Town, Building, or if you know the coordinates you can input the Latitude and Longitude.

2-PV Estimation: Here we are going to calculate the average production of our system.

3- Radiation database, choosing between the Climate-SAF PVGIS or the Classic PVGIS, we will choose the Climate-SAF PVGIS because is the most updated.

4- Type of Solar panel installed: Crystalline silicon, CIS, CdTe, in this case we will choose the Crystalline silicon.

5- Installed peak PV power, this point is to choose the radiation that our panel will experience the maximum performance, We will enter 1 kWp.

6- Estimated system losses, in this point we have to input the estimated losses of our panel, normally 14 %.

7- Fixed mounting options; in this stage we need to choose between the Free standing or the Building integrated and click at the Optimized slope.

8- Tracking options: if our system has a tracking device we can put the slope at the vertical an inclined axis or choose the Optimized slope if we want to know the best slope for our location.

9-Output options: Here We have to click at the options to show the graph of the average radiation, the horizon and if we want that data in a text file ( best option to analyze the data on an Excel), PDF or Web Page.
Finally we press Calculate.

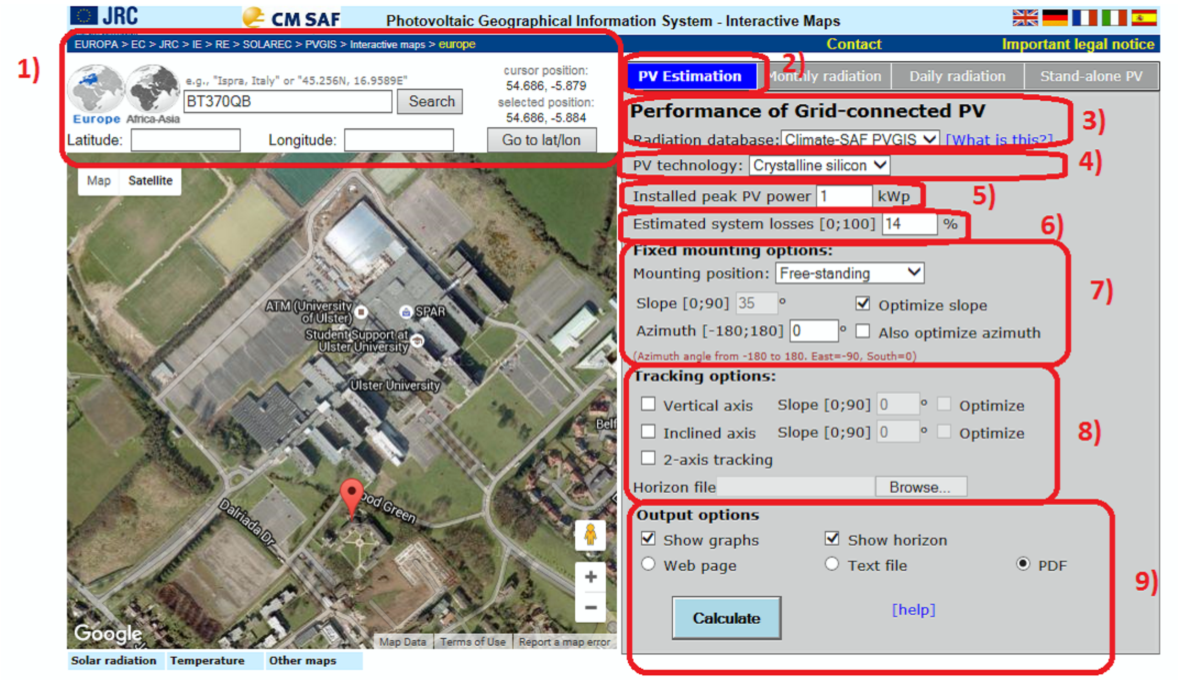


Figure 2.5: How to use the application.

With this we obtained the next tables with the irradiation for both locations:

| | Fixed system: inclination=36 deg., orientation=0 deg. (Optimum at given orientation) | | | |
|---|---|---|---|---|
| **Month** | **Ed** | **Em** | **Hd** | **Hm** |
| Jan | 3.31 | 103 | 4.14 | 128 |
| Feb | 3.94 | 110 | 5.01 | 140 |
| Mar | 4.62 | 143 | 6.01 | 186 |
| Apr | 4.67 | 140 | 6.18 | 185 |
| May | 4.85 | 150 | 6.52 | 202 |
| Jun | 5.04 | 151 | 6.90 | 207 |
| Jul | 5.10 | 158 | 7.09 | 220 |
| Aug | 4.87 | 151 | 6.75 | 209 |
| Sep | 4.45 | 134 | 6.04 | 181 |
| Oct | 4.01 | 124 | 5.33 | 165 |
| Nov | 3.44 | 103 | 4.39 | 132 |
| Dec | 3.00 | 93.1 | 3.75 | 116 |
| Year | 4.28 | 130 | 5.68 | 173 |
| Total for year | | 1560 | | 2070 |

Ed: Average daily electricity production from the given system (kWh)

Em: Average monthly electricity production from the given system (kWh)

Hd: Average daily sum of global irradiation per square meter received by the modules of the given system (kWh/m2)

Hm: Average sum of global irradiation per square meter received by the modules of the given system (kWh/m2)

Figure 2.6: Annual Solar irradiation in Spanish location.

| | Fixed system: inclination=39 deg., orientation=0 deg. (Optimum at given orientation) | | | |
|---|---|---|---|---|
| Month | Ed | Em | Hd | Hm |
| Jan | 0.88 | 27.3 | 1.06 | 33.0 |
| Feb | 1.56 | 43.6 | 1.91 | 53.6 |
| Mar | 2.59 | 80.2 | 3.25 | 101 |
| Apr | 3.34 | 100 | 4.33 | 130 |
| May | 3.74 | 116 | 4.91 | 152 |
| Jun | 3.45 | 103 | 4.60 | 138 |
| Jul | 3.26 | 101 | 4.36 | 135 |
| Aug | 2.86 | 88.7 | 3.79 | 117 |
| Sep | 2.48 | 74.3 | 3.20 | 95.9 |
| Oct | 1.67 | 51.6 | 2.10 | 65.1 |
| Nov | 1.19 | 35.6 | 1.46 | 43.8 |
| Dec | 0.87 | 26.9 | 1.05 | 32.4 |
| Year | 2.33 | 70.8 | 3.01 | 91.4 |
| Total for year | | 849 | | 1100 |

Ed: Average daily electricity production from the given system (kWh)

Em: Average monthly electricity production from the given system (kWh)

Hd: Average daily sum of global irradiation per square meter received by the modules of the given system (kWh/m2)

Hm: Average sum of global irradiation per square meter received by the modules of the given system (kWh/m2)

Figure 2.7: Annual Solar irradiation in UK location.

On the next graph we can see the difference in irradiation:

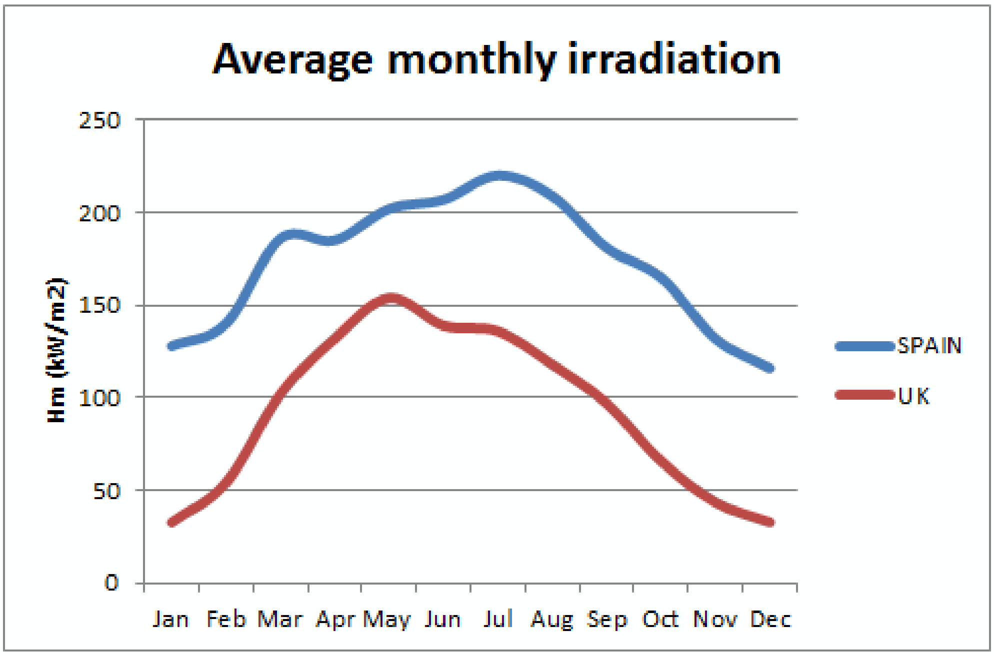


Figure 2.8: Comparison of irradiation between both countries.

with all these data we can calculate the number of Solar panels required for our system.

## 5.3 Average Speed Wind

All we need to calculate the Wind system for the UK's location is to google the website:

http://www.aeoluspower-windenergy.co.uk/wind-speed-database.html

Introduce the Post Code BT37 0QB and **Submit**:

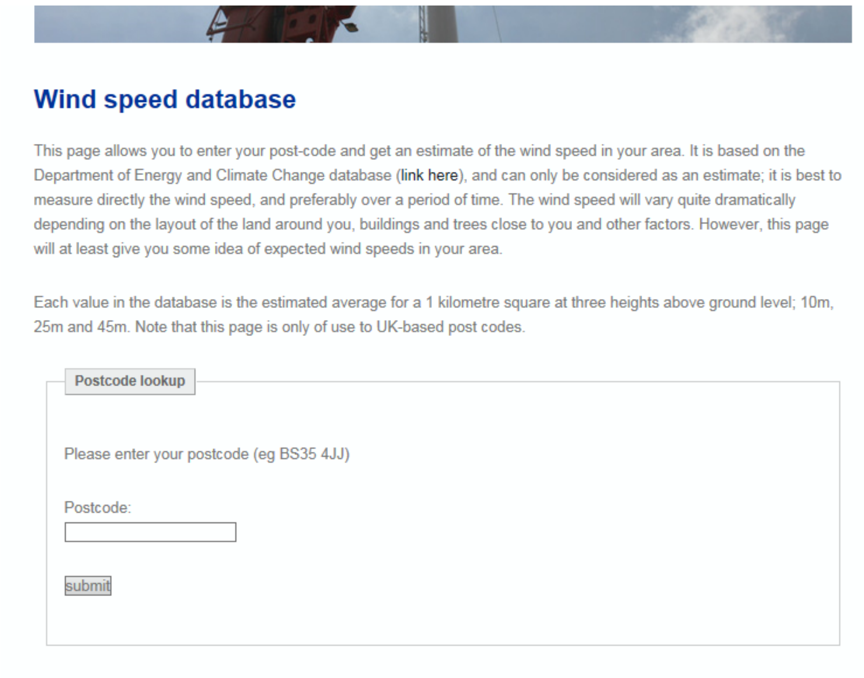


Figure 2.9: Website where we can find the average speed in UK.

