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DISEÑO DE UNA HUERTA SOLAR FOTOVOLTAICA DE  
1.2 MW, SITUADA EN CORELLA (NAVARRA, ESPAÑA)

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# **1.2MW Design of a Photovoltaic field**

**Spain (Corella, Navarra)**

# Abstract

The energy needs of humanity do not stop growing. On the other hand, the scientific community, don't stop to warn that if not stopped the emission of pollutants into the atmosphere (especially CO<sub>2</sub>) we are heading directly to the precipice of big extinction, not only of the plants and animals, also of men. This new amount of energy needed each year to meet global energy demand, is generated from vast majority from fuels, carbon-based: coal, gas and oil.

All this combined with the growth in oil barrel prices and increasing scarcity of this, present a big problem for our society.

This issue opens the door for inclusion in the market for renewable energy.

This project try to explain the assembly and design of a photovoltaic installation connected to the network of 1.2MW.

A garden is a solar photovoltaic system connected to the network that uses the sun to generate electricity using photovoltaic solar panels. The electricity produced is converted into alternating current and is injected to the electrical distribution network. The sale of this electricity is currently one of the best choices in the marketplace in terms of profitability and security.

The incomes that will provide installation are guaranteed by law (Royal Decree 1578/2008). This document set the price per kWh. sold to the power company.

A photovoltaic system consists furthermore the modules photovoltaic, of the BOS (Balance of system), which constitute it, the control unit, the investor and the processor, the structure mechanical support, electrical wiring and protection devices (fuses, sockets and switches ground).

For all that has been performing necessary:

- Economic and profitability
- Study of productivity
- Load of wiring, protection, pipes, earth, distance between panels, other calculations.
- Design the structure with a certain inclination to reduce the losses by shadows.
- Civil study
- Study of Safety and Health
- Technical specifications

- Budget
- Bibliography
- Annexes
- Location and objectives
- Description of the installation.
- Others

It should be borne in mind that the electricity produced by renewable sources of energy has priority access to the network, which is regulated by royal decree. Since all components have standardized connection assembly is done with great precision and speed, without technical problems for its connection to the network, so from that moment begins to generate electricity, and therefore profits.

In addition, the useful life of a photovoltaic system can be above the age of 40 and also, the manufacturers of solar photovoltaic offered an assurance of 25 years. Therefore, the primary objective of this project is to show values for determine if the installation is profitable or not.

# Acknowledgments

I take these lines to express my gratitude to everyone who has been at my side during these years of career. I have to thank in particular the support received by my family, especially my mother and father, who in distance support and encourage me, without them this project would not have ended.

Not forgetting all my friends who have always been concerned about the fate of my future. A special greeting to my friends from college, without them these 4 years could have been longer.

I also thank everybody in the laboratory of electronics and electricity that I have helped make this project succeed, and in particular to David T. Thank you for your encourage. I also want to thank Javi, Asier, my brother Jesus, and especially Estefania, always ready to assist in whatever, without them this project would be extended to infinity.

Finally I wish to thank Glyndwr University, especially my supervisor, Dr. Yanting Hu, for having allowed this magnificent project, and also to Pablo Sanchis and Alfredo Ursua, from the University of Pamplona. Without them, none of this would have been possible.

To all of you

THANKS!

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# – INTRODUCTION –



## **0. INTRODUCTION**

### **0.1. Project specifications**

The objective of this project is the design of a solar photovoltaic (PV) power plant with a network connection of 1.275.120 w in the property "La Sarda", located in Corella (Spain). To achieve this, 5544 panels of 230 w have been used. Each panel generates a current in maximum power of 7.91 A.

The goal of this installation is to add the electric energy generated by the photovoltaic panels to the network of the electric company that distributes the energy using 12 power transformers of 100KvA.

There are two main reasons to execute this project:

- Economic: From the economic point of view, these types of electrical installations can be very appealing as they benefit from unique economic and legal framework.

The Royal Decree Law establishes the price of the Kwh for electric companies. The amount they have to pay for the electricity generated by photovoltaic panels is approximately five times higher than the price the non PV customer pays for the same energy.

- Ecologic: Taking into account the energy problem nowadays, by using solar photovoltaic power technology we can create clean energy and reduce the consumption of pollutant energies and replace them with a clean and renewable energy source.

The steps to create a solar PV power installation are the following:

- Economic Survey
- Study the location and its solar resources
- Installation dimensioning
- Legal Framework



Figure 1: Example of installation. Photography by solar garden located in Bonete (Spain). [17]

## 0.2. Interesting data

### Spain

10 / 2008	Roof top	Ground mounted					
Up to 2 MW	€ct 33,- / kWh	€ct 29,- / kWh					
Cap in 2009	200 MW	100 MW					
Building regulations	Min . 6,25 kWp to be installed on new and renovated buildings of a certain size, exemptions for various building types (e.g. residential) exist						
Tax credits	Corporate / income tax reduction of 6% of investment cost, max 35% of total tax charge. Digressing rates apply: 2009: 4%, 2010: 2% thereafter the tax credit runs out						
Investment grants	Depending on the region						
Other information	FIT payment fix for 25 years	Max. growth of subsidized marked 10%					

Figure 2: Introduction, interesting data, Spain. [18]

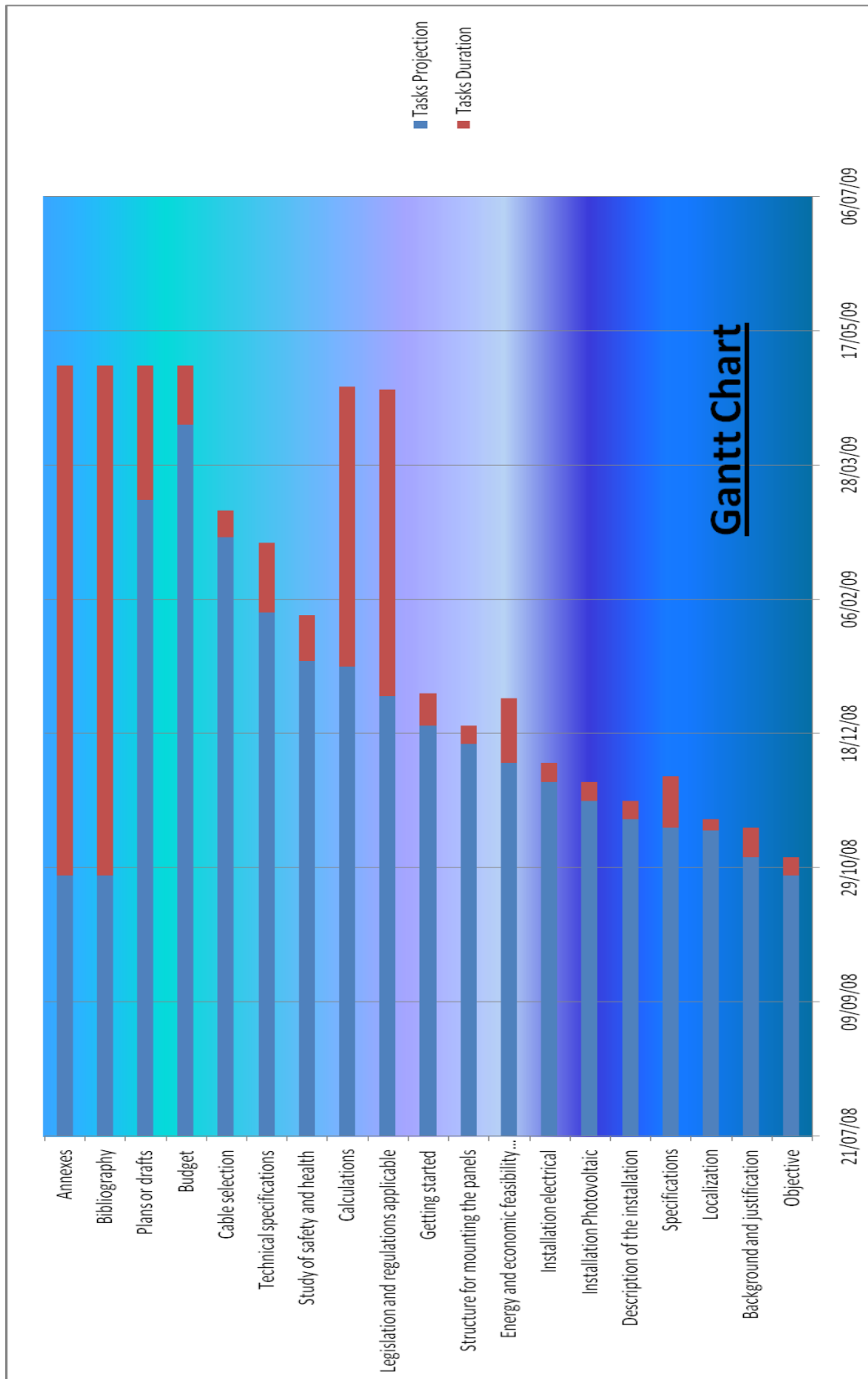
## 0.3. Work plan

- Report introduction:
- Objective (26oct-1nov)
  - Background and justification: (2nov-12nov)
    - Current energy problem, renewable energy and solar energy.
- Localization(with photo satellite, if is possible) (12nov-15nov)
- Specifications (13nov-1Dec)
- Description of the installation(with drawings of the installation)(16-22nov)
  - Installation photovoltaic(23-29 Nov)
  - Installation electrical.(30Nov-6 Dec)
- Energy and economic feasibility study(7Dec-30 Mar)
- Structure for mounting the panels (14-20 Dec)
- Getting Started (21-30 Dec)
- Legislation and regulations applicable(1Jan-11Jan)
- Calculations (12Jan-1May)
  - Pipes
  - Protections

- Wiring
- Structure
- Study of safety and health (14Jan-30Jan)
- Technical specifications (1Feb-25Feb)
- Cable selection (1 Mar-9Mar)
- Budget (12 April-1 May)
- Plans or drafts (15 Mar-1 May)
- Bibliography (26Oct-1 May)
- Annexes (26 Oct-1 May)
- Analysis (26 Oct-1 May)
- Conclusion (25 May)
- Summary of design (26 May)
- Covers (28 May)
- Review (26 Oct-1 May)



## 0.4. Gantt chart





**– CONTAINS –**



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# – Chapter 1 –

## REPORT INTRODUCTION

# **1. CHAPTER 1: REPORT INTRODUCTION**

## **1.1. Aims – Objectives**

The purpose of this project is the realization of a garden solar photovoltaic 1.2 Mw in Corella, population that belongs to the province of Navarra, in Spain. I have chosen this place for the location of the installation because the weather conditions and terrain claim that the profitability of the facility is high.

The installation will use the money that the actual legislation provides for the sale of electricity. Determine if the installation is profitable or not.

The investments in these types of facilities are quite high, the technical design and economic of these projects is of utmost importance to achieve the expected investment. The solar source is not going to fail, the risk lies in poor design or poor planning, so is necessary to pay much attention.

## **1.2. Background and justification**

### **1.2.1. Problem current energy**

Before starting, is necessary to establish a framework to encompass the historic circumstances that have occurred in recent decades in the energy sector, without which certainly have led to the development of renewable energy as an alternative production of electricity.

On the one hand, it has produced a great proliferation of gases harmful to the environment, accentuating phenomena as the greenhouse effect, and even leading to fears social a climate change that could be starting.

Also, it is necessary to recall the extraordinary increase in the price of a barrel Oil has been given in recent times. This is due to the shortage of this resource in the world market, also caused by the continuing growth of the demand for the economies in the expansion process.

According to the Association for the Study of Oil and Gas, ASPO, production World oil will begin its decline between 2007 and 2010, which will a severe shortage.

Resort to other types of energy such as from the combustion of coal or combined cycle gas is not the total solution to this problem, because the emissions are continuous. [2]

### **1.2.2 Renewable energy**

Due to the above, and coupled with the significant dependence energy presents Spain (around 80%), it becomes necessary to use alternative energy support for the production of electricity. The growth substantial renewable sources, along with a significant improvement in the efficiency energy, respond to reasons of economic strategy, social and environmental, besides it will be the basis for fulfilling international commitments on environment.

It is necessary to recall the environmental advantages offered by energy renewable versus fossil resources, the increased use of renewable sources reduces the contribution of the energy system to the greenhouse effect.

In Spain it comes to maintaining the European commitment to renewable sources of cover at least 12% of the total energy consumed by 2010. [2]

Ultimately, the aim is to strengthen the policy and provide energy, while fulfilling certain commitments environmental, such as the Kyoto Protocol. All this with the sole purpose of effectively contribute to sustainable economic development.

### **1.2.3 Photovoltaic solar energy**

Although, at present the photovoltaic solar energy is very reduced, a significant and rapid growth its implementation, given the commitment of countries to elect for this type of clean energy, and development of technology. The photovoltaic industry is experiencing in recent years an average annual growth exceeding 30%. Traditionally the use of photovoltaic solar energy has been aimed at isolated applications of electricity grid. However, since a few years the incorporation of this technology to the urban environment has facilitated its distribution and development. This is the only technology capable of producing where it is consumed, greatly reducing the congestion of the networks as well as losses electricity transmission. [4]

As has been previously introduced and later will be described in more detail in this project, the system of obtaining electricity from solar energy, is carried out of way easy, clean and fast.

The inconvenient is that is a technology that is not yet is highly developed, which makes the investment is high. That is why State offers aid in the form of premiums, which will be studied later.

It is interesting to note that at present 89% of the installed modules are connected directly to network (installation in this project). This includes systems installed on the roofs of the houses (majority solution in Germany and Japan) and the large installation (majority solution in Spain). [3]

#### **1.2.4. Rationale**

Until not long ago energy was related to the photovoltaic panels that were in some (few) rooftops of buildings, however, it is becoming more usual to see a large number of photovoltaic modules aligned at large tracts of land, are the Great plants for production of photovoltaic electricity (power greater than 200 kW), passing the installed power in these installations of 28 MW in 2000 to 951 MW by the end of 2007, of whom more than half (480MW) were installed in the same year. Germany with 480 MW installed, followed by Spain with 286 MW and 164 MW U.S. account for more than 90% of the total power installed worldwide. [5]

To see the evolution that has taken in recent years the installation of photovoltaic plants in the world only is necessary consulted the annual report of Great photovoltaic plants in the world "photovoltaic Large Power Plants, Annual Report 2007". This report said that in the world the total power installed, since late 2007, was 951 MW of which 770 MW are installed in Europe. Topping the list of countries; Germany with 47%, followed by 28% Spain and U.S. with 15%. [6]

In Spain in the last three years the growth has been exponential. This trend, is observed in the listing of the largest photovoltaic power installed in the world, here we find that 40 of the 50 largest photovoltaic power plants (60 to 6.3 MW installed) are in Spain, with over 580 MW installed, growth that the Royal Decree 1578/2008 regulates and limits to 400 MW over the next 3 years.

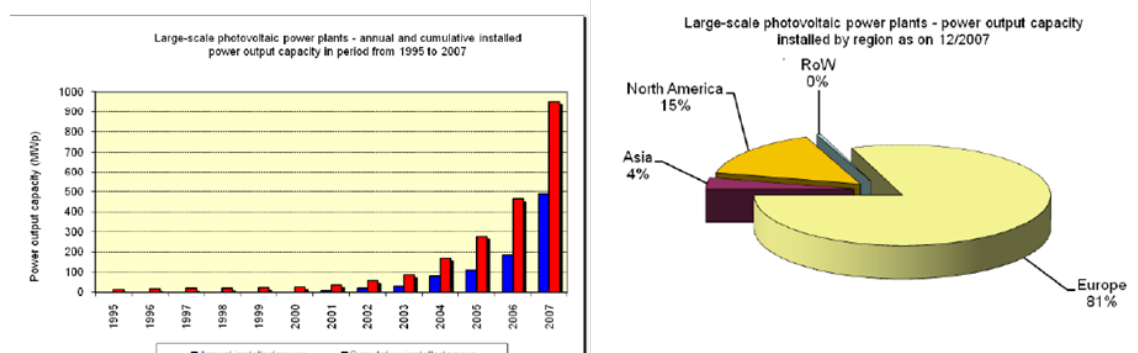


Figure 3: Large- scale photovoltaic power plants in the world. [19]

To make this process of increasing power has developed various legal texts through which has been regularizing and systematizing the methodology of implementation and operation of these plants.

Thus, in these texts can find two legal regimes production electricity: one ordinary or regular and one special, which encompasses all renewable. [7]

In the latter, it is possible to subsidize the cost of generating and rewarding producers through European funds, state or community, with the sole aim to introduce this technology in a simple manner in the Spanish electricity system.

We present this project to fill in the Order of 7 November 2005, the Department of Industry, Commerce and Tourism, laying down rules additional processing and the connection of certain generation facilities electric power system and special groups in the same distribution networks.

This facility will be designed in accordance with Royal Decree 436/2004, dated March 12, laying down the methodology for updating and systematic regime of the legal and economic activity of electricity production in the special regime. [7]

The solar will be comprised of 12 parks 100kW each. The parks will evacuate the energy generated at a single important cable, drop wire.

The photovoltaic solar energy has been in recent years, the energy that has achieved a higher take off.

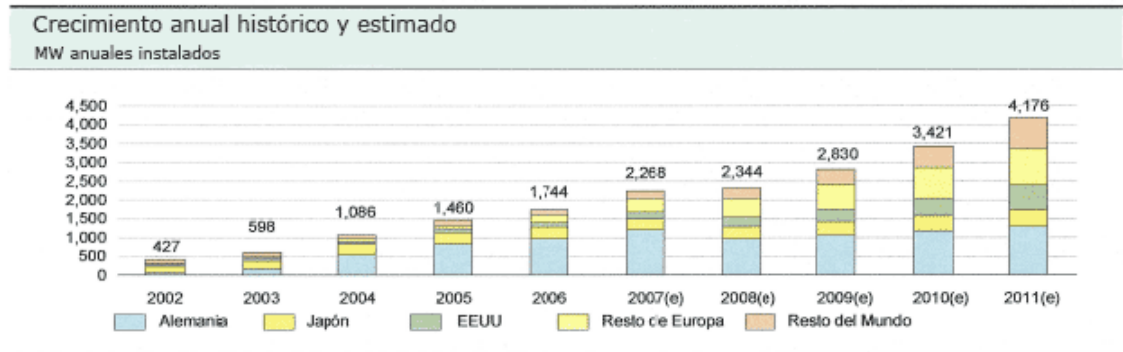


Figure 4: Estimated historical evolution of the total installed photovoltaic power in the world. [20]

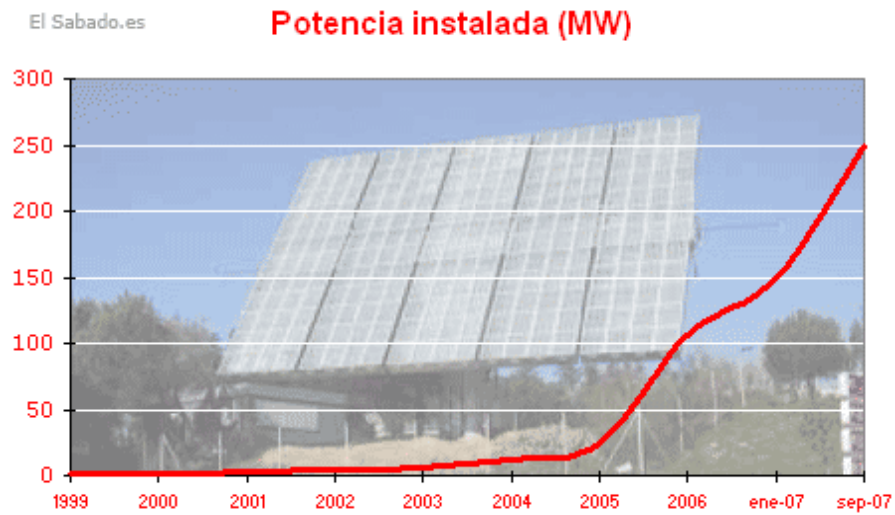


Figure 5: Power installed in Spain. [20]



### 1.3. Location

The location of my project is in Corella (Navarra). This is an area of dry land. This is a fairly flat terrain, surrounded by terrains which are plains too, bringing the total of it profitable.

The panels will be placed in a steel structure with an inclination of 35 degrees with the ground, and of course oriented to the south, as being fixed bearing, so get the maximum utilization.

Investors and transformers will be located in a house`s prefabricate.

The parcel has access trough of the national highway N-115.Corella, Polygon 10, Plot 284, Place: the surface "Sarda" m<sup>2</sup>: 36514.50

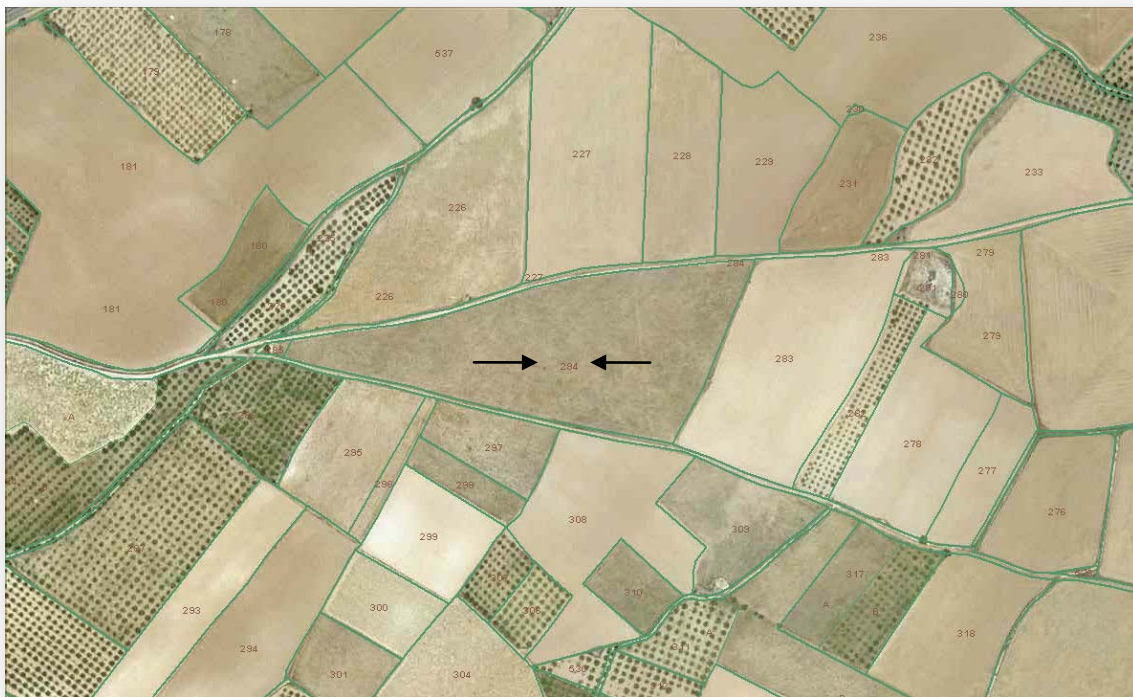


Figure 6: Map of the garden. [21]

Property register + Ortophoto 1:5.000 (Datum ED-50):minX=605.500 mminY=4.664.287 mUTM-30N (Datum ED-50):maxX=606.504 mmaxY=4.664.899 m Pixels: 1187x723.[4]

## 1.4. Specifications

The installation is divided in two key parts. The first part is the field of panels, which capture the direct and diffuse radiation from the sun and by means of excitement of the diodes that make up, it can get a certain current, to a given voltage, in continuous current. With the combination of these panels' series and in parallel, obtain a value of voltage, current and power suitable for the inverter.

The second part is formed by the inverter, which converts DC continuing to alternating current (AC), to values of frequency and intensity required by the company. In this part of the installation is included the transform. It also is the transform, which sets a value of tension suitable for connection to the network.

### 1.4.1. More detailed description on the installation

#### 1.4.1.1. Introduction

Photovoltaic modules are the devices that have made reliable power beyond the power lines possible. PV is the most widely used alternative power source. Even those lucky enough to have a viable hydro or wind site often choose to have a few PV modules for back-up or seasonal use. A PV module produces electrical current when it is exposed to sunlight. The technology is closely related to and was a spinoff of 1950s transistor technology. PVs provide clean, uncomplicated power whenever and wherever the sun shines on them. [1]

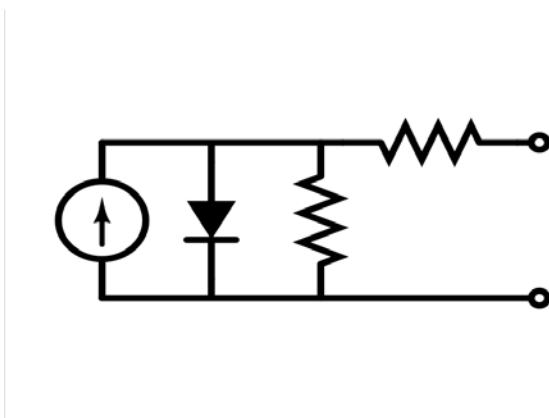


Figure 7: Schema generation of solar power in a conventional module. [15]

### 1.4.1.2. A brief technical explanation

A single PV cell is a sandwich consisting of two very thin wafers generally made of very pure silicon. These wafers have been doped with elements that produce a surplus of electrons in one layer (called the n-layer) and a deficit of electrons in the other layer (called the p- layer). When bombarded by the photons in sunlight, some of these electrons are liberated and start to flow. Electricity results not from the heat of the sunlight, but from millions of these liberated flowing away from the n- layer. Some of these wandering electrons make their way to metallic conductors on the silicon surface, the flow on though the electrical circuit. The PV cell acts like an electron pump. A single silicon cell produces just under half volt, while amperage is dependent on cell size efficiency. A module consists of many individual cells that are arranged and wired in series and parallel to provide the required voltage and amperage output. The module is encapsulated with tempered glass or some other transparent material on the front surface and some kind of protective and waterproof material on the back. The edges are sealed for weatherproofing, and there is often an aluminium frame holding everything together in a mountable unit. A junction box or wire leads providing electrical connections can usually be found on the module's backplane.

### 1.4.1.3. Construction types

There are currently three commercial production technologies for PV cells:

- Single crystal: this is the oldest and most expensive technique, but it is the most efficient sunlight conversion technology available. *Boules* (large cylindrical loafs) of pure single- crystal silicon are grown in an oven, then sliced into wafers, doped, and assembled. This is the same process used in manufacturing transistors and integrated circuits, and so is very well-developed, efficient, and clean. Silicon crystals are characteristically blue (because they absorb all other colors), and single crystalline cells look like deep blue glass.

- Multicrystalline: In this technique, which is also called polycrystalline, less monolithic loaves are grown or cast, then slice into wafers off a large block of multicrystalline silicon. It is slightly lower in conversion efficiency compared to single crystal, but the process is less exacting and so manufacturing cost are lower. Crystals are usually on the order of centimeter (two-fifths of an inch) and can usually be seen in the cell's deep blueness.

- Amorphous: The silicon material is vaporized and deposited on glass or stainless steel. This production technology cost less than the other methods, but the cells are also less efficient. Early production methods produced a product that faded up to 50% in output over the first few years before stabilizing. Present day technology claims to have dramatically reduced this fading problem. These cells are often almost black in colour.

The industry has standardized on a module output which fits into a 12 volt DC regime. This means they usually produce 14 to 18 volts output, as the source voltage must be higher for battery charging. [1]

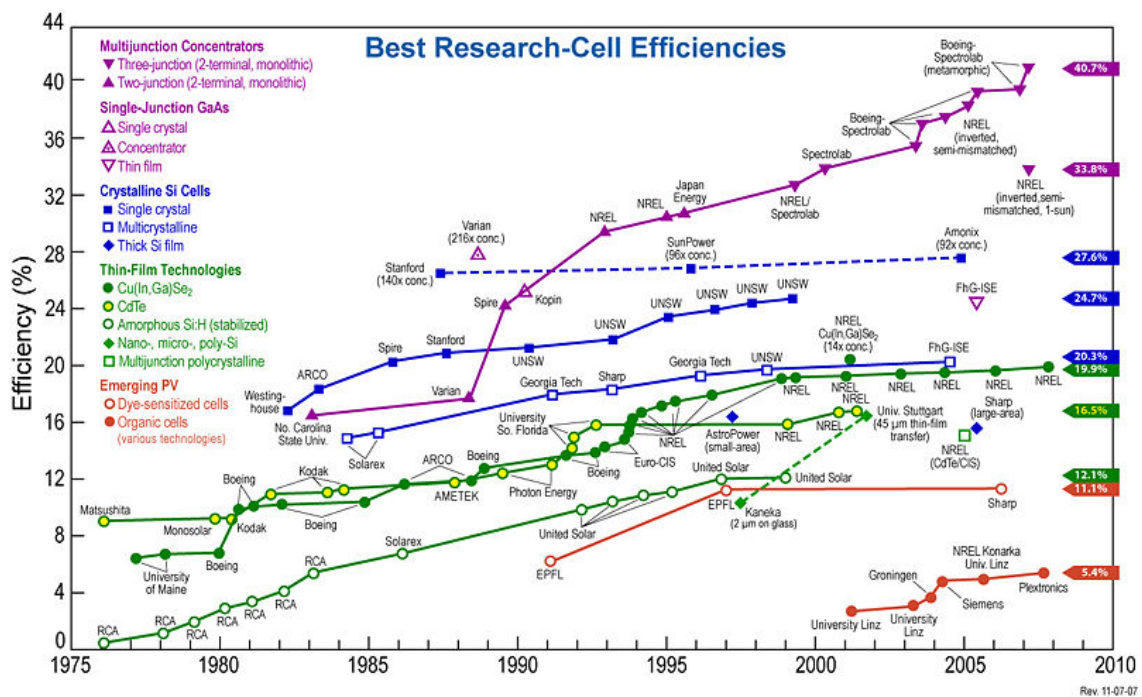


Figure 8: Evolution of efficiency of different technologies. [15]

The Figure 2, shows the evolution of the efficiency of each technology in the last 30 years (the years of the existence of the solar photovoltaic). Likewise, it demonstrates that there are many technologies with the potential to achieve high efficiencies.

Thus, in accordance with this, the modules that will be used in this project, are of polycrystalline, although if is necessary adjust the budget will be used Amorphous.

On the other hand and speaking about the general features of the installation, it has also taken into account the energy produced and energy consumed by panels, so it is necessary to the installation of two meters, or one bidirectional, to enable rapid

response to the counting of the Kwh. injected into the network and the Kwh consumed by the team.

This is a direct consequence of the terms of the RD 1578/2008. This RD said that all energy produced must be injected to the grid, and not for auto consumption of the plant.

That is because the RD provides a premium during the first 25 years of operation of the facility, so that the same investment will be profitable. If this installation consume part of the energy that it produce, would be losing the difference between the prices per kWh. conventional and Kwh solar, which would make useless the concept of economic aid that this RD introduce.

For this reason, the solar generator will never be auto producer, if not simply producer. The objective of this legislation is to get a selective energy saving, making maximum use of solar energy free and fair manner, at the expense of conventional, as it aims to save energy and increase our energy independence.

The tariffs, bonuses and incentives set at present are:

- 32,00 (c€/kWh) produced.

To make the installation is the most profitable possible, and knowing that the installation is the 1.2 Mw. Nominal, will be divided into 12 plots of 100 kW each.

As for the distribution of the plant in the ground, it will be more accessible. The panels are put towards the south to get on well harnessing solar maximum, because they lack solar followers. In addition, it are provides them with an angle of 35 degrees, to achieve the maximum performance, namely that the sun's rays are perpendicular to the largest panel long as possible during the summer months. With all of this is to balance the maximum use throughout the year, to ensure the profitability of the installation.

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# – Chapter 2 –

## DESCRIPTION OF THE INSTALLATION

## **2. CHAPTER 2: DESCRIPTION OF THE INSTALLATION**

### **2.1. System connected to the network**

A system connected to the network consists mainly of photovoltaic modules that make up the photovoltaic generator, the inverter that converts the current continuous of the panels in alternating and injected into the network and finally, the meter of energy that is injected into the network. Since the photovoltaic modules are highly reliable, the element that more attention technique requires is the investor.

Following are the components of a typical photovoltaic installation:

#### **2.1.1- Photovoltaic Installation**

##### **➤ 2.1.1.1. Photovoltaic generator**

Is made up of panels and supporting structures. While power generation is produced in the solar cell, basic unit is the use of photovoltaic module. A module consists of a set of solar cells connected in series (strings) or parallel-series combinations that provide an electrical outlet into direct current through two terminals or two cables. The module provides rigidity and protection against the environment to the whole cell, and incorporates safety elements that protect the exterior of the circuit.

Also, the panel have to be oriented in such ways that obtain the maxim use (south orientation and inclination to 35 degrees on support structure).

It will be the first factor which influences the production of energy and this will have economically repercussions on the system.

The general characteristics that must be met by photovoltaic modules are:

- The modules must meet the specifications UNE-EN 61215:1997 (replaced by the UNE-EN61215: 2005 before May 1, 2008). Regarding the evidence of impact, it must withstand the blow from a ball of hail (25 mm) at a certain speed.
- For crystalline silicon modules of thin layer, must comply with UNE-EN 61646:1997, and be qualified by a laboratory accredited by the national accreditation recognized by the European Network for Accreditation (EA), as the TÜV.

- The modules are Class II and have a degree of protection IP65, for use with different voltage systems up 1000Vcc.[3]
- Guarantee of performance for 25 years:
  - Power to 10 years, at least 90% of the initial power.
  - Power to 25 years, at last 80% of the initial power.[8]

➤ **2.1.1.2. Protections**

In this installation, must be applied the Regulations Electronic Low Voltage[8], in the which provides the protections that have been in place to protect all the installation of a potential short circuits or electric shock, besides maintaining the quality service. To do this, use the following devices: the circuit DC will be used fuses and circuit switches to be used magneto-thermal differential, besides the general switch of connection-disconnection a network.

In addition to these protections, be must take into account those of the converters for network connection and the photovoltaic plates.

The facility will incorporate all the elements necessary to ensure the quality of electricity supply, as well as security and protections of the people and the installation photovoltaic, in compliance with EU directives Security in Low Voltage Electrical and Electromagnetic Compatibility. [3]

➤ **2.1.1.3. Investor**

The current produced by the photovoltaic panels is continuous. This element is responsible for transform the continuous current in alternating for consumption. Also, they must act as insulation to disconnection-connection automatic of the installation. In systems connected to the network, is its fundamental ability for adapt to the electrical network, avoiding modify their characters.

The general characteristics to be met by the investor are:

- Investors will comply the directives of Electrical Safety in Low Voltage and Electromagnetic Capability.
- The basic characteristics of the investor are the following:



- Principe of operation: Source of Current
- Motor.
- Automatic monitoring of the point of maximum power of the generator.
- Not will work in island or in isolation.
- The power of the investor will be at least 80% of the peak power of photovoltaic generator.
- Investors will have the following protections (both for people and for the team itself):
  - Fault Protection of isolation.
  - Protection against frequency off the range (49-51 Hz).
  - Protection against output voltage out of range (0.85 A-1, 1Un)
  - Protection against reverse polarity at the DC.
  - Overvoltage protection.
  - Protection against overheating.
  - Protection against the operation mode in island.
  - Protection against disruption in the network.
- Each investor will have the markings required for proper operation and will incorporate the automatic controls, that will be essential to ensure their proper supervision and management.
- Each investor will incorporate at least the following manual controls:
  - On / off general.
  - Connection and disconnection AC of inverter to the interface.
  - The values of efficiency to 25 and 100% of the nominal output power must be above 90 and 92% for investors of more than 5 kW.
  - The auto consumption of the teams (in vacuum losses) on "stand-by" or "night mode" must be less than 2% of its nominal output power.
  - The power factor of the power generated should be greater than 0.95, between 25 and 100% of the nominal power.

- The investor must inject into network, greater powers for 10% of its rated power.
- Investors will have a minimum degree of protection IP 22 for investors in the interior of buildings and inaccessible places, IP32 for investors in the interior of buildings and places accessible and IP 65 for investors installed in places open. In any case will be fulfilled the actual law.
- Investors will be guaranteed for operation under the following condition:
  - Between 0 ° C and 40 C temperature and 0% to 85% relative humidity.[3]

➤ **2.1.1.4. Centre of processing (CT)**

The installation is fitted with one or more transforms. Its mission is to convert the low voltage (LV), (230/400 v) in medium voltage (MT), (15000.20000 v), incorporating the protections in MT.

At the exit of the investor will put a transformer with voltage relationship 380(400)/20000 transformation V/V, to connect to network.

In addition, this transformer protects the system as follows: firstly, that may prevent move small components of direct current to the network, which ensures quality of supply, on the other hand, with its neutral earthing guarantees electrical isolation between the AC and the area of continuous, thereby giving a great security system.

All facilities M.T. are located in a single building inside the compound, which contains the necessary gear to raise the voltage and to connect with the online distribution of the company. In this building is called processing centres or connection centre.