After this, the website will show the wind speed at 45, 25 and 10 meters height:

**Wind speed database results**

**45 m height**

| 45m | West | Centre | East |
|---|---|---|---|
| North | 7 | 7.2 | 7.4 |
| Middle | 7.1 | 7.1 | 7.3 |
| South | 7.3 | 7.2 | 7.4 |

**25 m height**

| 25m | West | Centre | East |
|---|---|---|---|
| North | 6.3 | 6.6 | 6.7 |
| Middle | 6.4 | 6.4 | 6.7 |
| South | 6.7 | 6.5 | 6.7 |

**10 m height**

| 10m | West | Centre | East |
|---|---|---|---|
| North | 5.5 | 5.8 | 5.9 |
| Middle | 5.5 | 5.6 | 5.9 |
| South | 5.9 | 5.7 | 5.9 |

The above tables show the windspeed for your location, in the centre. Each square represents an area of 1 km by 1 km. The other squares show the windspeed for the areas north, east, west and south of you.

Three tables are shown, representing the windspeed at different heights above the ground. It tends to be that the higher you go vertically, the greater the wind speed, so the three tables show speed at 45 metres, 25 metres and 10 metres. The figures are windspeed in metres/sec.

Figure 2.10: Average Speed depending of the height in UK

for our study we are going to use the speed at 10 meters heigh due to this speed is the lowest and as we have seen at the performance curve of our generator, is the most unfavorable.

To obtain the data of the speed wind from Spain we are going to use the Wind Atlas from the Energy Institute of Spain (IDAE) and download the average wind speed maps of Spain at 30 meters:


Figure 2.11: Average Speed at 30 meters height in Spain.

Link to download the map:

http://atlaseolico.idae.es/inc/get_map.php?pdf=spd30_es

# Chapter 6. Results:

## 6.1 Photovoltaic Installation:

### 6.1.1 Spain

The energy consumption in Spain is: **27.552 kWh**

The amperes per hour daily consumed, in a installation at 48 V and an inverter with an efficiency of 95.8%, are : **599 Ah / Day**

The month with the most unfavorable irradiation is: **December (116 kWh/m2)**

The Amperes per hour consumed on December are: **18580 Ah/Month**

The Consumption Coefficient (**Cdm**) for the month of December is : **160**

With a Cdm of 160, a Peak current from our panel of **8.37 A** and an Oversize Coefficient (Ks) of **1.45** the lines in parallel will be: **28**

Being our design at **48 V** and using a panel that works at **24 V** the panels required per line will be: **2**

Finally the total amount of panels for our installation in Spain will be **: 56 Panels**

### 6.1.2 UK

The Daily energy consumption in UK is: **25.872 kWh**

The amperes per hour daily consumed, in a installation at 48 V and an inverter with an efficiency of 95.8%, are : **563 Ah / Day**

The month with the most unfavorable irradiation is: **January (32,8 kWh/m2)**

The Amperes per hour consumed on December are: **17440 Ah/Month**

The Consumption Coefficient (**Cdm**) for the month of December is : **532**

With a Cdm of 160, a Peak current from our panel of **8.37 A** and an Oversize Coefficient (Ks) of **1.45** the lines in parallel will be: **92**

Being our design at **48 V** and using a panel that works at **24 V** the panels required per line will be: **2**

Finally the total amount of panels for our installation in Spain will be **: 184 Panels**

## 6.2 Wind Installation:

### 6.2.1 Spain

The annual energy consumption required to generate is **: 9,922 kWh**

Annual average speed in BT37 0QB at 10 meters height: **4.5 m/s**

Annual hours : **8760 h**

Output Power at 5.6 m/s from our turbine: **1075 Watts**

ŋinstallation: **0.9**

ŋinverter: **0.9**

Annual energy produced by one turbine: **7,627.77 kWh**

### 6.2.2 UK

The annual energy consumption required to generate is **: 9,313 kWh**

Annual average speed in BT37 0QB at 10 meters height: **5.6 m/s**

Annual hours : **8760 h**

Output Power at 5.6 m/s from our turbine: **1680 Watts**

ŋinstallation: **0.9**

ŋinverter: **0.9**

Annual energy produced by one turbine : **11,921 kWh**

## Chapter 7. Discussion

First of all, we have to compare the differences between that each type of installation has in each country, and for that we are going to start with the Solar production.

Related with this technology, as we can see in the results we are going to need 330 % more Photovoltaic panels in Northern Ireland than in Spain, even being the consumption in Norther Ireland an 6.14 % lower than in Spain.

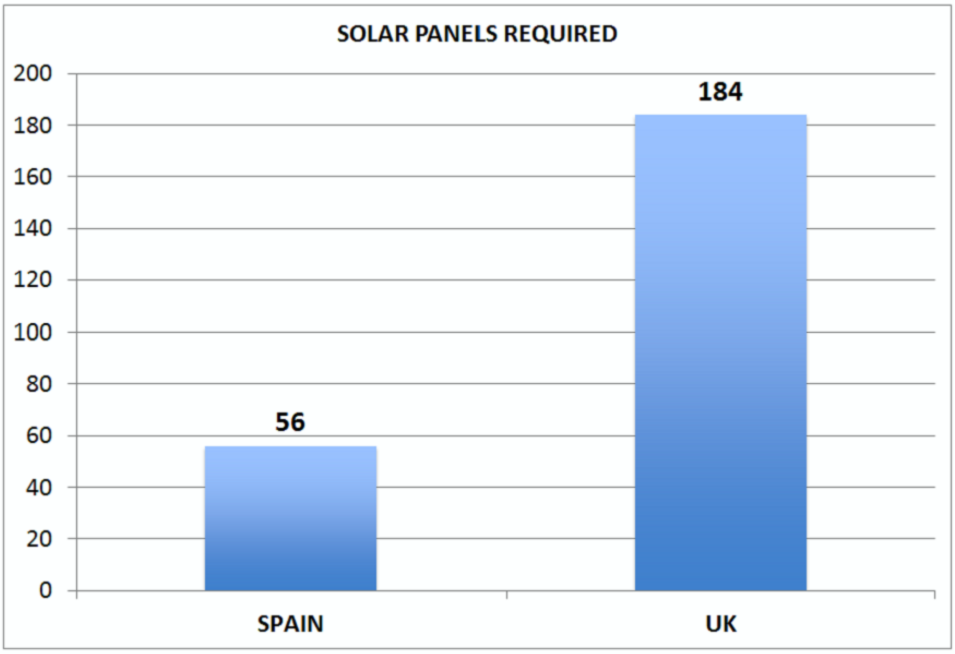


Figure 3.1: Solar panels require by location.

But, Is this difference of 3.3 times in Photolvoltaic panels predictable? Yes, it is; just looking at the difference between the month with me most unfavorable irradiation of each country, 116 kWh/m2 from Spain against the 32.8 kWh/m2 irradiated over Northern Ireland, that makes a difference of 351% between both countries.

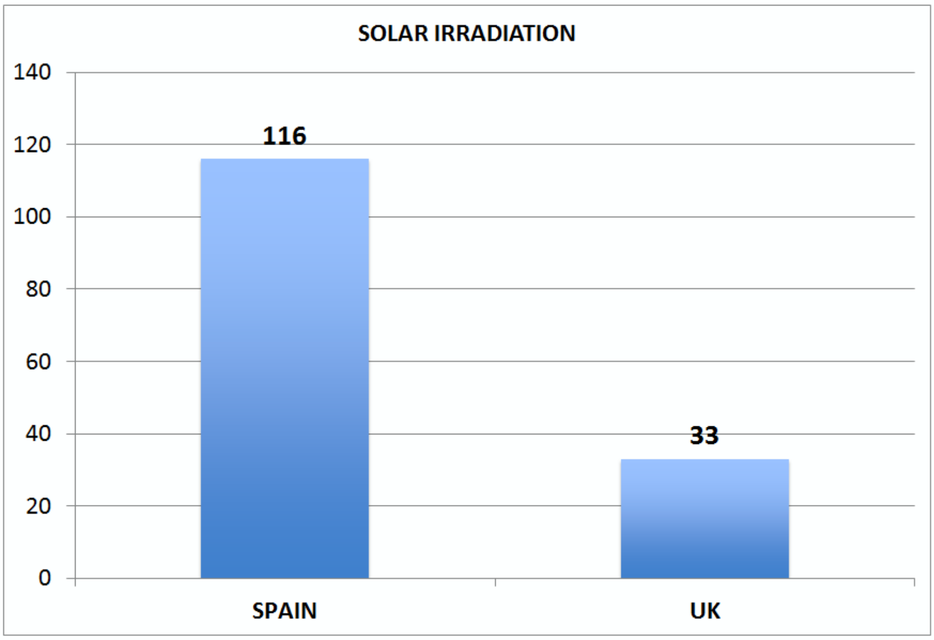


Figure 3.2: Irradiation comparison during the most unfavorable month in each location.

From the economical point of view, cost of the installation in Spain, with all the necessary for it, inverter to convert into AC the current generated, the regulators to regulate the current from the panels and the supporting structured for the panels, the cost come up to the 23,977.27 € that amount of money is for a 14,560 kW installation, that means that the kiloWatt installed cost 1.65 €.
Analyzing the Northern Irish installation the cost of all the necessary for 184 panels, with a power of 47,840 kW, amounts to 72,395.63 €, that give us a cost of 1.51€/kW installed.

But these figures do not mean much for us, the objective of this project is to know if is faceable these installations, for that, first we need to know is how much it would cost the consumptions of energy for a regular power required of 5.75 kW, power advised by the energy suppliers for a regular house.

In Spain the annual cost (VAT included) for an annual consumption of 9922 kWh is the 1830 €, that means that if the cost of the energy bill would not increase, our energy bill of 30 years would be 54900€.
Comparing this cost with the price of our installation for 30 years, changing inverter and regulators every 15 years, it will be 28,814.66 €. This leaves us a savings of **26,085.34€,** savings that can be used in the contracting of a cleaning service for our panels twice per year if we want.

In addition for this period of time we would save **11,8766** kg of CO2 to the atmosphere.

In addition the payback time is in 14 years, saving this year 1,642.73€.

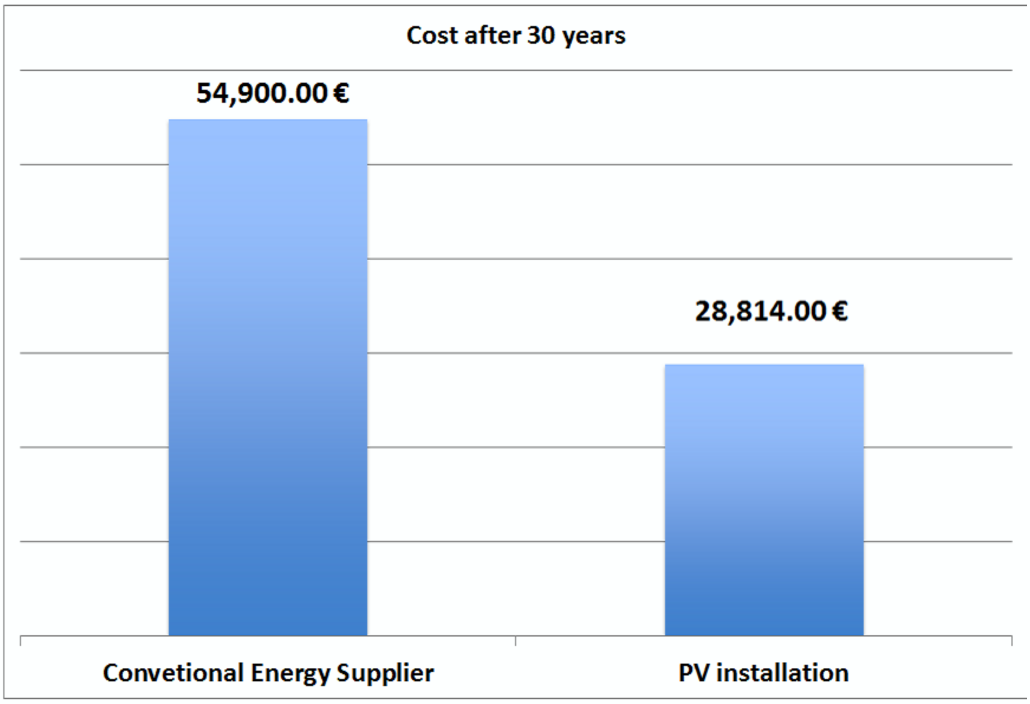


Figure 3.3: Cost comparison between Conventional supply and Solar supply in Spain.

Concerning to UK, the annual cost (VAT included) for a 9313 kWh is about 1770€ (1388£), redoing our calculations for 30 years, our electricity bill would amount to 53,148 € (41642£).

The cost for the same period of time of our solar installation will be of 81,934.98 € making the same changes of inverter and regulators and **12,9131** kg of CO2 saved to the atmosphere

That leaves us a overrun of **28,786.98€.**

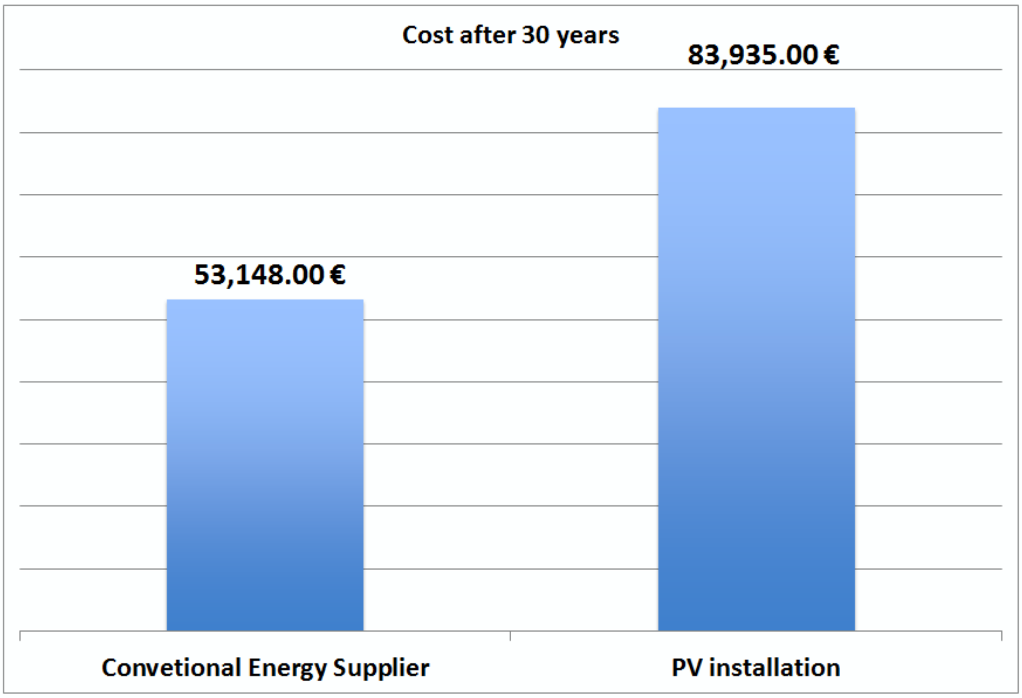


Figure 3.4: Cost comparison between Conventional supply and Solar supply in UK.

In conclusion, from the economical side, the only location where is possible to install enough Photovoltaic panels to supply the consumption is **Spain.**

One important part of the installation is the space required by the panels, given that the solar panels can not be located wherever we want, it has to be a place without shadows, considering that a panel covered by a shadow acts like a consumer and not as a producer.

But first of all is to know the space of one panel and then calculate the minimum space that we are a going to require.

Our panel has the next dimensions:

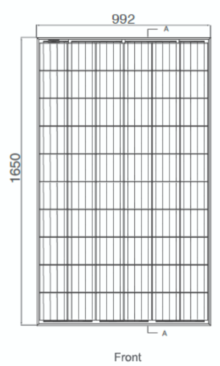


Figure 3.5 Panel dimensions: 992mm width and 1,650mm length, total area **1.6368 m2**

For Spain that means installing all the panels together, something that could no be possible, a minimum area of **91.6608** m2.

For Northern Ireland the minimum area required is the **301.1712** m2, if we would be able to draw a square of the same area, it will has a side of 17.3542 meter, longer than a double decker bus (17 meters)

Concerning with the Wind generation, as a unpredictable source of energy, we can not say that we are going to generate a certain amount of energy in a short period of time, but what we can say that for a long period of time we are going to produce certain amount of energy because the last 10 years this, amount of hours at certain speed have been recorded by the anemometer.
We can have based our study on the average speed and extrapolated this speed to the total hours of a year (8,760).

With this in Spain we have calculated that one generator can produce 7,627.77 kWh in one year, this is 2294.23 kWh less than the 9922 kWh we need to supply our house for one year, so at least we are going to need 2 turbines to produce that amount of energy.
This two turbines are going to produce a maximum of 15,255.54 kWh per year.
We say maximum because if you install more than one turbine in one place and this turbines are not enough separated, and they coincide in the same direction of the wind, the first one will absorb the energy of the wind leaving the second one with less energy as the predicted.
This just can be avoided again if we made an study of the direction of the wind in our location and install the turbines following this study.

In any case a maximum of **15,255.54** kWh per year is **153.75**% more energy than the required, this gives us a grade of reliability sufficiently high.

In the case of Northern Ireland we have calculated that one turbine can produce 11,921kWh, this is 128% more energy than the required, this is a lower grade of reliability than Spain, but we have to take in account that Northern Ireland is known

as one of the most windy places in Europe and has one of the highest density of wind production of Europe, knowing this, a 128% is enough for our annual consumption. This leaves us a blade diameter of 4 meters, 2 times the high of a person 2 meters tall, this means a big turbine to install more than one on the top of your house or your backyard, being possible this type of installation just in Northern Ireland.
The payback in Norther Ireland, taking as reference the cost of the turbine, inverter and post as 24,000 € we are going to make profitable our investment in 14 years, and in a time span of 30 years we are going to save 24,330€ replacing the inverter once in 30 years.

For the same period of time in Spain we are not going to be able to save money in 30 years, in fact, we are going to spend 930€, this cost is caused of the cost of 2 aero generators come up to 54000€, including in this cost the replacement of both inverter every 15 years. This makes not faceable the installation of this technology for the Spanish location.

## Chapter 8. Conclusion

Starting with a brief resume about the history of the solar and wind energy and the situation that the actual ppm of CO2 we are going to go through a general overview of the main figures extracted from the calculations and the results, and analyzing how easy was to obtain the data of average speed wind or the solar irradiation of our locations and conclude if under our conditions of calculation which technology is more convenient for each location.

We can determine that the story of the Solar photovoltaic is not precisely sort, quite the opposite, it is large, it is 140 year long and it is still improving, as every new technology its discovery was completely casual, and unsuccessful, but all the beginnings are tough, but 70 years after its discovery the first photovoltaic cell was produced with a cost of 300 per Watt, after this, with the help of the army of the United States of America using solar cells at their first satellite the industry of photovoltaic cells became to be interesting and a very profitable market.
after these events, we arrive to the current days, when a solar panel of 260 Watts cost 245€ (0.94€ per Watt).

The story of the wind production is almost the same, with the first wind turbine of 12kW installed in 1888 in Ohio, and with a use more orientated to the large production, the wind technology has improve over the year up to reach windmills with a output power 8 Mega Watts.

That makes as to think about the CO2 emissions and how is the current situation.

Nowadays the presence of CO2 in the atmosphere is around the 400 ppm, but is that much?
If we compare this figure with the data from 1950, the ppm were 180, that means an increase of 222%, and just in 50 years, but this rise was not linear, was in exponential as we can see in the Figure 4.1 , and more critical, the rise of the temperature follows the same path as we can see in the Figure 4.2.