➤ **2.1.1.5. Measuring equipment**

The photovoltaic generator needs two counters or a single bi-directional, placed between the investor and the network. Thus, it may be measured on the one hand energy generated by the installation that is injected into the network and on the other hand the energy that can have been consumed by the photovoltaic generator in terms of lack of solar radiation, or consumption by the installation holder. So, that all the energy generated to inject network, so the holder will receive premium

income generation in special regime, and that all the energy consumed is take the network to the normal price of electricity, to get, the more profitable installation.

Every plant will contain a equipment of measurement that will measure the individual production of each of the plants of 100kw.

## **2.1.2. Description of the electrical installation**

### **➤ 2.1.2.1. Connections- continuous current**

The connection between the field panels and the investor will be done through lines link (junction), so obtaining a balanced system at the entrance to the investor, preceded by an electric box called box-current protections and connections continuous, where he will find the protections of the field panels. The modules photovoltaic have output cables for the connection between them (series / parallel), and the cables with the same section for the connection the each line series to the investor. Since the investor is powered by a single entry, it will be necessary to have a box of terminals to spend ten drivers to one.

All this will be a line in continuous current.

### **➤ 2.1.2.2. Individual derivation**

The derivation includes all circuit in alternating current.

At the exit of the investor, the circuit will have a cadre of protections (magneto- Thermal differential) responsible for controlling the intensity of output of the inverter and protect the starting line three phase. The box protection will be united by a three-phase line with the transform, which in turn will be united with the cadre of command and protection, where will have the accountants, or the bidirectional.

The criteria for installation are follows:

- The pipes and canals protectors will have a section that allows nominal expand the section of the drivers installed initially at 100%.

- The minimum nominal outside diameter of the tubes in derivations individual will be 32 mm.
- In any case, there will be a pipe reserves for possible expansions.
- When the derivations individual run vertically will stay inside a pipe or piece of wall manufacture RF120 fire resistance, prepared exclusively for this purpose.
- The minimum height of the covers of registration will be 0.3 m. Its upper part is installed, at least to 0.2 m above the ground.

The characteristics that have to meet the drivers are as follows:

- Drivers will be multi-conductors, including the driver of neutral and the protection of copper, its rated voltage 0.6/1KV.
- The cables are not propagators of the fire and emission of smoke and opacity will be reduced.
- The section of the cables will be uniform throughout its route and without connections, except the connections made at the location of accountants and protection devices.
- The minimum is 6  $mm^2$  copper for drivers phase and neutral protection.
- The maximum allowed voltage drop between the source and the end of the route must not exceed 2%, in the path of alternating current. These values are set in the technical specifications of the IDAE. [9][10][11][12]

### ➤ 2.1.2.3. Box general of protection and measure

In according to the regulations of low- voltage electrical:

There will be a box of protection and measurement equipment for the parcel.

It will be available inside the stand.

Inside the box general of protection and measure will be installed all fuses in all drivers of phase, with power for to cut the short-circuit.

➤ **2.1.2.4. Electrical connection**

The installation will be connected of the network through a high-media voltage substation, Iberdrola.

These will necessary to build a line that communicates the central link to the garden with the substation, and whose design is not within the scope of this project.

- Wiring:

- All low voltage cables are copper and suitable for use, air or buried (RV-K 0.6 / 1 kV to UNE 21123). [11]
- Dimensioning all wires for to reduce the yield losses by voltage drop in cables and connectors, complying with the specifications in the technical specifications for network-connected photovoltaic (IDAE) on voltage reductions allowed: <1.5% in CC and <2% in AC. [9]
- The section of the cables is choose according to the voltage drop and power line. It is important to minimize the length of the cables, therefore strive that distance between the investor and the panels will be minimum.

- Earthling connection:

The installation of earth will be conducted in accordance with the "Regulations Electronic Low Voltage" and Royal Decree 1663/2000 on Photovoltaic solar connection to the network Low Voltage:

- The masses of the facility will be connected to a single land completely independent. On the other hand will be the neutral of the distribution company.
- Investors will have got isolation transformers at the exit to ensure a total electrical isolation between PV and the distribution network.[11][3]

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# – Chapter 3 –

## FEASIBILITY STUDY AND ECONOMIC PROFITABILITY

## **3. CHAPTER 3: FEASIBILITY STUDY AND ECONOMIC PROFITABILITY**

### **3.1. Introduction**

The first step is to analyze the viability, profitability and reliability of the investment in PV. To study these, there is a need to estimate the amount of solar energy generated and the price the electric company has to pay for the energy.

Once both the recovery time of the investment and the expected benefit are known, an accurate decision on the most profitable type of investment can be taken.

### **3.2. Study introductive**

#### **Data:**

➤ Data of the field:

- Location: Corella.
  - Polygon: 10
  - Plot: 284
  - The surface “Sarda” (name of the field): 36514.50 m<sup>2</sup>
1. Plot: right next to my farm there is a field of solar panels, owned enterprise Iberdrola (which so easy to me the things) so I guess assumed the approximately flat with a loss per orography shading of 1.5%.
  2. Distance to the line of Evacuation: “Iberdrola” poured the energy there, so the line is very close to my farm. (M.T. Not is objective of this project).
  3. Tracking system: fixed structure.
  4. Tilt panels on the horizontal: 35 degrees.
  5. Latitude: 42.1 degrees.

6. Albedo: 20% (*"The albedo of an object is the extent to which it diffusely reflects light from the Sun. It is therefore a more specific form of the term reflectivity. Albedo is defined as the ratio of diffusely reflected to incident electromagnetic radiation."*). [15]
7. Power Park: 1200 kWp.
8. Distribution of modules on the ground (in planes or Chapter D).
9. Technology employed: Polycrystalline silicon (is better than amorphous silicon is cheaper but has less well).
10. Parameters and inverter module: (is described in the part of calculations, Chapter D, catalogues are included in the annex).
11. Production: 1240 kWh/kWp year (for 100kw).

This value is applied to the 12 mini-parks of 100kw each, thus:

The power of your park is 1.275,120 kWp (12 investors), so the production of the park is:

$$1.240 * 1.275,120 = 1581148.8 \text{ kWh years [13][14][9]}$$

12. Electricity tariff: The RD 1578/2008 said: 0,32 € / kWh .So, it enters the first announcement of this year.
13. The most common way to measure the cost, is kwh / currency, the relationship wp / currency, is also used very often.
14. Pay for the sale of energy:  $1.581.148,8 * 0,32 = 505.967,616$  € / year.
15. Investment: Suppose a cost of 5 € / Wp, (2.7 € / Wp panels, 0.3 € / Wp investor, 0,3 € / Wp structure, and 1, 7 € / Wp of civil engineering, electrical installation, resulting line project execution equipment, permits and licenses ...).
16. Project cost:  $€ 5 / Wp * 1.200.000Wp = 6.000.000$  €
17. Funding: With this project do an analysis of return (TIR of 12%, for example) and you go to the bank and give you (if everything is in order) to what is called project finance. You get 20% of that value and they give you 80%. The lyrics are paying with the energy it produces and sells...
18. Each year, due to the degradation of the plates, is a little less and therefore there are an annual cost of operation & maintenance, manager of last resort,



insurance (which takes a percentage of those 505.967,616 € / year) ... Taking all this as an approximation, the depreciation would be carried out in about 13 years ( $6.000.000/505.967,616 = 11,86$  years ---->  $11,86 + 1.14 = 13$  years (approximated valuation, by has been described earlier in this article), so we will have 7 years ( $25-13 = 7$  years) to earn money, as the installation will take about 20 years, that this is what said the new rules.( RD 1578/2008, annexes). According to manufacturers and industry experience, are 25 year of warranty for earn money

With Amorphous silicon will pay off soon, but the energy performance crystalline silicon materials are much higher. The efficiency of the crystalline silicon is 14% and 8% of amorphous silicon.

Zone I:  $H < 3,8$

Zone II:  $3,8 < H < 4,2$

Zone III:  $4,2 < H < 4,6$

Zone IV:  $4,6 < H < 5,0$

Zone V:  $H > 5,0$

H (Average daily radiation) in kWh/m<sup>2</sup>.

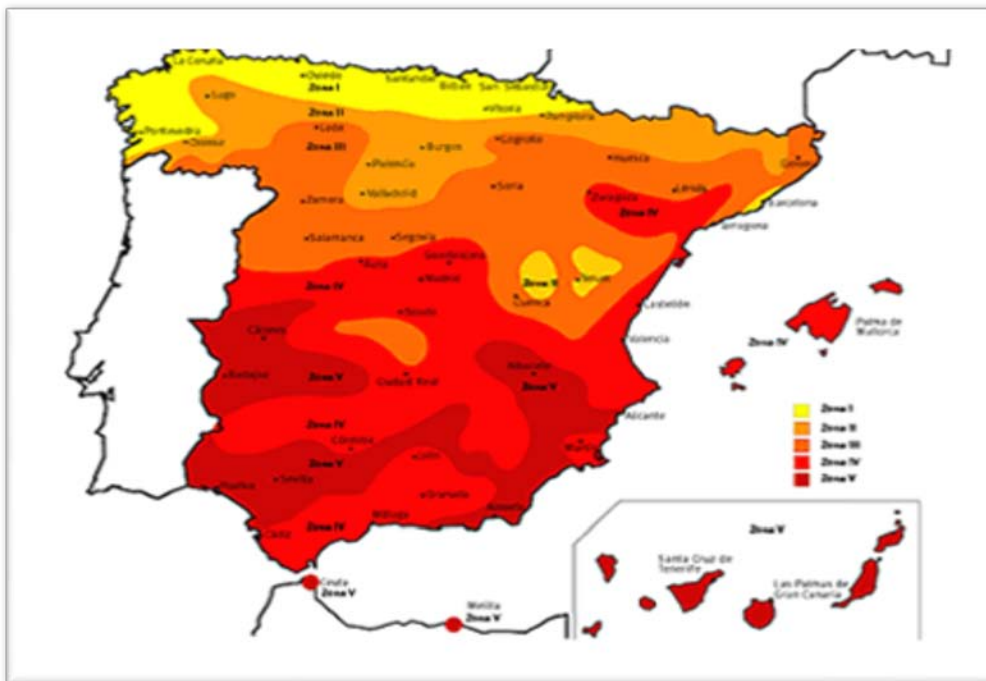


Figure 9: Irradiation daily average in Spain as climate zones. [22]

As seen on the map, the garden is located in zone 3, therefore the data obtained in my study (Table, Figure 13) are consistent with those of the INM (World Weather Information Service).

### **3.3. Calculations of the annual production of energy (with more detail) and financial analysis.**

This section presents the monthly and annual production of the theoretical maximum solar energy photovoltaic of the park, depending on irradiation, the peak power installed and the performance of the facility.

To determine the production is followed the method of calculating the technical specifications of the IDAE, based on estimates from various sources (ASIF, specialized publications, etc.) and taking the values of radiation at the site of the park and appearing in the database PVGIS (in standard conditions), which is updated constantly by the Joint Research Centre of the European Union.

The monthly and annual average value of daily radiation on the plane of the solar generator,  $G_{dm}(\alpha, \beta)$ , kWh / (m<sup>2</sup> day), being the azimuth  $\alpha$  and  $\beta$  inclination generated on horizontal, is obtained From the monthly and annual averages of daily radiation on a horizontal surface,  $G_{dm}(0)$ , kWh / (m<sup>2</sup> day), obtained in the PVGIS.

To calculate the energy efficiency of the installation or “*performance ratio*”, PR, is taken into account:

- The dependence of the efficiency with the temperature.
- The efficiency of the wiring.
- The losses by scattering parameter and dirt.
- The losses for errors in monitoring the point of maximum power.
- The energy efficiency of the investor.
- Others.

The “*performance ratio*” was estimated to install basic aim of this project is:

$$PR = 76.8\%$$

The estimate of energy injected to the grid is done according to the following equation:

$$E_p = [G_{dm}(\alpha, \beta) \cdot P_{mp} \cdot PR] / G_{CEM} \text{ en kWh/day}$$

Where:

- $G_{dm}(\alpha, \beta)$  = average value daily monthly and annual radiation on the plane of the solar generator in kWh / ( $m^2$  day).
- $P_{mp}$  = Power peak of solar generator.
- PR = .Energy efficiency of the installation or "performance ratio".
- $G_{CEM}$  = 1 kW/ $m^2$  at Standard Conditions of measure (The conditions standard measure irradiance are of 1000 W/ $m^2$ , a spectral distribution AM 1.5 and a temperature of the cells of 25 ° C).

Based on the above it is estimated that **the production of photovoltaic solar of the park is 1581148.8 kWh/year.**

$$1581148.8 \times 25 \text{ years} = \mathbf{39528720 \text{ kWh in total}}$$

Then:

$$39528720 \text{ kWh} \times 0.32 \text{ €/ kWh} = 12.649.190,4 \text{ € in total.}$$

Below, is included, the studies with the PVGIS both "Monthly radiation" (in which has been based the earlier study) and "PV Estimation" (less accurate).

Analysis of production

Similiar

It also includes financial analysis of the installation. It follows that the total cost of installation is paid in 12,2 years, as the park produce 505,968€/ year then:

$$505,968€ \times 12,2 \text{ years} = 6.172.809,6 €$$

Broadly, the project will be amortized in 12 years, and the park will generate revenue up to 25 years (that should diminish this value due the operation and maintenance). Included a graphic that indicates the total to 25 years (money accumulated 10 million Euros). Due to inflation and rates and costs are updated with time:

$$505,968€ / \text{year} \times 25 \text{ years} = 12,649,200 € \text{ (total earnings)}$$

The difference between the "total earnings" and accumulated earnings total is large, this is due to expenditure on operation and maintenance management and others.

In conclusion:

$$10.000.000 € \text{ (cumulative)} - 6.172.809,6 € = \mathbf{3.827.190,4 € \text{ (total earnings in 25 years "net")}.}$$

Figure 10: Production analysis of solar photovoltaic park.

and financial analysis. [10][16]



## Grid-Connected System: Simulation parameters

**Project :** **PFC CAL**

**Geographical Site** **Corella** **Country** **Spain**

**Situation** Latitude 42.1°N Longitude 1.7°W  
 Time defined as Legal Time Time zone UT+1 Altitude 300 m  
 Albedo 0.20

**Meteo data :** Corella , synthetic hourly data

**Simulation Variant :** **Simulation variant**

Simulation date 19/04/09 13h13

### Simulation parameters

**Collector Plane Orientation** Tilt 35° Azimuth 0°

**Horizon** Free Horizon

**Near Shadings** No Shadings

### PV Array Characteristics

**PV module** Si-poly Model **P220 / 6+ (230W)**  
 Manufacturer Solon AG

Number of PV modules In series 21 modules In parallel 22 strings  
 Total number of PV modules Nb. modules 462 Unit Nom. Power 230 Wp  
 Array global power Nominal (STC) **106 kWp** At operating cond. 96 kWp (50°C)  
 Array operating characteristics (50°C) U mpp 584 V I mpp 164 A  
 Total area Module area **759 m<sup>2</sup>**

### PV Array loss factors

Heat Loss Factor ko (const) 29.0 W/m<sup>2</sup>K kv (wind) 0.0 W/m<sup>2</sup>K / m/s  
 => Nominal Oper. Coll. Temp. (800 W/m<sup>2</sup>, Tamb=20°C, wind 1 m/s) NOCT 45 °C

Wiring Ohmic Loss Global array res. 115.1 mOhm Loss Fraction 3.0 % at STC  
 Serie Diode Loss Voltage Drop 0.7 V Loss Fraction 0.1 % at STC  
 Module Quality Loss Loss Fraction 3.0 %  
 Module Mismatch Losses Loss Fraction 2.0 % at MPP  
 Incidence effect, ASHRAE parametrization IAM = 1-bo (1/cos i - 1) bo Parameter 0.05

**System Parameter** System type **Grid-Connected System**

**Inverter** Model **Sunny Central 100KVA**  
 Manufacturer SMA

Inverter Characteristics Operating Voltage 450-820 V Unit Nom. Power 100 kW AC

**User's needs :** Unlimited load (grid)

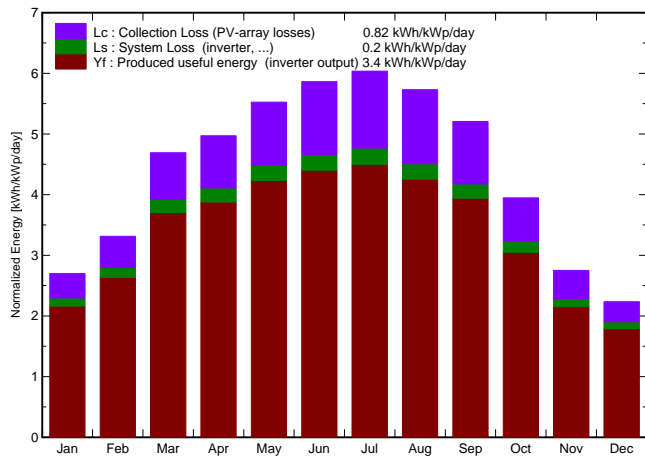
## Grid-Connected System: Main results

**Project :** PFC CAL  
**Simulation Variant :** Simulation variant

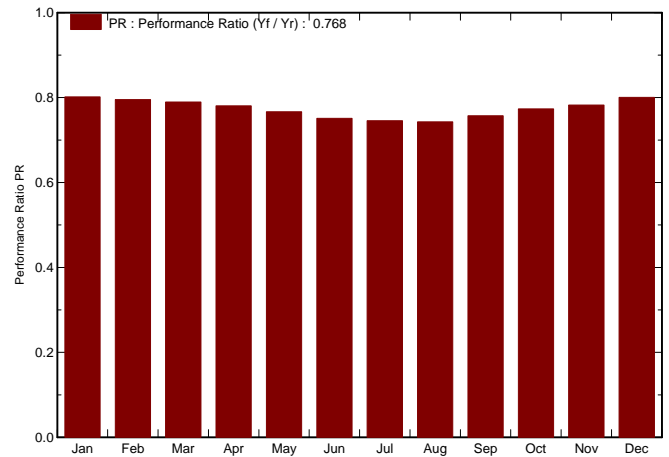
<b>Main system parameters</b>		<b>System type</b>	<b>Grid-Connected</b>	
PV Field Orientation		tilt	35°	azimuth 0°
PV modules		Model	P220 / 6+ (230W)	Pnom 230 Wp
PV Array		Nb. of modules	462	Pnom total <b>106 kWp</b>
Inverter		Model	Sunny Central 100KVA	Pnom 100 kW ac
User's needs		Unlimited load (grid)		

**Main simulation results**  
 System Production **Produced Energy 132 MWh/year** Specific 1240 kWh/kWp/year  
 Performance Ratio PR **76.8 %**

**Normalized productions (per installed kWp): Nominal power 106 kWp**



**Performance Ratio PR**



### Simulation variant Balances and main results

	<b>GlobHor</b> kWh/m <sup>2</sup>	<b>T Amb</b> °C	<b>GlobInc</b> kWh/m <sup>2</sup>	<b>GlobEff</b> kWh/m <sup>2</sup>	<b>EArray</b> kWh	<b>EOutInv</b> kWh	<b>EffArrR</b> %	<b>EffSysR</b> %
<b>January</b>	52.1	7.50	83.7	81.3	7572	7130	11.92	11.22
<b>February</b>	67.5	8.60	92.8	90.2	8325	7841	11.81	11.13
<b>March</b>	119.7	12.30	145.4	141.1	12920	12199	11.70	11.05
<b>April</b>	139.8	13.90	149.1	144.6	13105	12362	11.58	10.92
<b>May</b>	177.9	18.00	171.2	165.6	14780	13947	11.37	10.73
<b>June</b>	190.8	22.40	175.9	169.9	14868	14038	11.13	10.51
<b>July</b>	198.4	24.20	187.2	181.1	15701	14825	11.05	10.43
<b>August</b>	174.2	24.20	177.6	172.1	14850	14017	11.01	10.40
<b>September</b>	134.4	20.90	156.2	151.5	13310	12564	11.23	10.60
<b>October</b>	93.0	17.20	122.3	118.9	10654	10049	11.47	10.82
<b>November</b>	56.7	10.90	82.5	80.1	7298	6863	11.65	10.95
<b>December</b>	44.3	7.50	69.3	67.3	6273	5896	11.92	11.20
<b>Year</b>	1448.8	15.68	1613.2	1563.7	139655	131731	11.40	10.76

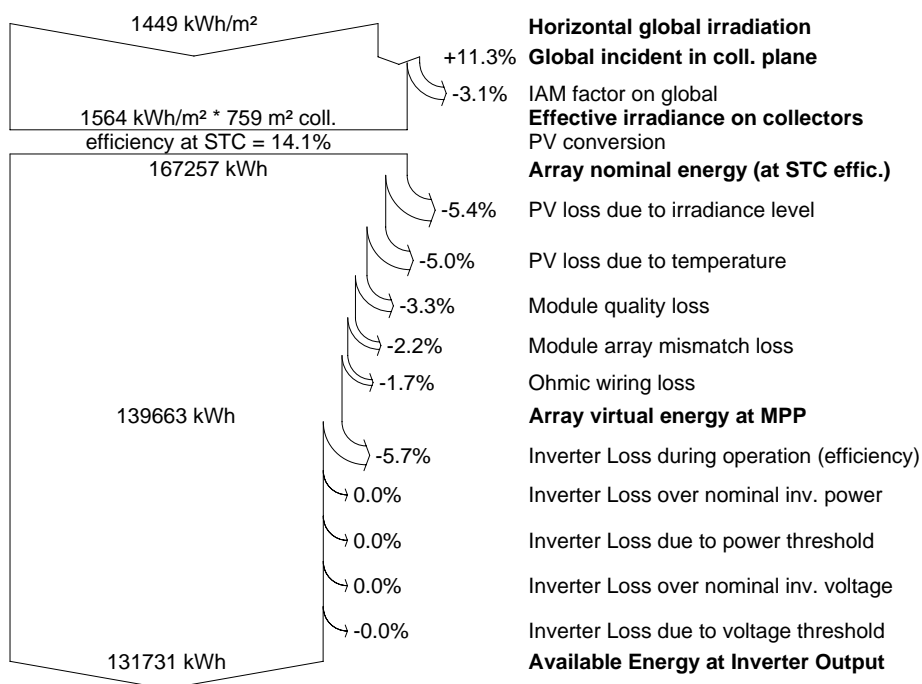
Legends:	GlobHor	Horizontal global irradiation	EArray	Effective energy at the output of the array
	T Amb	Ambient Temperature	EOutInv	Available Energy at Inverter Output
	GlobInc	Global incident in coll. plane	EffArrR	Effic. Eout array / rough area
	GlobEff	Effective Global, corr. for IAM and shadings	EffSysR	Effic. Eout system / rough area

## Grid-Connected System: Loss diagram

**Project :** PFC CAL  
**Simulation Variant :** Simulation variant

<b>Main system parameters</b>	System type	<b>Grid-Connected</b>	
PV Field Orientation	tilt	35°	azimuth 0°
PV modules	Model	P220 / 6+ (230W)	Pnom 230 Wp
PV Array	Nb. of modules	462	Pnom total <b>106 kWp</b>
Inverter	Model	Sunny Central 100KVA	Pnom 100 kW ac
User's needs	Unlimited load (grid)		

### Loss diagram over the whole year



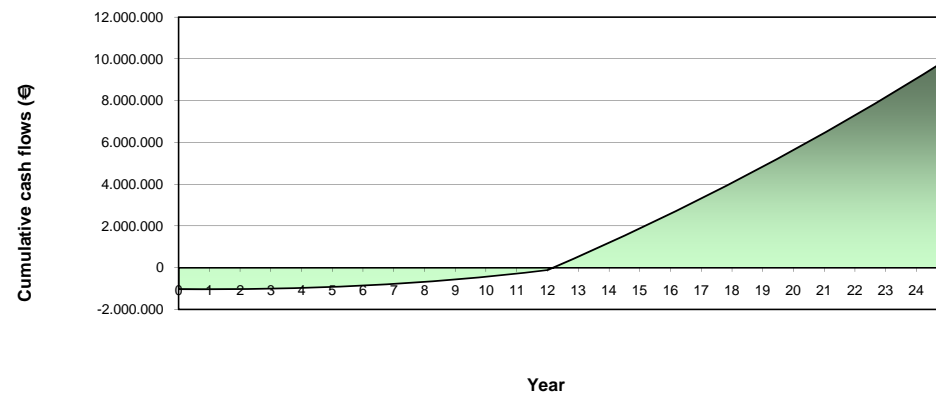
Proposed case power system			Incremental initial costs
Technology	Photovoltaic		
Analysis type	<input checked="" type="radio"/> Method 1 <input type="radio"/> Method 2		
<b>Photovoltaic</b>			
Power capacity	kW	1.275,12	<input type="text" value=""/>
Manufacturer	Solon		<input type="text" value=""/>
Model	P 220 / 6+ (230W)		<input type="text" value=""/>
Capacity factor	%	14,2%	<input type="text" value=""/>
Electricity exported to grid	MWh	1.581,1	
Electricity export rate	€/MWh	320,00	

[See product database](#)

Emission Analysis

Financial Analysis			
<b>Financial parameters</b>			
Inflation rate	%	<input type="text" value="3,0%"/>	
Project life	yr	<input type="text" value="25"/>	
Debt ratio	%	<input type="text" value="80%"/>	
Debt interest rate	%	<input type="text" value="5,00%"/>	
Debt term	yr	<input type="text" value="12"/>	
<b>Initial costs</b>			
Power system	€	<input type="text" value="0"/>	0,0%
Other	€	<input type="text" value="5.100.480"/>	100,0%
<b>Total initial costs</b>	€	5.100.480	100,0%
<b>Incentives and grants</b>			
	€	<input type="text" value=""/>	0,0%
<b>Annual costs and debt payments</b>			
O&M (savings) costs	€	<input type="text" value="65.776"/>	
Fuel cost - proposed case	€	<input type="text" value="0"/>	
Debt payments - 12 yrs	€	<input type="text" value="460.371"/>	
<b>Total annual costs</b>	€	526.147	
<b>Annual savings and income</b>			
Fuel cost - base case	€	<input type="text" value="0"/>	
Electricity export income	€	<input type="text" value="505.968"/>	
<b>Total annual savings and income</b>	€	505.968	
<b>Financial viability</b>			
Pre-tax IRR - equity	%	<input type="text" value="15,2%"/>	
Pre-tax IRR - assets	%	<input type="text" value="4,3%"/>	
Simple payback	yr	<input type="text" value="11,6"/>	
Equity payback	yr	<input type="text" value="12,2"/>	

Cumulative cash flows graph





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# – Chapter 4 –

## CALCULATIONS

## **4. CHAPTER 4: CALCULATIONS**

### **4.1. Introduction**

First, it is necessary to know the technical characteristics of the selected items for the installation, type of panel used, type of investor, processing centres, wiring, protection, the tubes, structure used, configuration and distance between strings of panels in order to avoid losses by shading, distribution and other characteristics to properly locate all the items and equipment needed in the field.

### **4.2. Photovoltaic solar panel**

The panel used is the mark of Solon P220 / 6+: This panel is composed of 60 cells in series.

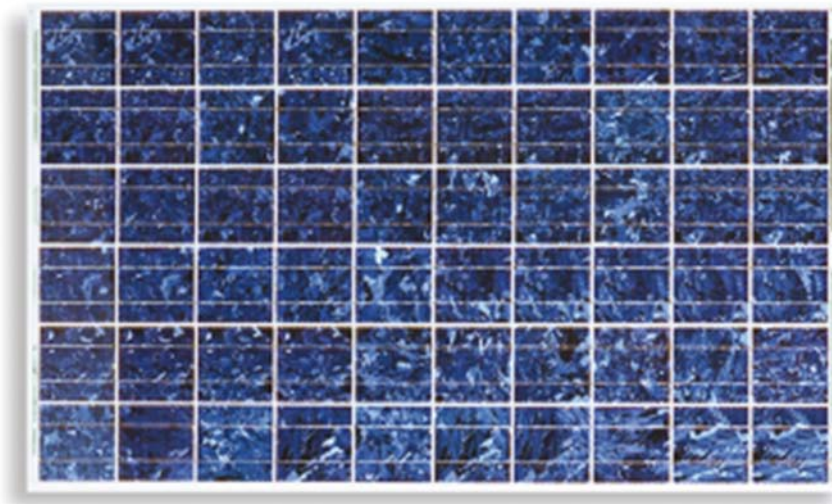


Figure 11: Panel selected. [23]

Calculations module:

Tecnical data of the photovoltaic module*			
Name	Symbol	Unit	Value
Voltage MPP	$U_{MPP}$	V	29,1
Current MPP	$I_{MPP}$	A	7,91
Power MPP	$P_{MPP}$	W	230
Open circuit voltage	$U_{OC}$	V	36,7
Cortocircuit current	$I_{SC}$	A	8,52
Maximum system voltage DC	$U_{CCMAX}$	V	860
Coefficients/temperature			
Coefficient of voltage	$T_K(U_{OC})$	mV/°C	-127,575
Coefficient of current	$T_K(I_{SC})$	mA/°C	4,125
Coefficient of power	$T_K(P_{MPP})$	mW/°C o %/°C	-0,44

\*In standard conditions

Site			
Extreme temperature extrem.max.	$T_{AMB MAX}$	°C	70
Extreme temperature.min.	$T_{AMB MIN}$	°C	-10

Extrem behavior module			
Open circuit voltage (-10°C)	$U_{OC(-10°C)}$	V	40,9
Voltage MPP (-10°C)	$U_{MPP(10°C)}$	V	33,4
Voltage MPP (70°C)	$U_{MPP(70°C)}$	V	23,2
Current max. (70°C)	$I_{MPP(70°C)}$	A	8,44

Summary extreme behavior module			
Max. Voltage module	$U_{MAX}$	V	40,9
Min. Voltage module	$U_{MIN}$	V	23,2
Max. Number to the modules in the system	$N_{MAX}$	n	21

Figure 12: Features of photovoltaic module. [Own elaboration]

**The max. Number the modules in the system = max. System voltage DC/max. Voltage module =  $860/40.9 = 21$  (rounding). (1 String→21 Panels in series).**

### 3. Inverter

The inverter used is of the mark Sunny Central, and the model is SC 100:



Figure 13: Inverter selected. [24]

The inverter that is used IS the Sunny Central, and the model is SC 100.

Calculations inverter:

Technical data of the PV inverter			
Name	Symbol	Unit	Value
Maximum power PV	$P_{FVMAX}$	kW	110,00
Nominal power CC	$P_{CCNOM}$	kW	100,00
Limit superior voltage MPP	$U_{FVINFIN}$	V	450
Limit inferior voltage MPP	$U_{FVSUP}$	V	820
Tension maximum CC Admissible	$U_{CCMAX}$	V	900
Nominal intensity	$I_{CCNOM}$	A	157,48
(Nominal intensity per circuit cc)	$I_{CCNOMString}$	A	0,00
Maximum intensity CC admissible	$I_{CCMAX}$	A	235,00
(Maximum intensity per circuit cc)	$I_{CCMAXString}$	A	0,00

Number of modules in series (per string)			
Maximum number of modules	$n^{\circ}_{(MFV\ máx)}$	n	20,0
Minimum number of modules	$n^{\circ}_{(MFV\ min)}$	n	19,4

Determination of the allowable voltage inverter			
Maximum number of modules per investor	$n^{\circ}_{(MFV/INV)}$	n	499
Maximum number of modules in series	$n^{\circ}_{(MFV/STRING)}$	n	20

Final recommendation			
Strings (modules in serie)	$n^{\circ}_{(MFV/STRING)}$	n	21
Number of strings (strings in parallel)	$n^{\circ}_{(STRING/INV)}$	n	22

Final configuration			
Strings (modules in serie)	$n^{\circ}_{(MFV/STRING)}$	n	21
Number of strings (strings in parallel)	$n^{\circ}_{(STRING/INV)}$	n	22
Number of modules per inverter	$n^{\circ}_{(MFV/INV)}$	n	462
Peak power per inverter	$P_{FVINV}$	kWp	106,37
Relation Wp/We	Wp/We	%	6,4%

Installation requirements (modules and inverter)			
Voltage limit inferior	$U_{MPP(a+70^{\circ}C)} > U_{FVINFERIOR}$		486,3
Voltage limit superior	$U_{MPP(a10^{\circ}C)} < U_{FVSUPERIOR}$		700,7
Voltage limit admissible	$U_{OC(a-10^{\circ}C)} < U_{CCMAX}$		859,2
Intensity limit superior	$I_{MFVMAX} < I_{CCMAX}$		189,8

Figure 14: Features of investor. [Own elaboration]

## 4.4. Processing centre

The processing centre used is of the mark Ormazabal:



Figure 15: Processing centre, Ormazabal. [25]

Technical data of the processing center		
Name	Unit	Value
Cells of MT, with integral isolation in gas SF6	KV	until 24
Transformer LT/MT	KVA	100,00
Square LT, with switch in charge and fuses	A	160 and 250

Physical characteristics		
Length	mm	4460,0
Width	mm	2380,0
Height	mm	2585
Weight (empty)	Kg	12000

\*Possibility to place inside the inverter

Figure 16: Feature of processing centre. [Own elaboration]

In conclusion, 21 panels will be connected in series forming a string and 22 strings of panels will be connected in parallel, giving a total of 462 panels with a total power of 100kW. So there will be an inverter of 100kW for each group of 462 panels, connected with a investor of 100Kw and a centre of processing connected with the investor, which contains a transformer of 100kw.

## 4.5. Wiring

For the calculation of the drivers section it will be born in mind:

- Regulation Electro -Technique of Low Tension, Technical Instructions
- Norms IT UNE of reference
- The temperature of service of the cable
- Maximum intensity of the cable as the nature of the isolation
- The voltage drop
- The nature of the cable (copper or aluminium)
- Short circuit intensity
- Inductance of the cables
- Correction factors for cables groups, under pipe, etc

Two criteria will be applied for the sizing of the wiring:

### **The voltage drop criterion**

It is very important to minimize everything possible the length of the cable to be used, trying for it that the distances between the panels and the investor are the minors possible.

The section of the cables must be chosen so that the maximum sags between the origin and the end of the trip are below the following limits:

- The voltage drop of the drivers in the part of low CC of 1,5 %.
- The voltage drop of the drivers in the part of low CA of 3 %.

Next the formulae appear for the supply in direct current:

Normally the sag expresses as well as per cent of the tension to itself in terminals of the load:

$$v = (AV / VB) \times 100$$

Where

$v = \text{sag in the line in \%}$

$AV = \text{absolute sag (V)}$

$V_B = \text{tension in terminals of the load (V)}$

The calculation of the section of the line can be obtained from the voltage drop of the line:

$$AV = R_L = l = \rho \times ((2 \times L) / S) \times I$$

$$S \geq \rho \times ((2 \times L) / S) \times (I/AV)$$

Where:

$S = \text{section of the driver of line (mm}^2\text{)}$

$\rho = \text{resistivity of the driver } (\omega \cdot \text{mm}^2/\text{m})$

$L = \text{length of the line (m)}$

$I = \text{intensity (A)}$

$AV = \text{the voltage drop of the line (V)}$

And next the formulas appear for the supply three-phase in alternate:

The voltage drop of the line between phases is  $\sqrt{3}$  times the voltage drop for phase:

$$AV = 3 \times R_1 \times I \times \cos \phi$$

Where:

$\Delta V = \text{compound the voltage drop (V)}$

$R_1 = \text{resistance of a phase of line } (\Omega)$

$I = \text{effective current that every driver covers (A)}$

$\cos \phi = \text{f.d.p. of the recipients (will be considered } \cos \phi = 0,9)$



In turn, the section of the driver is deduced from the resistance of the driver:

$$RL = \rho \times L / S$$

On her having substituted in the previous expression, it will give the value of the section:

$$S = \sqrt{3 \times \rho \times I \times L \times \cos \phi / AV} = \rho \times I \times PA / (AV \times VB)$$

The formula used for the calculation of the temperature of the cable is:

$$T = T_o + (T_{max} - T_o) * (I / I_{max})^2$$

Where:

*T*: Real temperature estimated in the driver.

*T<sub>o</sub>*: Temperature ambience of the driver.

*T<sub>max</sub>*: Admissible maximum temperature for the driver as his guy of insulation.

*I*: Intensity foreseen for the driver.

*I<sub>max</sub>*: Admissible maximum intensity for the driver as the guy of installation.

The formula used for the calculation of the conductivity of the cable is:

$$\gamma_{\theta} = 1 / [(1 / \gamma_{20}) \times (1 + \alpha \times (\theta - 20))]$$

Being:

$\alpha$  = conductivity to the work temperature

$\gamma_{20}$  = conductivity to the temperature of 20°C

$\gamma_{\theta}$  = coefficient of change of resistance specifies for temperature of driver in °C-1, with a value for the copper of 0,00392 °C-1.