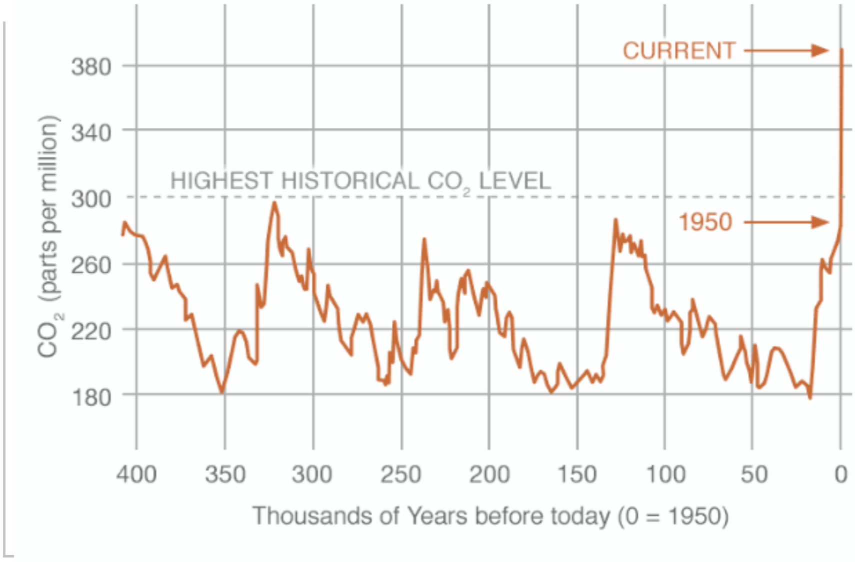


Figure 4.1: CO2 ppm levels over the last 460 years.

http://climate.nasa.gov/vital-signs/carbon-dioxide/

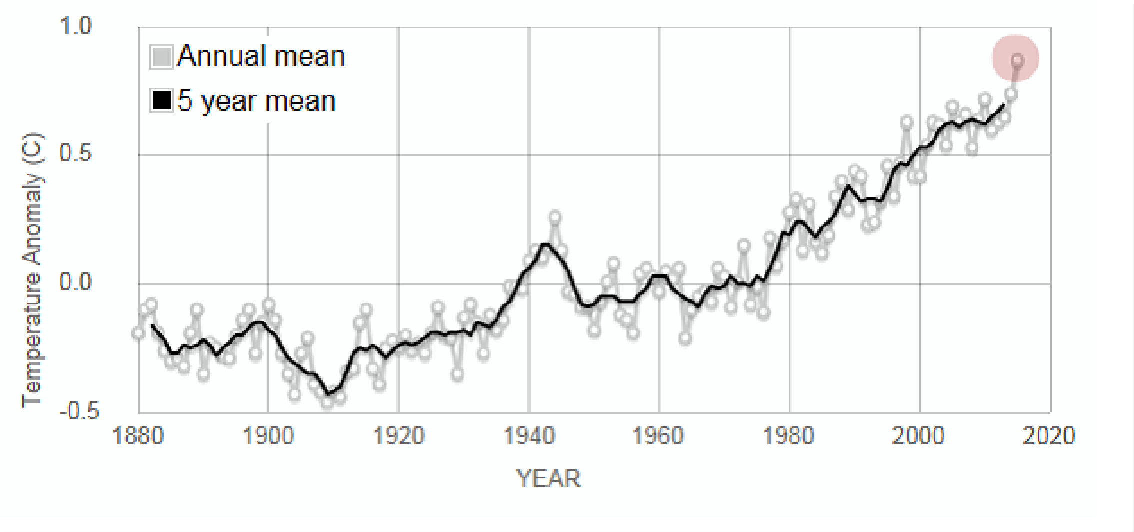


Figure 4.2: Temperature anormaly over the last 130 years.

http://climate.nasa.gov/vital-signs/global-temperature/

This means that if we do not change our way of living wanting, we are going to have to do it even if we will not want it, because the sea levels will increase because of the melted ice from the poles, the desertification around the world will increase and that could change our alimentation, habits, everything.

With this we arrive to the core of the dissertation, the comparison between Spain and UK in Photovoltaic and Wind energy installations (Table 1.1 & 1.2) using PVGIS for the irradiation and the average annual speed for the wind.

| **SPAIN** | **UK** |
|---|---|
| Energy Consumed (kWh) | |
| 56 | 184 |
| Annual Energy Bill | |
| 91.66 | 301.17 |
| CO2 Produced | |
| 14.56 | 47.84 |

Table 1.1: Comparison between energy consumption in both locations.

| **SPAIN** | **UK** | **SPAIN** | **UK** |
|---|---|---|---|
| Solar Panels | | Aerogenerators | |
| 56 | 184 | 2 | 1 |
| Area required (m2) | | Power installed (kW) | |
| 91.66 | 301.17 | 12 | 6 |
| Power installed (kW) | | Energy Generated (kWh/year) | |
| 14.56 | 47.84 | 15,255 | 11,921 |
| Cost of installation | | Cost of installation | |
| 23,977.27 € | 72,395.63 € | 54,000 € | 27,000 € |
| Irradiation (kWh /m2) | | Average Speed Wind | |
| 116 | 33 | 4.5 | 5.6 |
| Payback Period | | Payback Period | |
| 14 years | Never | 14 years | Never |
| Savings after 30 years | | Savings after 30 years | |
| 26,085 € | -28,787 € | -940 € | 24,330 € |

Table 1.2: Comparison of both type of installation.

We can extract the next conclusions:

With a energy consumption very similar 9922 kWh in Spain to 9313 kWh in UK the Solar installation is 3 times bigger in UK and that is related to the 3 times lower irradiation in UK than in Spain

Because of the low irradiation, the cost of the installation in UK comes up to the 72k €, making impossible the payback, the opposite happens in Spain, where an installation of 14.56 kW can be amortized in 14 years and make savings of 26k € in 30 years.

We can see as well that the Wind installation is impossible in Spain because the payback never happens, thing that occurs in 14 years in the UK installation, making savings of 24k €

We save 3.959 kilos of CO2 in Spain and 4.304 in UK per year, this means that for 30 years we can save 118,766 and 129,130 kilos respectively, the double than the maximum weight that a Boeing 737-800 ( widely used by Ryanair) when it lands.

We can conclude that with just knowing the solar irradiation and the annual average speed the installation most convenient for each country will be:

Solar for Spain

Wind for UK.

I will like to mention as well that the wind installation was not calculated with all the data required for a more precise calculation because the data that concerns to the wind as hours of wind at a certain speed, or the direction of the wind is just possible paying for it, in fact you can found lots of information on internet but just paying for them, thing that makes really difficult to calculate the conditions at your location, with this data, the cost of the installation would be lower and more affordable because maybe the turbine required would be smaller, ore ven using the same turbine that we have use with an output power of 6 kW the energy produced would be higher, giving the oportunity of selling that energy an make even higher the savings after 30 years.

## Chapter 9. Future work

First problem that I found about the research of information about previous studies comparing the energy generation between countries in the European Union is that , it does not exist any of them, we can found studies about energy consumption, generation in each country, we can also new if this energy is generated from fossil fuel or renewable sources,but we can not new how is a countrie doing against the rest of Europe in term of clean technologies, because of course we can know how much power of wind energy is installed in UK, Spain or Germany, but we can not know if this is the best of each country, for that we need to make common plans of energy, because is has non common sense that Germany has more power installed in Photovoltaic cells than Spain, and for that we need to creat a united plan to leverage the clean sources of Europe, and leave behind all the egos of the politicians and the people, and have a thought of a big comunity where we speak different languages and if in Norther Ireland the production fo wind energy is one of the best of Europe, and in Spain solar generation is it best bet, the best is to share the generation from this sources and make them affordable from the European Union, not just from the country where are they installed.

For that Europe has to made more studies in different regions and determine in which places are going to be installed a certain kind of technology and with that if we can achive a strong net where the countries of the European Union can share the production of the technology, we will reach the objective of 0 emissions of $CO_2$ generating electricity.

This with the investmen in new technologies like the graphene, material that implemented in the solar cells can revolution the industry, increasing the efficiency of them up to 70% without increasing the cost of them, and the investment of the off-shore wind farms, farms where the production is more steady and higher caused of the wind in th sea is more steady and predictable and these kind of farms can also get installed a underwater mills and generate electricity using the flow of the sea.

Finally, the goal that the European Union has to reach is to be more Union and less selfish, because if we have the thought as a united nations, and we do not depend that much from foreing countries, who just think in its own interest, we will be strong again.

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## Appendix A. Additional Material