<b>Material</b>	<b><math>\gamma_{20}</math></b>	<b><math>\gamma_{70}</math></b>	<b><math>\gamma_{90}</math></b>
<b>Cooper</b>	56	48	44
<b>Aluminium</b>	35	30	28
<b>Temperature</b>	<b>20°C</b>	<b>70°C</b>	<b>90°C</b>

Figure 17: Conductivity for the copper and aluminium to different temperatures. [11]

- For the calculation of the admissible maximum intensity ( $I_{max}$ ) they have been applied a few correction factors according to the arranged for the REBT. These factors and intensities are those who appear in the following norms:
  - Norm UNE 20435 for admissible maximum intensity in cables of installation to the air.
  - Table 5 of ITC-BT 07 for admissible maximum intensity in cables buried.

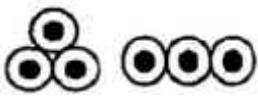
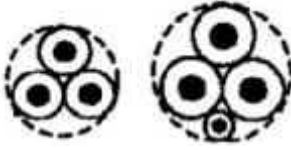
Nominal section mm <sup>2</sup>	Group of three wire single-pole (1)(2)			1 cable formed for three poles or four (3)		
						
	Type of insulation					
	XLPE	EPR	PVC	XLPE	EPR	PVC
6	72	70	63	66	64	56
10	96	94	85	88	85	75
16	125	120	110	115	110	97
25	160	155	140	150	140	125
35	190	185	170	180	175	150
50	230	225	200	215	205	180
70	280	270	245	260	250	220
95	325	325	290	310	305	265
120	380	372	335	355	350	305
150	425	415	370	400	390	340
185	480	470	420	450	440	385
240	550	540	485	520	505	445
300	620	610	550	590	565	505
400	705	690	615	665	645	570
500	790	775	685	-	-	-
630	885	870	770	-	-	-

Figure 18: Admissible maximum intensity, in amperes, for cables with copper drivers in installation buried (permanent service). [11]

Type of insulation

XLPE - reticulated Polyethene - maximum Temperature in the driver 90°C (permanent service).

EPR - propileno Ethylene - maximum Temperature in the driver 90°C (permanent service).

PVC - Polcloruro of vinyl - maximum Temperature in the driver 70°C (permanent service).

Temperature of the area 25°C.

Installation depth 0,70 m.

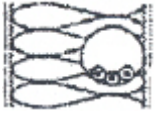
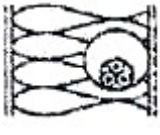





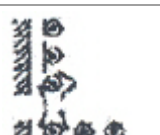
Thermal Resistivity of the area 1 Km/W

(1) The neutral driver includes, if it exists.

(2) For the case of two cables single-pole, the admissible maximum intensity will be the correspondent to the column of the three of cables single-pole of the same section and type of isolation, multiplied by 1,225.

(3) For the case of a bipolar cable, the admissible maximum intensity will be the correspondent to the column of the cable three-pole or four-poles of the same section and type of isolation, multiplied 1,225.

➤ Table 1 of ITC-BT 19 for admissible maximum intensity in cables of interior facilities

A		Conductors in insulated pipes embedded in walls insulation		3x PVC	2x PVC		3x XLPE o EPR	2x XLPE o EPR					
A2		Multicore cables in pipes embedded in walls insulation	3x PVC	2x PVC		3x XLPE o EPR	2x XLPE o EPR						
B		Conductors in insulated pipes embedded in surface or mount work				3x PVC	2x PVC			3x XLPE o EPR	2x XLPE o EPR		
B2		Multicore cables in tubes and embedded in the surfaces mount work			3x PVC	2x PVC		3x XLPE o EPR		2x XLPE o EPR			
C		Multicore cable directly on the wall.					3x PVC	2x PVC		3x XLPE o EPR	2x XLPE o EPR		
E		Multicore cables outdoor. Distance to the wall not less than 0,3D						3x PVC		2x PVC	3x XLPE o EPR	2x XLPE o EPR	
F		Cables single-pole in mutual contact. Distance to the wall not less than D.							3x PVC			3x XLPE o EPR	
G		Cables single-pole separated min. D.									3x PVC		3x XLPE o EPR

	mm <sup>2</sup>	1	2	3	4	5	6	7	8	9	10	11
<b>Cooper</b>	1,5	11	11,5	13	13,5	15	16	-	18	21	24	-
	2,5	15	16	17,5	18,5	21	22	-	25	29	33	-
	4	20	21	23	24	27	30	-	34	38	45	-
	6	25	27	30	32	36	37	-	44	49	57	-
	10	34	37	40	44	50	52	-	60	68	76	-
	16	45	49	54	59	66	70	-	80	91	105	-
	25	59	64	70	77	84	88	96	106	116	123	166
	35		77	86	96	104	110	119	131	144	154	205
	50		94	103	117	125	133	145	159	175	188	250
	70				149	160	171	188	202	224	244	321
	95				180	194	207	230	245	271	296	391
	120				208	225	240	267	284	314	348	455
	150				236	260	278	310	338	363	404	525
	185				268	297	317	354	386	415	464	601
	240				315	350	374	419	455	490	552	711
300				360	404	423	484	524	565	640	821	

Figure 19: Admissible intensities (A) to the air 40 ° C. Drivers' N<sup>o</sup> with load and nature of the insulation. [11]

1. From 25 mm<sup>2</sup> of section.
2. Including channels for facilities-grilles - and section conduits not to circulate.
3. Or in not perforated salver.
4. Or in perforated salver.
5. D is the diameter of the cable.

- Table 6 of ITC-BT 06 for correction factor in air cables.

<b>Number of cables</b>	<b>1</b>	<b>2</b>	<b>3</b>	<b>More than 3</b>
<b>Factor correction</b>	1,00	0,89	0,80	0,75

Figure 20: Factors of correction of the admissible maximum intensity in case of group of cables isolated in bundle, installed to the air. [11]

- Table 8 of ITC-BT 07 for correction factor in buried cables

<b>Factor of correction</b>									
<b>Separation between cables</b>	<b>Number of the cables in the ditch</b>								
	<b>2</b>	<b>3</b>	<b>4</b>	<b>5</b>	<b>6</b>	<b>8</b>	<b>10</b>	<b>12</b>	
<b>D=0 (contact)</b>	0,80	0,70	0,64	0,60	0,56	0,53	0,50	0,47	
<b>d= 0,07 m</b>	0,85	0,75	0,68	0,64	0,6	0,56	0,53	0,50	
<b>d= 0,10 m</b>	0,85	0,76	0,69	0,65	0,62	0,58	0,55	0,53	
<b>d= 0,15 m</b>	0,87	0,77	0,72	0,68	0,66	0,62	0,59	0,57	
<b>d= 0,20 m</b>	0,88	0,79	0,74	0,70	0,68	0,64	0,62	0,60	
<b>d= 0,25 m</b>	0,89	0,80	0,76	0,72	0,70	0,66	0,64	0,62	

Figure 21: Correction factor for groups of three-phases cables or trios of cables single-pole. [11]

- Article 5 of ITC-40 for that the cables of the alternate part dimension and for intensity not lower than 125 % of the maxim intensity of the generator.

#### **Thermal criterion:**

There will be verified the admissible maximum intensity of the elected cable, comparing it with the existing one in the circuit. If the existing one is minor than the admissible maxim the elected cable is valid. The norms will be applied previous for the calculation of the admissible maximum intensity.

Applying both criteria we obtain the following results:

The cables that will be used in this installation are with dielectric insulation dry, type RV-K, of the following general characteristics:

Cable type	RETENAX FLEX RV-K
Driver	Cooper
Sections	1.5-400mm <sup>2</sup>
Rated voltage	0.6/1KV – 12/20KV
Insulation	Polietileno reticulated (XLPE)
Cover	Policloruro of vinilo (PVC)

Figure 22: Cables used in the installation. [Own elabotation]

The CC lines will belong to two drivers, one of phase and other of neutral. The lines of CA they will belong to four drivers, three of phase and one for neutral in all the stretches except in the one that joins the exit of the transformer with the protection picture and hook up in CA, with three phase drivers, neutral isolated and masses connected to landing independent from the network of feeding (TT).

Lines	L(m)
Wiring modules	2,5
String- Junction box	27
Junction box -Investor	3
Investor-Transformer	2
Transformer – Drop wire	350

Figure 23: Length of lines of the installation. [Own elaboration]

❖ Design of the connection of the panels of the string:

First an estimation of the section is going to be realized by means of the limitation of sag to 1.5 %:

$$S \geq 2 \times \rho \times L \times I / AU = 2 \times 0.00175 \times 2.5 \times 7.62 / 1.5 \% \times 28.9 = 0.153 \text{ mm}^2$$

For a normalized section of  $6 \text{ mm}^2$  the admissible maximum current is of 46 A, that is more than sufficient, since the nominal current of every panel is of 7.62 A.

Then, the used driver is:

$$\text{RV-K 0.6/1KV } 1 \times 6 \text{ mm}^2 \text{ (Cu)}$$

❖ Design of the connection of the string to the connections box:

First an estimation of the section is going to be realized by means of the limitation of sag to 1.5 %:

$$U_{\text{string}} = 21 \text{ panels} \times 29.1 = 611.1 \text{ V}$$

$$S \geq 2 \times \rho \times L \times I / AU = 2 \times 0.00175 \times 27 \times 7.91 / 1.5 \% \times 611.1 = 0.0815 \text{ mm}^2$$

For a normalized section of  $6 \text{ mm}^2$  the admissible maximum current is of 46 A, that is more than sufficient, since the nominal current of every panel is of 7.91 A.

Then, the used driver is:

$$\text{RV-K 0.6/1KV } 2 \times 6 \text{ mm}^2 \text{ (Cu)}$$



❖ Design of the connection of the box of connections to the investor:

First an estimation of the section is going to be realized by means of the limitation of sag 1.5 %:

$$S \geq 2 \times \rho \times L \times I / AU = 2 \times 0.00175 \times 3 \times (22 \text{ (strings)} \times 7.91) / 1.5 \% \times 611.1 = 0.199 \text{mm}^2$$

For a normalized section of  $95 \text{mm}^2$  the admissible maximum current is of 260A, that is more than sufficient, since the entire current is of 174.02 A. Then, used driver is:

$$\text{RV-K 0.6/1KV } 2 \times 95 \text{mm}^2 \text{ (Cu)}$$

❖ Design of the connection of the investor to the transformer:

First an estimation of the section is going to be realized by means of the limitation of sag to 2 %:

$$S \geq 2 \times \rho \times L \times I / AU = 2 \times 0.00175 \times 2 \times (22 \text{ (strings)} \times 7.91) / 2 \% \times 611.1 = 0.099 \text{mm}^2$$

At first it can seem that in spite of using the driver of the previous part is sufficient as for the admissible current, but it is necessary to bear in mind that investor can provide a maximum current of 145 A, with what the section normalized necessary it is of  $240 \text{mm}^2$  since his admissible maximum current is of 430 A. This way, the used driver will be:

$$\text{RV-K 0.6/1KV } 3 \times 240 + 1 \times 120 \text{ mm}^2 + \text{TT (Cu)}$$

❖ Design of the connection transformer – drop wire:

The first thing is to calculate the intensity that is going to support the cable, with the following one expression:

$$P_{\text{tot}} = 21 \text{ panels} \times 22 \text{ strings} \times 230 \text{W} = 106260 \text{W}$$

$$I = P_{\text{tot}} / \sqrt{3} \times U_n \times \cos \phi = 106260 / \sqrt{3} \times 20000 \times 0.9 = 3.408 \text{ A}$$

Next there appears a table extracted from the RBT, which shows the intensity admissible maxim, in amperes, in permanent service and in alternating current, of cables with drivers with dry isolation (HEPR):

Rated voltage $U_0/U$ kV	Nominal section of the conductors $mm^2$	Intensity
		3 Single pole
12/20	150	330
	240	435
	400	560
18/30	150	330
	240	435
	400	560

Figure 24: intensity admissible maxim, in amperes, in permanent service and in alternating current, of cables with drivers with dry isolation. [11]

Then, at first the most suitable section is 150  $mm^2$ .

Now it is necessary to verify if this one section is valid before short circuit. It will suppose for such an end that the potency of short circuit that provides the network is of 500MVA during a second, since he does not get ready of this fact on the part of company. This way, the following current of short circuit is obtained:

$$I_{cc} = S_{cc} / \sqrt{3} \times U_n = 500 \times 10^6 / \sqrt{3} \times 20000 = 14433 \text{ A}$$

Next there appears a table extracted from the RBT in which they appear admissible currents of short circuit for a certain tension and for one certain duration:

Insulation	Tension kV	Section mm <sup>2</sup>	Short-circuit duration t in s								
			0,1	0,2	0,3	0,5	1,0	1,5	2,0	2,5	3,0
PR	12/20	150	44,7	31,9	25,8	19,9	14,1	11,5	9,9	8,8	8,1
	18/30	240	71,5	51,1	41,2	31,9	22,5	18,4	15,8	14,1	12,9
		400	119,2	85,2	68,8	53,2	37,61	30,8	26,4	23,6	21,6

Figure 25: Appear admissible currents of short circuit for a certain tension and for one certain duration. [11]

For a value of  $I_{cc}$  superior to 14.4 KA during 1 second, the suitable section is of 240  $mm^2$  (for  $U_n=15KV$ ). Then the driver will be:

$$RVK\ 12/20KV\ 3x240 + 1x120\ mm^2\ (Cu)$$

The cables that have been chosen are formed by flexible drivers of Cu, class 5 isolated with polyethene reticulated (XLPE) and covering of polychloride of vinyl (PVC), made with the Norm IT UNE 21123 (IEC-502).

LINES	DESIGNATION
Wiring modules	RV-K 0,6/1kV 1 x 6
String- Junction box	RV-K 0,6/1kV 2 x 6
Junction box-Investor	RV-K 0,6/1kV 2 x 95
Investor-Transformer	RV-K 0,6/1KV 3x240 + 1x120 +
Transformer-Drop wire	RV-K 0,6/1KV 3x240 + 1x120

Figure 26: Identification of the cables. [Own elaboration]

R: XLPE isolation (polyethene reticulated).

V: covering of PVC (polychloride of vinyl).

K: Flexible driver (class 5) for fixed service.

0,6kV: effective value of the tension between driver and ground (simple tension).

1kV: effective value of the tension between drivers (compound tension).

Number of drivers x nominal section.

From this election, it is necessary to determine the perm or of warming and the short circuit intensity.

The intensity in permanent diet, current density, produces warming. Therefore, the admissible maximum intensity in permanent service it depends in every case of the maximum temperature that the isolation could support without altering his electrical, mechanical or chemical properties. The table that appears next presents the admissible maximum temperature according to the type of isolation and of the load diet.

In this case for XLPE insulation and in permanent load diet maximum temperature is of 90°C.

Type of insulation dry	Tmax In permanent service	Tmax In short-circuit $t \leq 5s$
XLPE	90°C	250°C

Figure 27: Cables isolated with dry isolation; maximum temperature, in °C, assigned to the driver. [26][11]

As in the intensity in permanent diet, the short circuit intensity it provokes a warming in the drivers, and although the duration of the absence is short, the temperature reached by the drivers can be very high.

In the table that appears next the current thickness is indicated of short circuit admissible for the drivers of copper and isolation of XLPE, used it is this installation

	DURATION OF THE SHORT-CIRCUIT IN SECONDS					
	0.1	0.2	0.3	0.5	1.0	1.5
XLPE AND EPR	449	318	259	201	142	116

Figure 28: Short circuit current density, in A/mm<sup>2</sup>, for copper drivers. [11]

## 4.6. Pipes and protective canalizations

The interior surface of the pipes will not have to present in any point edges, roughness's or fissures capable of damaging the drivers or isolated cables or of causing wounds to fitters or users.

The dimensions of the not buried pipes and with union threaded used in electrical facilities are those who are prescribed in IT UNE IN 60.423.

The denomination will be realized according to the outside diameter.

The minimal internal diameter will have to be declared by the manufacturer.

In the relative thing to the resistance to the effects of the fire, the established will follow for the norms.

### ❖ Pipes in fixed canalizations in surface

In the superficial canalizations, the pipes will have to be preferably rigid and in special cases curved pipes will be able to be used.

His minimal characteristics will be indicated in the following table. (Table 1, ITC-BT-21).

CHARACTERISTIC	GRADE
Compressive strength	Strong
Impact resistance	Half
Minimum temperature of installation and service	-5°C
Maximum temperature of installation and service	+60°C
Bending resistance	Rigid
Electrical properties	Electrical continuity/insulation
Resistance of penetration by solid objects	Versus objects $D > 1\text{mm}$
Resistance to the loads suspended	--

Water penetration resistance	Against vertically falling water drops when the tube system is inclined 15°
Resistance to corrosion of pipes and metal compounds	Protect internal and external half
Resistance to flame propagation	Not propagated

Figure 29: Minimal characteristics for pipes in fixed ordinary superficial canalizations.

[11]

In the second table that appears next, they represent the minimal outside diameters of the pipes according to the number and the section of the drivers or cables to be led, in each of the stretches of the installation. According to table 2, ITC-BT-21.

Nominal section of the conductors single-pole (mm <sup>2</sup> )	Exterior diameter of the tubes				
	Number of conductors				
	1	2	3	4	5
1,5	12	12	16	16	16
2,5	12	12	16	16	20
4	12	16	20	20	20
6	12	16	20	20	25
10	16	20	25	32	32
16	16	25	32	32	32
25	20	32	32	40	40
35	25	32	40	40	50
50	25	40	50	50	50
70	32	40	50	63	63
95	32	50	63	63	75
120	40	50	63	75	75
150	40	63	75	75	--
185	50	63	75	--	--
240	50	75	--	--	--

Figure 30: Minimal outside diameters of the pipes according to the number and the section of the drivers or cables to be led. [11]

LINES	Snominal ( $mm^2$ )	Minimum outside diameter of the tubes
Wiring module	1x6	12
String-Junction box	2x6	16
Junction box-Investor	2x95	50
Investor-Transformer	3x240+ 1x25 + TT	150
Transformer- Drop wire	3x240 + 1x25	240

Figure 31: Minimal outside diameter of the pipes according to the number and the section of the drivers. [Own elaboration]

## 4.7. Protections

It will be provided to the electrical installation of a series of protections that make her sure. Safe for the drivers and devices and for the persons.

### Overload

Surcharge is the intensity excess in a circuit, a defect of isolation, a breakdown or an excessive demand of load.

The principal effect of a surcharge is the warming of the drivers to not admissible temperatures, provoking the deterioration of the same ones and of his insulators, and reducing his useful life.

The final target of protection from surcharges is to allow those that correspond to a normal service, but disconnecting them with advance so that not the time of admissible surcharge is exceeded.

The protection device will be able to be or a court circuit all-pole thermal-magnetic (circuit) breaker with thermal court curve, or a fusible short-circuit (ITC-BT-22). The last one is chosen in this case.

The characteristics of the team of protection from surcharge it will have to expire with the following two conditions:

$$I_{sc} \leq I_n \leq I_{ca}$$

$$I_{cd} \leq 1.45 \times I_{ca}$$

Where:

$I_{sc}$ : Intensity of dimensioning of the circuit.

$I_n$ : Nominal intensity of the circuit breaker.

$I_{ca}$ : Intensity of admissible load of the cable.

$I_{cd}$ : Disconnection intensity.

### Short circuits:

Short circuit is the union of two or more parts of an electrical circuit, with one potential difference between across small impedance. The origin occurs rarely to be in an incorrect connection or in a defect of isolation.

The team of protection from short circuits will have to expire with the following one condition:

1. The step energy (shot intensity for short circuit to the square in the clearing time) he will have to be a minor that the  $I_{cu}$  (maximum intensity of short circuit supported by the cable).

$$I^2 \times t \leq I_{cu}$$

2. The capacity of court of the switch or of the fuse (power of court  $I_{cc}$ ) it will have to be major than the maximum short circuit Intensity in the place where install the protection to him.

$$I_{cu} = K^2 \times S^2$$

Where:

$I_{cu}$ : Power of court, maximum capacity of short circuit.

$k$ : Value of correction of the material (115 for Cu drivers).

$S$ : Section of the driver in  $mm^2$ .



In the alternating current circuit the value of the current of short circuit must be indicated by the distribution company in the connection point, before the absence of this one fact, a value will be estimated according to the technical guide of application of BT of the Department of Science and Technology. A maximum short circuit intensity will be estimated three-phase of 25kA.

The cause of choosing this value is because in the BT distribution network it takes like maximum short circuit intensity three-phase 50kA; bearing in mind the impedance in the line of the assault the short circuit intensity to the exit of the General Picture of Control and Protection is estimated in 20kA.

From this fact the impedance is calculated in the assault line.

$$I_{cc} = U_n / R$$

$$20 \text{ KA} = 230 \text{ V} / R$$

$$R = 0.0115 \Omega$$

How generally the feeding impedance is not known to the network it is admitted that in case of short circuit the tension in the beginning of the installation of the users be able to consider the supply tension to be 0,8 times.

The defect phase - ground will take as the most unfavourable and it will be despised inductance of the cables. This consideration, although it is a simplification of reality, it is valid for this case.

For the calculation of the current of short circuit in every point it is applied:

$$I_{cc} = 0.8 \times U / R$$

*Where:*

*I<sub>cc</sub>: current of short circuit.*

*U: tension of feeding phase neutral.*

*R: resistance of the phase driver between the considered point and the feeding.*

 **On tension:**

Surge is the elevation of the tension to very high values during a transitory one of few milliseconds.

The Regulation of LT contemplates three types of on tension, which are the surge type I border (caused by atmospheric discharges), the surge type manoeuvres (generally provoked by commutations in the network) and surge to industrial frequency (provoked by defects in the network).

The influence that the surge can have in the safety of the persons, facilities and teams, as well as his after effect in the continuity of the service is function of:

The ITC-BT 23, it establishes the levels of tension supported to impulse for the different ones teams of BT, and the protection requests against on tension.

On the photovoltaic generator, they can be generated on tension of origin atmospheric of certain importance. For it, the current entry will be protected it continues of the investor, by means of bipolar class devices II, valid for most of teams connected to network.

These devices have a low performance time (<25ns) and a current of performance of 15kA, with a low residual tension to 2kV. There does not become necessary the protection of cables, pipes, book-keepers, etc., for allowing these higher values of residual tension (4-6kV).

✚ **Electrical equipment:**

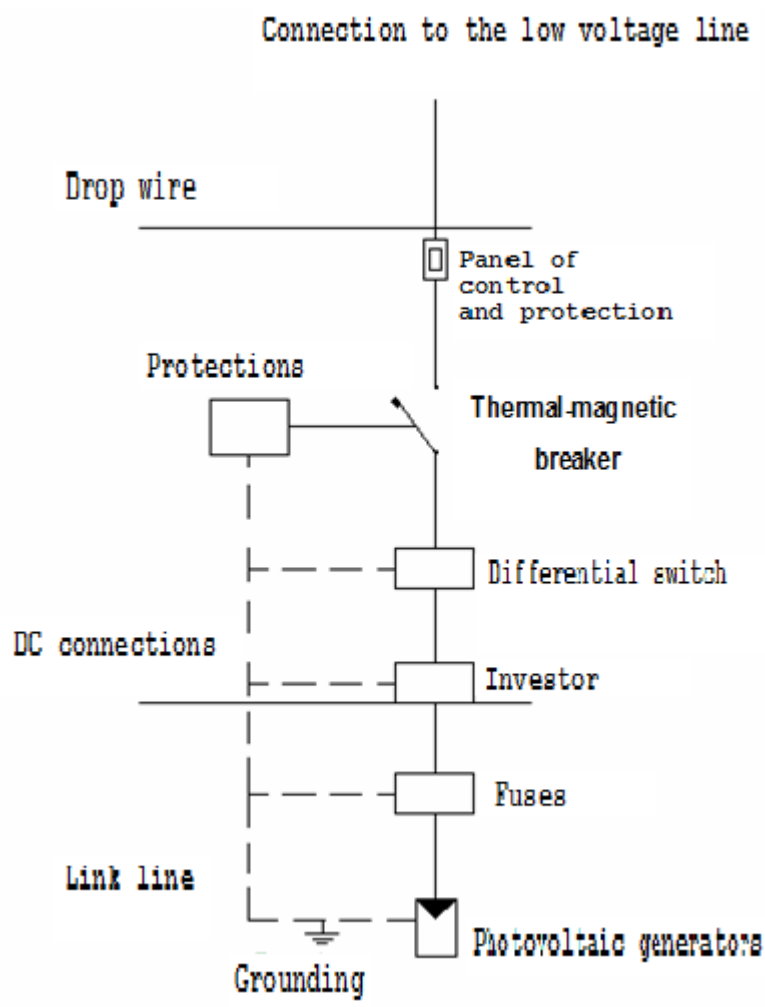


Figure 32: Scheme of interconnected photovoltaic head office. [2]

✚ **Fuses**

LINES	Snominal(mm <sup>2</sup> )	I(A)	I <sub>max.</sub> permitted (A)
String – Junction box	2x6	8.25	46
Transformer- Drop wire	3x240+1x25	235	430

Figure 33: Drivers in whom the fuses are placed. [Own elaboration]

The fuse in direct current controls if the potency of entry to the investor is excessive, the normal thing is that he is the proper investor the one that forces to the generator to work out of the point of maximum potency.

$$I_{SC} \leq I_n \leq I_{CA}$$

$7,8 \leq I_n \leq 46$  There have been chosen fuses of 32A, with this fuse the thermal protection is guaranteed of the driver of 6mm<sup>2</sup> and of his respective change of section in the terminals box.

#### INDUSTRIAL CYLINDRICAL FUSES gG:

Size: 22x58

Nominal intensity:  $I_n = 32 \text{ A}$ .

Tension:  $U = 690 \text{ V}$ .

Court power: 80 kA.

The fuse in alternating current protects the connection of the transformer to the assault.

$$I_{SC} \leq I_n \leq I_{CA}$$

$$141 \leq I_n \leq 430$$

A fuse of 160 A has been chosen.

#### FUSES NH gG 690V WARNING DOUBLE

Size: NH00

Nominal intensity:  $I_n = 160 \text{ A}$ .

Tension:  $U = 690 \text{ V}$ .

Court power: 120 kA.

### Switches:

The value of R will be obtained of the stated table next where it appears equivalent impedance for the CA stretch; it will be considered that the driver it finds to a temperature of 20°C, to obtain this way the maximum possible value of  $I_{cc}$ .

LINES	$S_{nominal} (mm^2)$	R ( $\Omega/km$ )	R ( $\Omega$ )
Transformer- Drop wire	3x240 + 1x25	0,125	0.45

Figure 34: Equivalent impedance. [Own elaboration]

To calculate the short circuit the following expression is necessary:

$$I_{ST} = 0.8 * 20000 / \sqrt{3} \times 0.45 = 20.5 \text{ KA}$$

The court power has to be, therefore, superior to 20.5 KA.

According to the norm EN60269 it will have to expire:

$$I_{SC} \leq I_n \leq I_{CA}$$

$$141 \leq I_n \leq 430$$

The switch has been chosen with a nominal intensity of 160 A.

### Circuit breaker thermal-magnetic:

It will be four-poles with a power of court of 65kA and with nominal intensity of 160 A.

This switch is located in the picture of book-keepers of the photovoltaic installation, and it will be accessible only to the distribution company, in order to realize the disconnection manual, which allows the achievement, of sure form, works of maintenance in network of the electrical company. This inaccessibility has to introduce a second

Thermal-magnetic that is the one that really protects the installation of the surcharges and short circuits. This way this second thermal-magnetic will act before the switch general, except circuits of certain importance originated from the network.

It will be used thermal-magnetic of type C after there do not exist currents of starter raised in consumption.

#### CIRCUIT BREAKER SERIES 140M-M5F:

Nominal intensity:  $I_n = 160 \text{ A}$ .

Tension:  $U = 400 \text{ V}$ .

Court power:  $65 \text{ kA}$ .

#### **Distinguishing switch:**

There has been chosen a sensibility of  $30\text{mA}$  in the part of alternate to protect before derivations to this circuit. In order to that only it acts for mistakes to ground, it will belong to one assigned current major than the assigned one of the protection thermal-magnetic.

Therefore, it has been elected a four-poles of  $200 \text{ A}$ .

#### VIGICOMPACT MH NS250N TM200D 4P3R

Nominal intensity:  $I_n = 200 \text{ A}$ .

#### **Protection from direct and indirect contacts:**

For protection from direct electrical contacts they will be born in mind measurements:

- Obstacles interposition.
- Safe distance between the active parts of the facilities.
- Effective isolation of the active parts.

For protection of indirect electrical contacts it is carried out by the switch differential (which characteristics have been already calculated in the previous paragraph) completed with the putting to ground of the installation, which happens to be described to continuation.

### **Putting to ground:**

The masses of the installation will be connected to a ground independent from that of neutral of the distribution company in accordance with the Regulation Electro-technique for low tension.

For it, two landings will be realized separating the direct current side of the installation and the side of alternating current. In both cases the masses get connected of the teams straight to the principal ground bar, so much the structure of the support of the photovoltaic generator in the part of CC, like the terminal of putting to ground of investor in the part of CA, in order to not create dangerous tension differences for the persons.

Also, one is provided with the putting to ground of the transformer, which goes for separated.

The electrical connection of the panels and of his structures support to the landig it will be realized of parallel form.

The reason by which this separation is carried out is that the materials with which the panels and the structure are formed present different properties (different resistivity), with what, if a discharge will originate on the structures one would produce derivations from one to other one, which is not advisable.

Next the brief description of the landing is realized:

The putting to ground consists of joining to the terrestrial mass a point of the installation electricity company across an electrical connection of low resistance.

The landing of the installation will be constituted for:

- Terminal or point of putting to ground, constituted by connection device (space, terminal) that allows the union between the drivers of the line of linkage and principally of ground.

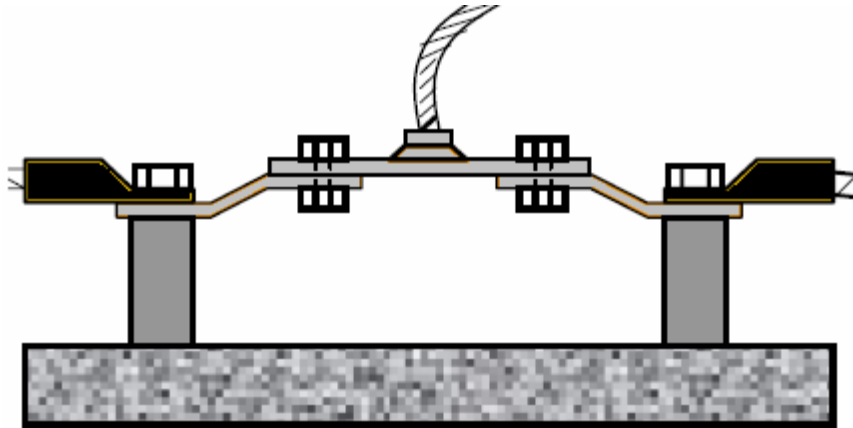


Figure 35: Description of the landing realized. [8]

- Linkage line with ground, formed by the drivers who join the electrode with the putting point to ground, with minimal section of 35 mm<sup>2</sup>.
- Electrode, metallic mass permanently in good contact with the area.

#### 4.8. Distance minim between panels

The distance  $d$ , measurement on the horizontal one, between a few modules lines obstacle, of height  $h$ , which could produce shades on the installation will have to guarantee a minimum of 4 hours of the sun concerning the midday of the winter solstice. This distance  $d$  it will be superior to the value obtained by the expression:

$$d = h / \tan (61^\circ - \text{Latitude}) = (990 \times 3) / \tan (61^\circ - 42.1^\circ) = 8674\text{mm}$$



Where, " $1/ \tan (61^\circ - \text{Latitude})$ " is a coefficient not dimensional named  $k$ .

Some significant values of  $k$  they can be seen in the table according to the local latitude.

Latitude	29 °	37 °	39 °	41 °	43 °	45 °
$k$	1,600	2,246	2,475	2,747	3,078	3,487

Figure 36: Significant values of  $k$ , according to the local latitude. [11]

In order to clarify possible doubts with regard to the capture of relative information to  $h$  and  $d$ , it appears the following figure with some examples:

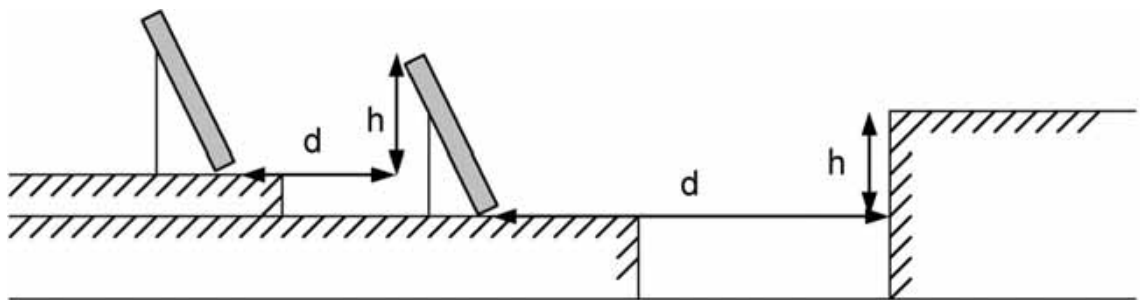


Figure 37: Distance between panels. [11]

The separation between the later part of a line and the beginning of the following one will not be low to the obtained one by the previous expression, applying  $h$  to the difference of heights between the high part of one line and the low part of the following one, carrying all the measurements out in accordance with the plane that contain the bases of the modules.

So since the entire distance between the base of modules it will be:

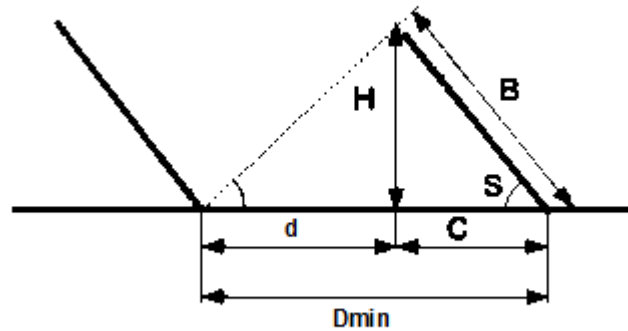


Figure 38: Distance between lines or strings of panels. [11]

$$C = B \times \cos(S) = (990 \times 3) \times \cos 35^\circ = 2432,9 \text{ mm}$$

$$D_{min} = d + C = 8674 + 2432,9 = 11106,9 \text{ mm (between panels lines)}$$

## 4.9. Structure of support and anchoring

The structure will be used as follows (flat structure):

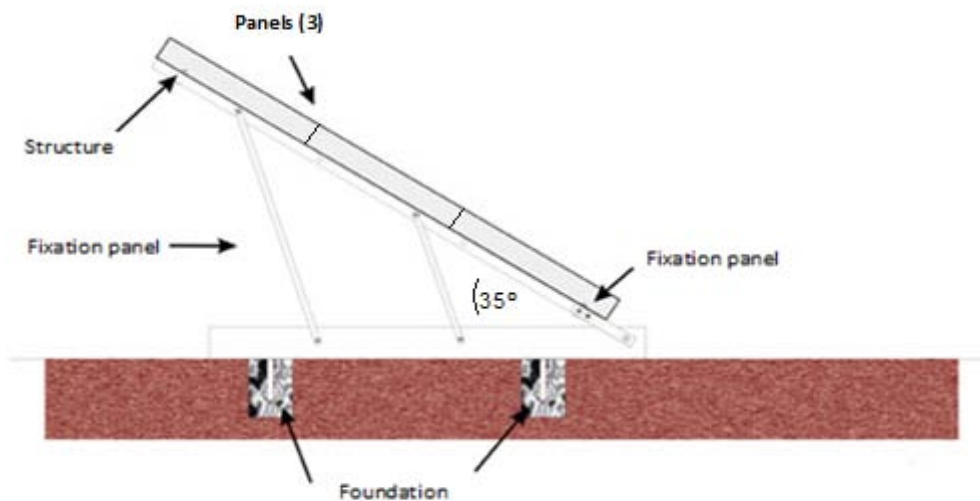


Figure 39: Structure used. [27]

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# – Chapter 5 –

## CIVIL WORK

## **5. CHAPTER 5: CIVIL WORK**

### **5.1. Ways, Platforms, Trenches and Buildings**


#### **5.1.1. Access road**

The access to the parks is realized from the National highway N-115.

#### **5.1.2. Explanation**

In order to allow the position of the buildings and to allow the access to transports involved in the assembly of the installation, the area will be graded where place the buildings creating a few ways that allow the access to the same ones, if it was necessary.

#### **5.1.3. Canalizations for wiring**

 Settle for underground canalization of half tension

There have been designed the trenches for which they will think up the electrical circuits and the cable of ground of accompaniment, which the centers of transformation join between themselves and up to the point of union with the electrical line. This trenches network has had a tendency whenever it has been possible for perimeters of the plants in order to avoid the crossing with the trenches that lodge the cables of direct current that there form the circuits that come to the investors. When it goes out of you parcel up where the parks are, the trench will pass for the boundary of the servitude of the existing ways.

The drivers will stay at trenches of 1,1m of depth and of 0,6m of breadth although this breadth can be a variable as the number of circuits that they lodge to allow operations of opening and laying.

The bed of the trench must be smooth and be free of living edges, singings, stones, etc.

In the same there will be placed the cable of ground of accompaniment and a layer of sand of mine or of river wash-down, bootblack and release exempt from organic substances, clay or earthy particles, and the size of the grain it will be comprised between 0,2 and 3 mm, of a 10 cm thickness, on that they will deposit the cables corresponding to the three single-core cables laid together of 15 kV to install.

Over the cable an others and layer of identical characteristics will go with a thickness 20 cm minimum. If there was used ground preceding from the same trench it would be necessary to sift it. On this ground layer there will have a tendency two pipes of PVC of 90mm of diameter, which it will contain control cables. A mechanical protection of PPC (Polyethene) will be placed transversely on the tracing of the cable. Two sand layers will cover entire width of the trench. Next a layer of proceeding ground will have a tendency of excavation.

One will take care that this ground layer is exempt from stones or pieces of rubble. At a distance of 40 cm of the soil there will be placed a tape of signalling as warning of the presence of electrical cables.

By every single pole three single-core cables laid together there will be placed both the mechanical protection and the tape of signalling. Finally one will stop refilling the trench with proceeding ground of excavation, must use for his rolled one and compression, mechanical means.

The underground cables to his step along ways, highways and those foresee traffic the cables will go to a 1 m minimal depth. Whenever it is areas in which possible the crossing will become perpendicular to the axis of the road and will be done across canalizations covered with 20 cm of concrete. The of pipes for the cables of potency will be two since in case of several cables or cables in trefoil formation of cables it will be necessary to have as minimum of a pipe of reservation. For the control cables the number of pipes will be three.

At the arrival of the centres of transformation and in the marked changes of direction there will construct chests of concrete of 50x50x65 interior with concrete covering and every 50 m there will be placed signalling the position of the chests and pipes, they will be defined in work.

### Settle for underground canalization of Low Tension

The interconnection between the investors' building the monoliths that the teams lodge of measurement and the centre of transformation will be realized by means of a Fall network Tension in buried trench.

This trenches network has had a tendency for the perimeters of the plants in order to avoid crossing with the trenches that lodge the cables of direct current that form the circuits that come to the investors.

The drivers will stay at trenches of 0,85m of depth and 0,75 m wide for to allow the operations of opening and laying.

The bed of the trench must be smooth and be free of living edges, singings, stones, etc. In the same wash-down will place a sand layer of mine or of river, bootblack and release, exempt of organic substances, clay or earthy particles, and the size of the grain will be included between 0,2 and 3 mm, of a 10 cm thickness on that the pipes will settle for the five corresponding circuits of the cables in trefoil formation L.T. + Neutral kV for the potency of the parks.

Another pipe of identical characteristics will be placed for the lines of lighting and force that they return to the investors buildings. These pipes will serve also to take the L.T ground, to the centre of transformation and the monoliths that the teams of invoicing lodge, by means of isolated cable.

There will be placed a pipe of 63mm in the bed of the trench to lodge and to isolate the cable of ground which in the centre of transformation, it will join all the L.T grounds.

There will have a tendency two pipes of PVC of 63mm of diameter, which will contain the control cables.

Over the pipes another sand layer will go.

A mechanical protection of PPC (Polyethene) will be placed transversely on the tracing of the cable. The two sand layers will cover the entire width of the trench. Next a layer will have a tendency of ground proceeding from the excavation. At a distance of 40 cm

of the soil a signalling tape will be placed like warning of the presence of electrical cables.

By every pipe there will be placed both the mechanical protection and the tape of signalling. For last one will stop refilling the trench with ground proceeding from the excavation, having to use for his rolled one and compression, mechanical means.

In the planes they can see the sections type of trenches and of the crossings.

The underground cables to his step along ways, vehicular, those areas in which foresee rolled traffic the cables will go to 1, 2 m minimal depth. Whenever it is possible the crossing will become perpendicular to the axis of the road and will be done across canalizations covered with 20 cm of concrete. The minimal number of pipes for the cables of potency will be two since in case of several cables or three groups of cables it will be necessary to have as minimum of a pipe of reservation. For the control cables the number of pipes will be three.

At the arrival of the buildings and in the marked changes of direction they will be constructed chests of concrete of 50x50x65 interior with concrete covering and every 50m they will be placed milestones of signalling, the position of the chests and pipes, will be defined in work.

#### **5.1.4. Building for the centre of transformation and connection**

For the whole group he will install to himself the only building that it will lodge between another switchgear, a transformer of 100kVA for each mini-plot 100kW.

##### **5.1.4.1. Description**

The Centres of Transformation, of surface and interior maneuver (type hut), consist of the surrounding one of concrete of structure pretty block, in whose interior they all join the electrical components, of M.T, up to the L.T pictures, including the transformers, devices of control and interconnections between the diverse elements.

The principal advantage that these Centres of Transformation present is that so much

construction as the assembly and interior equipment can be realized entirely in factory, guaranteeing with it a uniform quality and reducing greatly works of civil work and assembly in the installation point. Also, his elegant design allows his installation both in areas of industrial character and in urban environments.

#### **5.1.4.2. Surrounding**

The surrounding one of these centres is of armed vibrated concrete. It consists of two parts:

One that agglutinates the fund and the walls, which it incorporates the doors and ventilation grills native, and other one that constitutes the roof.

The pieces constructed in concrete offer 300 kg / cm resistance typical.

Also, they have a metallic armor which allows the interconnection between themselves and to the collector of grounds. This union is realized by means of copper strips, giving place to a surface equipotential that it wraps completely to the centre. The doors and grills are isolated electrically, presenting a resistance of 10 kOhm with regard to the ground of the surrounding one.

The covering is formed by concrete pieces with insertions in the top part for his manipulation.

In the low part of the frontal and later walls the step orifices are located for cables of M and L.T. These orifices are average perforated the opening being realized in work of those who are necessary for every application. Of equal form, he has a few orifices way perforated practicable for the exits to the exterior grounds.

#### **5.1.4.3. Dividing wall of interior separation**

A dividing wall will be constructed to separate the area of cells of connection (M.T) of the area dedicated to the operation of the parks.



#### **5.1.4.4. Accesses**

In the frontal wall there are located the doors of access of pedestrians, the doors of transformer (both with opening of 180th) and the ventilation grills. All these materials they are made of steel sheet. The access doors have a closing system with object to guarantee the functioning safety to avoid untimely openings of the same of the Centre of Transformation.

#### **5.1.4.5. Ventilation**

The grills of natural ventilation are formed by mud's in the shape of "V" invested one, designed to form a labyrinth that avoids the entry of rainwater in the Centre of Transformation.

#### **5.1.4.6. Finished**

Finished of the exterior surfaces it is carried out by rough acrylic colour painting target in the walls and brown in the perimeter of the covering or roof, doors and grills of ventilation. The metallic pieces exhibited on the outside are treated appropriately against corrosion.

These prefabricated buildings have been credited by the quality Certificate UNESA.

#### **5.1.4.7. System of illumination**

The team is provided with system of illumination connected and governed from the picture of LT, who has a switch.

#### **5.1.4.8. Several**

Admissible surcharges and environmental conditions of functioning as current regulation.

#### 5.1.4.9. Foundation

For the place of the Centres of Transformation an excavation is necessary, on whose fund extends a layer of compact and levelled sand of 100 mm of thickness.

#### 5.1.4.10. Detailed characteristics

- Transformers N<sup>o</sup>: 12 (in total, 12 mini-plots 100kW)
- Type of ventilation: Double
- Doors of access to pedestrian: 2 doors
- Exterior dimensions
  - Length: 4460 mm
  - Height: 2585 mm
  - Width: 2380 mm
  - Weight: 12000 kg (empty).
- Dimensions of the excavation
  - Length: 1000 mm

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# – Chapter 6 –

## SPECIFICATIONS

## **6. CHAPTER 6: SPECIFICATIONS**

### **6.1. Electricity L.T and M.T**

#### **6.1.1 SCOPE OF THIS DOCUMENT**

The object of these Specifications is to determine the Technical Prescriptions that have to apply in the present project.

In case of contradiction between the diverse documents of this Project, the priority order will be:

- Specifications
- Planes
- Memory (Contained)
- Budget

#### **6.1.2. ASSEMBLY AND GENERAL CONDITIONS OF ELECTRICAL MATERIALS OF L. T.**

##### **6.1.2.1 Scope of the Sheet**

In this sheet all the precise conditions are gathered for the supply and assembly devices and materials split into parts separated from work.

##### **6.1.2.2 Regulation**

It will be of obligatory fulfilment the sheet of Technical conditions of Facilities of Photovoltaic Solar energy Connected to Network, of October, 2002 prepared by the Department of Solar energy of the IDAE.

### **6.1.2.3 Materials**

All the materials to be used in these facilities will be normal products of a manufacturer of recognized electrical guarantee and, in general, equal or similar to the types specified in the budget of the Project.

### **6.1.2.4 Work units**

It is a question of giving and of mounting the following work units:

- Assembly of the photovoltaic badges investing control closets and invoicing
- Installation of the assault of linkage between them

All the planes will have to take the approval of the contractor and of the direction of work to execute the corresponding facilities.

### **6.1.2.5 Assembly and general conditions of the electrical materials**

All the materials to be used will be of the first quality, according to the regulatory technical characteristics.

- Finished the installation, this one will be put to the regulatory tests in the presence of the Director of Work.
- The isolation between drivers and between these and ground will have to have a resistance of 250kohmios like minimum.
- The resistance of the landing will be located about 3 ohms.
- No conduit will have to go half-rigid for the soils, rigid pipe will be used.
- In the records boxes there will not be used any type of junction, which is not realized by means of terminals.
- All the drivers will best amped and with colour it is normalized light.
  - o Blue: for the neutral driver
  - o Black or brown: for the phase drivers
  - o Yellow - green (two-colour): for the protection driver

- The colour of the conduit will not be able to falter r in the whole trip of the laying.
- The charges that the line could suffer will be distributed between three phases, so that the system remains balanced
- As soon as the installation was finished all the tests will be realized they were necessary on the part of the property (sections, isolations, resistances, intensities, circuit breakers balanced of lines, selectivity, etc.)
- The installation will have to be realized in accordance with the Regulation Electro-Technique for Low Tension, with all his paragraphs (drivers' sections, diameters of pipes, etc.).
- The fitter will deliver to the property the documents necessary for the functioning of the same one.

#### Isolated drivers

The isolated drivers will be of copper and they will be isolated by plastic. Those of Direct current will be of double isolation.

They will be protected also, properly against the corrosion, will have sufficient mechanical resistance to support the efforts which could be submitted and will expire with the norm IT UNE 21. 024.

The drivers will be single-poles and his nominal tension will not be lower than 1.000 volts.

The section of these drivers will be adapted to the due intensities, never low to determine in the paragraph of calculations of the project.

### **6.1.3 Typical of cables M.T.**

#### **6.1.3.1 Scope of the Sheet**

There are specified in this Sheet all the conditions needed for the electrical cables used in facilities of Half Tension.

### 6.1.3.2. Norms and applicable specifications

- a) Regulation of lines of Alta Tension
- b) Regulate on Conditions and Technical Guarantees of Safety in Power plants, Substations and Canters of Transformation
- c) Regulation Electro-Technique of Low Tension
- d) Norms IT UNE applicable to these materials
- e) Norms CEI for electrical materials

### 6.1.3.3. Electrical drivers

#### Drivers without isolating

The drivers will be of hard electrolytic copper of the fixed diameter, without mechanical imperfection and in accordance with the prescribed in the norms AEE nº 18 and IT UNE 20.003 and 21.011.

The conductivity will not be lower than 98 % of the International Values whose resistance ohm is 0, 01786 ohms for meter of length and mm <sup>2</sup> to the temperature of 20°C. As temperature coefficient for the corrections of values of different temperatures from 20°C will take the value of 0,004 ohms as a degree centigrade. The break load will not be lower than 42 Kg / mm <sup>2</sup>.

#### Isolated cables

##### 1) Driver, internal revetment and fillings.

- a) The driver will be formed by aluminium threads.
- b) The internal revetment can be extruded or curb.
- c) Into the cables with circular isolated drivers curb will admit internal revetment if the interstices between the isolated drivers are occupied properly by different filling elements.
- d) The internal revetment will be of polyethene reticulated (XLPE) and the fillings will be of a suitable material. It is allowed to use a suitable tape, in the shape of open helix before the application of the internal revetment extruded.

- e) The material used in the internal revetments and in the fillings, must be adapted for the temperature of being a vice of the cable and compatibly with the material of the isolation.
- f) The approximate thickness of the revetment curb must be 0,4 mm in the fictitious diameters of the sets of low or equal twisted isolated drivers to 40 mm and 0,6 mm in the top diameters.
- g) The characteristics of the polyethene reticulated will expire with specified for the miscellany XLPE of the norm IT JOINS 21.124.

#### Types protection of the cable

##### 1) Metallic screen

The cable will arrange of metallic type protection screen. This will be constituted by one or several hoops, a braid, a crown of wires, or for a combination of wires and hoops.

Also it can be constituted by the surrounding one or arm or that fulfils the indicated in the following prescriptions:

- a) The hoops screens must be formed well by one or several continuous hoops of cooked copper, of a 0,1 mm thickness as minimum applied in helix with one on position of at least 15 %, or for a continuous hoop of cooked copper, applied longitudinally with one on 10 mm minimal position and corrugated.

##### 2) Exterior covering.

All the cables will have to be provided s with not metallic exterior covering. Except specification justified against the exposed thing there will be used like covering a miscellany of polychloride of vinyl (PVC) especially stabilized for his use in exterior. They will have to fulfil too with the characteristics demanded for the miscellany type ST2 in the norm IT UNE 21.124. Other prescriptions can find in the stage IX to XIII of the norm IT UNE 21.123-81 (1). The quality of the material of the covering must be adapted for the temperature of service of the cable.



✚ Election of the cable.

For the election of the cables of high tension the following factors have been born in mind;

- a) Tension of the network
- b) Intensity to be transported
- c) Short circuit intensities between phases, between phase and ground and his duration.

➤ General prescriptions pair to essays of cables of high tension

- TEMPERATURE AMBIENCE

Unless it is specified in against in case of a particular essay, test dielectrics must carry out to a temperature ambience of  $20 + ^\circ\text{C}$  and other essays to  $20 + 5 ^\circ\text{C}$ .

- FREQUENCY AND FORM OF THE WAVE OF THE TENSIONS OF ESSAY TOFRECUENCI TO INDUSTRIALIST

The frequency of the tensions of essay with alternating current, must not be not lower than 49Hz not superior to 61 Hz. The form of the wave of these tensions must be practically senoidal. The stated values there are effective values.

- FORM OF THE WAVE OF THE TENSIONS OF ESSAY WITH IMPULSES

In accordance with the norm IT UNE 21-132, the front of the wave must be comprised between 1seg.and 5 seg. and the time up to half of the value of the comb between 40 seg. and 60 seg, the impulse wave must expire also, the indicated in the norm UNE 21-308.

- TYPE OF ESSAYS

There can be carried out two types of essays that next are described

- a) Individuals
- b) Special

- The individual essays must be:

- a) Measurement of the electrical resistance of the drivers
- b) Tension essay
- c) Essay of partial discharges in case of the cables isolated with PE or XPLE of tension top to 1,8/3 kV and in case of the cables isolated with PVC or EPR of top tensiona3,6/6 kV.

All these individual essays must fulfill the norm IT UNE 21-123-81 (1).

- The special essays must be:

- a) Examination of the driver
- b) Dimensional cross-checks
- c) Electrical essay of the tension cables nominal superior to 3, 6/6 kV
- d) Lengthening essay in warm of the EPR and d the XLPE
- e) I test to fall temperature of the PVC

All these special essays must fulfill the norm IT JOINS 21-123 -81 (1).

## 6.2. MOVEMENT OF GROUNDS

### A) CLEAR AND CLEAR OF THE AREA

#### DEFINITION AND SCOPE

The clearing operations and clear of the area there are the necessary ones to leave the natural area, between limits of explanation, completely free of obstacles, weeds, trees, fences, retaining wall, garbage, debris and any other undesirable material in opinion of the Director of the works, so that the above mentioned areas remain suitable and do not

determine the beginning of the works of excavation and/or embanked.

This work unit includes:

- The removal of the materials
- The operations of load transport and discharge of the materials in dump, as well as his piled up one or provisional storage and all the operations are precise up to his spilled definitively.
- Any auxiliary element or of protection necessary, like fences, retaining wall, etc.
- The conservation in the good state of the piled up materials and of the dumps where not combustible materials and the law sunburned themselves indemnifications, taxes, expenses, etc., of the dumps and of the places of storage or the widespread one and compression of the materials in the project dump.
- Any work, machinery, material or auxiliary element necessary for the correct and rapid execution of this unit of work.

#### EXECUTION OF THE WORKS

The execution of the works will be realized according to the ready thing on this matter in artículo300 of the Sheet of General Technical Prescriptions for Works of Highways and Bridges (PG-3/75) of the M.O. P.T.

#### MEASUREMENT

This work unit will measure itself and pay for cubic meters (m3) really executed, measured on the plane that shapes the area. It is understood for "really executed", the whole surface that is between explanation lines and that does not correspond to surfaces of destroyed buildings or to highways, ways, existing routes of communication or in general any paving or existing road surface.

## B) EXPLANATIONS

### DESCRIPTION

Deforestations and terraces in the area. There remain excluded the rocky areas that are necessary explosives or the very soft ones.

### COMPONENTS

For fillings, contribution of grounds.

### PREVIOUS CONDITIONS

- Plants, sections and enclosed natural slopes of the explanation to be realized.
- Servitudes that can be affected by the explanation
- Topographic plane with level curves of the area of the explanation, with the most notable accidents.
- Level of the water table and currents of groundwater
- Clear and superficial cleanliness
- Restate
- There will be checked the state of the facilities that they could affect to the explanation, taking the necessary measures of conservation and protection.

### EXECUTION

- The slides will be avoided for erosions and filtrations, taking the precise measures not to alter the resistance of the area without excavating.
- There will be placed exterior fixed points of reference to the perimeter of the explanation, extracting the levels of level and displacement, so much horizontal like vertical.
- There will be requested the companies given evenness information about the facilities that could be affected by the explanation.

- The Optional Direction will always take the decisions that were necessary in the following topics:
- In those constructions that exceed the limits of the explanation.
- In those areas in which rock appears.
- In the rims along with already established constructions.
- In those areas of the explanation in which there appear natural courses of surface or deep waters.
- In those slopes and walls in that it is necessary to place are inforcement.
- In the opening of the loan s that could be necessary.
- For unforeseen circumstances, anomalies or urgencies.
- The works will stop of embanked when the temperature descends of 2° C.
- One will try to avoid the vehicle traffic s and a machine already compacts.
- When vibrant rollers are used for to compact, some spent will have to happen in the end without applying vibration.
- The vegetable ground will have to separate of the rest of the graded products allowing him his later use only in protection of slopes or landscaped areas.

#### CONTROL

##### Deforestations:

- A control will do of redesign every 50 m to itself, of perimeter and not less of one for deforestation,10 cm without being accepted in cases of errors superior to 2, 5 ‰ and changes of ±.

#### REGULATION

- NTE - ADE/1.977
- PCT-DGA/1.960
- PG-4/1.988
- IT JOINS: 7377-76; 7378 - 75.

- NLT: 107; 11; 117; 152.

#### SAFETY AND HEALTH

- The machinery to be used will support the safe distance to the air electric power lines.
- The minimal breadth of the provisional ramps for the machinery movement to be á of 4, 50 m., expanding in the curves, there being always born in mind the manoeuvrability of the used machinery.
- Whenever a machine initiates a movement or of reverse gear, it will do it with an acoustic sign.
- Before the day begins there will happen the brakes and safety mechanisms of vehicles and machinery.
- One will accumulate neither the area of the excavation, nor other materials, along with rims of coronation of slopes.
- When the excavated area could transmit contagious illnesses it will be disinfected before his transport, without being able to use for loan, having the personal baggage adapted for his protection.
- The dust formation will be avoided, being necessary to water and to use personally mask or suitable material.
- The refine of the walls will be carried out for depths not bigger than 3,00 m.
- They will be fulfilled also, all the general dispositions on Safety and Health in the Work that exist and all the Municipal Ordinances that are of application.

#### MEASUREMENT

- In deforestations, for m of the volume excavated on profiles, even clear, I restate and refined, without considering the bulking, measuring to part the load and transport to the dump.

- All those changes in excess that arise for negligence of the Contract, for expediency or erosion, will not subscribe.

## C) EXCAVATIONS IN TRENCHES

### DESCRIPTION

Narrow and long excavation that is done in an area to realize the foundation or to install an underground conduction.

### COMPONENTS

- Madeira for surveys and propping-ups.

### PREVIOUS CONDITIONS

- Before beginning the excavation of the trench it will be necessary that the redesign has verified the Optional Direction
- It will have to have plants and enclosed sections.
- There will have been investigated the servitudes that can be affected by the grounds movement like networks of drinking water, sanitation, precipitation tanks, electricity, telephony, optical fibre heating lighting, etc., elements buried air lines and situation and use of the routes of communication.
- The cut will be studied stratigraphy and the characteristics of the area to be excavated, like type of area, moisture and consistency.
- Type, situation, depth and dimensions of next foundations that are at a distance of the wall of the equal or min or cut of 2 times the depth of the trench or well.
- Evaluation of the tension to compression that the next foundations transmit to the area.
- The areas to be annotated in the trenches work will not be smaller than 1,00 m animal, for the transit of pedestrians and of 2,00 m. for vehicles measured from the rim of the cut.

## EXECUTION

- The redesign will be carried out in such a way that fixed reference points will exist, both of levels and of level, always out of the excavation area.
- There will take in work a detailed control of the measurements of the excavation of the trenches.
- The beginning of the excavation of trenches will be realized when there exist all the elements necessary for his excavation, included the wood for a possible shoring.
- The Optional Direction will always indicate the depth of the funds of the excavation of the trench, although it should be different from that of Project, being his finished I clean at level or staggered.
- The Contract will have to assure the stability of the slopes and vertical walls of all the excavations that it should realize, applying the means of shoring, propping-up, survey and superficial protection of the area, which he considers to be necessary in order detachments, collapses and slides preventing from being able to hurt to persons or to the works, although you fell way s they were not defined in the Project, or had not been arranged by the Optional Direction.
- The Optional Direction will be able to arrange in any moment the laying of shoring, propping-ups, surveys and superficial protections of the reindeer.
- All the necessary measurements will be adopted as the Contract to avoid the entry of the water, supporting free from the same one the excavation area, being placed drainages, protections, ditches, grilles and conduits of sewer pipe that are necessary.
- The fund of the trench will have to remain free of ground, fragments of rock, shaken rock, layers of inadequate area or any strange element that could debilitate his resistance. The cracks and cracks will be cleaned being refilled by compact material or concrete.
- The separation between the slash of the machine and the shoring will not be major than time and a half the depth of the trench in this point.



### CONTROL

- Every 20,00 m. or fraction, there will be done a control of dimensions of the redesign, there without being accepted errors superior to 2,5 %. and top changes to  $\pm 10$  cm, as for distances between axes.
- The distance at the level of the fund of the trench, will be pushed back when 0,00 overcomes the level +/-.

### REGULATION

- NTE - ADZ/1.976
- PG-4/1.988
- PCT-DGA/1.960
- NORMS UNE 56501; 56505; 56507; 56508; 56509; 56510; 56520; 56521; 56525;56526; 56527; 56529; 56535; 56537; 56539; 7183 and 37501.

### SAFETY AND HEALTH

- An area will be annotated, 1,00 m not minor. neither for the pedestrians' transit, 2,00 m nor more small. for the vehicle steps, measured from the vertical rim of the cut.
- When the cross walk is for useable or that of vehicles I join the rim of the cut of the trench, he will get ready of mobile fences that every 10,00 m will be illuminated. with points of portable light and grade of not minor protection of IP-44.
- The gathering of materials and grounds, in depth trenches May r to 1,30 m., it will be realized at a distance not smaller than 2,00 m. of the rim of the cut of the trench.
- A worker will exist out of the trench, whenever the depth of this one is major de1,30 m. and beech someone being employed at his interior, to be able to help in the work and ask for help in case of emergency.
- In trenches of depth bigger than 1, 30 m., and whenever the Optional Direction specifies it the shoring laying will be obligatory standing out or n

20 cm minimum. of the superficial level of the area.

- The trenches that overcome the 1, 30 m depth., it will be necessary to use stairs for entry and exit of the same ones so that no worker is at a distance superior to 30,00 m. of one of them, being placed from the fund of the excavation up to 1,00 m, being placed correctly in transverse sense.
- When the excavated area could transmit contagious illnesses it will be disinfected before his transport, without being able to use for loan, having the personal baggage adapted for his protection.
- It will be counted in the work with a provision of levers, wedges, bars, props, planks, etc., that will be reserved for emergency case, without being able to use for the shoring.
- They will be fulfilled also, all the general dispositions on Safety and Hygiene in the Work that exist and all the Ordinances Policemen who are of application.

#### MEASUREMENT AND EVALUATION

- The excavations for trenches will subscribe for m, on the real profiles of the area and before refilling.
- There will not be considered to be the collapses, or the excesses produced by collapses or errors.
- The Contractor will be able to present to the Optional Direction for his approval the concrete budget of the measurements to be taken to avoid the collapses when after the conditions of the area to begin the works they do not agree with foreseen in the Project.

## 6.3. CIVILWORK

### A) YOU STRUCTURE. CONCRETE

#### DESCRIPTION

Units of work realized with concrete to obtain the resistance requested in the project.

#### PREVIOUS CONDITIONS

- Manufacture and assembly of the forms
- Definition of the characteristics of the concrete
- Restate
- Conformity of D. F. with the laying and assembly of the described elements

#### COMPONENTS

- Cement
- Arid
- Water
- Necessary additives
- Head office concrete, with stamp INCE

#### EXECUTION

Before spilling the concrete:

- Restate of axes, levels of finished
- Cleanliness and dampened of s forms

During the concrete spilled one:

- The spilled one will be carried out from a 1 m maximum height, unless there are used methods of pumping over a distance that prevent the segregation of the components of the concrete. It will be realized for layers of 30 cm. To vibrate a without neither the armours nor the forms experiencing movements sudden or shakes, taking care that do not remain cocaine addict and supports the suitable recovering.
- The concrete, cement will be suspended when the temperature descends from 0 °C, at next 48 hs special means will be able to be used for this circumstance, but under the authorization of the D.F.
- Horizontal meetings will not be left, but if in spite of everything they were taking place, one will proceed to the cleanliness, plastered or stung of contact surfaces, spilling next mortar rich in cement, and to spill concrete later. If they had passed more than 48 hs the meeting will talk each other with resins epoxy.
- There will not be mixed concretes of different types of cement.

After the cement, concrete:

- The cured one will be carried out keeping the surfaces of the pieces humid until 70 % of his resistance is reached
- One will proceed to the uncasing in the vertical surfaces spent 7 days, and of the horizontal ones not before 21 days. All this following the indications of the D.F.

#### REGULATION

- EHE – 98
- NTE-EH. Structure, concrete
- Norms IT UNE: 83301-91, 83302-84, 83304-84, 83313-90

- INCE sealed for the prepared concrete
- Homologation I seal CIET SID

#### CONTROL

It will be verified

- The redesign, dimensions, levelling out and plumbed of the pieces
- The separation and thickness of the meetings

It will be practise

- The consistency and resistance of the concrete according to the EH-91, and the indications of the D.F.
- The pieces will be pushed back with the following shortcomings
- Results of the essays lower than the stated ones
- Give of the concrete with beginning of setting
- Deficient disposition of the forms, armours, and surveys
- Concrete to inadequate temperature, according to regulation and specifications of the D.F.
- Shells appearance May animal that the maximum size of the arid one, disintegrations, fissures of more than 0, 2 mm.
- Collapses superior to 5 mm.
- Thicknesses of major meetings of the specified in project, or with changes of more than 5 mm.

#### SAFETY

More frequent risks

- Crushing for the concrete mixer
- Falls at the same level
- Falls from high platforms
- Blows produced s for the used machinery

- **Personal protections**

- Canopy of protection, networks, and visors, pair to protection of the fall of objects.
- All the used machines will have landing, and his connection will be by means of pin.
- The step will not be allowed below the area of spilled of concrete.
- In all I marry them s the indications of the safety Study will follow

- **MEASUREMEN**

Certain work units will be able to measure for m<sup>2</sup> or for unit, always following the criteria reflected in the measurements.

- **MAINTENANCE**

There will be provided by the Contractor the papers that gather the admissible charges of the structural elements.

## **6.4. CONDITIONS OF USE, MAINTENANCE AND SAFETY**

The enclosures and buildings will always have to be closed, so that there prevents the access of the persons foreign to the service.

Inside the facilities it will not be possible to store any element that does not belong to the proper installation.

For the achievement of the oportune manoeuvres to use á stool, lever of operation, gloves, etc., and they will always have to be in the perfect use state, what will be verified periodically.

Before the putting in service in load of the installation, a putting will be realized in service in empty pair to the cross-check of the correct functioning of the machines.

There will be realized a few cross-checks of the resistances of isolation and of ground of the different components of the electrical installation.

The whole electrical installation must be signposted correctly and must have the warnings and necessary instructions so that they prevent the errors of interruption, incorrect manoeuvres, and accidental contacts with the elements in tension or any other type of accident.

The instructions will place on firstly you help that must appear in case of accident in a place perfectly visibly.

## 6.5. CERTIFICATES AND PAPERS

Ad will join, for the procedure of this project before the organisms competent public, the stated papers next:

- Administrative authorization of the work.
- Project signed by a competent technician.
- Tension certificate of step and contact, expressed by an authorized company.
- Certification of end of work.
- Maintenance contract.
- Conformity on the part of the company supplier.

## 6.6. LOG BOOK, INSTRUCTIONS

He will get ready in this installation of a book of orders, in which there will register all the incidences arisen during the useful life of the said centre, including every visit, review etc.

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# – Chapter 7 –

## STUDY OF SAFETY AND HEALTH



## **7. CHAPTER 7: STUDY OF SAFETY AND HEALTH**

### **7.1. Objective**

To comply with the provisions of R.D. 1627/1997 of 24 October, which down the minimum requirements of health and safety on construction sites, identifying, analyzing and studying occupational hazards that can be prevented, indicating the necessary technical arrangements for this; related of the risks that can not be eliminated, specifying the technical protection measures and to control and reduce those risks.

It is also the subject of this safety study to comply with Law 31/1995 of 8 November, Prevention of Occupational Risks in relation to the obligation of the employer owner of a workplace, to inform and give instructions regarding the appropriate risks in the workplace and the protection and prevention measures concerned.

As the budget is below 450,000 € is not necessary to develop Study of a Specific Safety and Health to evaluate the risks and measures being taken (Art. 4.1 RD 1627/1997), so that presents a basic study.

### **7.2. Features of the building work**

Descriptions of the work and situation.

The situation of the building work and the description about this is reflected in this project.

#### **7.2.1. Electricity supply**

The supply of electrical energy is provided by the building company.

### **7.2.2. Drinking water supply**

Where drinking water supplies can not be performed through the usual conduits will required others ways for get the objective.

### **7.2.3. Water dirty tip**

There will be enough toilets and in goods states. If possible, water feces is connected to the sewerage system in the site or in the vicinity.

In the absence of sewerage system, is necessary avoid damages about the environment.

### **7.2.4. Interferences and services affected**

There is more than one company in the project who should appoint a coordinator of Health and Safety Directorate, which will resolve in the same from the standpoint of safety and health at work. The designation of the Coordinator shall be submitted for approval by the Promoter.

In works of extension and / or remodeling of facilities in service, there must be a Health and Safety Coordinator to be the characteristics described in paragraph above, who will resolve the interference with appropriate measures that may arise.

## **7.3. Civil works and assembly**

For the analysis of risks and preventive measures to take, divide the work by constructive units within the sections of civil works and staging.

### **7.3.1 Civil works**

Description about the constructive unit, risk and preventive measures.

### 7.3.1.1 Movement of land and foundation

#### a) Frequently Risk

- Fall into the ditches.
- Knock caused by machinery.
- Fall as personnel, vehicles, machinery or materials at the bottom of the excavation.

#### b) Preventive measures

- Monitor the progress of the excavation, removing unstable bowling and visors, preventing the possibility of rain or frost.
- Prohibit the stay of personnel in the vicinity of the machines in movement.
- Signpost properly the movement of heavy machinery and works machines.
- Make rules of the operators of the machinery used.
- The loads of the trucks will not exceed the limits and regulations.
- Establish a proper maintenance of machinery.
- Prohibit step to any person outside the work.
- Marking and fencing the perimeter of the work, as well as the singular points in the inside.
- Establish areas of passage and access to the work.
- Provide adequate protection to staff and ensure their use.
- Establish the restrictions in the areas as needed.

### 7.3.1.2 Structure

#### a) Frequently Risk

- Falls from height of people in all phases of shuttering, uncasing, start work with concrete and assembly to the prefabricated parts.
- Cuts on the hands.
- Punctures caused by tie wire, iron, etc..
- Falling objects at different levels (hammers, etc.)..

- Blows to the hands, feet and head.
- Indirect contact by electrocution.
- Fall as the same level.
- Burn.
- Overstraining.

b) Preventive measures

- Use tools in pouches.
- Outside form with adequate tools and procedures prescribed.
- Prohibit climbing formwork.
- Monitor the lifting of loads for to be stable.
- Controlling the discharge of concrete with the help of the crane.
- Prohibit the movement of personnel under suspended loads.
- The discharge of the concrete so postage will be provided from mobile platforms properly protected.
- Appropriate situation of safety nets, ensuring before starting the works of structure.
- Utilize portable electric tools are double insulated and its connection effected by an appropriate pin equipped with electric switch high sensitivity differential.

### 7.3.1.3 Enclosures

a) Frequently Risk

- Falls from height.
- Load-shedding suspended.
- Bruises and cuts on the limbs cause by the objects and tools.
- The arising from the use of aids, (scaffolding, ladders, etc.).

b) Prevention measures

- Mark work areas
- Use the platform working properly.

#### **7.3.1.4 Masonry**

##### **a) Frequently Risk**

- Fall as the same level.
- Fall as a different level.
- Projection of particle (bricks set).
- Projection of particles in the use of pointers.
- Cuts and wounds.
- Risks of using electric machines with the hands.

##### **b) Prevention measures**

- Cleaning of each of the work sites, with the roadways free of obstacles (tools, materials, etc.).
- The work areas will have adequate illumination.
- Provide adequate protection for the staff and ensure their use.
- Utilize proper working platforms.
- The portable power tools with the connections to control panel equipped with differential breaker high sensitivity.

#### **7.3.2 Assembly (mounting)**

Description of the constructive unit, risks and prevention measures and protection.

##### **7.3.2.1 Placing supports**

##### **a) Frequently Risk**

- Falls to different levels.
- Shocks or beatings.
- Projection of particles.
- Indirect electrical contact.

b) Prevention measures

- Verify that the working platforms are appropriate and have support surfaces in conditions.
- Have adequate lighting.
- Provide appropriate and useful tools.
- Provide adequate personal protection for mechanical work and ensure their use.
- The portable power tools with the connections to control panel equipped with differential breaker high sensitivity.

**7.3.2.2 Mounting of Cells or Prefabricated, power transformers and Tables L.T**

a) Frequently Risk

- Catch on objects.
- Falling objects as heavy.
- Excessive effort.
- Shocks or beatings.

b) Prevention measures

- Verify that no one is in the path of the load.
- Review the hooks, etc., checking if they are suitable for the load to raise.
- Check the correct distribution of charges in various offshoots of the cable.
- Give orders not to move or stay under suspended.
- Mark the area where the loads are handled.
- Check the status of the following elements:
  - Cables, pulleys and drums.
  - Controls and systems stop.
  - Limited re load and late career.
  - Brakes.
- Provide adequate protection the personnel for cargo handling and ensure their use.

- Adjusting the work strictly to the characteristics of the crane (maximum load length of the boom, counterweight loading tip). To this end, there must be a sign sufficiently visible to the maximum loads allowed.

➤ Operations up tension

a) Frequently Risk

- Contact Electric H. T. and L.T.
- Arch Electric H.T. and L.T.

b) Prevention measures

- Coordinate with the company supplying electric the necessary maneuvers.
- Open with the electric cut the possible potential sources of tension.
- Check the work in the absence of tension.
- Mark the work area to all components of the group and the situation in which are tensions places.
- Adequate personal protection and ensure their use.