### A.1 Wind map Spain

### A.2 Wind map UK

### A.3 Solar irradiation Spain from PVGIS

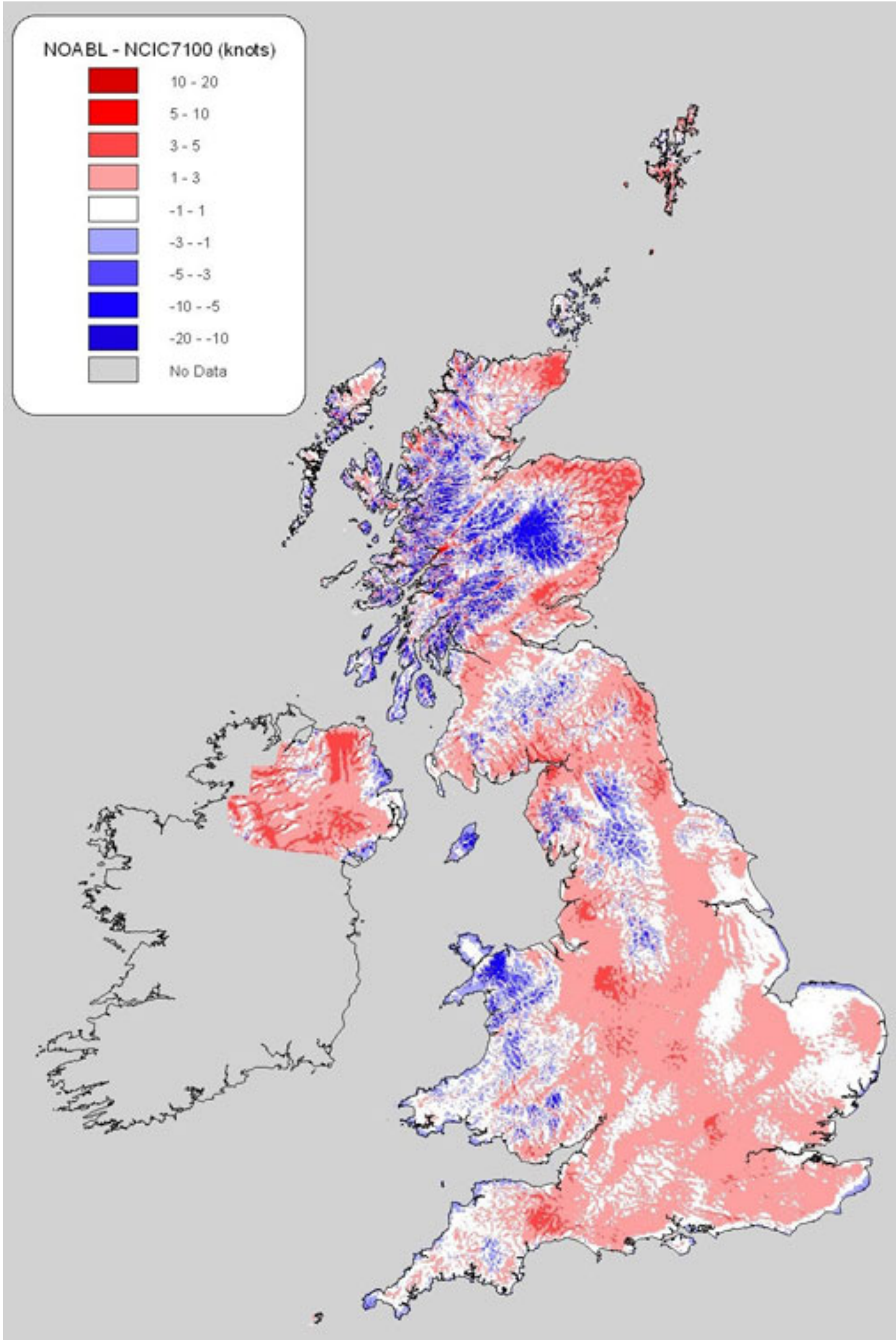
### A.4 Solar irradiation UK from PVGIS

### A.5 Technical data Solar panel

### A.6 Technical data Wind mill

# MAPA EÓLICO DE ESPAÑA

## Velocidad Media Anual a 30 m de altura


NOABL - NCIC7100 (knots)
10 - 20
5 - 10
3 - 5
1 - 3
-1 - 1
-3 - -1
-5 - -3
-10 - -5
-20 - -10
No Data

# Performance of Grid-connected PV

## PVGIS estimates of solar electricity generation

Location: 39°27'30" North, 0°28'6" West, Elevation: 51 m a.s.l.,
Solar radiation database used: PVGIS-CMSAF

Nominal power of the PV system: 1.0 kW (crystalline silicon)
Estimated losses due to temperature and low irradiance: 10.0% (using local ambient temperature)
Estimated loss due to angular reflectance effects: 2.5%
Other losses (cables, inverter etc.): 14.0%
Combined PV system losses: 24.5%

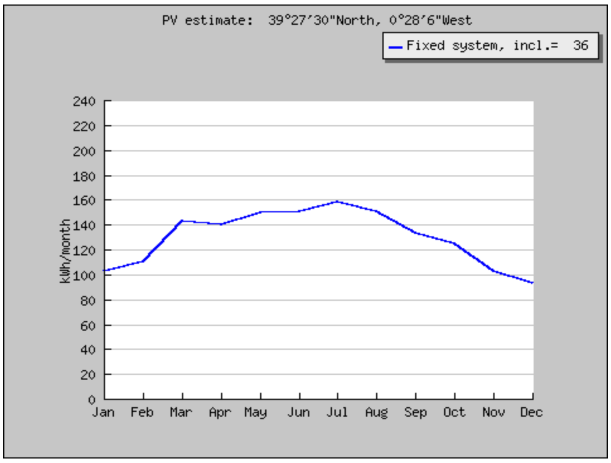
| | **Fixed system: inclination=36 deg., orientation=0 deg. (Optimum at given orientation)** | | | |
|---|---|---|---|---|
| **Month** | **Ed** | **Em** | **Hd** | **Hm** |
| Jan | 3.31 | 103 | 4.14 | 128 |
| Feb | 3.94 | 110 | 5.01 | 140 |
| Mar | 4.62 | 143 | 6.01 | 186 |
| Apr | 4.67 | 140 | 6.18 | 185 |
| May | 4.85 | 150 | 6.52 | 202 |
| Jun | 5.04 | 151 | 6.90 | 207 |
| Jul | 5.10 | 158 | 7.09 | 220 |
| Aug | 4.87 | 151 | 6.75 | 209 |
| Sep | 4.45 | 134 | 6.04 | 181 |
| Oct | 4.01 | 124 | 5.33 | 165 |
| Nov | 3.44 | 103 | 4.39 | 132 |
| Dec | 3.00 | 93.1 | 3.75 | 116 |
| Year | 4.28 | 130 | 5.68 | 173 |
| Total for year | | 1560 | | 2070 |

Ed: Average daily electricity production from the given system (kWh)

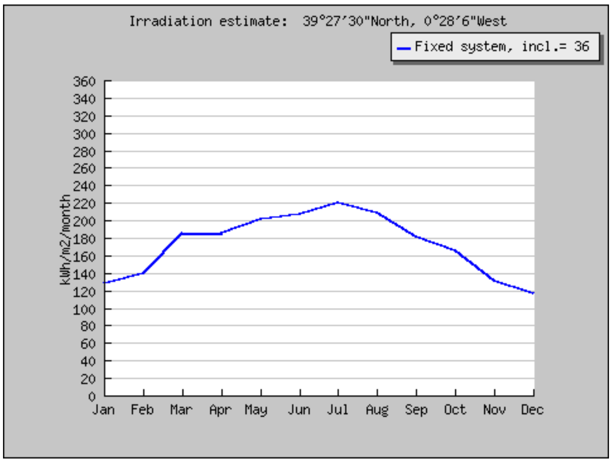
Em: Average monthly electricity production from the given system (kWh)

Hd: Average daily sum of global irradiation per square meter received by the modules of the given system (kWh/m2)

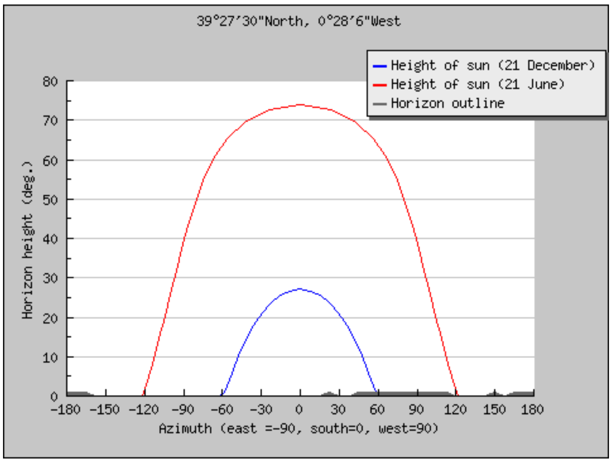
Hm: Average sum of global irradiation per square meter received by the modules of the given system (kWh/m2)




Monthly energy output from fixed-angle PV system




Monthly in-plane irradiation for fixed angle




Outline of horizon with sun path for winter and summer solstice



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# Performance of Grid-connected PV

## PVGIS estimates of solar electricity generation

Location: 54°41'11" North, 5°53'27" West, Elevation: 26 m a.s.l.,
Solar radiation database used: PVGIS-CMSAF

Nominal power of the PV system: 1.0 kW (crystalline silicon)
Estimated losses due to temperature and low irradiance: 6.9% (using local ambient temperature)
Estimated loss due to angular reflectance effects: 3.1%
Other losses (cables, inverter etc.): 14.0%
Combined PV system losses: 22.4%

| | **Fixed system: inclination=39 deg., orientation=0 deg. (Optimum at given orientation)** | | | |
|---|---|---|---|---|
| **Month** | **Ed** | **Em** | **Hd** | **Hm** |
| Jan | 0.88 | 27.3 | 1.06 | 33.0 |
| Feb | 1.56 | 43.6 | 1.91 | 53.6 |
| Mar | 2.59 | 80.2 | 3.25 | 101 |
| Apr | 3.34 | 100 | 4.33 | 130 |
| May | 3.74 | 116 | 4.91 | 152 |
| Jun | 3.45 | 103 | 4.60 | 138 |
| Jul | 3.26 | 101 | 4.36 | 135 |
| Aug | 2.86 | 88.7 | 3.79 | 117 |
| Sep | 2.48 | 74.3 | 3.20 | 95.9 |
| Oct | 1.67 | 51.6 | 2.10 | 65.1 |
| Nov | 1.19 | 35.6 | 1.46 | 43.8 |
| Dec | 0.87 | 26.9 | 1.05 | 32.4 |
| Year | 2.33 | 70.8 | 3.01 | 91.4 |
| Total for year | | 849 | | 1100 |

Ed: Average daily electricity production from the given system (kWh)

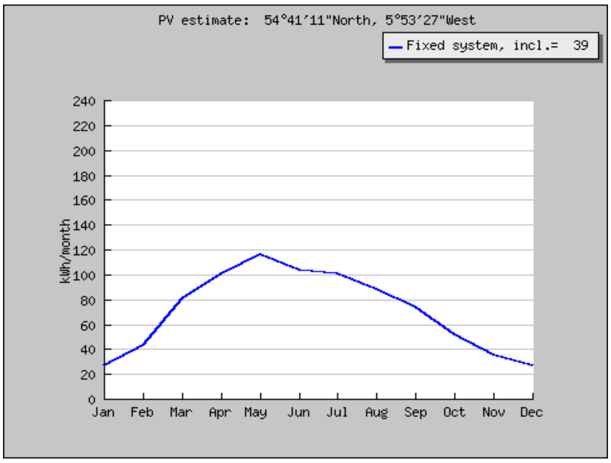
Em: Average monthly electricity production from the given system (kWh)

Hd: Average daily sum of global irradiation per square meter received by the modules of the given system (kWh/m2)

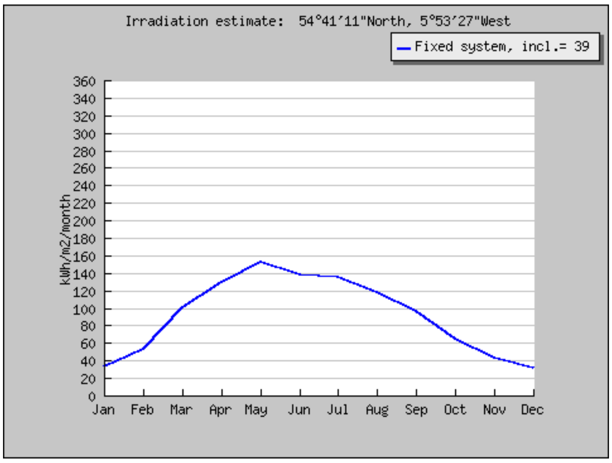
Hm: Average sum of global irradiation per square meter received by the modules of the given system (kWh/m2)

European Commission
Joint Research Centre
Ispra, Italy

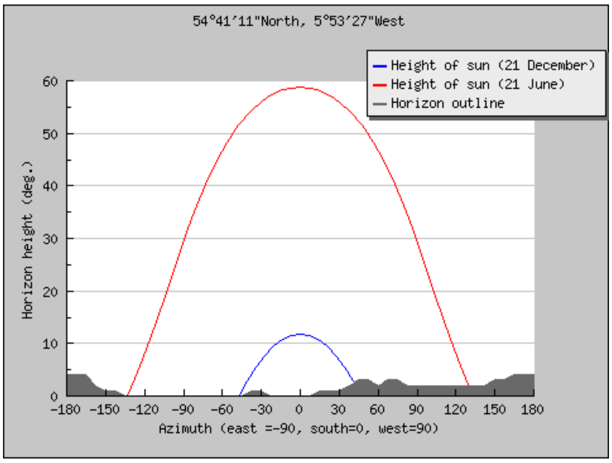
# Photovoltaic Geographical Information System




Monthly energy output from fixed-angle PV system




Monthly in-plane irradiation for fixed angle




Outline of horizon with sun path for winter and summer solstice



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www.jinkosolar.com

Solar JinKO
Building Your Trust in Solar

# JKM270P-60

## *255-270 Watt*

POLY CRYSTALLINE MODULE

Positive power tolerance of 0/+3%

ISO9001:2008、ISO14001:2004、OHSAS18001 certified factory.
IEC61215、IEC61730 certified products.