## 7.4. General aspects

The optional direction of the work credited to the proper training about of the Work on Prevention and First Aid. Likewise, will check that exist a plan for emergency. The direction of these services should be showed in visible strategic sites of the work, with indication of the number of phones.

### 7.4.1 First-aid kit

Available at work, in the locker room or in the offices a kit that will be headed by a person designated by the company, with the means to carry out treatments emergency in case of accident.

## 7.5. Applicable law

### 7.5.1 Official rules

- Law 31/1995 on Prevention of Occupational Hazards of 8 November.
- Text of the General Law on Social Security. 2.65/1974 decree of May 30
- R.D. 1627/1997, of October 24. Minimum rules Health and Safety during construction.
- R.D.39/1997 of January 17. Regulation of Prevention Services.
- R.D. Workplaces.
- R.D. Task Forces.
- R.D. Individual Protection.
- R.D. N Signposting Security.
- O.G.S.H.T. I Title I, Chapter VI.

## 7.6. Budget

In the budget for the study of health and safety will be assigned an equivalent amount to 40% of the Health and Safety that apply to each plant of 100 kW.



---

# – Chapter 8 –

## BUDGET

## 8. CHAPTER 8: BUDGET

### 8.1. Civil work

Civil work		
Description	Units	Price(€)
<b><u>Civil work:</u></b>	€/Wp	0,40
<b><u>Earthmoving</u></b>	.	.
$m^3$ Excavation in all types of land for location of stands, with media mechanical	.	.
<b><u>Trenches</u></b>	.	.
To clear and clearing of underbrush	.	.
Holes in ground, varying widths of different depth.	.	.
Filled with granular material for electric cable protection.	.	.
Tubes to isolate cable ground M.T. and L.T.	.	.
Signaling PVC Tape	.	.
m Protection plate of cables between sand and wires	.	.
Tasks filling trenches and compacting.	.	.
<b><u>Buildings</u></b>	.	.
Building Control and connection to the network consists of a mono block structure, reinforced concrete, the dimensions specified in Annex. Includes the building and all exterior elements, transportation, assembly and accessories.	.	.
Fenced enclosure and door access, including transportation packaging and placement.	.	.
<b><u>Engineering services</u></b>	.	.
Rethinking the work of field survey and previous reports.	.	.
<b>Total:</b> 5544 panels x 230Wp =1275120 Wp		<b>510.048</b>

Figure 40: Budget of civil work. [Own elaboration]

## 8.2. Electrical installations and photovoltaic

Electrical installations and photovoltaic		
Description	Units	Price (€)
<b><u>Photovoltaic panel:</u></b> Solon P220/6+ (5544)	€/Wp	1,9
<b><u>Investor:</u></b> Sunny Central 100kw (12)	€/Wp	0,24
<b><u>Structures:</u></b> Support steel galvanized, especial model for modules P220/6+ on soil.	€/Wp	0,23
<b><u>Processing centre:</u></b> Ormazabal (CT) (12)	€/u	60.000
<b><u>Electrical installations:</u></b> Wiring Electrical meter Lighting installation for normal and emergency. Fuses gG Automatic switch thermal-magnetic Diferential switch automatic Copper conductor	€/Wp . . . . . .	0,35
<b>Total:</b> 5544 panels x 230Wp =1275120 Wp		<b>4.188.326,4</b>

Figure 41: Budget of electrical installations and photovoltaic. [Own elaboration]

### 8.3. Safety and health

Safety and health		
Description	Unit	Price (€)
<b><u>Safety and health</u></b>		
Study of safety and health as reflected in the project document.	.	3974,00
Operating equipment that allows the execution of maneuvers with sufficient insulation to protect personnel during the operation, maintenance and operations.	.	480,00
<b><u>Total:</u></b>		<b>4.454</b>

Figure 42: Budget of safety and health. [Own elaboration]

### 8.4. Summary of the budget

Summary			
<b>1</b>	<b>Civil work</b>		510.048
<b>2</b>	<b>Electrical installations and photovoltaic</b>		4.188.326,4
<b>3</b>	<b>Safety and health</b>		4.454
	<b>Total material execution</b>		<b>4.702.828,4</b>
	<b>General cost</b>	10%	470.282,84
	<b>Industrial benefits</b>	6%	282.169,704
	<b>IVA(tax)</b>	16%	752.452,544
	<b>Total budget (€)</b>		<b>6.207.733,488</b>

The total of the present budget is: SIX MILLIONS TWO HUNDRED AND SEVEN THOUNDAND-SEVEN HUNDRED THIRTY THREE AND FOUR HUNDRED EIGHTH EIGHTH cents € (IVA included).

Figure 43: Total budget. [Own elaboration]

---

# – Chapter 9 –

## SUMMARY OF DESIGN

## **9. CHAPTER 9: SUMMARY OF DESIGN**

### **9.1. Summary of design**

It has been made the design of a photovoltaic solar field of 1.2 MW, which will have economic costs, a determinate production and profits.

Thus:

- Total cost of project and initial investment required is: 6.207.733.488 €
- Useful life of facility: 25 years
- Recovery time of the initial investment: 12,2 years.
- Estimated time to make profits: 12,8 years
- Total production of the facility: 1.581.148,8 kWh / year
- Total production of the field in 25 years: 39.528.720 kWh
- Money generated each year: 505.968 €
- Money accumulated total: € 10.000.000
- Net earnings in 25 years: 3.827.190,4 €

Thus, of this study realized, the area where the parcel is located and its climate, as well as all the data obtained indicate that the facility under study is a profitable installation to long term. So, it can be concluded that it has very good future prospect.



# – CONCLUSION –



## **10. CONCLUSION**

### **10.1. Conclusion**

Has been designed a solar farm of 1.2 MW, with a very good prospect and values of high profitability. Therefore the project objective has been achieved.

To get to reach this point has been necessary to do the following general sections:

- ✓ Calculations of wiring, protection, pipes, earth, distance between panels, and other calculations.
- ✓ Design the structure with a certain inclination to reduce the losses by shadows.
- ✓ Civil study
- ✓ Study of Safety and Health
- ✓ Technical specifications
- ✓ Budget
- ✓ Bibliography
- ✓ Annexes
- ✓ Location and objectives
- ✓ Description of the installation.
- ✓ Analysis
- ✓ Economic and profitability
- ✓ Study of productivity
- ✓ Description of the installation
- ✓ Planes
- ✓ One line diagrams
- ✓ Others
- ✓ ...

A possible improvement could be; to made a more exhaustive study of energy losses due to the shadows, because in this project has only been taken into account the orientation of the panels and the distance between lines of strings to reduce losses at its majority.

Also, is included a diagram on the lost production part, called "Loss diagram over the whole year", like complement.





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*Written by España Ministerio de Ciencia y Tecnología, María Teresa Gómez-Mascaraque*  
*Colaborador María Teresa Gómez-Mascaraque Pérez, María Teresa García Mascaraque Pérez*  
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*Publicado por Creaciones Copyright, 2006*  
*ISBN 8496300218, 9788496300217*  
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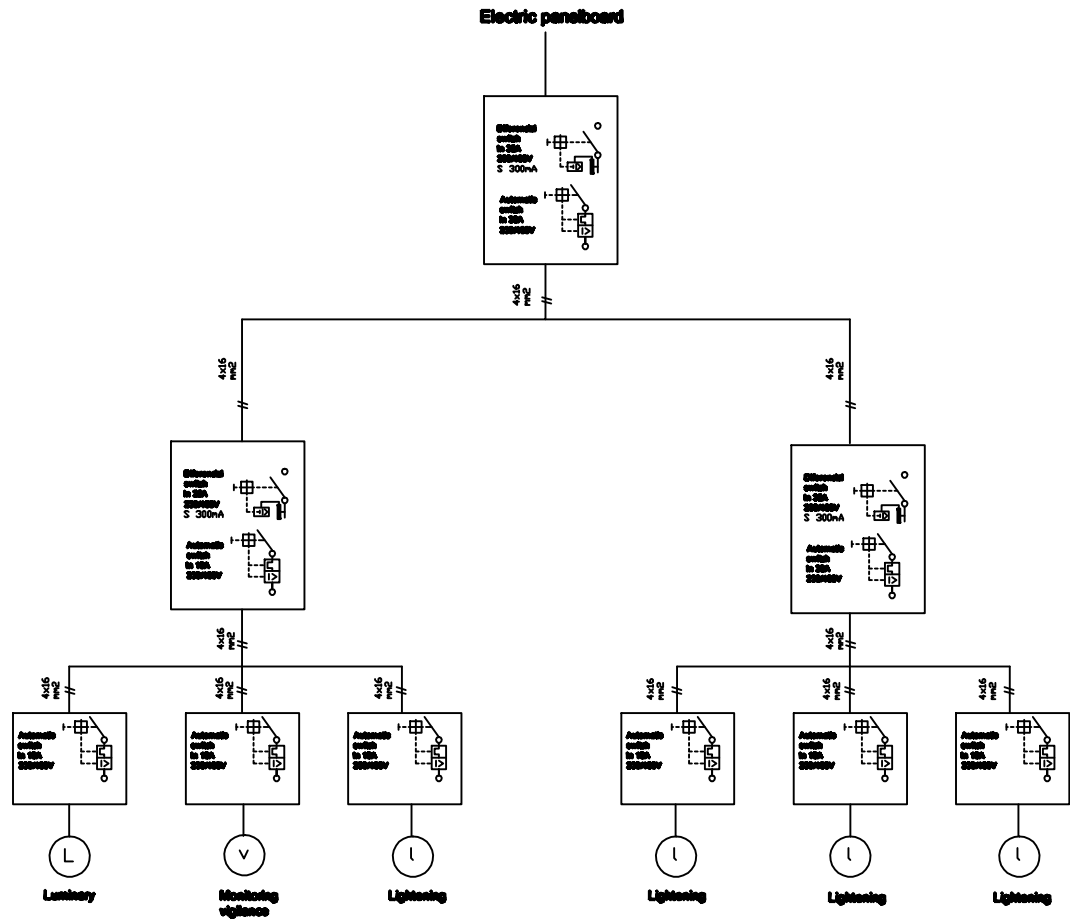
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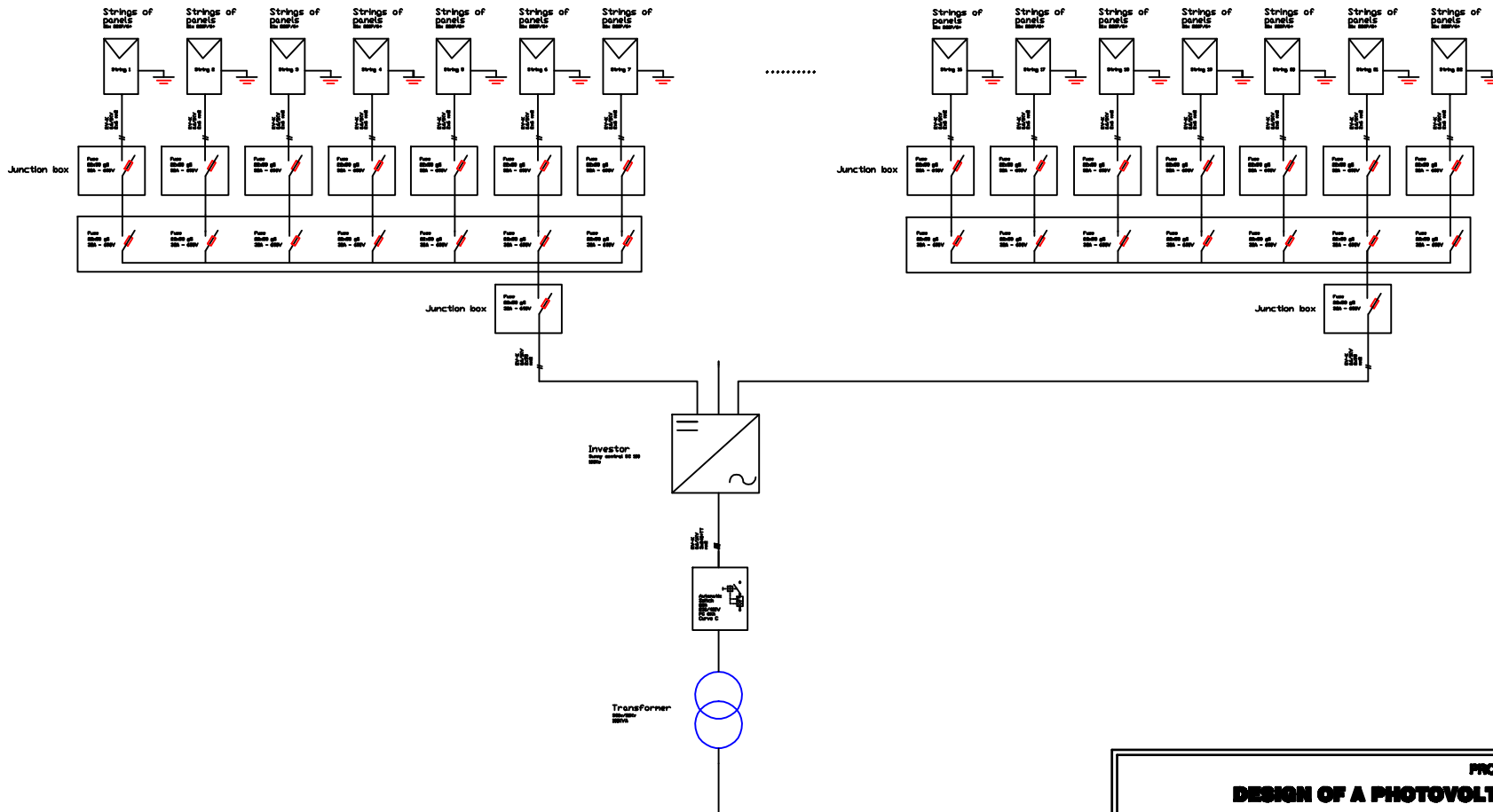
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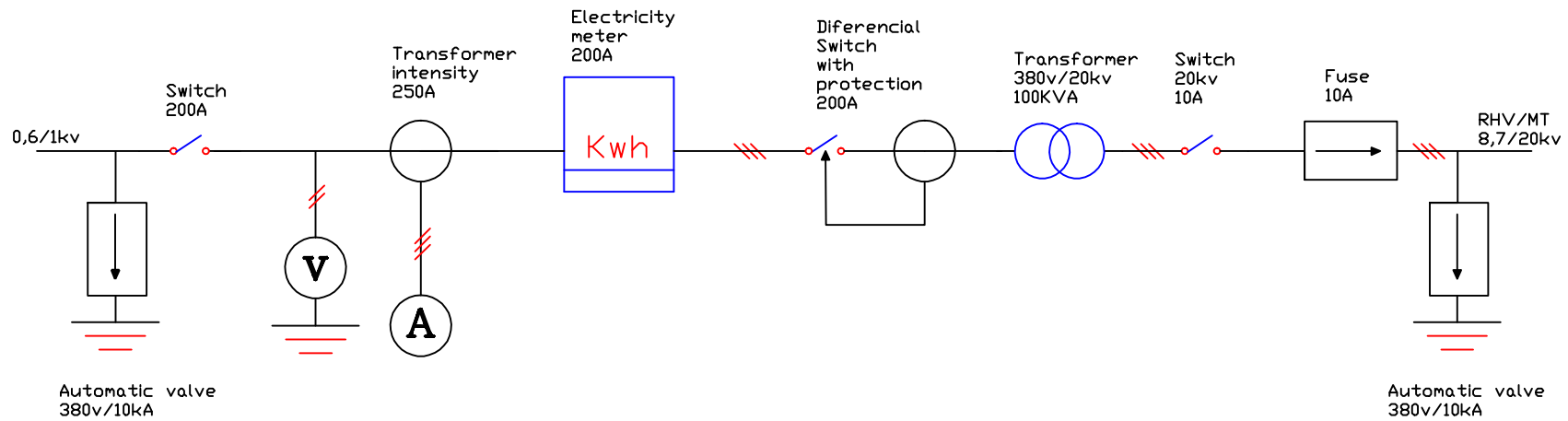
# – PLANES –



<b>PROJECT EXECUTION</b>	
<b>DESIGN OF A PHOTOVOLTAIC FIELD</b>	
CORELLA, SPAIN	
<b>Electrical installation auxiliary</b>	
<b>1 may 2009</b>	
<b>Beng. Electric and electronic engineering /Carlos Arigita Lasheras</b>	
<b>@Cyndur University</b>	<b>Supervisor: Dr. Yandi Hu</b>

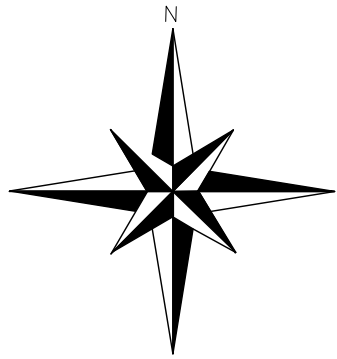


<b>PROJECT EXECUTION</b>	
<b>DESIGN OF A PHOTOVOLTAIC FIELD</b>	
<b>CORRELLA, SPAIN</b>	
<b>General wiring</b>	
<b>1 may 2009</b>	
<b>Beng Electric and electronic engineering /Carlos Arigita Lasheras</b>	
<b>@Cyndur University</b>	
<b>Supervisor:Dr.Yandil Hu</b>	



<b>PROJECT EXECUTION</b>	
<b>DESIGN OF A PHOTOVOLTAIC FIELD</b>	
CORELLA, SPAIN	
<b>Installation of the transformer</b>	
<b>1 may 2009</b>	
<b>Beng. Electric and electronic engineering /Carlos Arigita Lasheras</b>	
<b>@Cyndur University</b>	<b>Supervisor:Dr.Yanli Hu</b>





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PROJECT EXECUTION

### DESIGN OF A PHOTOVOLTAIC FIELD

CORELLA\_SPAIN

Situation on the ground

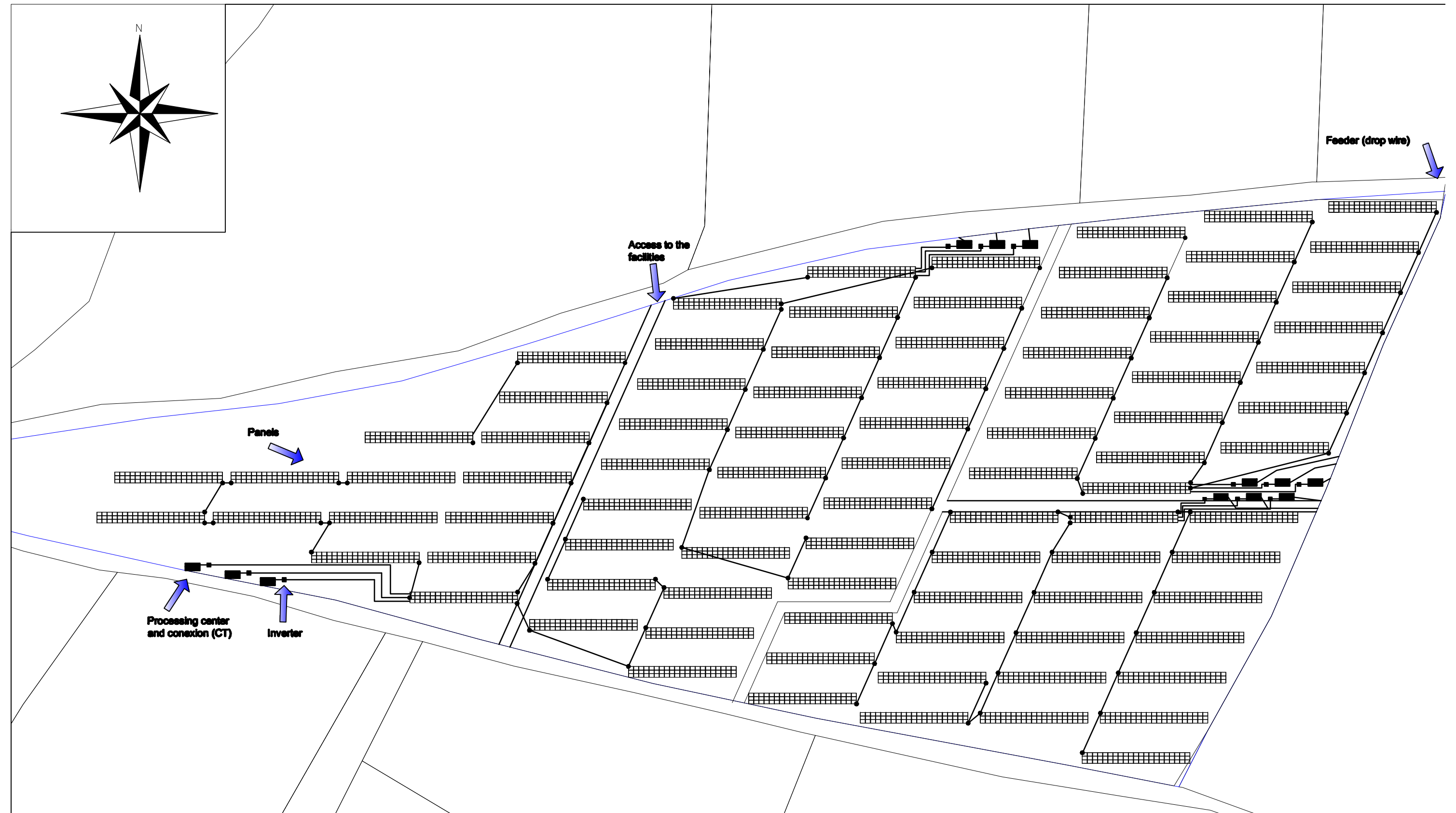
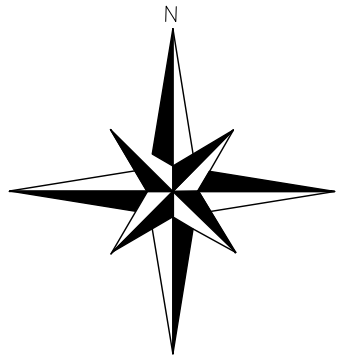
1 may 2009

E:1/1000

Beng.Electric and electronic engineering /Carlos Arigita Lasheras

Glyndwr University

Supervisor:Dr.Yanti Hu



<b>PROJECT EXECUTION</b>	
<b>DESIGN OF A PHOTOVOLTAIC FIELD</b>	
CORELLA_SPAIN	
<b>Distribution of panels</b>	
1 may 2009	E:1/1000
Beng.Electric and electronic engineering /Carlos Arigita Lasheras	
Glyndwr University	Supervisor:Dr.Yanti Hu

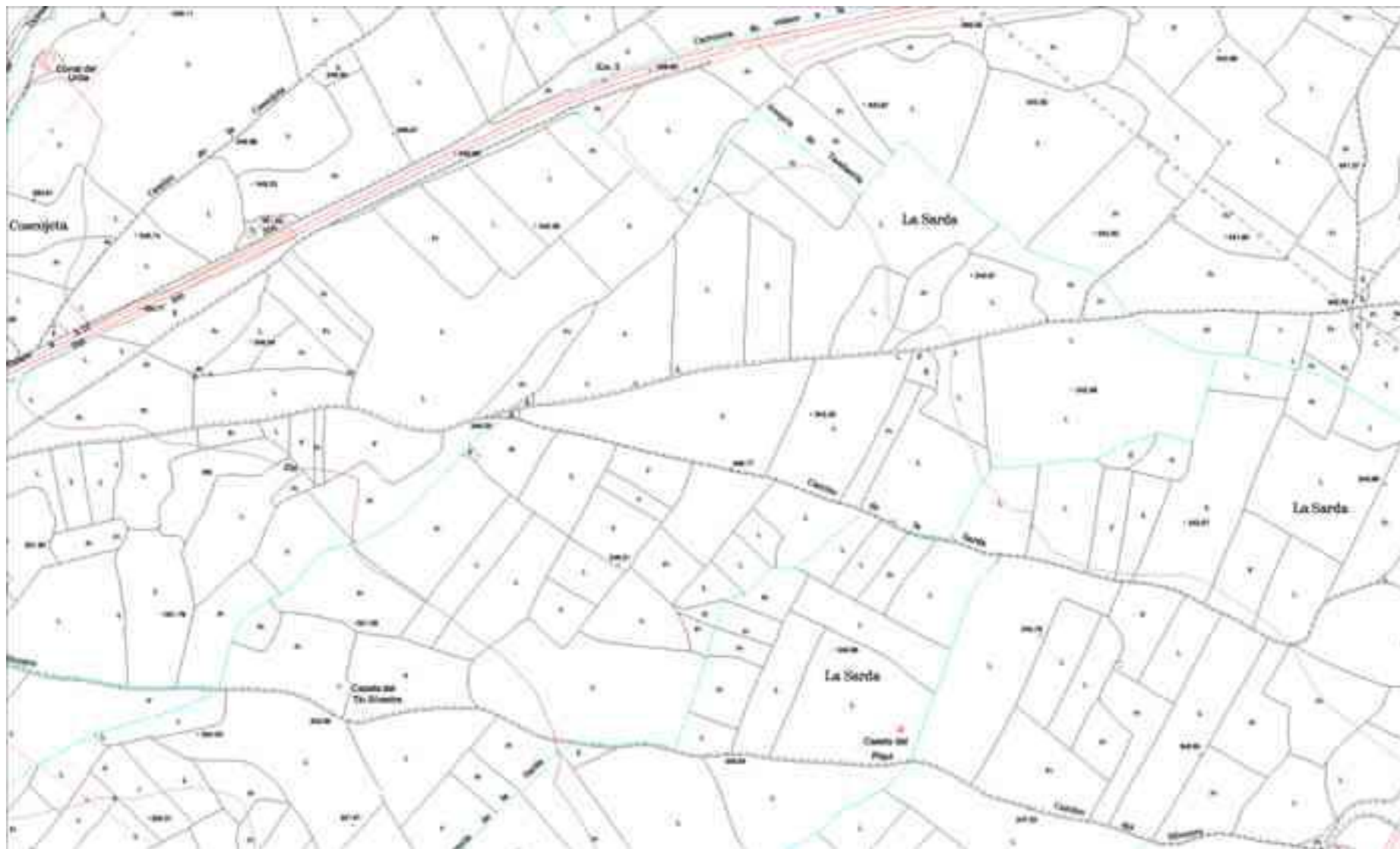


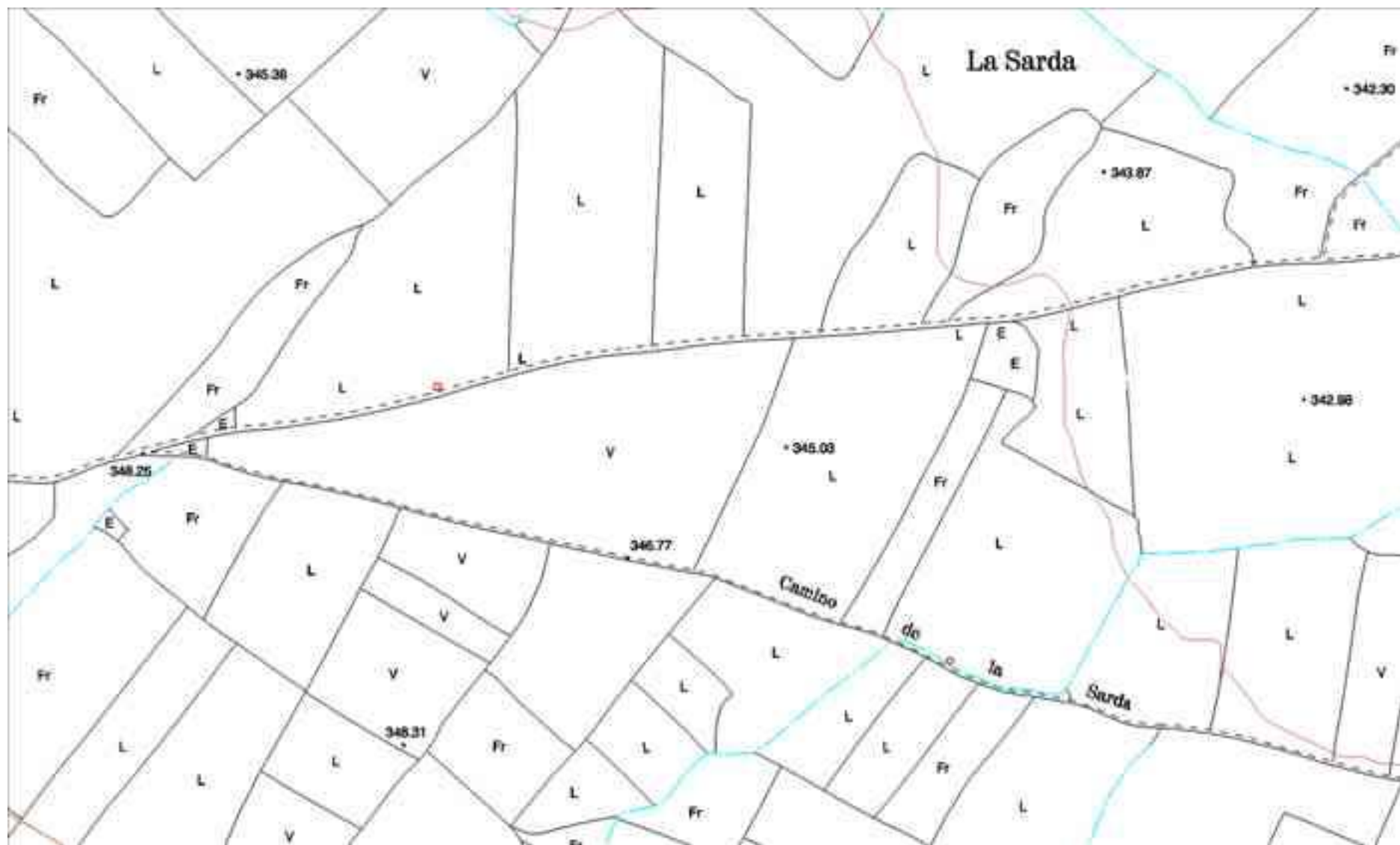
# – APPENDICES –





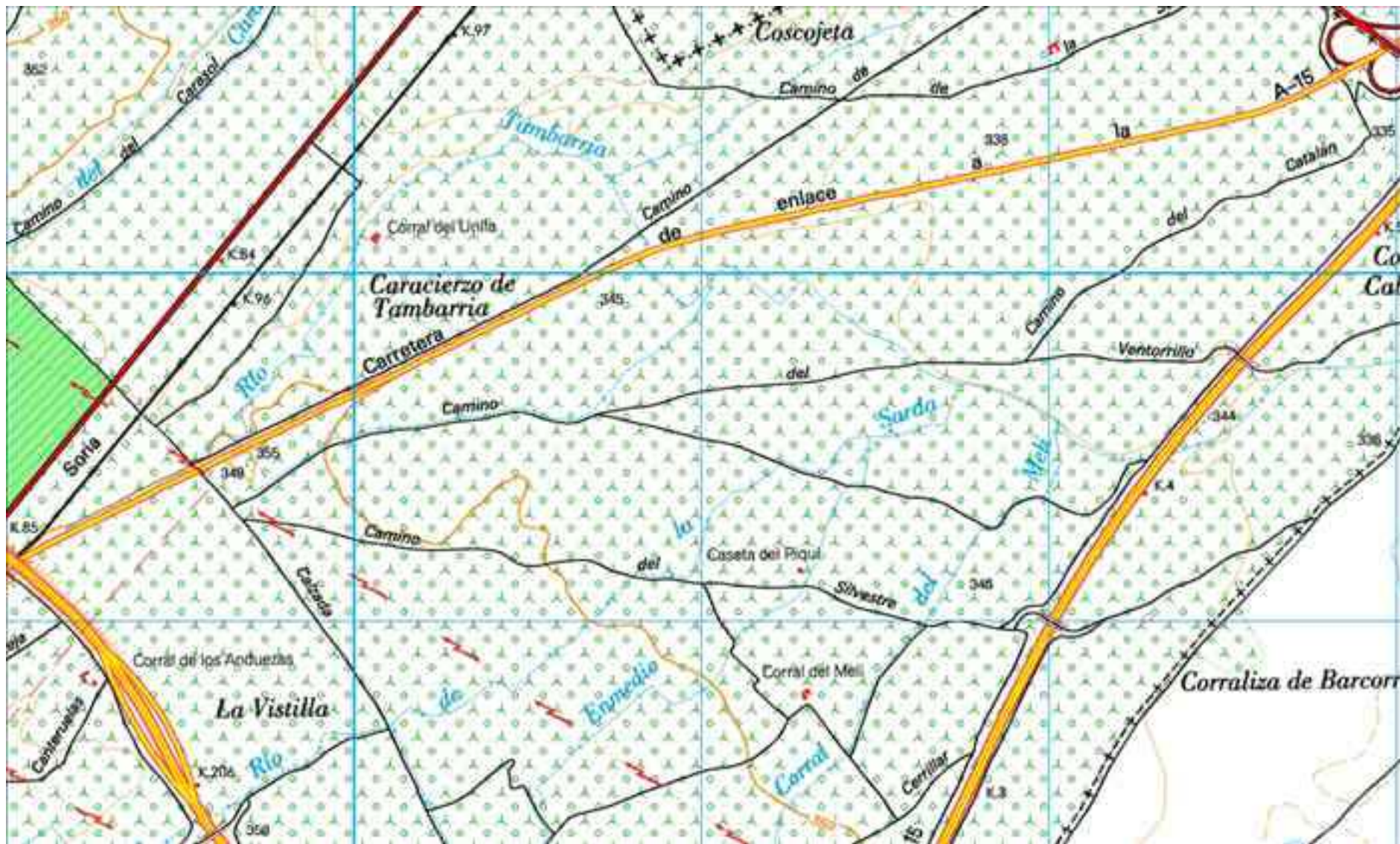












## Incident global irradiation for the chosen location

Location: 42°7'28" North, 1°43'7" West, Elevation: 344 m a.s.l.,

Nearest city: Tudela, Spain (11 km away)

Optimal inclination angle is: 35 degrees

Annual irradiation deficit due to shadowing (horizontal): 0.0 %

Month	Hh	Hopt	H(90)	lopt	T24h	NDD
Jan	1680	2760	2780	63	6.8	315
Feb	2410	3480	3110	55	7.6	255
Mar	3860	4870	3670	44	10.9	172
Apr	4660	5010	2970	27	12.6	117
May	5740	5600	2700	14	16.7	21
Jun	6360	5940	2540	8	21.1	3
Jul	6400	6110	2700	12	23.0	0
Aug	5620	5870	3160	23	22.9	1
Sep	4480	5420	3740	39	19.4	24
Oct	3000	4190	3560	52	15.8	125
Nov	1890	3000	2930	61	9.9	290
Dec	1430	2430	2520	65	6.7	347
Year	3970	4560	3030	35	14.5	1670

Hh: Irradiation on horizontal plane (Wh/m<sup>2</sup>)

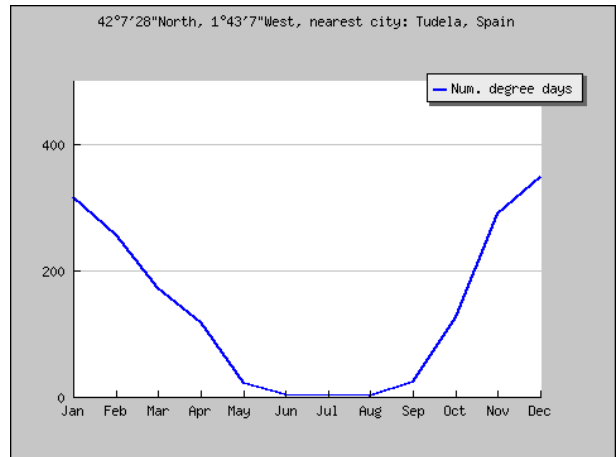
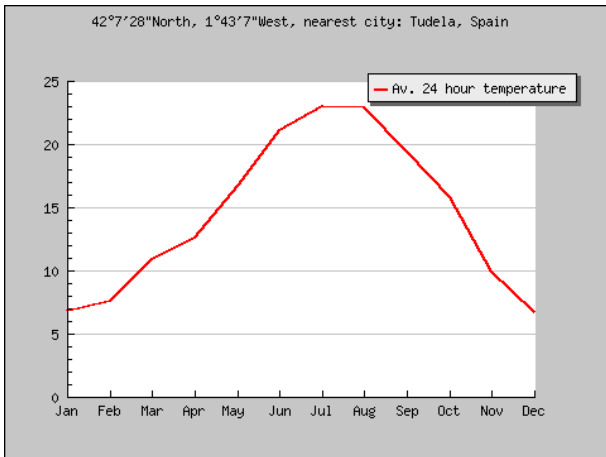
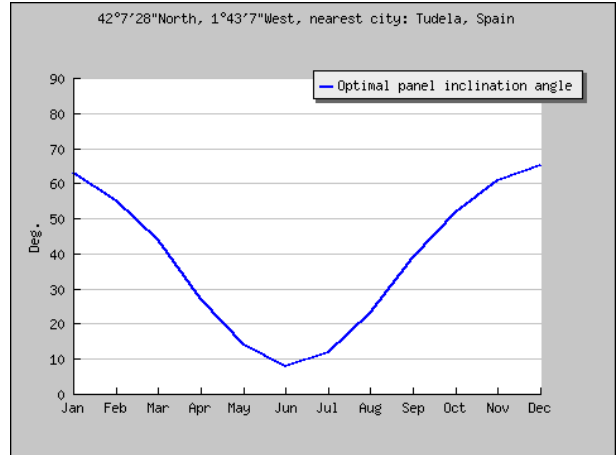
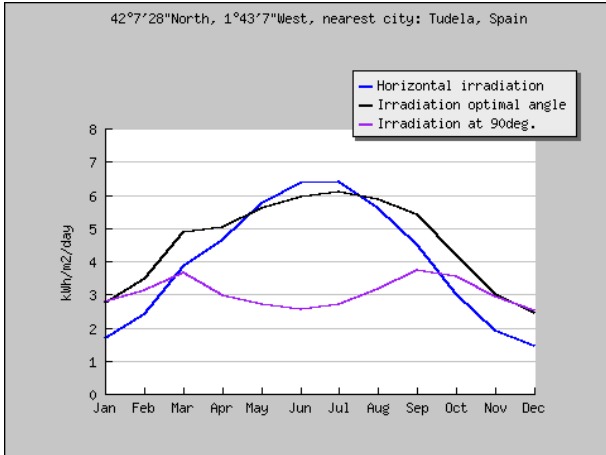
Hopt: Irradiation on optimally inclined plane (Wh/m<sup>2</sup>)

H(90): Irradiation on plane at angle: 90deg. (Wh/m<sup>2</sup>)

lopt: Optimal inclination (deg.)