(4BB)

PV CYCLE · TÜVRheinland CERTIFIED · CE · MCS

## KEY FEATURES

**4 Busbar Solar Cell:**
4 busbar solar cell adopts new technology to improve the efficiency of modules , offers a better aesthetic appearance, making it perfect for rooftop installation.

**High Efficiency:**
High module conversion efficiency (up to 16.50%), through innovative manufacturing technology.

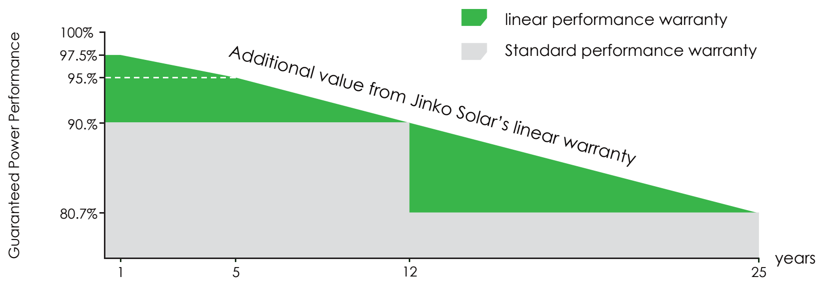
**Low-light Performance:**
Advanced glass and solar cell surface texturing allow for excellent performance in low-light environments.

**Severe Weather Resilience:**
Certified to withstand: wind load (2400 Pascal) and snow load (5400 Pascal).

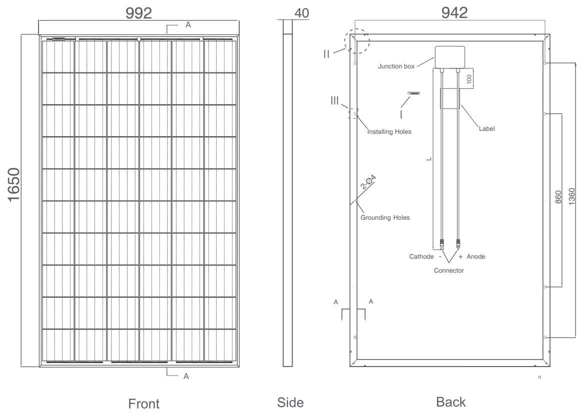
**Durability against extreme environmental conditions:**
High salt mist and ammonia resistance certified by TUV NORD.

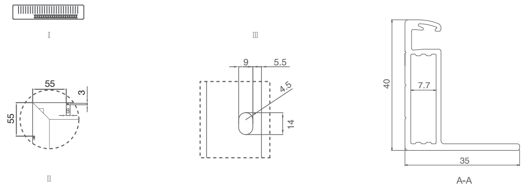
## LINEAR PERFORMANCE WARRANTY

**10 Year Product Warranty • 25 Year Linear Power Warranty**



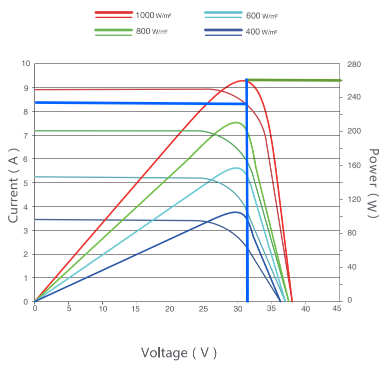
## Engineering Drawings



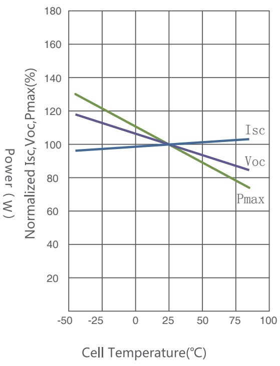




## Electrical Performance & Temperature Dependence

Current-Voltage & Power-Voltage Curves (260W)




Temperature Dependence of Isc,Voc,Pmax




## Mechanical Characteristics

| | |
|---|---|
| Cell Type | Poly-crystalline 156×156mm (6 inch) |
| No.of cells | 60 (6×10) |
| Dimensions | 1650×992×40mm (65.00×39.05×1.57 inch) |
| Weight | 19.0 kg (41.9 lbs) |
| Front Glass | 3.2mm, High Transmission, Low Iron, Tempered Glass |
| Frame | Anodized Aluminium Alloy |
| Junction Box | IP67 Rated |
| Output Cables | TÜV 1×4.0mm², Length: 900mm or Customized Length |

## Packaging Configuration

( Two boxes=One pallet )

25pcs/ box, 50pcs/pallet, 700 pcs/40'HQ Container

# SPECIFICATIONS

| Module Type | JKM255P | | JKM260P | | JKM265P | | JKM270P | |
|---|---|---|---|---|---|---|---|---|
| | STC | NOCT | STC | NOCT | STC | NOCT | STC | NOCT |
| Maximum Power (Pmax) | 255Wp | 189 Wp | 260Wp | 193Wp | 265Wp | 197Wp | 270Wp | 200Wp |
| Maximum Power Voltage (Vmp) | 30.8V | 28.5V | 31.1V | 28.7V | 31.4V | 29.0V | 31.7V | 29.4V |
| Maximum Power Current (Imp) | 8.28A | 6.63A | 8.37A | 6.71A | 8.44A | 6.78A | 8.52A | 6.80A |
| Open-circuit Voltage (Voc) | 38.0V | 35.2V | 38.1V | 35.2V | 38.6V | 35.3V | 38.8V | 35.4V |
| Short-circuit Current (Isc) | 8.92A | 7.26A | 8.98A | 7.31A | 9.03A | 7.36A | 9.09A | 7.38A |
| Module Efficiency STC (%) | 15.57% | | 15.88% | | 16.19% | | 16.50% | |
| Operating Temperature(℃) | -40℃~+85℃ | | | | | | | |
| Maximum system voltage | 1000VDC (IEC) | | | | | | | |
| Maximum series fuse rating | 15A | | | | | | | |
| Power tolerance | 0~+3% | | | | | | | |
| Temperature coefficients of Pmax | -0.41%/℃ | | | | | | | |
| Temperature coefficients of Voc | -0.31%/℃ | | | | | | | |
| Temperature coefficients of Isc | 0.06%/℃ | | | | | | | |
| Nominal operating cell temperature (NOCT) | 45±2℃ | | | | | | | |

STC: Irradiance 1000W/m² Cell Temperature 25°C AM=1.5

NOCT: Irradiance 800W/m² Ambient Temperature 20°C AM=1.5 Wind Speed 1m/s

* Power measurement tolerance: ± 3%

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# BORNAY 600




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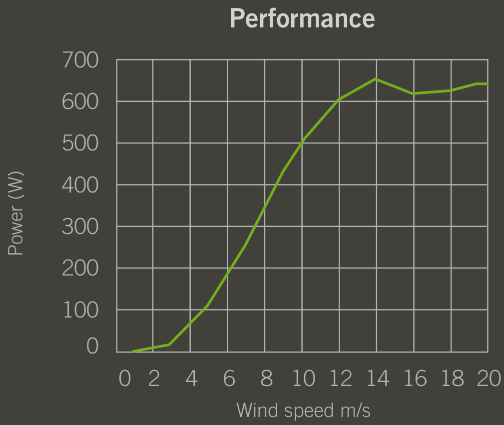
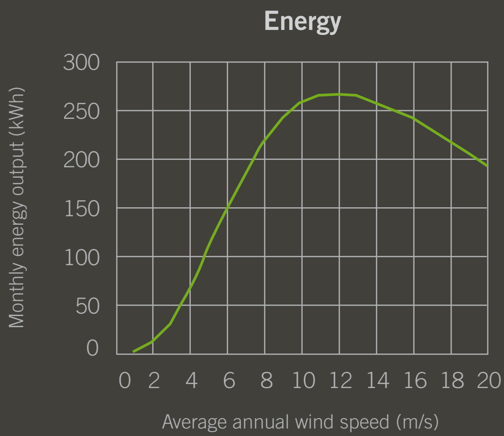
600W

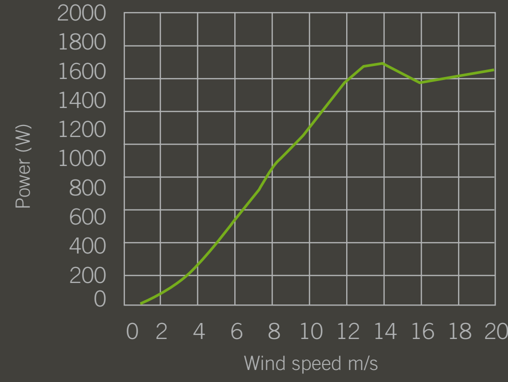

Performance
Power (W)
700
600
500
400
300
200
100
0
0 2 4 6 8 10 12 14 16 18 20
Wind speed m/s


Energy
Monthly energy output (kWh)
300
250
200
150
100
50
0
0 2 4 6 8 10 12 14 16 18 20
Average annual wind speed (m/s)

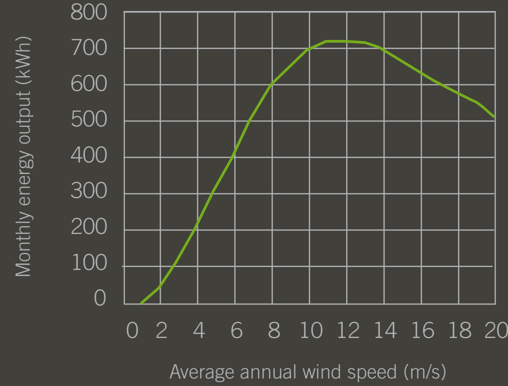
# BORNAY 1500

20 21


## Performance




## Energy



# BORNAY 3000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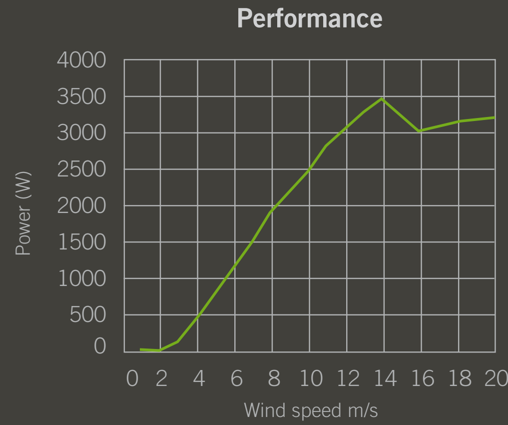
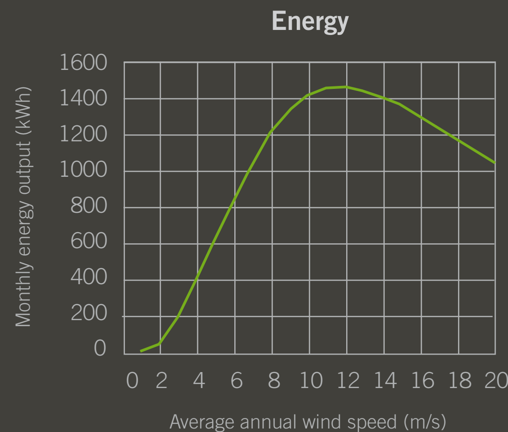
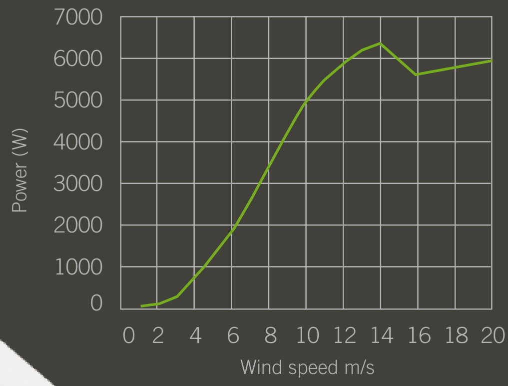
3000 W


Performance
Power (W)
4000
3500
3000
2500
2000
1500
1000
500
0
0 2 4 6 8 10 12 14 16 18 20
Wind speed m/s

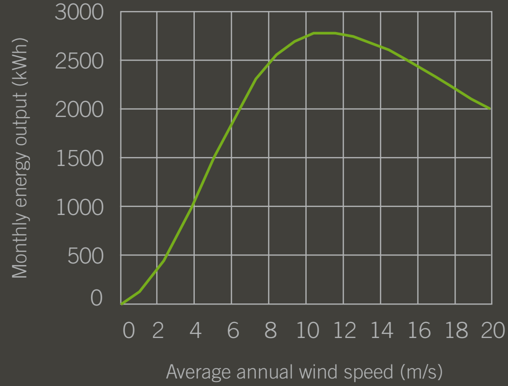

Energy
Monthly energy output (kWh)
1600
1400
1200
1000
800
600
400
200
0
0 2 4 6 8 10 12 14 16 18 20
Average annual wind speed (m/s)

# BORNAY 6000


## Performance




## Energy



## Technical specifications

| | |
|---|---|
| Number of blades | 3 |
| Diameter | 4 mts |
| Material | Fiberglass and carbon fiber |
| Direction of rotation | Counterclockwise |
| Control systems | 1. Electronic regulator<br>2. Passive by tilting |

## Electrical specifications

| | |
|---|---|
| Alternator | Three phases permanent magnet |
| Magnets | Neodymium |
| Nominal power | 6000 w |
| Voltage | 48, 120 v |
| RPM | @ 600 |
| Regulator | 48 v 150 Amp<br>120v. Grid connection |

## Performance, windspeed

| | |
|---|---|
| For turn on | 3,5 m/s |
| For nominal power | 12 m/s |
| For automatic brake system | 14 m/s |
| Survival | 60 m/s |

## Physical specifications

| | |
|---|---|
| Windturbine weight | 107 kg |
| Regulator weight | 18 kg |
| Packaging | 120 x 80 x 80 cm - 149 kg |
| Dimensions - weight | 260 x 40 x 15 cm - 22 kg |
| Total | 0,91 $m^3$ - 171 Kgr |
| Warranty | 3 years |

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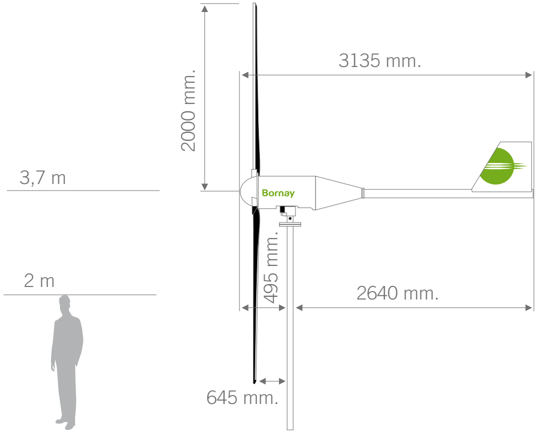

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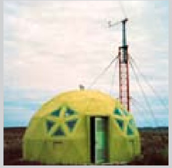
# Typical Installations









# Off Grid Applications

| Consumes | Quantity | Power | Hours | Daily consum |
|---|---|---|---|---|
| Lighting | 8 | 13 | 2 | 208 Wh |
| Lighting | 5 | 10 | 5 | 250 Wh |
| TV | 1 | 250 | 4 | 1000 Wh |
| Video | 1 | 150 | 1 | 150 Wh |
| Computer | 1 | 180 | 4 | 720 Wh |
| Fridge | 1 | 180 | 12 | 2160 Wh |
| Washing machine | 1 | 750 | 1 | 750 Wh |
| Small consumes | 1 | 500 | 2 | 1000 Wh |
| | | | **Consumes** | 6238 Wh |

## Batteries

| | |
|---|---|
| Battery voltage | 24 volts |
| Days of autonomy | 3 days |
| Battery capacity | 897 Ah - C100 |

## Inverter

| | | | |
|---|---|---|---|
| Input voltage | 24 volts | Charger | Yes |
| Output voltage | 220 volts | Three phases | No |
| Frequency | 50 Hz | Sinewave | Pure |
| Maximum power | 2164 W peak | Inverter | 3000 W |

| Production | Quantity | Power | Isolation | Daily consum |
|---|---|---|---|---|
| Solar Modules | 10 | 100 | 4 | 4000 Wh |

| | Windspeed | Power | Quantity | Daily consum |
|---|---|---|---|---|
| Windturbine 1500 neo 24 v. | 5 | 245 | 1 | 2695 Wh |
| | | | **Producction** | 6695 Wh |

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# Telecommunications

### A Wind Turbine

Generates electricity from wind power, either during the day or at night. Its power varies relative to the needs of the installation.

### I Inverter

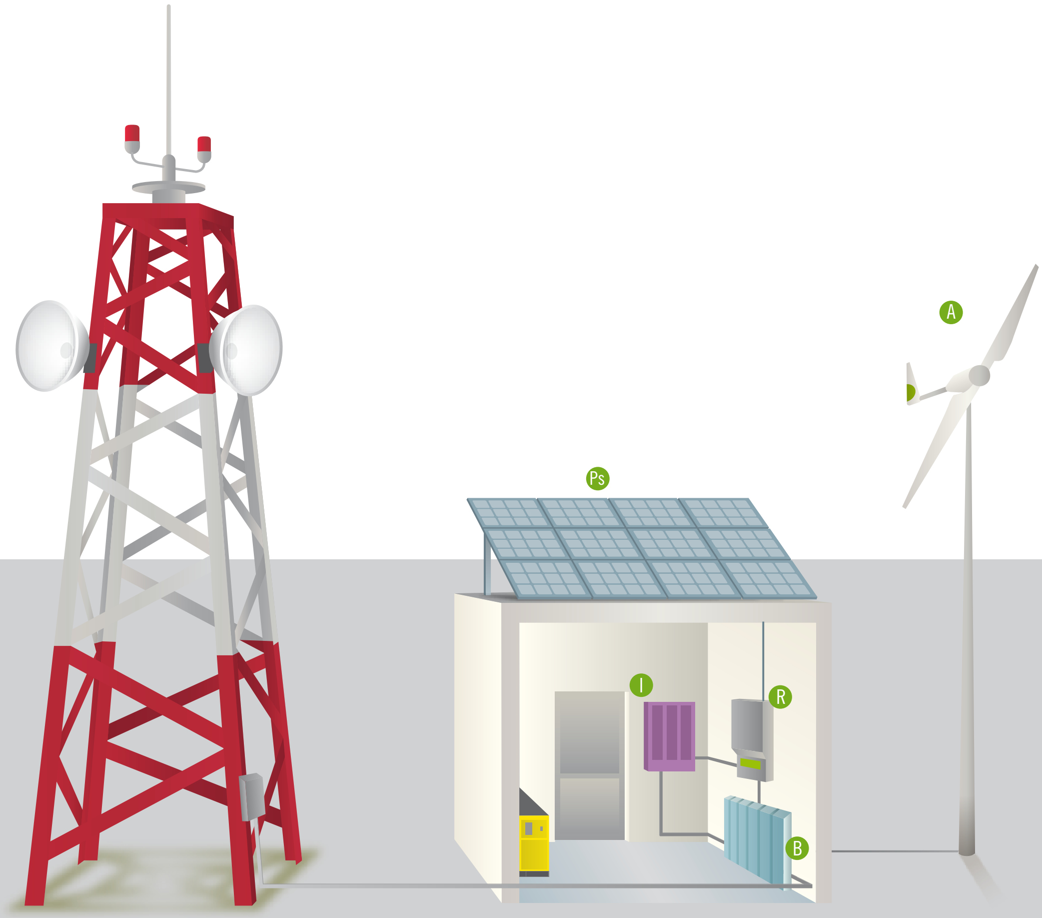
Transforms the stored continuous electricity into domestic electricity (alternating current at 220 V). A charger can be integrated to charge the batteries from an external source, like a diesel generator.