T24h: 24 hour average of temperature (°C)

NDD: Number of heating degree-days (-)



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## Performance of Grid-connected PV

### PVGIS estimates of solar electricity generation

Location: 42°7'28" North, 1°43'7" West, Elevation: 344 m a.s.l.,  
Nearest city: Tudela, Spain (11 km away)

Nominal power of the PV system: 1800.0 kW (crystalline silicon)  
Estimated losses due to temperature: 9.8% (using local ambient temperature)  
Estimated loss due to angular reflectance effects: 2.7%  
Other losses (cables, inverter etc.): 14.0%  
Combined PV system losses: 24.5%

Fixed system: inclination=35 deg., orientation=0 deg.				
Month	Ed	Em	Hd	Hm
Jan	4020.00	125000	2.76	85.6
Feb	4970.00	139000	3.48	97.5
Mar	6730.00	209000	4.87	151
Apr	6820.00	205000	5.01	150
May	7450.00	231000	5.60	174
Jun	7750.00	232000	5.94	178
Jul	7920.00	245000	6.11	189
Aug	7640.00	237000	5.87	182
Sep	7220.00	217000	5.42	163
Oct	5750.00	178000	4.19	130
Nov	4300.00	129000	3.00	90.0
Dec	3550.00	110000	2.43	75.4
Year	6180.00	188000	4.56	139
Total for year		2260000		1670

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/m<sup>2</sup>)

Hm: Average sum of global irradiation per square meter received by the modules of the given system (kWh/m<sup>2</sup>)

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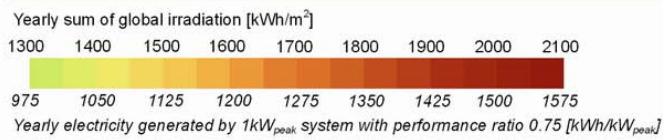
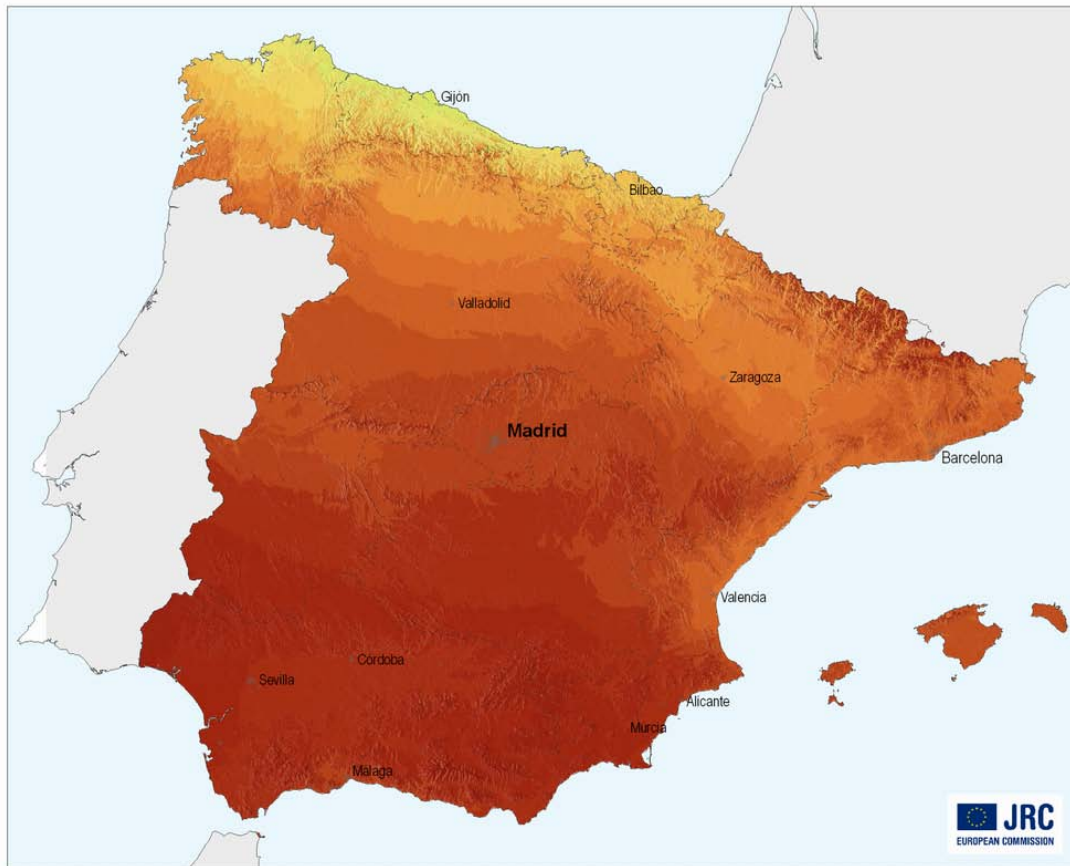
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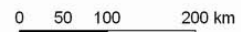
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**Global irradiation and solar electricity potential  
Optimally-inclined photovoltaic modules**

**Spain**

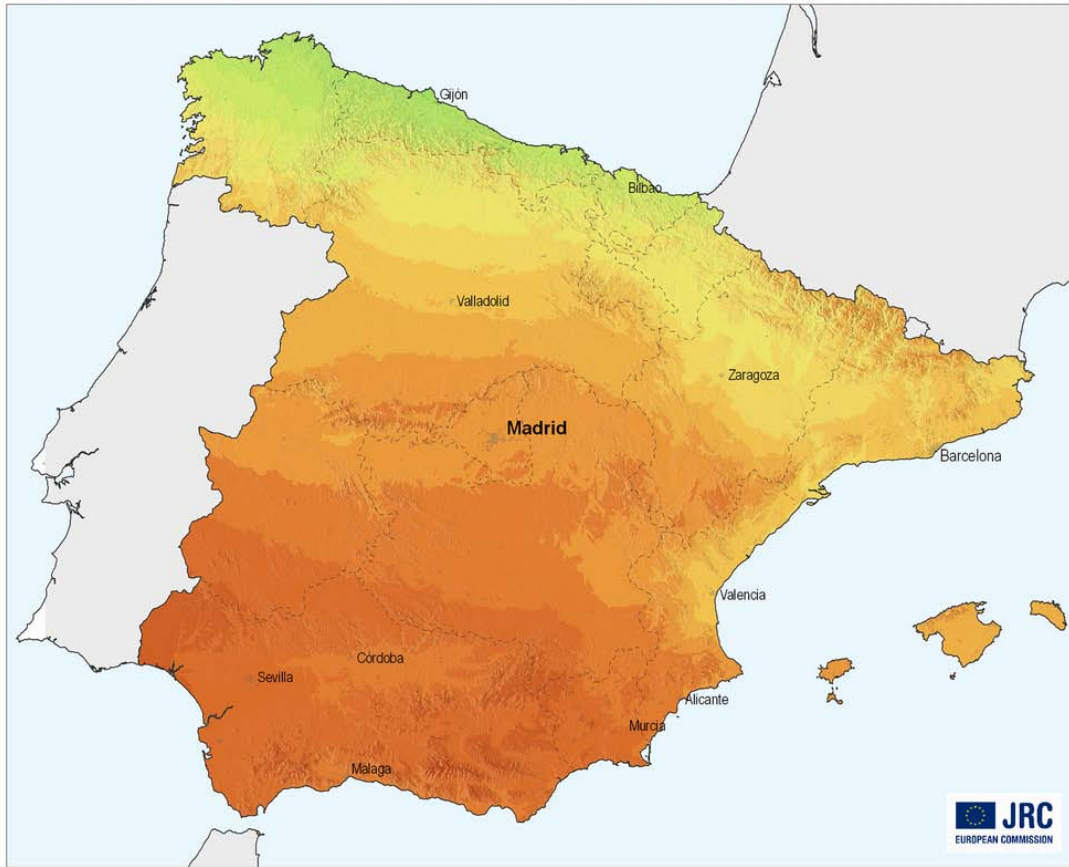


Authors: M. Šúri, T. Cebeauer, T. Huld, E. D. Dunlop  
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**Global irradiation and solar electricity potential**  
Horizontally mounted photovoltaic modules

**Spain**



Yearly sum of global irradiation [kWh/m<sup>2</sup>]

<1100 1200 1300 1400 1500 1600 1700 1800>



<825 900 975 1050 1125 1200 1275 1350>

Yearly electricity generated by 1kW<sub>peak</sub> system with performance ratio 0.75 [kWh/kW<sub>peak</sub>]

Authors: M. Šúri, T. Cebecauer, T. Huld, E. D. Dunlop

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0 50 100 200 km



# SOLON photovoltaic modules

- Reduce CO<sub>2</sub> emissions by 15,000 kg/kW<sub>p</sub> over a 20-year period
- Greater power from the same surface area
- SOLON Solar glass ensures high energy yields
- Individual performance data sheets for each module
- Made in Germany

## Modules

SOLON is one of the main manufacturers of solar modules in Europe, offering its customers only high-grade quality modules. An excellent energy yield is guaranteed because we use high-quality crystalline solar cells and tempered solar glass that is extremely transparent.

## SOLON solar glass

We use special solar glass from well-known German suppliers for manufacturing our photovoltaic modules. This glass has a special surface structure and increased light transmittance. This significantly increases the energy yields of the SOLON solar energy systems – over the entire module lifetime.

## Frames

Our module frames are made from extruded anodised aluminium. They are extremely torsion resistant, have drainage bores, and are suitable for all existing installation systems. Please read our installation notes carefully before beginning installation work. On request SOLON can provide modules without frames.

## Power output guarantee

The module's output will still be 90 percent in 10 years, and 80 percent in 25 years, based on the minimum output levels at delivery. Please find our power output guarantee on our website at [www.solon-pv.com/english/service](http://www.solon-pv.com/english/service).

## Certification

SOLON modules are tested by TÜV (German Technical Inspection Agency), certified according to IEC 61215, and comply with protection class II.

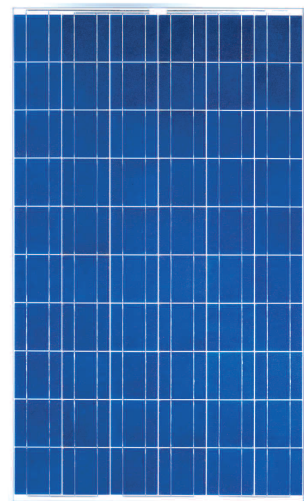
## Contact

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Ederstrasse 16  
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Tel.: + 49-(0)30-8 18 79 100  
Fax: + 49-(0)30-8 18 79 110  
E-mail: [export@solonag.com](mailto:export@solonag.com)  
Internet: [www.solon-pv.de](http://www.solon-pv.de)

# SOLON P220/6+

## Mechanical specifications

Length:	1,660 mm
Width:	990 mm
Height:	42 mm
Weight:	26 kg
Junction box:	A SOLON junction box with bypass diodes
Cable:	Solar cable, length 1,100 mm, 4 mm <sup>2</sup> , prefabricated with MC plug
Front glass:	White toughened safety glass, 4 mm
Cells:	60 pc. polycrystalline Si 6.2" (156 x 156 mm)
Cell encapsulation:	EVA (Ethylene-Vinyl-Acetate)
Back:	Tedlar composite film
Frame:	Anodised aluminium profile
Dimensions of the frameless module:	1,653 x 983 x 5 mm (L x W x H)



## Electrical specifications (typical)

Module class/peak power Pmax (± 3 %):	235 W <sub>p</sub>	230 W <sub>p</sub>	225 W <sub>p</sub>	220 W <sub>p</sub>	215 W <sub>p</sub>	210 W <sub>p</sub>	205 W <sub>p</sub>	200 W <sub>p</sub>
Rated voltage U <sub>mpp</sub> :	29.2 V	29.1 V	29.0 V	28.9 V	28.8 V	28.5 V	28.2 V	27.8 V
Rated current I <sub>mpp</sub> :	8.06 A	7.91 A	7.77 A	7.62 A	7.46 A	7.36 A	7.27 A	7.21 A
Open circuit voltage U <sub>oc</sub> :	36.80 V	36.7 V	36.6 V	36.45 V	36.35 V	36.2 V	35.9 V	35.6 V
Short circuit current I <sub>sc</sub> :	8.70 A	8.52 A	8.37 A	8.25 A	8.18 A	8.11 A	8.05 A	7.98 A
Maximum system voltage:	860 V	860 V	860 V	860 V	860 V	860 V	860 V	860 V
Module efficiency:	14.3 %	14.0 %	13.7 %	13.4 %	13.1 %	12.8 %	12.5 %	12.3 %

Temperature coefficient of open circuit voltage: -0.35 %/K

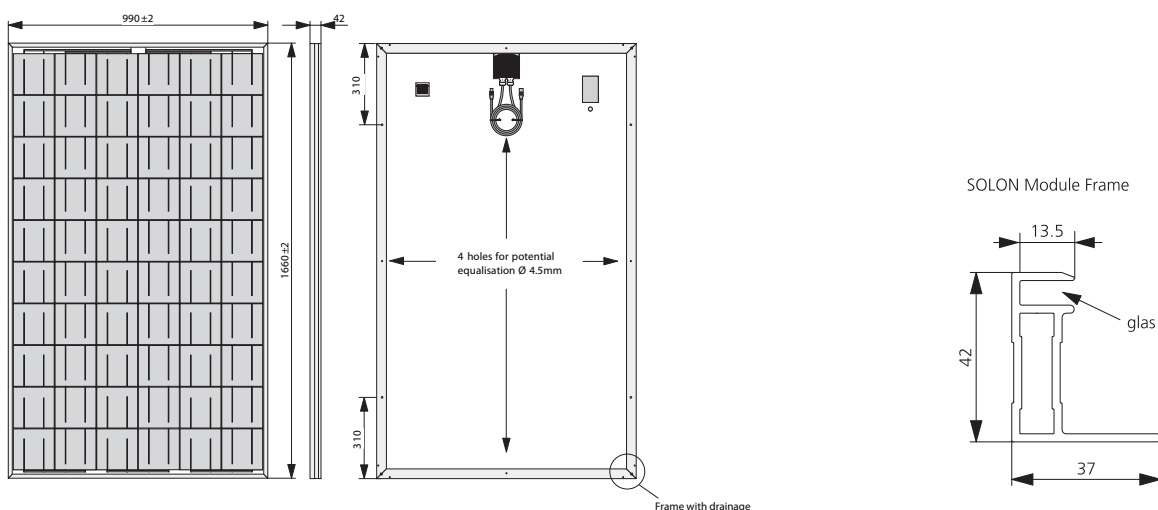
Temperature coefficient of short circuit current: 0.05 %/K

Temperature coefficient of power: -0.44 %/K

These values are effective for irradiation of 1,000 W/m<sup>2</sup>, AM 1.5, and a cell temperature of 25 °C (standard test conditions). The modules can be delivered with their respective data sheets upon request.

## Operating conditions

Temperature range:	-40 °C to +85 °C
Hail:	maximum diameter of 28 mm with impact speed of 86 km/h
Maximum surface load capacity:	tested up to 5,400 Pa according to IEC 61215 (advanced test)





## Datos técnicos

- Magnetotérmico de CC con rearme automático
- Protección contra sobretensión en el lado de CC y de CA
- Regulación opcional de la potencia reactiva
- Aumento del rendimiento mediante Sunny Team (opcional)
- Monitorización de la instalación y evaluación de los datos mediante el registrador de datos integrado
- Posibilidad de monitorización remota vía Internet / GSM / GPRS
- Envío de alarmas de error y estado por correo electrónico o mensaje de texto al móvil
- Monitorización opcional de la corriente de String
- 48 horas de servicio in situ durante un plazo de 20 años (opcional)

	SC 100	SC 150
<b>Valores de entrada</b>		
Potencia FV máx. recomend. (P <sub>FV</sub> )	110 kW <sub>p</sub>	175 kW <sub>p</sub>
Rango de tensión FV, MPPT (U <sub>CC</sub> )	450 V - 820 V	450 V - 820 V
Tensión máx. de CC (U <sub>CC, max</sub> )	900 V	900 V
Corriente máx. de entrada (I <sub>CC, max</sub> )	235 A	354 A
Factor de distorsión de CC (U <sub>pp</sub> )	< 3 %	< 3 %
Número máx. de Strings (en paralelo)	3	5
Protección sobretensión de la CC	sí	sí
<b>Valores de salida</b>		
Potencia nominal de CA (P <sub>CA, nom</sub> )	100 kW	150 kW
Potencia nominal de CA (I <sub>CA, nom</sub> )	145 A	216 A
THD CA	< 3 %	< 3 %
Rango de trabajo tensión de red (U <sub>CA</sub> )	3 x 400 V ± 10 %	3 x 400 V ± 10 %
Frecuencia de red (f <sub>CA</sub> )	50 Hz / 60 Hz	50 Hz / 60 Hz
Factor de potencia (cos φ)	≥ 0,99 a P <sub>AC, nom</sub>	≥ 0,99 a P <sub>AC, nom</sub>
Protección sobretensión de la CA	sí	sí
<b>Rendimiento (tolerancias según IEC 61683)</b>		
Rendimiento máx.	95,7 %	95,3 %
Rendimiento europeo	93,2 %	94,7 %
<b>Grado de protección</b> conforme a DIN EN 60529	IP20	IP20
<b>Peso y dimensiones</b>		
Ancho / alto / fondo (mm)	1200/2120/850	2000/2120/850
Peso	900kg	1450kg
<b>Datos generales</b>		
Consumo propio en funcionamiento	< 1 % P <sub>AC, nom</sub>	< 1 % P <sub>AC, nom</sub>
Consumo propio nocturno	< 50 W	< 50 W
<b>Condiciones ambientales</b>		
Temp./Humedad rel. (sin condensación)	0 a +50 °C* / 15 a 95 %	0 a +40 °C / 15 a 95 %

\* Cumplimiento de los valores nominales hasta una temperatura ambiente de +40 °C

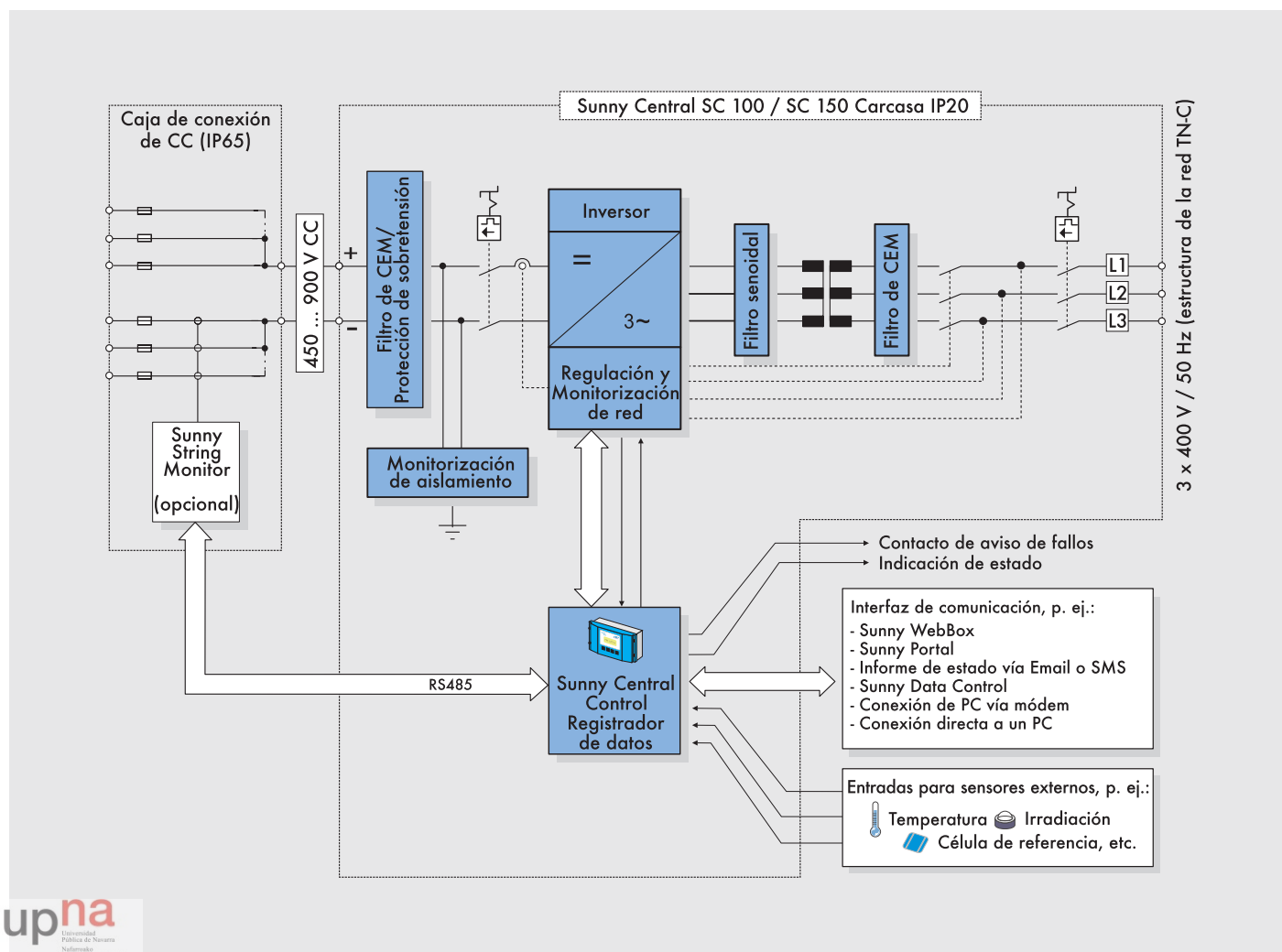
# Sunny Central SC 100, SC 150

## SC 100

Para la conexión de instalaciones en el rango de los 110 kWp el Sunny Central SC 100 es el inversor recomendado de la familia de los inversores centrales. Se emplea con frecuencia en instalaciones homogéneas sobre cubiertas o en "pequeñas" instalaciones en campo abierto. En el lado de CC dispone este inversor de 3 entradas protegidas para la conexión del generador fotovoltaico.

## SC 150

El Sunny Central SC 150 está optimizado para instalaciones de hasta 175 kWp. El SC 150 se emplea frecuentemente tanto en instalaciones en campo abierto como en instalaciones homogéneas sobre cubiertas. En el lado de CC dispone de entradas protegidas para un total de 5 cajas de distribución de CC.





# ORMAZABAL



## Centros de Transformación



**CFI Centro Fotovoltaico Integrado**

Hasta 24 kV



### DESCRIPCIÓN

Solución para la transformación de energía solar en instalaciones fotovoltaicas conectadas a la red de Media Tensión, compuesta por un edificio prefabricado monobloque capaz de albergar el Centro de Transformación y los elementos específicos de este tipo de instalaciones.

**upna**

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Todos los derechos reservados  
Eskubide guztiak erresalbatu dira



## CARACTERÍSTICAS GENERALES

**Centro de Transformación** compuesto por:

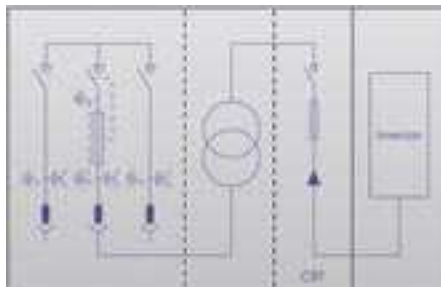
- Envoltorio monobloque de hormigón armado vibrado.
- Celdas de MT.
- Cuadro de BT.
- Transformador BT/MT.

**Recinto de Inversor** independiente:

Diseñado para la ubicación y funcionamiento en condiciones óptimas del inversor.

## EQUIPAMIENTO ELÉCTRICO

- Celdas de MT con aislamiento integral en gas SF<sub>6</sub>, modulares y/o compactas, hasta 24 kV (configuraciones 2L1P, 1L1P, 0L1L1P, ...).
- Transformador de distribución BT/MT hasta 24 kV / 100-160 kVA con llenado integral en aceite (posibilidad en silicona y midel).
- Cuadro de BT con interruptor en carga (160 A y 250 A) y bases portafusibles (disponibilidad de integración de circuitos de Servicios Auxiliares).
- Equipo extractor helicoidal mural para ventilación forzada en el recinto del inversor.
- Posibilidad de ubicación de los inversores más comunes del mercado.



Ejemplo: Configuración con celdas CGMCOSMOS-2LP.

## VENTAJAS

- Solución completa e integrada, con espacios independientes y diferentes accesos, según los requerimientos de la explotación y/o mantenimiento de los equipos.
- Edificio diseñado específicamente para la ubicación en su interior de aparataje eléctrico, teniendo además, entre otras, las siguientes características: resistencia a inclemencias meteorológicas, integración en el entorno y mínimo impacto visual.
- Rendimiento óptimo de ventilación. Mejor control del ambiente, con un menor consumo, al independizar el recinto de Inversor.
- Disminución de costes de obra civil.
- Integración completa de los elementos en fábrica (opcional).

## CARACTERÍSTICAS FÍSICAS

### Dimensiones exteriores

Longitud [mm]	4460
Anchura [mm]	2380
Altura vista [mm]	2585

Peso envoltorio (vacía) [kg]	12000
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Nota: Para otras configuraciones / valores consultar a nuestro Departamento Técnico-Comercial.

**RETENAX FLEX RV-K**

UNE 21123-2

**CARACTERÍSTICAS CABLE**

Cable flexible



Resistencia a la absorción de agua



Resistencia a los rayos ultravioletas



Resistencia al filo



Resistencia a los agentes químicos



Resistencia a las grasas y aceites



No propagación de la llama



No propagación del incendio



Reducida emisión de halógenos

- Norma constructiva: UNE 21123-2.
- Temperatura de servicio (instalación fija): -25 °C, +90 °C.
- Tensión nominal de servicio: 0,6/1 kV.
- Ensayo de tensión en c.a. durante 5 minutos: 3500 V.

**Ensayos de fuego:**

- No propagación de la llama: UNE EN 50265-2-1 ; IEC 60332-1 ; NFC 32070-C2.
- No propagación del incendio: IEEE 383.
- Reducida emisión de halógenos: UNE EN 50267-2-1 ; IEC 60754-1 ; Emisión ClH < 14%

**DESCRIPCIÓN****CONDUCTOR:****Metal:**

Cobre electrolítico recocido.

**Flexibilidad:**

Clase 5, según UNE 21022.

**Temperatura máxima en el conductor:**

90 °C en servicio permanente, 250 °C en cortocircuito.

**AISLAMIENTO:****Material:**

Mezcla de polietileno reticulado (XLPE), tipo DIX3 según HD 603-1.

**Colores:**

Amarillo/verde, azul, gris, marrón y negro; según UNE 21089-1.

(Ver tabla de colores según número de conductores).

**CUBIERTA:****Material:**

Mezcla de policloruro de vinilo (PVC), tipo DMV-18 según HD 603-1.

**Colores:**

• Negro, con franja en color identificativa de la sección y que permite escribir sobre la misma para identificar circuitos.

• Blanco, suministrado en cajas en las secciones: 2x1,5, 2x2,5, 3G1,5, 3G2,5.

**APLICACIONES**

• Para redes de distribución, acometidas, instalaciones de alumbrado exterior e instalaciones industriales al aire o enterradas, en las que se requiere una mayor facilidad de manipulación, manteniendo al mismo tiempo unas prestaciones elevadas frente a sobrecargas y cortocircuitos.

- Redes subterráneas de distribución (ITC-BT 07).
- Instalaciones subterráneas (ITC-BT 07).
- Alumbrado exterior subterráneo (ITC-BT 09).
- Instalaciones interiores o receptoras (ITC-BT 20).

No está permitido en instalaciones provisionales en general (obras, ferias, stands...ITC-BT 33 y 34) ni para servicios móviles. (Ver Pireflex)

## RETENAX FLEX RV-K



UNE 21128-2

## FRANJAS LONGITUDINALES DE COLORES IRISTECH DE LA CUBIERTA

SECCIÓN	COLOR	SECCIÓN	COLOR	SECCIÓN	COLOR
1,5	Rojo	6	Gris	25	Amarillo
2,5	Azul	10	Naranja	35	Verde
4	Marrón	16	Azul Claro	>35	Blanco

## CABLES DISPONIBLES EN STOCK\*

## SECCIONES DISPONIBLES EN STOCK

1 CONDUCTOR (NE)				4 COND.(AZ-GR-MA-NE)			
1 x 2,5	1 x 4	1 x 6	1 x 10	**4 G 1,5	**4 G 2,5	**4 G 4	**4 G 6
1 x 16	1 x 25	1 x 35	1 x 50	4 x 6	**4 G 10	4 x 10	**4 G 16
1 x 70	1 x 95	1 x 120	1 x 150	4 x 16	4 x 25	4 x 35	4 x 50
1 x 185	1 x 240	1 x 300	-	4 x 70	4 x 95	4 x 120	4 x 150
2 COND.(AZ-MA)				4 x 185	4 x 240	-	-
2 x 1,5	2 x 2,5	2 x 4	2 x 6	5 COND.(AV-AZ-GR-MA-NE)			
2 x 10	2 x 16	-	-	5 G 1,5	5 G 2,5	5 G 4	5 G 6
3 COND.(AV-AZ-MA)				5 G 10	5 G 16	5 G 25	5 G 35
3 G 1,5	3 G 2,5	3 G 4	3 G 6				
3 G 10	3 G 16	-	-				

\*Sujeto a modificaciones,(consultar tarifa vigente).

\*\*AV-GR-MA-NE

Código de colores: AV-Amarillo/Verde ; AZ-Azul ; GR-Gris ; MA-Marrón ; NE-Negro

Nota: La "G", en lugar del signo "x", indica que el conductor de protección es "amarillo/verde".

## CARACTERÍSTICAS TÉCNICAS

## CÁLCULO DE LA CAÍDA DE TENSIÓN

SECCIÓN NOMINAL mm <sup>2</sup>	TRES CABLES UNIPOLARES		UN CABLE TRIPOLAR	
	cos φ = 1	cos φ = 0,8	cos φ = 1	cos φ = 0,8
1,5	26,5	21,36	26,94	21,27
2,5	15,92	12,68	16,23	13,1
4	9,96	8,1	10,16	8,23
6	6,74	5,51	6,87	5,59
10	4	3,31	4,06	3,34
16	2,51	2,12	2,56	2,13
25	1,59	1,37	1,62	1,38
35	1,15	1,01	1,17	1,01
50	0,85	0,77	0,86	0,77
70	0,59	0,56	0,6	0,56
95	0,42	0,43	0,43	0,42
120	0,34	0,36	0,34	0,35
150	0,27	0,31	0,28	0,3
185	0,22	0,26	0,22	0,26
240	0,17	0,22	0,17	0,21
300	0,14	0,19	0,14	0,18
400	0,11	0,17	0,11	0,16

Para determinar la caída de tensión, en V, se multiplicará el coeficiente de la tabla por la corriente que recorre el cable, en A, y por la longitud de la línea en km. Los valores de la tabla se refieren a corriente alterna trifásica; para corriente monofásica pueden tomarse los mismos valores resultantes, multiplicados por 1,15.



**RETENAX FLEX RV-K**

UNE 21128-2

**DIMENSIONES, PESOS Y RESISTENCIAS (Aproximados)**

SECCIÓN NOMINAL mm <sup>2</sup>	ESPESOR DE AISLAMIENTO mm	DIÁMETRO EXTERIOR mm	PESO TOTAL kg/km	RESISTENCIA DEL CONDUCTOR A 20 °C Ω/km
1 x 1,5	0,7	5,7	42	13,3
1 x 2,5	0,7	6,2	54	7,98
1 x 4	0,7	6,6	70	4,95
1 x 6	0,7	7,2	91	3,3
1 x 10	0,7	8,3	135	1,91
1 x 16	0,7	9,4	191	1,21
1 x 25	0,9	11	280	0,78
1 x 35	0,9	12,5	389	0,554
1 x 50	1	14,2	537	0,386
1 x 70	1,1	15,8	726	0,272
1 x 95	1,1	17,9	968	0,206
1 x 120	1,2	18,9	1170	0,161
1 x 150	1,4	21,2	1460	0,129
1 x 185	1,6	23,8	1830	0,106
1 x 240	1,7	26,7	2310	0,0801
1 x 300	1,8	29,3	3100	0,0641
2 x 1,5	0,7	8,7	95	13,3
2 x 2,5	0,7	9,6	125	7,98
2 x 4	0,7	10,5	165	4,95
2 x 6	0,7	11,7	215	3,3
2 x 10	0,7	13,9	330	1,91
2 x 16	0,7	16,9	503	1,21
2 x 25	0,9	20,6	775	0,78
2 x 35	0,9	23,6	1060	0,554
2 x 50	1	27	1470	0,386
3 x 1,5	0,7	9,2	110	13,3
3 x 2,5	0,7	10,1	150	7,98
3 x 4	0,7	11,1	200	4,95
3 x 6	0,7	12,3	270	3,3
3 x 10	0,7	14,7	415	1,91
3 x 16	0,7	18	639	1,21
3 x 25	0,9	21,4	946	0,78
3 x 35	0,9	25,1	1355	0,554
3 x 50	1	28,8	1900	0,386
3 x 70	1,1	32,3	2550	0,272

**RETENAX FLEX RV-K**

UNE 21123-2

SECCIÓN NOMINAL mm <sup>2</sup>	ESPESOR DE AISLAMIENTO mm	DIÁMETRO EXTERIOR mm	PESO TOTAL kg/km	RESISTENCIA DEL CONDUCTOR A 20 °C Ω/km
3 x 95	1,1	35,9	3290	0,206
3 x 120	1,2	39,2	4060	0,161
3 x 150	1,4	44,2	5070	0,129
3 x 185	1,6	50,3	6400	0,106
3 x 240	1,7	56,7	8200	0,0801
3 x 300	1,8	62,2	10450	0,0641
4 x 1,5	0,7	9,9	135	13,3
4 x 2,5	0,7	11	180	7,98
4 x 4	0,7	12,1	245	4,95
4 x 6	0,7	13,5	330	3,3
4 x 10	0,7	16,2	520	1,91
4 x 16	0,7	19,9	796	1,21
4 x 25	0,9	24	1240	0,78
4 x 35	0,9	27,7	1700	0,554
4 x 50	1	32,2	2430	0,386
4 x 70	1,1	35,8	3260	0,272
4 x 95	1,1	39,8	4210	0,206
4 x 120	1,2	43,7	5178	0,161
4 x 150	1,4	49,5	6476	0,129
4 x 185	1,6	56,1	8778	0,106
4 x 240	1,7	63,2	10526	0,0801
5 x 1,5	0,7	10,8	160	13,3
5 x 2,5	0,7	12	215	7,98
5 x 4	0,7	13,2	300	4,95
5 x 6	0,7	14,8	400	3,3
5 x 10	0,7	17,7	630	1,91
5 x 16	0,7	21,8	976	1,21
5 x 25	0,9	26,2	1460	0,78
5 x 35	0,9	30,6	2070	0,55

# Protecciones industriales Cilíndricos



## Fusibles Cilíndricos Industriales

gG

### FUSIBLES CILINDRICOS INDUSTRIALES gG

TAMAÑO	I <sub>n</sub> (A)	REFERENCIA		U (V)	POTENDE CORTE (kA)	REFERENCIA		U (V)	POTENDE CORTE (kA)	Unid./CAJA
		SIN indicador	CON indicador			CON percutor				
22x58	2	422002	422102	690	80					10/50
	4	422004	422104	690	80	422204	690	80		10/50
	6	422006	422106	690	80	422206	690	80		10/50
	8	422008	422108	690	80	422208	690	80		10/50
	10	422010	422110	690	80	422210	690	80		10/50
	12	422012	422112	690	80	422212	690	80		10/50
	16	422016	422116	690	80	422216	690	80		10/50
	20	422020	422120	690	80	422220	690	80		10/50
	25	422025	422125	690	80	422225	690	80		10/50
	32	422032	422132	690	80	422232	690	80		10/50
	40	422040	422140	690	80	422240	690	80		10/50
	50	422050	422150	690	80	422250	690	80		10/50
	63	422063	422163	690	80	422263	690	80		10/50
	80	422080	422180	500	120	422280	500	120		10/50
	100	422000	422100	500	120	422200	500	120		10/50
125	422015	422115	400	120	422215	400	120		10/50	



### NEUTROS

TAMAÑO	I <sub>n</sub> (A)	REFERENCIA	Unid./CAJA
8x31	N	430000	10/100
10x38	N	431000	10/100
14x51	N	432000	10/50
22x58	N	433000	10/50



NORMAS IEC 60269-1 · IEC 60269-2 · IEC 60269-3-1 · EN 60269-1 · EN 60269-2

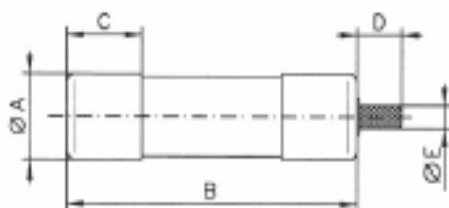


# Protecciones industriales Cilíndricos



## Fusibles y Bases Cilíndricos Industriales [CARACTERÍSTICAS TÉCNICAS]

### FUSIBLES CILINDRICOS INDUSTRIALES



TAMAÑO	A	B	C	D	E
8,5x31,5	8,5	31,5	6,3	-	-
10,3x38	10,3	38	10	-	-
14,3x51	14,3	51	13	8	4
22,2x58	22,2	58	16	8	4

NORMAS IEC 60269-1 · IEC 60269-2 · IEC 60269-3-1 · EN 60269-1 · EN 60269-2



2022

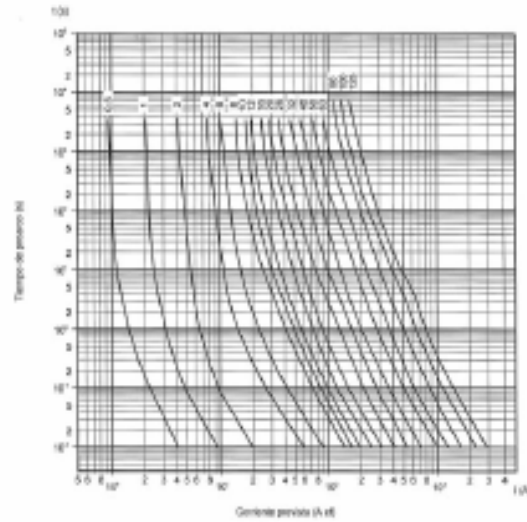


# Protecciones industriales Cilíndricos

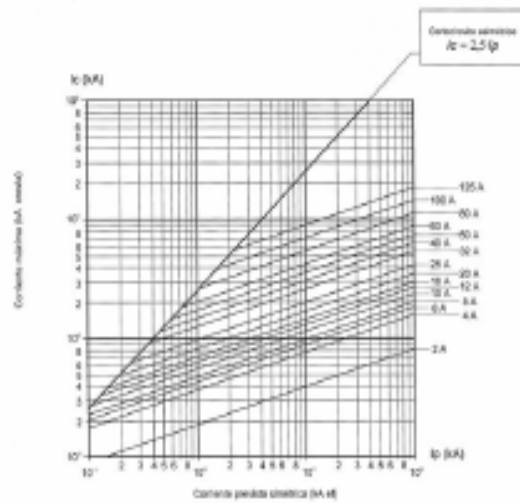
Fusibles Cilíndricos Industriales [ CARACTERÍSTICAS TÉCNICAS ]

gG

## CARACTERÍSTICAS t-I



## CARACTERÍSTICAS DE LIMITACION



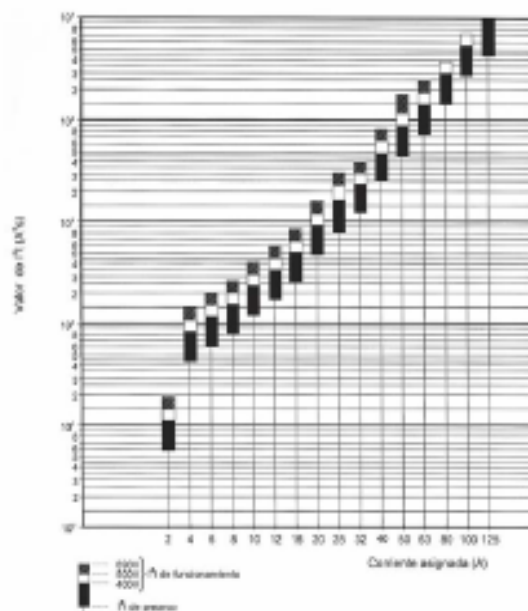
NORMAS IEC 60269-1 - IEC 60269-2 - IEC 60269-2-1 - EN 60269-1 - EN 60269-2

# Protecciones industriales Cilíndricos



Fusibles Cilíndricos Industriales [ CARACTERISTICAS TECNICAS ]

## CARACTERISTICAS I<sup>2</sup>t



## POTENCIAS DISIPADAS (W)

In (A)	TAMAÑO			
	8,5x31,5 (W)	10x38 (W)	14x51 (W)	22x68 (W)
0,5	1,2	1,43	—	—
1	2,0	2,77	3,90	—
2	0,5	0,60	0,90	1,00
4	0,8	0,70	1,00	1,10
6	1,1	0,85	1,15	1,30
8	1,3	0,75	1,00	1,10
10	1,0	1,00	1,30	1,60
12	1,2	1,30	1,70	1,80
16	1,5	1,60	2,00	2,10
20	2,0	2,00	2,60	2,70
25	2,6	2,60	3,30	3,30
32	—	2,90	3,60	3,60
40	—	—	4,75	4,00
50	—	—	4,80	5,60
63	—	—	—	6,90
80	—	—	—	7,80
100	—	—	—	9,00
125	—	—	—	11,4

NORMAS IEC 60269-1 · IEC 60269-2 · IEC 60269-3-1 · EN 60269-1 · EN 60269-2





# Protecciones industriales NH

## Cartuchos fusibles NH (APR) Industriales

### gL/gG 500V



Cartuchos fusibles de cuchilla (NH) clase gG, de alto poder de corte, para protección de uso general tanto ante sobrecargas como cortocircuitos, indicado como protección de líneas o equipos en tensiones nominales hasta 500V. Modelos compactos en intensidades inferiores de cada talla. Indicador doble frontal/superior, para una óptima visualización tanto en bases abiertas como en seccionadores tripolares cerrados. Construidos con cuerpo cerámico de alta resistencia a la presión interna y a los choques térmicos, lo que permite un alto poder de corte. Fabricados según normas IEC, EN, VDE y DIN. Certificación VDE.

### FUSIBLES NH gG 500V DOBLE INDICADOR

TAMAÑO	$I_n$ (A)	REFERENCIA	U (V)	Potencia/corte (kA)	Unid./CAJA
T-00					
NH000   C00	2	376000	500	120	3/60
	4	376005	500	120	3/60
	6	376010	500	120	3/60
	10	376015	500	120	3/60
	16	376020	500	120	3/60
	20	376025	500	120	3/60
	25	376030	500	120	3/60
	32	376035	500	120	3/60
	35	376040	500	120	3/60
	40	376045	500	120	3/60
	50	376050	500	120	3/60
	63	376055	500	120	3/60
	80	376060	500	120	3/60
	100	376065	500	120	3/60
NH00	125	376070	500	120	3/60
	160	376075	500	120	3/60



TAMAÑO	$I_n$ (A)	REFERENCIA	U (V)	Potencia/corte (kA)	Unid./CAJA
T-0					
NH0	6	376110	500	120	3/30
	10	376115	500	120	3/30
	16	376120	500	120	3/30
	20	376125	500	120	3/30
	25	376130	500	120	3/30
	32	376135	500	120	3/30
	35	376140	500	120	3/30
	40	376145	500	120	3/30
	50	376150	500	120	3/30
	63	376155	500	120	3/30
	80	376160	500	120	3/30
	100	376165	500	120	3/30
	125	376170	500	120	3/30
	160	376175	500	120	3/30



400000



**NORMAS** IEC 60269-1 · IEC 60269-2 · IEC 60269-2-1 · EN 60269-1 · EN 60269-2 · VDE 0636 · DIN 43620

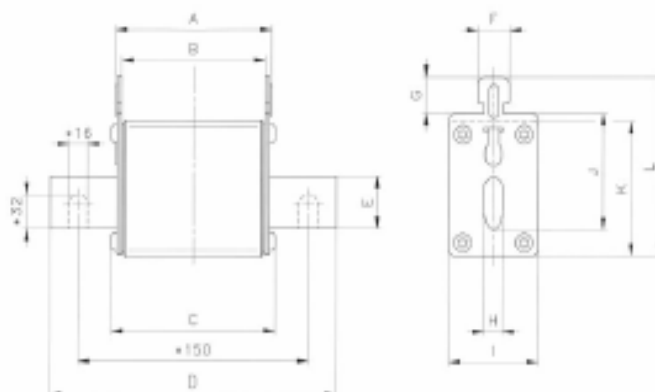
Dimensiones pág. 48  
 Características I<sup>2</sup>t y limitación pág. 50  
 Características I<sup>2</sup>t y potencias disipadas pág. 51  
 Utilización de los fusibles DF ELECTRIO en corriente continua (DC) pág. 204

40



# Protecciones industriales NH

Cartuchos fusibles NH (APR) Industriales [CARACTERÍSTICAS TÉCNICAS]



## FUSIBLES NH gG 500V

TAMAÑO	A	B	C	D	E	F	G	H	I	J	K	L
NH000	49	45	52,5	79	15	9,8	9,5	6	20,5	36	41	52,5
NH00	49	44	52,5	79	15	9,8	9,5	6	30	36	47	59
NH0	66	60,5	67	126	15	9,8	9,5	6	30	36	47	59,5
NH C1	68	62	70	136	15	9,8	9,5	6	30	40	47	65
NH1	68	62	72	136	20	9,8	9,5	6	40	40	52	64
NH C2	68	62	71,5	150	20	9,8	9,5	6	40	48	52	72
NH2	68	62	71,5	150	25	9,8	9,5	6	54	48	60	72
NH C3	68	62	71,5	150	26	9,8	9,5	6	54	60	60	85
NH3	68	61,5	72	150	32	9,8	9,5	6	70	59,5	75	86
NH4	68	62	84	200	50	9,8	10	8	103	87	103	119

## FUSIBLES NH gG 690V

TAMAÑO	A	B	C	D	E	F	G	H	I	J	K	L
NH000	49	44,5	51,5	79	15	9,8	9,5	6	20	36	40	52,5
NH00	49	44,5	51,5	79	15	9,8	9,5	6	29	36	47	59
NH C0	67,5	62,5	66	126	15	9,8	9,5	6	20	36	40	52,5
NH0	67	62,5	65,5	126	15	9,8	9,5	6	29	36	47	59
NH1	68	62	70	136	20	9,8	9,2	6	60	40	50	64
NH2	68	62	71	150	26	9,8	9,2	6	58	48	58	72
NH3	66,5	61,5	72	150	32	9,8	10	6	67	59,5	67	83

## FUSIBLES NH aM

TAMAÑO	A	B	C	D	E	F	G	H	I	J	K	L
NH000	49	44,5	51,5	79	15	9,8	9,5	6	20	36	40	52,5
NH00	49	44,5	51,5	79	15	9,8	9,5	6	29	36	47	59
NH C0	67,5	62,5	66	126	15	9,8	9,5	6	20	36	40	52,5
NH0	67	62,5	65,5	126	15	9,8	9,5	6	29	36	47	59
NH1	67	61,5	72	136	20	9,8	10	6	48	39,5	48	64
NH2	67	61,5	72	150	26	9,8	10	6	58	47,5	58	72
NH3	66,5	61,5	72	150	32	9,8	10	6	67	59,5	67	83

NORMAS IEC 60269-1 · IEC 60269-2 · IEC 60269-2-1 · EN 60269-1 · EN 60269-2 · VDE 0636 · DIN 43620



410



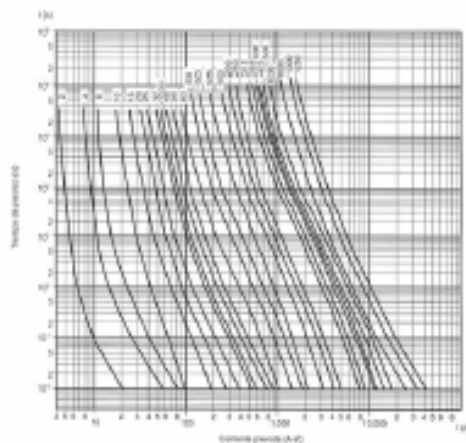


# Protecciones industriales NH

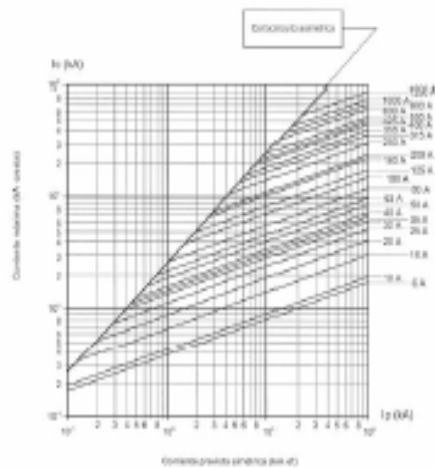
Fusibles NH gG 500V [ CARACTERISTICAS TECNICAS ]

gL/gG

## CARACTERISTICAS t-I



## CARACTERISTICAS DE LIMITACION



NORMAS IEC 60269-1 · IEC 60269-2 · IEC 60269-3-1 · EN 60269-1 · EN 60269-2 · VDE 0436 · DIN 43420

50

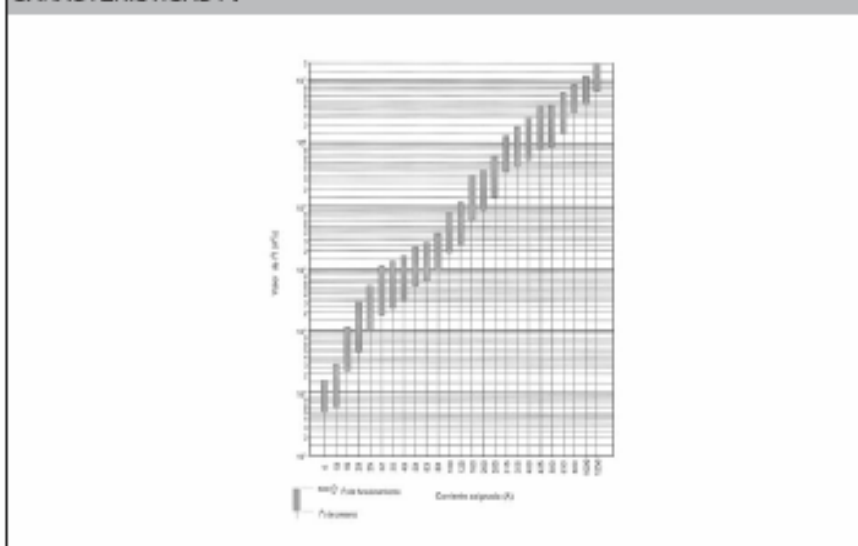
# Protecciones industriales NH



Fusibles NH gG 500V [CARACTERISTICAS TECNICAS]

gL/gG

## CARACTERISTICAS It



## POTENCIAS DISIPADAS (W)


In (A)	TAMAÑO							
	000	00	0	1	2	3	4	
2	0,68	-	-	-	-	-	-	
4	0,70	-	-	-	-	-	-	
6	0,80	-	1,1	-	-	-	-	
10	1,5	-	1,7	-	-	-	-	
16	2,3	-	3,0	-	-	-	-	
20	2,2	-	3,2	-	-	-	-	
25	2,8	-	3,2	-	-	-	-	
32	3,7	-	4,8	-	-	-	-	
35	3,7	-	4,4	-	-	-	-	
40	4,0	-	4,7	-	-	-	-	
50	4,9	-	6,3	6,7	-	-	-	
63	4,5	-	5,6	5,6	6,0	-	-	
80	6,3	-	7,1	7,1	7,0	-	-	
100	7,4	-	7,5	7,1	8,0	-	-	
125	-	10,0	10,0	11,6	12,0	-	-	
160	-	10,0	11,5	12,3	12,0	-	-	
200	-	-	-	15,0	15,0	-	-	
250	-	-	-	19,0	19,0	20,0	-	
315	-	-	-	24,8*	21,0	21,0	-	
355	-	-	-	25,1*	27,0	27,0	-	
400	-	-	-	-	29,0	29,0	-	
425	-	-	-	-	35,5*	32,0	-	
500	-	-	-	-	39,4*	37,0	33,0	
630	-	-	-	-	-	46,0	46,0	
800	-	-	-	-	-	67,3*	57,0	
1000	-	-	-	-	-	-	85,0	
1250	-	-	-	-	-	-	108*	

(\*) Fusibles sobrecalibrados

NORMAS IEC 60269-1 · IEC 60269-2 · IEC 60269-3-1 · EN 60269-1 · EN 60269-2 · VDE 0636 · DIN 43630



2011



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## VIGICOMPACT MH NS250N TM200D 4P3R

Referencia: 31941  
EAN: 3303430319412  
Clave comercial: A



Después de la incorporación del bloque Vigi, se conservan todas las características del interruptor automático:

- Conformidad a las normas.
- Grados de protección, aislamiento de clase II en cara delantera.
- Seccionamiento con corte plenamente aparente.
- Características eléctricas.
- Características de los bloques de relés.
- Modos de instalación y conexionado.
- Auxiliares de señalización, medida y mando.
- Accesorios de instalación y conexión.

**Conformidad a las normas:**

- CEI 60947-2 anexo B / EN60947-2.
- Decreto del 14 de noviembre 1988.
- CEI 6255-4 y CEI 60801-2 a 6: protección contra los disparos intempestivos debidos a las sobretensiones transitorias, rayos, maniobra de aparatos en la red, descargas electrostáticas, ondas radioeléctricas.
- CEI 60755: clase A. Insensibilidad a las componentes continuas hasta 8 mA.
- Funcionamiento hasta -25 °C según norma VDE 664.



**Señalización a distancia:**

Los bloques Vigi pueden incorporar un contacto auxiliar para señalización a distancia del disparo por defecto diferencial.

**Alimentación:**

Los bloques Vigi son alimentados por la propia tensión de la red protegida. Por tanto, no necesitan alimentación exterior. Funcionan, incluso, con únicamente tensión entre dos fases.

Características	
Aparato	NS250
Relé	TM-D
Núm. de polos protegidos	4P 3R
Tipo	N
Familia	NS100-NS250
Calibre	200
Vigi	Con

**2.546,41 EUR**

Añadir a productos seleccionados

[http://www.voltimum.es/catalogue.jsp?mode=details&product\\_id=31941&family\\_id=008001MEE-V285A161062737&catalogType=F&brand=MEE&navense=\(1 de 2\)4/06/2006 22:07:31](http://www.voltimum.es/catalogue.jsp?mode=details&product_id=31941&family_id=008001MEE-V285A161062737&catalogType=F&brand=MEE&navense=(1 de 2)4/06/2006 22:07:31)

Serie 140  
**Interruptores automáticos**  
 Selección de productos

2

Protección magnetotérmica

- Disparador térmico regulable
- Disparador magnético 13 x I<sub>n</sub> máx.
- Compensación de temperatura
- Protección contra fallo de fase
- Clase de disparo 10



140M-C2E



140M-C2E



140M-C2E



140-CMN

Intensidad nominal I <sub>n</sub> [A]	Disparador térmico Rango de ajuste [A]	Disparador magnético Intens. de funcionamiento [A]	Maniobra de moles trifásicos						I <sub>cu</sub> [kA]	I <sub>cs</sub> [kA]	Ref. pedido	UE
			Trifásico (kW) (50 Hz) Ⓢ			Trifásico (HP) (50 Hz) Ⓢ						
			230 V	400 V	690 V	230 V	460 V	575 V				
<b>140M-C2E Tamaño 1, High break</b>												
0.16	0.1...0.16	2.1	—	0.02	—	—	—	—	100	100	140M-C2E-A16	*
0.25	0.16...0.25	3.3	—	0.06	—	—	—	—	100	100	140M-C2E-A25	*
0.4	0.25...0.4	5.2	—	0.09	—	—	—	—	100	100	140M-C2E-A40	*
0.63	0.4...0.63	8.2	0.06/0.09	0.12/0.16	0.25	—	—	—	100	100	140M-C2E-A63	*
1.0	0.63...1.0	13	0.12	0.25	0.37/0.55	—	1/2	3/4	100	100	140M-C2E-B10	*
1.6	1.0...1.6	21	0.16/0.25	0.37/0.55	0.75/1.1	—	1	1	100	100	140M-C2E-B16	*
2.5	1.6...2.5	33	0.37	0.75	1.8	3/4	1-1/2	2	100	100	140M-C2E-B25	*
4.0	2.5...4.0	52	0.55/0.75	1.1/1.5	2.2/3.0	1	3	3	100	100	140M-C2E-B40	*
6.3	4.0...6.3	82	1.1/1.5	2.2	4.0	2	5	5	100	100	140M-C2E-B63	*
10	6.3...10	130	2.2	3.0/4.0	5.5/7.5	3	7-1/2	10	100	100	140M-C2E-C10	*
16	10...16	208	3.0/4.0	5.5/7.5	11/13	5	10	15	50	50	140M-C2E-C16	*
20	14.5...20	260	4.0/5.5	7.5/10	15/17	7-1/2	15	20	15	15	140M-C2E-C20	*
25	16...25	325	—	11	18.5/22	7-1/2	15	20	15	15	140M-C2E-C25	*
<b>140M-D8E Tamaño 2, High break PLUS</b>												
2.5	1.6...2.5	33	0.37	0.75	1.8	3/4	1-1/2	2	100	100	140M-D8E-B25	
4.0	2.5...4.0	52	0.55/0.75	1.1/1.5	2.2/3.0	1	3	3	100	100	140M-D8E-B40	
6.3	4.0...6.3	82	1.1/1.5	2.2	4.0	2	5	5	100	100	140M-D8E-B63	
10	6.3...10	130	2.2	3.0/4.0	5.5/7.5	3	7-1/2	10	100	100	140M-D8E-C10	
16	10...16	208	3.0/4.0	5.5/7.5	11/13	5	10	15	100	50	140M-D8E-C16	1
20	14.5...20	260	4.0/5.5	7.5/10	15/17	7-1/2	15	20	50	25	140M-D8E-C20	
25	16...25	325	—	11	18.5/22	7-1/2	15	20	50	25	140M-D8E-C25	
<b>140M-F8E Tamaño 3, High break PLUS</b>												
10	6.3...10	130	2.2	3.0/4.0	5.5/7.5	3	7-1/2	10	65	50	140M-F8E-C10	
16	10...16	208	3.0/4.0	5.5/7.5	11/13	5	10	15	65	50	140M-F8E-C16	
20	14.5...20	260	4.0/5.5	7.5/10	15/17	7-1/2	15	20	65	50	140M-F8E-C20	
25	16...25	325	5.5/8.3	11	18.5/22	10	20	25	65	50	140M-F8E-C25	1
32	23...32	415	7.5	15	22/25	10	25	30	65	50	140M-F8E-C32	
45	32...45	585	11/13	18.5/22	30/40	15	30	40	65	50	140M-F8E-C45	
<b>140-CMN</b>												
25	16...25	350	5.5/7.5	7.5/13	15/22	8	17	22	65	65	140-CMN-2500	
40	25...40	560	10/11	15/22	25/30	12	30	38	65	50	140-CMN-4000	1
63	40...63	862	13/20	25/32	37/55	22	45	60	65	50	140-CMN-6300	
80	63...80	1280	22/25	37/45	63/75	30	70	85	50	25	140-CMN-8000	

Opciones	Complemento de la ref. pedido	Descripción	Ejemplo de pedido
* Unidades de embalaje	sin indicación	📦 Embalaje individual (1 ud, suministro normal)	140M-C2E-A16
	M	📦 Unidad de embalaje (20 uds)	140M-C2E-A16M

Accesorios - Página 2-14  
 Características técnicas - Página 2-22  
 Dimensiones - Página 2-46

# I. Disposiciones generales

## MINISTERIO DE INDUSTRIA, TURISMO Y COMERCIO

**15595** *REAL DECRETO 1578/2008, de 26 de septiembre, de retribución de la actividad de producción de energía eléctrica mediante tecnología solar fotovoltaica para instalaciones posteriores a la fecha límite de mantenimiento de la retribución del Real Decreto 661/2007, de 25 de mayo, para dicha tecnología.*

En agosto de 2005 fue aprobado el Plan de Energías Renovables 2005-2010, con el propósito de reforzar los objetivos prioritarios de la política energética del Gobierno, aumentar la seguridad y calidad del suministro eléctrico y mejorar el respeto al medio ambiente, junto con la determinación de dar cumplimiento a los compromisos internacionales que para España derivan del Protocolo de Kioto y de nuestra pertenencia a la Unión Europea y alcanzar los objetivos del Plan Nacional de Asignación de derechos de emisión de gases de efecto invernadero, 2008-2012.

Dicho Plan de Energías Renovables 2005-2010, que conllevó la revisión del Plan de Fomento de las Energías Renovables en España 2000-2010, se debió a un crecimiento de algunas tecnologías inferior al inicialmente previsto y, por otro parte, a un incremento de la demanda notablemente superior a los escenarios manejados en el Plan inicial. Se introdujeron importantes modificaciones al alza de los objetivos de potencia establecidos y, en concreto, el objetivo de potencia eólica en 2010 se amplió de 8.155 MW a 20.155 MW y el objetivo de potencia fotovoltaica se amplió de 150 MW a 400 MW.

El vigente Real Decreto 661/2007, de 25 de mayo, por el que se regula la actividad de producción de energía eléctrica en régimen especial, establece el nuevo marco retributivo a aplicar a las instalaciones de energías renovables y de cogeneración, con objeto de alcanzar en 2010 los objetivos recogidos en el Plan de Energías Renovables 2005-2010, y en la Estrategia de Ahorro y Eficiencia Energética en España (E4).

El crecimiento de la potencia instalada experimentado por la tecnología solar fotovoltaica está siendo muy superior al esperado. Según la información publicada por la Comisión Nacional de Energía (CNE) en relación al cumplimiento de los objetivos de las instalaciones del régimen especial, determinado de acuerdo con los artículos 21 y 22 del Real Decreto 661/2007, de 25 de mayo, en agosto de 2007 se superó el 85 por ciento del objetivo de potencia instalada fotovoltaica para 2010 y en el mes de mayo de 2008, se han alcanzado ya los 1.000 MW de potencia instalada.

Esta rápida evolución ha comportado numerosas inversiones industriales relacionadas con la tecnología solar fotovoltaica, desde la fabricación de polisilicio, obleas y módulos hasta los seguidores o los inversores, de manera que actualmente en España se pueden producir todos los elementos de la cadena que interviene en una instalación solar fotovoltaica.

Se hace necesario dar continuidad y expectativas a estas inversiones, como también definir una pauta progresiva de implantación de este tipo de tecnología, que además puede contribuir al cumplimiento de los objetivos del Plan de Energías Renovables 2005-2010 y de los que fije el nuevo Plan de Energías Renovables 2011-2020, a partir de los objetivos asignados a España en la nueva Directiva de Energías Renovables. Por ello se ha considerado oportuno elevar el objetivo vigente de 371 MW de potencia instalada conectada a la red, recogido en el Real Decreto 661/2007, de 25 de mayo.

A tal fin, se propone un objetivo anual de potencia que evolucionará al alza de manera coordinada con las mejoras tecnológicas, en lugar de utilizar la potencia total acumulada para fijar los límites del mercado de esta tecnología. Esto debe ir acompañado de un nuevo régimen económico que estimule la evolución tecnológica y la competitividad de las instalaciones fotovoltaicas en España a medio y largo plazo.

Por otro lado, el marco de apoyo a esta tecnología, que representa el Real Decreto 661/2007, de 25 de mayo, por el que se regula la actividad de producción de energía eléctrica en régimen especial, que ha demostrado su eficacia, debe adaptarse también con la rapidez suficiente a la evolución de la tecnología, para asegurar su eficiencia. Así como una retribución insuficiente haría inviábiles las inversiones, una retribución excesiva podría repercutir de manera significativa en los costes del sistema eléctrico y desincentivaría la apuesta por la investigación y el desarrollo, disminuyendo las excelentes perspectivas a medio y largo plazo para esta tecnología. De ahí que se considere necesaria la racionalización de la retribución y, por ello, el real decreto que se aprueba modifica el régimen económico a la baja, siguiendo la evolución esperada de la tecnología, con una perspectiva a largo plazo.

El nuevo régimen económico también pretende reconocer las ventajas que ofrecen las instalaciones integradas en edificios, ya sea en fachadas o sobre cubiertas, por sus ventajas como generación distribuida, porque no aumentan la ocupación de territorio y por su contribución a la difusión social de las energías renovables. El Real Decreto extiende esta ventaja a las instalaciones de carácter agropecuario en coherencia con lo dispuesto en la Ley 45/2007, de 13 de diciembre, para el Desarrollo Sostenible del Medio Rural.

Para garantizar un mercado mínimo para el desarrollo del sector fotovoltaico y, al mismo tiempo, asegurar la continuidad del sistema de apoyo, se establece un mecanismo de asignación de retribución mediante la inscripción en un registro de asignación de retribución, en un

momento incipiente del desarrollo del proyecto, que dé la necesaria seguridad jurídica a los promotores respecto de la retribución que obtendrá la instalación una vez puesta en funcionamiento.

Asimismo, se establece una nueva definición de potencia. Con ello se consigue mayor precisión en el procedimiento de cómputo de la potencia de cada instalación fotovoltaica, a efectos de la aplicación de la retribución correspondiente. Se pretende racionalizar la implantación de grandes instalaciones en suelo pertenecientes a una multiplicidad de titulares, de tal forma que se evite la parcelación de una única instalación en varias de menor tamaño, con el objetivo de obtener un marco retributivo más favorable.

De acuerdo con lo previsto en la disposición adicional undécima, apartado tercero, de la Ley 34/1998, de 7 de octubre, del Sector de Hidrocarburos, este real decreto ha sido sometido a informe preceptivo de la Comisión Nacional de Energía.

Esta disposición se dicta al amparo de lo establecido en el artículo 149.1.25.<sup>a</sup> de la Constitución Española, que atribuye al Estado la competencia exclusiva para determinar las bases del régimen minero y energético. A este respecto cabe señalar que por el contenido de sus disposiciones la ley no resulta un instrumento idóneo para su establecimiento y se encuentra justificada su aprobación mediante real decreto.

En su virtud, a propuesta del Ministro de Industria, Turismo y Comercio, con la aprobación previa de la Ministra de Administraciones Públicas, de acuerdo con el Consejo de Estado y previa deliberación del Consejo de Ministros en su reunión del día 26 de septiembre de 2008,

## DISPONGO:

### CAPÍTULO I

#### Objeto y ámbito de aplicación

##### Artículo 1. *Objeto.*

Constituye el objeto de este real decreto el establecimiento de un régimen económico para las instalaciones de producción de energía eléctrica de tecnología fotovoltaica a las que no les sea de aplicación los valores de la tarifa regulada previstos en el artículo 36 del Real Decreto 661/2007, de 25 de mayo, por el que se regula la actividad de producción de energía eléctrica en régimen especial, por su fecha de inscripción definitiva en la sección segunda del Registro administrativo de instalaciones de producción de energía eléctrica dependiente de la Dirección General de Política Energética y Minas, denominado en lo sucesivo, Registro administrativo de instalaciones de producción en régimen especial, de acuerdo con lo previsto en el 9.1 del Real Decreto 661/2007, de 25 de mayo.

##### Artículo 2. *Ámbito de aplicación.*

El presente real decreto será de aplicación a las instalaciones del grupo b.1.1 del artículo 2 del Real Decreto 661/2007, de 25 de mayo, instalaciones de tecnología fotovoltaica, que obtengan su inscripción definitiva en el Registro administrativo de instalaciones de producción en régimen especial dependiente de la Dirección General de Política Energética y Minas con posterioridad al 29 de septiembre de 2008.

##### Artículo 3. *Tipología de las instalaciones.*

A efectos de lo dispuesto en el presente real decreto las instalaciones del subgrupo b.1.1 del artículo 2 del Real

Decreto 661/2007, de 25 de mayo, se clasifican en dos tipos:

a) Tipo I. Instalaciones que estén ubicadas en cubiertas o fachadas de construcciones fijas, cerradas, hechas de materiales resistentes, dedicadas a usos residencial, de servicios, comercial o industrial, incluidas las de carácter agropecuario.

O bien, instalaciones que estén ubicadas sobre estructuras fijas de soporte que tengan por objeto un uso de cubierta de aparcamiento o de sombreado, en ambos casos de áreas dedicadas a alguno de los usos anteriores, y se encuentren ubicadas en una parcela con referencia catastral urbana.

Las instalaciones de este tipo se agrupan, a su vez, en dos subtipos:

Tipo I.1: instalaciones del tipo I, con una potencia inferior o igual a 20 kW

Tipo I.2: instalaciones del tipo I, con una potencia superior a 20 kW

b) Tipo II. Instalaciones no incluidas en el tipo I anterior.

## CAPÍTULO II

### Registro de preasignación de retribución

#### Artículo 4. *Registro de preasignación de retribución.*

1. Para el adecuado seguimiento de los proyectos de instalaciones de producción en régimen especial de tecnología fotovoltaica, se establece una sub-sección de la sección segunda del Registro administrativo de instalaciones de producción de energía eléctrica a que se refiere el artículo 21.4 de la Ley 54/1997, de 27 de noviembre, del Sector Eléctrico, dependiente del Ministerio de Industria, Turismo y Comercio. Dicha subsección será denominada, en lo sucesivo, Registro de preasignación de retribución.

2. Para tener derecho a retribución recogida en este real decreto, será necesaria la inscripción, con carácter previo, de los proyectos de instalación o instalaciones en el Registro de preasignación de retribución.

3. Las inscripciones en el Registro de preasignación de retribución, irán asociadas a un periodo temporal que se denominará en lo sucesivo, convocatoria, dando derecho a la retribución que quede fijada en dicho periodo temporal.

#### Artículo 5. *Cupos de potencia.*

1. A efectos de lo dispuesto en el presente real decreto, para cada convocatoria de inscripción en el Registro de preasignación de retribución se establecerá unos cupos de potencia por tipo y subtipo que estarán constituidos por las potencias base, y en su caso, las potencias adicionales traspasadas o incorporadas de acuerdo a lo dispuesto en el apartado 4 de este artículo y al anexo IV.

2. Se establecen las siguientes potencias base para las convocatorias del primer año.

a) Tipo I: 267/m MW, con el reparto siguiente: 10 por ciento para el subtipo I.1 y 90 por ciento para el subtipo I.2.

b) Tipo II: 133/m MW.

Siendo m, el número de convocatorias por año para los que se establezca la inscripción en el Registro de preasignación de retribución, de acuerdo con lo dispuesto en el anexo III de este real decreto.

3. Las potencias base correspondientes a las convocatorias del segundo año y sucesivos se calcularán, tomando como referencia las potencias base, de cada tipo y subtipo, de las convocatorias correspondientes al año

anterior incrementándolas o reduciéndolas en la misma tasa porcentual acumulada que se reduzca o incremente, respectivamente, la retribución correspondiente a las convocatorias celebradas durante el año anterior, de acuerdo con lo establecido en el artículo 11 de este real decreto.

4. Se establece el mecanismo de traspaso de potencia adicional a la potencia base para la convocatoria siguiente recogido en el anexo IV de este real decreto, cuando no se cubra alguno o todos los cupos de potencia de una convocatoria.

5. El Ministerio de Industria, Turismo y Comercio publicará en su página web, con anterioridad al cierre de cada convocatoria, los cupos de potencia para cada una de tipos y subtipos, así como los valores de las tarifas reguladas que les sean de aplicación.