### B Batteries

Stores the energy produced by the wind turbine and solar panels, making it available for later use. It is recommended to have battery banks that last a minimum of three days.

### R Controller

Controls the electricity generated by the wind turbine, the solar panels. It also controls the state of the battery. Prevents the overcharge and discharge of the battery bank.

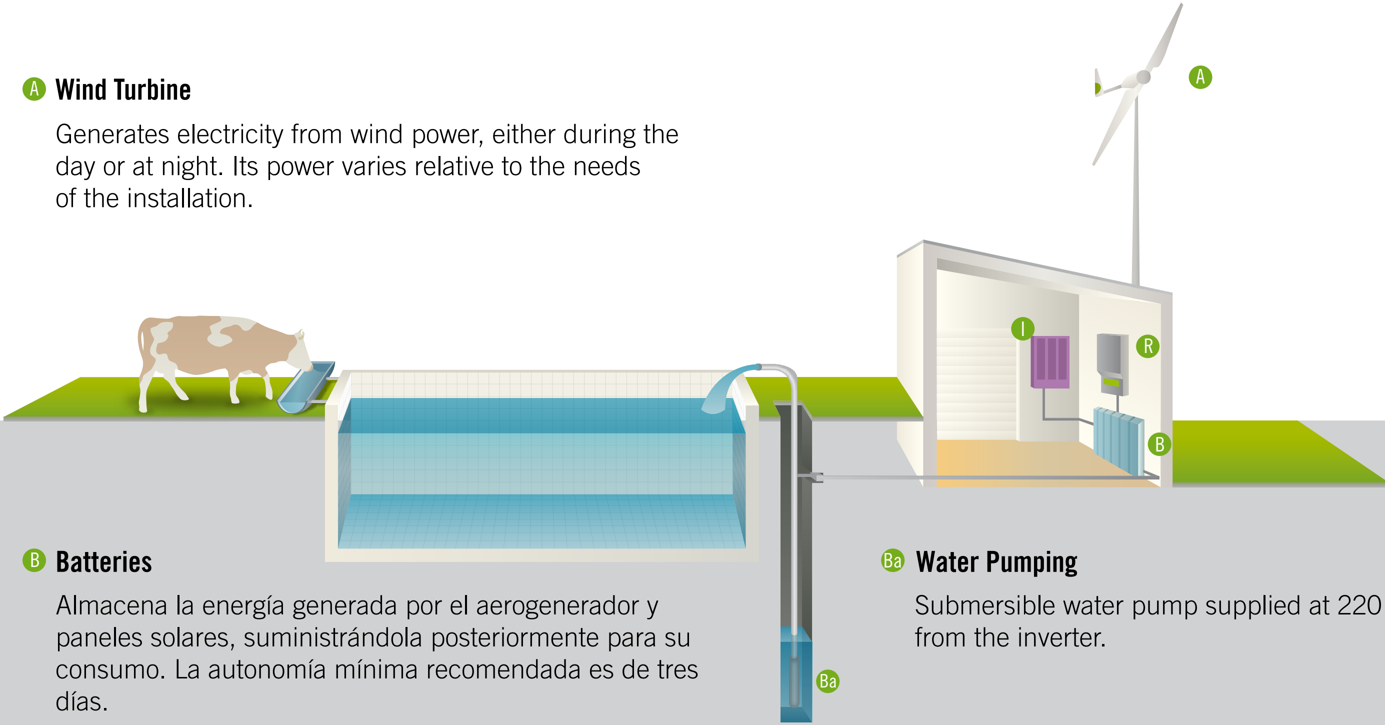



## Ps Solar Panels

Generates electricity using solar radiation: therefore, its use is limited to daylight hours. Combined with a wind turbine, they guarantee a stable electricity production throughout the entire year. The number of solar panels and its power depends on the total energy required for the installation.

# Water pumping






### Ⓐ Wind Turbine

Generates electricity from wind power, either during the day or at night. Its power varies relative to the needs of the installation.

### Ⓑ Batteries

Almacena la energía generada por el aerogenerador y paneles solares, suministrándola posteriormente para su consumo. La autonomía mínima recomendada es de tres días.

### Ba Water Pumping

Submersible water pump supplied at 220 vac from the inverter.

### Ⓘ Inverter

Transforms the stored continuous electricity into domestic electricity (alternating current at 220 V). A charger can be integrated to charge the batteries from an external source, like a diesel generator.

### Ⓡ Controller

Controls the electricity generated by the wind turbine, the solar panels. It also controls the state of the battery. Prevents the overcharge and discharge of the battery bank.

# Grid connection

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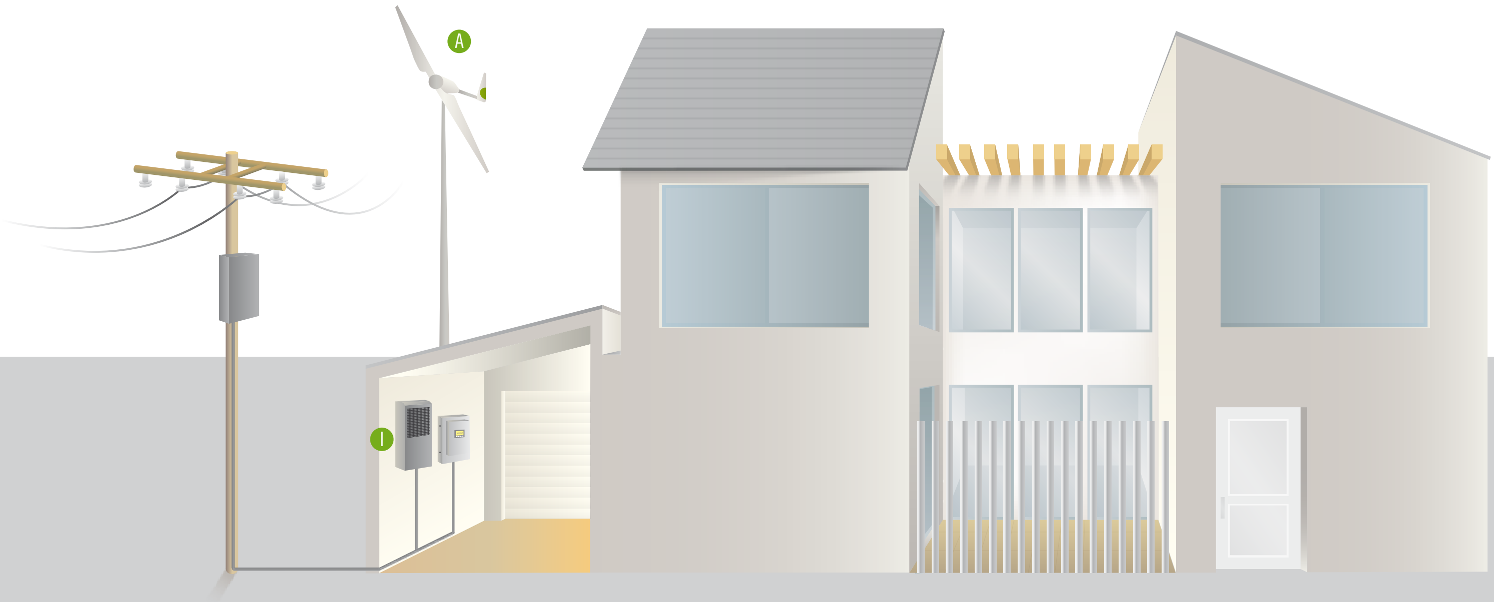


**A Wind Turbine**

Generates electricity from wind power, either during the day or at night.

**I Inverter**

Synchronizes the energy generated by the windturbine and/or solar modules with the electrical grid and produces the input into the grid.

| Technical specifications | BORNAY 600 | BORNAY 1500 | BORNAY 3000 | BORNAY 6000 |
|---|---|---|---|---|
| Number of blades | 2 | 2 | 2 | 3 |
| Diameter | 2 mts | 2,86 mts | 4 mts | 4 mts |
| Material | Fiberglass and carbon fiber | Fiberglass and carbon fiber | Fiberglass and carbon fiber | Fiberglass and carbon fiber |
| Direction of rotation | Counterclockwise | Counterclockwise | Counterclockwise | Counterclockwise |
| Control systems | 1. Electronic regulator<br>2. Passive by tilting | 1. Electronic regulator<br>2. Passive by tilting | 1. Electronic regulator<br>2. Passive by tilting | 1. Electronic regulator<br>2. Passive by tilting |
| **Electrical specifications** | | | | |
| Alternator | Three phases permanent magnet | Three phases permanent magnet | Three phases permanent magnet | Three phases permanent magnet |
| Magnets | Ferrite | Neodymium | Neodymium | Neodymium |
| Nominal power | 600 w | 1500 w | 3000 w | 6000 w |
| Voltage | 12, 24, 48 v | 24, 48, 120 v | 24, 48, 120 v | 48, 120 v |
| RPM | @ 1000 | @ 700 | @ 500 | @ 600 |
| Regulator | 12 v 60 Amp<br>24 v 30 Amp<br>48 v 15 Amp | 24 v 80 Amp<br>48 v 40 Amp<br>120v. Grid connection | 24 v 150 Amp<br>48 v 75 Amp<br>120v. Grid connection | 48 v 150 Amp<br>120v. Grid connection |
| **Performance, windspeed** | | | | |
| For turn on | 3,5 m/s | 3,5 m/s | 3,5 m/s | 3,5 m/s |
| For nominal power | 11 m/s | 12 m/s | 12 m/s | 12 m/s |
| For automatic brake system | 13 m/s | 14 m/s | 14 m/s | 14 m/s |
| Survival | 60 m/s | 60 m/s | 60 m/s | 60 m/s |
| **Physical specifications** | | | | |
| Windturbine weight | 38 kg | 41 kg | 93 kg | 107 kg |
| Regulator weight | 7 kg | 8 kg | 14 kg | 18 kg |
| Packaging | 50 x 77 x 57 cm - 55 kg | 50 x 77 x 57 cm - 57 kg | 120 x 80 x 80 cm - 135 kg | 120 x 80 x 80 cm - 149 kg |
| Dimensions - weight | 104 x 27 x 7 cm - 4,7 kg | 153 x 27 x 7 cm - 6,8 kg | 220 x 40 x 15 cm - 19 kg | 260 x 40 x 15 cm - 22 kg |
| Total | 0,22 $m^3$ - 59,7 Kgr | 0,23 $m^3$ - 61,8 Kgr | 0,90 $m^3$ - 154 Kgr | 0,91 $m^3$ - 171 Kgr |
| Warranty | 3 years | 3 years | 3 years | 3 years |