6. Las potencias base que se establecen en las convocatorias de inscripción en el registro de preasignación de retribución, podrán ser revisados al alza por parte del Ministro de Industria, Turismo y Comercio, a la vista de las conclusiones y objetivos de potencia que se determinen en el Plan de Energías Renovables 2011-2020, a que hace referencia la disposición adicional novena del Real Decreto 661/2007, de 25 de mayo.

#### Artículo 6. *Procedimiento de inclusión en el Registro de preasignación de retribución.*

1. La solicitud de inscripción en el Registro de preasignación de retribución, para un proyecto de instalación o instalación, se realizará, utilizando el modelo recogido como anexo I a este real decreto, aportando además, copia autenticada de la documentación establecida en el anexo II del mismo. Dicha solicitud irá dirigida a la Dirección General de Política Energética y Minas.

2. La solicitud deberá de presentarse en el Registro Administrativo de la sede del Ministerio de Industria, Turismo y Comercio, vía telemática a través de la página web del mismo, [www.mityc.es](http://www.mityc.es), o de forma presencial. Igualmente podrá presentarse la solicitud ante cualquiera de los lugares a que se refiere el artículo 38.4 de la Ley 30/1992, de 26 de noviembre, de Régimen Jurídico de las Administraciones Públicas y del Procedimiento Administrativo Común. La solicitud deberá ser presentada en el plazo establecido en el anexo III del presente real decreto, correspondiente a la convocatoria en la que se desee inscribir.

La solicitud presentada será válida para convocatorias sucesivas, en tanto en cuanto un proyecto o instalación no sea inscrita en el Registro de preasignación de retribución, bien por no cumplir los requisitos exigidos o bien por haber quedado cubierto el cupo de potencia, salvo declaración expresa en contra de participar en las mismas en el periodo establecido o cancelación de la solicitud, expresadas en el formulario establecido en el anexo I de este real decreto.

Aquellos solicitantes que hubieran participado en este procedimiento con anterioridad y deseen modificar su solicitud, no tendrán que volver a presentar la documentación válida ya presentada anteriormente, debiendo indicar dicha particularidad en la solicitud.

3. Recibidas las solicitudes y cerrado el plazo de presentación de las mismas, la Dirección General de Política Energética y Minas procederá a ordenarlas cronológicamente, dentro de cada uno de los tipos y subtipos previstos en el artículo 3, considerando, para cada una de ellos, la última fecha de los documentos a que hace referencia el anexo II de este real decreto. Una vez ordenadas se procederá a la asignación de retribución empezando, por las fechas más antiguas y hasta que sea cubierto el cupo de potencia previsto para esa convocatoria en cada tipología. La cobertura de cada cupo se hará por exceso, es decir, la última solicitud que sea aceptada será aquella,

para la cual, su no consideración supondría la no cobertura del cupo previsto.

En caso de igualdad de fecha para varias solicitudes, éstas se ordenarán, considerando como fecha preferente, por este orden, la de autorización administrativa, la de licencia de obras, y por último la de depósito del aval, y en caso de igualdad, tendrá preferencia el proyecto de menor potencia.

Cuando el exceso respecto del cupo previsto supere el 50 por ciento del mismo, el exceso de potencia respecto de la última solicitud cuya no consideración supondría la no cobertura del cupo, se detraerá de las solicitudes con igualdad de fechas, proporcionalmente a la potencia de cada solicitud.

4. Aquellos proyectos a los que les sea asignado potencia, serán inscritos por la Dirección General de Política Energética y Minas, en el Registro de preasignación de retribución, asociados a dicha convocatoria. El resto de solicitudes serán desestimadas en la convocatoria, entrando automáticamente en la siguiente, salvo la declaración en contra expresada en el apartado 2 del presente artículo.

5. La primera convocatoria de inscripción en el Registro de preasignación de retribución será la correspondiente al primer periodo temporal de 2009, de acuerdo con lo previsto en el anexo III de este real decreto.

#### Artículo 7. *Publicidad del resultado del procedimiento de preasignación de retribución.*

1. Se publicará, en la página web del Ministerio de Industria, Turismo y Comercio, la relación de proyectos que se han inscrito en el Registro de preasignación de retribución, y la de proyectos que han sido desestimados para dicha inscripción, antes de la fecha establecida en el anexo III del presente real decreto.

2. Igualmente, antes de esta fecha, la Dirección General de Política Energética y Minas notificará a los titulares de los proyectos que han participado en el procedimiento, el resultado de su solicitud.

#### Artículo 8. *Cancelación de la inscripción en el Registro de preasignación de retribución.*

1. Las instalaciones inscritas en el Registro de preasignación de retribución dispondrán de un plazo máximo de doce meses a contar desde la fecha de publicación del resultado en la página web del Ministerio de Industria, Turismo y Comercio, para ser inscritas con carácter definitivo en el Registro administrativo de instalaciones de producción en régimen especial dependiente del órgano competente y comenzar a vender energía eléctrica de acuerdo con cualquiera de las opciones del artículo 24.1 del Real Decreto 661/2007, de 25 de mayo.

2. En caso de incumplimiento de la obligación establecida en el apartado 1 anterior, se procederá, por parte de la Dirección General de Política Energética y Minas, a la cancelación por incumplimiento de la inscripción en el Registro de pre-asignación de retribución.

No obstante, no se producirá esta cancelación en el caso de que a juicio de la Dirección General de Política Energética y Minas, existan razones fundadas para que esta inscripción permanezca en el registro. A modo enunciativo y no limitativo, podrían considerarse razones fundadas a estos efectos, entre otros, retraso injustificado en la inscripción definitiva en el registro o en la firma del acta de puesta en servicio, por parte del órgano competente, y las posibles incidencias con el gestor de la red eléctrica a la que se conecta. A estos efectos, el promotor deberá remitir antes de que finalice el plazo establecido en el apartado 1, a esa Dirección General, una solicitud acompañada de la documentación que estime oportuno para

justificar dichas razones. La Dirección General resolverá la solicitud, en el plazo máximo de 30 días a contar desde la fecha de finalización del plazo establecido, fijando una prórroga de una duración máxima de cuatro meses a contar desde la comunicación de la misma al interesado.

Igualmente será causa de cancelación por incumplimiento de un proyecto en el Registro de preasignación de retribución el desistimiento voluntario de la tramitación administrativa de la instalación o la falta de respuesta a los requerimientos de la Administración de información o actuación realizados en el plazo de tres meses. En estos casos, el órgano competente comunicará a la Dirección General de Política Energética la procedencia de dicha cancelación, para que ésta ejecute la cancelación por incumplimiento de la inscripción en el citado Registro.

3. La cancelación por incumplimiento de la inscripción de un proyecto en el Registro de preasignación será comunicada al órgano competente. Esta cancelación supondrá la pérdida de los derechos asociados a la inscripción en dicho registro, sin perjuicio de la posibilidad del titular del proyecto o instalación de volver a solicitar la inscripción en el Registro administrativo de preasignación de retribución comenzando de nuevo el procedimiento.

4. La cancelación por incumplimiento de la inscripción de un proyecto en el Registro de pre-asignación supondrá la ejecución del aval depositado, de acuerdo con el artículo 59 bis o 66 bis del Real Decreto 1955/2000, de 1 de diciembre, o del previsto en el artículo 9 de este real decreto. Lo anterior, sin perjuicio de la no procedencia de ejecución del aval, de conformidad con lo establecido en los artículos citados. El órgano competente procederá a iniciar el procedimiento de ejecución o cancelación, según corresponda, de dicho aval en el plazo máximo de un mes a contar desde la cancelación de la inscripción, o en su caso desde la recepción de la comunicación de dicho hecho.

5. La inscripción definitiva de una instalación en el Registro administrativo de instalaciones de producción en régimen especial dependiente de la Dirección General de Política Energética y Minas supondrá, la cancelación de oficio de su inscripción en el Registro de preasignación de retribución.

6. Las resoluciones de la Dirección General de Política Energética y Minas previstas en este artículo no ponen fin a la vía administrativa y, en consecuencia, podrán ser objeto de recurso de alzada ante la Secretaría General de Energía, conforme a lo establecido en los artículos 114 y 115 de la Ley 30/1992, de 26 de noviembre, de Régimen Jurídico de las Administraciones Públicas y del Procedimiento Administrativo Común.

#### Artículo 9. *Aval.*

1. En el caso en el que, de acuerdo con lo previsto en el artículo 66 bis del Real Decreto 1955/2000, de 1 de diciembre, por el que se regulan las actividades de transporte, distribución, comercialización, suministro y procedimientos de autorización de instalaciones de energía eléctrica, una instalación estuviera exenta de la presentación del aval para el acceso a la red de distribución, o en el caso en cualquier otro caso en el que no existiera un depósito de un aval equivalente al menos a un importe equivalente a 500 €/kW de potencia, deberá depositarse ante la Caja General de Depósitos un aval por una cuantía de 50 €/kW o 500 €/kW de potencia del proyecto o instalación fotovoltaica del tipo I.1, o I.2, respectivamente. En el caso en el que la instalación contara con inscripción definitiva en el Registro administrativo de instalaciones de producción en régimen especial dependiente del órgano competente, no se exigirá el depósito de éste aval.

2. El aval a que hace referencia el apartado 1, será cancelado cuando el peticionario obtenga la inscripción definitiva en el Registro administrativo de instalaciones de producción en régimen especial dependiente de la Dirección General de Política Energética y Minas. Si a lo largo del procedimiento, el solicitante desiste voluntariamente de la tramitación administrativa de la instalación o no responde a los requerimientos de la Administración de información o actuación realizados en el plazo de tres meses, se procederá a la ejecución del aval. Se tendrá en cuenta a la hora de valorar el desistimiento del promotor, el resultado de los actos administrativos previos que puedan condicionar la viabilidad del proyecto. Entre otras, se considerará razón suficiente para la cancelación del aval, la no inclusión en el Registro de pre-asignación de retribución de un proyecto o instalación para la que se solicite su inclusión en dicho registro en todas las convocatorias que se celebren durante un periodo de doce meses, o la cancelación de la solicitud por parte del titular antes del cierre de la primera convocatoria en la que se presente.

#### Artículo 10. *Potencia de los proyectos.*

1. La potencia máxima de los proyectos o instalaciones que sean inscritos en el Registro de preasignación de retribución no podrá superar los 2 MW o los 10 MW para instalaciones de tipo I o II del artículo 3 de este real decreto, respectivamente.

2. A los efectos de la determinación del régimen económico establecido en el presente real decreto, se considerará que pertenecen a una única instalación o un solo proyecto, según corresponda, cuya potencia será la suma de las potencias de las instalaciones unitarias de la categoría b.1.1, las instalaciones o proyectos que se encuentren en referencias catastrales con los catorce primeros dígitos idénticos. A estos efectos, los titulares de las instalaciones suministrarán la referencia catastral de los inmuebles en los que se ubiquen las mismas.

Del mismo modo, a los efectos de la inscripción, en una convocatoria, en el Registro de preasignación de retribución, se considerará que pertenecen a un solo proyecto, cuya potencia será la suma de las potencias de las instalaciones unitarias, aquellas instalaciones que conecten en un mismo punto de la red de distribución o transporte, o dispongan de línea de evacuación común.

### CAPÍTULO III

#### Régimen económico

#### Artículo 11. *Tarifas.*

1. Los valores de la tarifa regulada correspondientes a las instalaciones del subgrupo b.1.1 del artículo 2 del Real Decreto 661/2007, de 25 de mayo, que sean inscritas en el registro de pre-asignación asociadas a la primera convocatoria serán los siguientes:

Tipología		Tarifa regulada (c€/kWh)
Tipo I	Subtipo I.1	34,00
	Subtipo I.2	32,00
Tipo II		32,00

2. Los valores de la tarifa regulada correspondientes a las instalaciones que sean inscritas en el registro de pre-asignación asociadas a la convocatoria n, se calcularán en función de los valores de la convocatoria anterior n - 1, de la siguiente forma:



Si  $P \geq 0,75 \times P_0$ ,

entonces:  $T_n = T_{n-1} [(1 - A) \times (P_0 - P) / (0,25 \times P_0) + A]$

Si  $P < 0,75 \times P_0$ ,

entonces:  $T_n = T_{n-1}$

Siendo:

$P$ , la potencia pre-registrada en la convocatoria n-1.

$P_0$ , el cupo de potencia para la convocatoria n-1.

$T_{n-1}$ , la tarifa para las instalaciones pre-registradas asociadas a la convocatoria n-1.

$T_n$ , la tarifa para las instalaciones pre-registradas asociadas a la convocatoria n.

$A$ , el factor  $0,9^{1/m}$  y  $m$  el número de convocatorias anuales.

3. Si durante dos convocatorias consecutivas no se alcanzara el 50 por ciento del cupo de potencia para un tipo o subtipo, se podrá incrementar, mediante Resolución de la Secretaría General de Energía, la tarifa para la convocatoria siguiente en el mismo porcentaje que se reduciría si se cubriera el cupo, siendo necesario, que durante dos convocatorias adicionales no se volviera a alcanzar el 50 por ciento del cupo para realizar un nuevo incremento.

4. La tarifa regulada de las instalaciones del subtipo .1, no podrá nunca ser inferior a la de las instalaciones del subtipo I.2. En el caso en el que, de acuerdo con el mecanismo previsto en este artículo, el valor de la tarifa regulada para el subtipo I.1 pudiera resultar inferior a del subtipo I.2, se considerará exclusivamente el mecanismo de modificación de la tarifa para el subtipo I.2, y se hará la tarifa regulada para el subtipo I.1, igual a la anterior.

5. La tarifa regulada que le sea de aplicación a una instalación, de acuerdo con el presente real decreto, se mantendrá durante un plazo máximo de veinticinco años a contar desde la fecha más tardía de las dos siguientes: la fecha de puesta en marcha o la de inscripción de la instalación en el Registro de preasignación de retribución, Dicha retribución no podrá nunca ser de aplicación con anterioridad a la fecha de inscripción en el mismo.

6. Las instalaciones que sean inscritas de forma definitiva en el Registro administrativo de producción en régimen especial dependiente del Ministerio de Industria, Turismo y Comercio, con posterioridad al 29 de septiembre de 2008, en tanto en cuanto no sean inscritas en el Registro de preasignación de retribución, percibirán la retribución prevista en el artículo 22.2 del Real Decreto 661/2007, de 25 de mayo.

#### Artículo 12. *Actualización de las tarifas.*

Los valores recogidos en el artículo 11 serán objeto de las actualizaciones previstas en el artículo 44.1 del Real Decreto 661/2007, de 25 de mayo, para las instalaciones del subgrupo b.1.1, a partir del día 1 de enero del segundo año posterior al de la convocatoria en que sean fijados.

### CAPÍTULO IV

#### Requisitos técnicos y de calidad

#### Artículo 13. *Establecimiento de requisitos técnicos y de calidad a las instalaciones.*

Por orden del Ministro de Industria, Turismo y Comercio se podrán establecer requisitos técnicos y de calidad de las instalaciones fotovoltaicas para contribuir a la seguridad de suministro, entre otros, la obligación de soporte de huecos de tensión, a los que tendrán que aco-

gerse las instalaciones y proyectos inscritos en el Registro de preasignación de retribución en el momento de su entrada en vigor y a las acogidas a la retribución establecida en el artículo 36 del Real Decreto 661/2007, de 25 de mayo, estableciéndose, en su caso, los necesarios mecanismos transitorios de adecuación de las instalaciones inscritas con carácter definitivo en el Registro administrativo de instalaciones de producción en régimen especial.

Esta obligación será condición necesaria para la percepción de la retribución que le corresponda.

### CAPÍTULO V

#### Inspección

#### Artículo 14. *Inspección de las instalaciones fotovoltaicas.*

1. La Administración General del Estado, a través de la Comisión Nacional de la Energía, y en colaboración con los órganos competentes de las Comunidades Autónomas correspondientes, realizará inspecciones periódicas y aleatorias a lo largo del año en curso, sobre las instalaciones de generación eléctrica a partir de tecnología fotovoltaica objeto del presente real decreto, siguiendo los criterios de elección e indicaciones que la Secretaría General de la Energía del Ministerio de Industria, Turismo y Comercio imponga en cada caso, ajustándose el número total de inspecciones efectuadas anualmente a un mínimo del 5 por ciento del total de instalaciones fotovoltaicas existentes, que representen al menos el 5 por ciento de la potencia instalada, todo ello sin perjuicio de la potestad atribuida a la Comisión Nacional de Energía, al amparo de la función octava de la disposición adicional undécima, tercero, 1 de la Ley 34/1998, de 7 de octubre, del Sector de Hidrocarburos, para la realización de inspecciones de oficio.

2. Para la realización de estas inspecciones, la Comisión Nacional de Energía podrá servirse de una entidad reconocida por la Administración General del Estado. Dichas inspecciones se extenderán a la verificación del cumplimiento de los requisitos técnicos exigibles que sean establecidos, de acuerdo a lo previsto en el artículo 13 de este real decreto, a la comprobación de la veracidad de los datos aportados durante el procedimiento de inscripción en el Registro administrativo de preasignación de retribución, así como de los requisitos establecidos en el artículo 3 del mismo.

3. La Comisión Nacional de Energía remitirá los resultados de las inspecciones realizadas al Ministerio de Industria, Turismo y Comercio, con copia al órgano competente, acompañadas del acta correspondiente en la que se hagan constar los hechos observados.

4. Si como consecuencia de una inspección de la Comisión Nacional de Energía se detectase cualquier irregularidad que tenga como consecuencia la percepción de una retribución superior a la que le hubiera correspondido, la Dirección General de Política Energética y Minas resolverá sobre la procedencia de la misma y, en su caso, recalculará la nueva tarifa resultante, de acuerdo con la tipología y el procedimiento de preasignación de retribución establecido en el presente real decreto, dando traslado de la misma a la Comisión Nacional de Energía a los efectos de las liquidaciones correspondientes. A modo enunciativo y no limitativo, podrían considerarse irregularidades en el procedimiento a estos efectos, entre otros, la alteración en los procedimientos administrativos seguidos, la presentación de documentación falseada o que una instalación hubiera sido clasificada indebidamente según lo establecido en el artículo 3, por parte del órgano competente, por razón de haber presentado la documentación con detalle insuficiente y que ésta no hubiera permitido al órgano competente determinar perfectamente

la inclusión dentro del tipo correspondiente del citado artículo.

## CAPÍTULO VI

### Régimen sancionador

Artículo 15. *Régimen sancionador.*

El incumplimiento de lo establecido en el presente real decreto, se sancionará, en su caso, de acuerdo con lo dispuesto en el título X de la Ley 54/1997, de 27 de noviembre, del Sector Eléctrico.

Disposición adicional primera. *Simplificación de procedimientos.*

Antes del 1 de abril de 2009, en virtud de lo establecido en el artículo 16 de la Orden ITC/1522/2007, de 24 de mayo, por la que se establece la regulación de la garantía del origen de la electricidad procedente de fuentes de energía renovables y de cogeneración de alta eficiencia, la Comisión Nacional de Energía remitirá a la Dirección General de Política Energética y Minas un informe relativo a la evaluación del marco legislativo y reglamentario vigente respecto a los procedimientos administrativos necesarios para la implantación de las instalaciones de producción de energía fotovoltaica en edificación, así como las medidas necesarias para eliminar o reducir los obstáculos existentes.

Disposición adicional segunda. *Comienzo de la venta de electricidad dentro del periodo de mantenimiento de la retribución.*

Con carácter general, a los efectos de lo establecido en el artículo 17.c) y 22.1 del Real Decreto 661/2007, de 25 de mayo, será condición necesaria para la percepción de la tarifa regulada o, en su caso, prima, el comienzo de la venta de la producción neta de energía eléctrica antes de la fecha límite que se establezca, justificándose mediante el conveniente registro de medida en el equipo de medida con anterioridad a dicha fecha.

Disposición adicional tercera. *Devolución del aval contemplado en los artículos 59 bis y 66 bis del Real Decreto 1955/2000, de 1 de diciembre.*

A los efectos de lo establecido en los artículos 59 bis y 66 bis del Real Decreto 1955/2000, de 1 de diciembre, la entrada en vigor del presente real decreto se considerará razón suficiente para la devolución del aval, siempre que no hubiera presentado solicitud de inscripción en el registro de preasignación de retribución.

Del mismo modo, a estos efectos se considerará razón suficiente para la cancelación del aval, la no inclusión en el Registro de preasignación de retribución de un proyecto o instalación para la que se solicite su inclusión en dicho registro en todas las convocatorias que se celebren durante un periodo de doce meses, o la cancelación de la solicitud por parte del titular antes del cierre de la primera convocatoria en la que se presente.

Disposición adicional cuarta. *Referencias catastrales en Navarra y el País Vasco.*

Se establecerá, por resolución del Secretario General de Energía, que se publicará en el «Boletín Oficial del Estado», el criterio de cómputo de potencia a que hace referencia el artículo 10.2 para las referencias catastrales,

en los sistemas de referencia catastral de la Comunidad Autónoma del País Vasco y la Comunidad Foral de Navarra.

Disposición adicional quinta. *Modificación de la retribución de la actividad de producción mediante tecnología fotovoltaica.*

Durante el año 2012, a la vista de la evolución tecnológica del sector y del mercado, y del funcionamiento del régimen retributivo, se podrá modificar la retribución de la actividad de producción de energía eléctrica mediante tecnología solar fotovoltaica.

Disposición adicional sexta. *Aplicación de tarifas de acceso a contratos de temporada de duración inferior o igual a cinco meses.*

A efectos de la aplicación de tarifas de acceso, en los contratos de temporada regulados en el artículo 6.2 del Real Decreto 1164/2001, de 26 de octubre, por el que se establecen tarifas de acceso a las redes de transporte y distribución de energía eléctrica, cuando su duración sea inferior o igual a cinco meses, los precios del término de potencia se aumentarán en un 35 por ciento para los meses de temporada alta y en un 15 por ciento para los restantes en que se reciba la energía, siempre que se cumpla lo siguiente:

a) En el caso de los consumidores acogidos a la tarifa de acceso 3.1.A que su consumo en el periodo tarifario 3 sea superior o igual al 40 por ciento del total.

b) En el caso de los consumidores acogidos a tarifas de acceso de seis periodos, 6.X.A, que su consumo en el periodo tarifario 6 sea superior o igual al 60 por ciento del total.

Disposición adicional séptima. *Periodicidad de la facturación y lectura de las tarifas domésticas.*

La facturación de las tarifas de suministro de energía eléctrica social y domésticas (hasta 10 kW de potencia contratada) a partir del 1 de noviembre de 2008 se efectuará por la empresa distribuidora mensualmente llevándose a cabo con base en la lectura bimestral de los equipos de medida instalados al efecto.

Disposición transitoria única. *Cupo de potencia adicional extraordinario para las convocatorias de los años 2009 y 2010.*

1. Se establecen, para el tipo II, unos cupos de potencia adicional extraordinarios para las convocatorias correspondientes a los años 2009 y 2010, de 100/m MW y 60/m MW, respectivamente por convocatoria, siendo m el número de convocatorias anuales que se convoquen.

2. Dichos cupos adicionales no se verán afectados, por los incrementos o decrementos que pudieran ser de aplicación a las potencias bases de acuerdo con lo previsto en el artículo 5.3 de este real decreto.

Disposición derogatoria única. *Derogación normativa.*

Queda derogada cualquier disposición de igual o inferior rango en lo que se oponga a este real decreto.

Disposición final primera. *Modificación del Real Decreto 661/2007, de 25 de mayo, por el que se regula la actividad de producción de energía eléctrica en régimen especial.*

1. Se modifican los apartados 1 y 2 del artículo 26 del Real Decreto 661/2007, de 25 de mayo, por el que se regula

la actividad de producción de energía eléctrica en régimen especial, que quedan redactados como sigue:

«1. Las instalaciones de la categoría a) y de los grupos b.4, b.5, b.6, b.7 y b.8, que hayan elegido la opción a) del artículo 24.1, podrán acogerse, con carácter voluntario, al régimen de discriminación horaria de dos periodos que se establece a continuación, en función de su categoría o grupo:

a) Para las instalaciones de la categoría a):

Punta	Valle
Periodos tarifarios 1 a 5	Periodo tarifario 6.

de acuerdo con la distribución de periodos tarifarios establecidos en el anexo II de la Orden ITC/2794/2007, de 27 de septiembre, por la que se revisan las tarifas eléctricas a partir del 1 de octubre.

b) Para las instalaciones de los grupos b.4, b.5, b.6, b.7 y b.8:

Invierno		Verano	
Punta	Valle	Punta	Valle
11-21 h	21-24 h y 0-11 h	12-22h	22-24 h y 0-12 h

siendo cambios de horario de invierno a verano o viceversa coincidentes con la fecha de cambio oficial de hora.

2. La tarifa regulada a percibir en este caso, se calculará como el producto de la tarifa que le corresponda por su grupo, subgrupo, antigüedad y rango de potencia, multiplicada, para el periodo punta, por 1,37 para las instalaciones de la categoría a) o 1,0462 para las de los grupos b.4, b.5, b.6, b.7 y b.8, y para el periodo valle, por 0,64 para las instalaciones de la categoría a) o 0,9670 para las de los grupos b.4, b.5, b.6, b.7 y b.8.»

2. Las instalaciones de la categoría a) del artículo 2 del Real Decreto 661/2007, de 25 de mayo, acogidas plenamente al mismo, que a la fecha de entrada en vigor del presente real decreto estuvieran acogidas a la opción de venta del artículo 24.1.a), de dicho Real Decreto 661/2007, de 25 de mayo, con discriminación horaria, pasarán de

forma automática al régimen de discriminación horaria introducido en el apartado 1 de esta disposición final.

Sin perjuicio de lo anterior, éstas podrán optar por comunicar su deseo de cambiar a la opción de venta a tarifa regulada sin discriminación horaria, antes del 1 de diciembre de 2008, aunque no hubiera transcurrido el periodo de un año indicado previsto en dicho real decreto.

El resto de instalaciones de la categoría a) acogidas al Real Decreto 661/2007, de 25 de mayo, o a su disposición transitoria primera, deberán atenerse a lo previsto en los artículos 24.4 y 26.3 de dicho real decreto o al artículo 22.4 del Real Decreto 436/2004, de 12 de marzo.

**Disposición final segunda. Desarrollo normativo y modificaciones del contenido de los anexos.**

Se autoriza al Ministro de Industria, Turismo y Comercio a dictar cuantas disposiciones sean necesarias para el desarrollo de este real decreto y para modificar el contenido de sus anexos cuando el desarrollo de esta tecnología o el funcionamiento de preasignación de retribución así lo aconsejen.

**Disposición final tercera. Carácter básico.**

Este real decreto tiene carácter básico al amparo de lo establecido en el artículo 149.1.13.<sup>a</sup> y 149.1.25.<sup>a</sup> de la Constitución, que atribuye al Estado la competencia exclusiva en materia de bases y coordinación de la planificación general de la actividad económica y de bases del régimen minero y energético respectivamente.

**Disposición final cuarta. Entrada en vigor.**

El presente real decreto entrará en vigor el día siguiente al de su publicación en el «Boletín Oficial del Estado». No obstante lo establecido en la disposición adicional sexta, tendrá efectos desde el 1 de julio de 2008.

Dado en Madrid, el 26 de septiembre de 2008.

JUAN CARLOS R.

El Ministro de Industria, Turismo y Comercio,  
MIGUEL SEBASTIÁN GASCÓN

## ANEXO I

### Solicitud inscripción en el registro de preasignación

0	Tipo de solicitud	
1	Nueva solicitud	
2	Modificación de solicitud con número de expediente	
3	Cancelación de solicitud con número de expediente	
4	Declaración expresa de no desear participar en sucesivas convocatorias con la presente solicitud	
10	Datos de la instalación	
11	Nombre	
12	Ubicación	
13	Dirección	
14	Municipio/Código Postal	
15	Provincia	
16	Referencia catastral de parcela/construcción	
17	Potencia	
18	Tipo	

20	Datos del titular	
21	Nombre.	
22	Domicilio Social	
23	Municipio/Código Postal	
24	Provincia	
25	NIF/ NIE	
26	Nacionalidad	
30	Datos a efectos de comunicaciones	
31	Dirección	
32	Tfno. de contacto	
33	Fax	
34	Correo electrónico	
40	Información aportada	
41	Fecha punto de conexión	
42	Fecha autorización administrativa	
43	Fecha aval	
44	Fecha licencia de obras	
45	Cuantía aval	
46	N.º de identificación del aval	
47	Fecha de Solicitud presentada anteriormente	
48	N.º de registro administrativo de Solicitud presentada anteriormente	
49	Identificación del punto de conexión (CUPS o denominación equivalente, o descripción del punto frontera previsto y localización del equipo de medida)	
50	Fecha de inscripción definitiva en el Registro administrativo de instalaciones de régimen especial dependiente del órgano competente	

## ANEXO II

### Documentación necesaria para la solicitud de inscripción en el registro de preasignación de retribución

1. La documentación necesaria aportar, de forma conjunta con la solicitud de inscripción en el registro de preasignación será la siguiente:

a) Autorización administrativa de la instalación, otorgada por el órgano competente, y concesión del acceso y conexión a la red de transporte o distribución correspondiente. En el caso de instalaciones del tipo I.1, se aportará exclusivamente concesión del acceso y conexión a la red de transporte o distribución correspondiente.

b) Licencia de obras del proyecto de instalación, otorgado por el órgano competente.

c) Resguardo de constitución del aval a que hace referencia el artículo 59 bis o 66 bis del Real Decreto 1955/2000, de 1 de diciembre, o, en su caso, el previsto en el artículo 9 del presente real decreto otorgado por el gestor de la red.

d) Inscripción definitiva en el Registro administrativo de instalaciones de producción en régimen especial dependiente del órgano competente, si la instalación dispusiera de ella.

2. Hasta el 30 de abril de 2009, para las instalaciones de potencia igual o inferior a 100 kW, no será necesaria la presentación de la Autorización administrativa de la instalación, otorgada por el órgano competente, y en su lugar se presentará la concesión del acceso y conexión a la red de transporte o distribución correspondiente.

3. A los efectos de la ordenación cronológica de las instalaciones prevista en el artículo 6.3 de este real decreto, hasta la finalización de la convocatoria del segundo trimestre de 2009, se considerará la fecha de la concesión del acceso y conexión a la red correspondiente, en lugar de la fecha de la autorización administrativa, sin perjuicio de la obligación, en su caso de presentación de dicha autorización.

4. A los efectos de la ordenación cronológica de las instalaciones prevista en el artículo 6.3 de este real decreto, hasta la finalización de la convocatoria del segundo trimestre de 2009, no se tendrá en cuenta la fecha de presentación del aval correspondiente sin perjuicio de la obligación, de presentación de su resguardo entre la documentación exigida en el apartado 1 de este anexo.

5. A los efectos de la ordenación cronológica de las instalaciones y asignación de retribución prevista en el artículo 6.3 de este real decreto, hasta la finalización de la convocatoria del segundo trimestre de 2009, se comenzará la asignación por aquellas instalaciones que dispongan de inscripción definitiva en el Registro administrativo de instalaciones de régimen especial dependiente del órgano competente, manteniendo el criterio cronológico de los documentos a que hacen referencia los párrafos a), b) y c) del apartado 1 de este anexo. Una vez asignada la retribución para las instalaciones que dispusieran de inscripción definitiva, si no se hubiera cubierto el cupo de potencia previsto para esa convocatoria, continuará la asignación para el resto de solicitudes.

**ANEXO III****Convocatorias y plazos de presentación de solicitudes para la inscripción en el registro de preasignación de retribución**

1. Se fija el número de convocatorias de inscripción en el registro de preasignación de retribución en cuatro convocatorias anuales, coincidentes con las fechas de resolución del procedimiento de preasignación.

2. Los plazos de presentación de solicitudes para la inscripción en el registro de preasignación regulado en el artículo 6 del presente real decreto, y de publicación de los resultados del procedimiento de preasignación de la retribución serán los siguientes:

i. Convocatoria 1.º trimestre del año.

Presentación de la solicitud. Entre el 1 de agosto del año anterior y el 31 de octubre del año anterior al de la convocatoria, ambos inclusive.

Publicación del resultado del procedimiento de preasignación de retribución: Antes del 1 de enero del mismo año.

ii. Convocatoria 2.º trimestre del año.

Presentación de la solicitud. Entre el 1 de noviembre y el 31 de enero del año anterior al de la convocatoria, ambos inclusive.

Publicación del resultado del procedimiento de preasignación de retribución: Antes del 1 de abril.

iii. Convocatoria 3.º trimestre del año.

Presentación de la solicitud. Entre el 1 de febrero y el 30 de abril, ambos inclusive.

Publicación del resultado del procedimiento de preasignación de retribución: Antes del 1 de julio.

iv. Convocatoria 4.º trimestre del año.

Presentación de la solicitud. Entre el 1 de mayo y el 31 de julio, ambos inclusive.

Publicación del resultado del procedimiento de preasignación de retribución: Antes del 1 de octubre.

3. Cuando las fechas previstas en el apartado anterior sean no hábiles a efectos administrativos se tomará el primer día posterior hábil.

4. Se establecen, para las dos primeras convocatorias de 2009, una duración del plazo de presentación de solicitudes y de publicación del resultado, diferentes. El calendario para estas dos convocatorias será el siguiente:

i. Convocatoria 1.º trimestre de 2009.

Presentación de la solicitud. Entre el 15 de octubre y el 15 de noviembre de 2008, ambos inclusive.

Publicación del resultado del procedimiento de preasignación de retribución: Antes del 16 de enero de 2009.

ii. Convocatoria 2.º trimestre de 2009.

Presentación de la solicitud. Entre el 16 de noviembre de 2008 y el 31 de enero de 2009, ambos inclusive.

Publicación del resultado del procedimiento de preasignación de retribución: Antes del 1 de abril de 2009.

**ANEXO IV****Mecanismo de traspaso de potencia sobre la potencia base**

1. Cuando en una convocatoria no se cubriera parte de alguno de los cupos de uno solo de los tipos del artículo 3 de este real decreto, independientemente de que en el caso del tipo I corresponda a uno o los dos subtipos, la potencia restante se traspasará como potencia adicional

sobre la potencia base, para la convocatoria siguiente, al otro tipo.

2. Cuando en una convocatoria no se cubriera parte de los cupos de los dos tipos del artículo 3 de este real decreto, independientemente de que en el caso del tipo I corresponda a uno o los dos subtipos, las potencias restantes se traspasarán como potencias adicionales sobre las potencias base, para la convocatoria siguiente, en los tipos respectivos.

3. En los dos casos previstos en los apartados 1 y 2 anteriores, la potencia adicional traspasada al tipo I, ya sea desde el tipo II, o desde el tipo I (suma de las potencias no cubiertas de los dos subtipos), se repartirá en cada uno de los dos subtipos de acuerdo con el porcentaje de las potencias base de cada uno de los subtipos que les sea de aplicación. En el caso de que la nueva convocatoria corresponda a un nuevo año, y los porcentajes de las potencias base de cada subtipo se vean afectados por el mecanismo previsto en el artículo 5.3 la potencia traspasada del tipo II al tipo I se repartirá de acuerdo con los nuevos porcentajes de reparto entre subtipos.

4. La potencia correspondiente a aquellos proyectos de instalaciones, que de acuerdo con lo previsto en el artículo 8 fueran cancelados en el Registro de preasignación de retribución, será incorporada como potencia adicional a la convocatoria siguiente a su cancelación, en el mismo tipo o subtipo, según corresponda.

5. Las potencias adicionales no se verán afectadas, por los incrementos o decrementos que pudieran ser de aplicación a las potencias bases de acuerdo con lo previsto en el artículo 5.3 de este real decreto.

**MINISTERIO DE LA PRESIDENCIA**

**15596** *ORDEN PRE/2701/2008, de 26 de septiembre, por la que se publica el Acuerdo de Consejo de Ministros sobre las medidas contempladas en el Real Decreto 307/2005, de 18 de marzo, por el que se regulan las subvenciones en atención a determinadas necesidades derivadas de situaciones de emergencia o de naturaleza catastrófica, a los damnificados por las inundaciones producidas por las tormentas de lluvia y granizo que han afectado durante los días 22 al 26 de septiembre de 2008 a diversas Comunidades Autónomas.*

El Consejo de Ministros, en su reunión de 26 de septiembre de 2008 y a propuesta de la Vicepresidenta Primera del Gobierno y Ministra de la Presidencia, ha adoptado el Acuerdo sobre las medidas contempladas en el Real Decreto 307/2005, de 18 de marzo, por el que se regulan las subvenciones en atención a determinadas necesidades derivadas de situaciones de emergencia o de naturaleza catastrófica, a los damnificados por las inundaciones producidas por las tormentas de lluvia y granizo que han afectado durante los días 22 al 26 de septiembre de 2008 a diversas Comunidades Autónomas.

Para general conocimiento se procede a la publicación del referido Acuerdo, que figura como anexo a la presente orden.

Madrid, 26 de septiembre de 2008.–La Vicepresidenta Primera del Gobierno y Ministra de la Presidencia, María Teresa Fernández de la Vega Sanz.

