

## **GRASPINNO**

Transnational model, strategies and decision support for innovative clusters and business networks towards green growth, focusing on green e-procurement in EE/RES for energy refurbishment of public buildings.

# **Deliverable: 3.9.1**

## **Final Report on the pilots**

### **Chamber of Commerce of**

### **Terrassa**

*Prepared by CCIT*

**Date: (27/03/2018)**



**La Cambra**  
Cambre de Comerç  
de Terrassa

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## 1. INTRODUCTION

CCIT choose two project for develop the GRASPINNO pilot.

### 1.- UPC: Polytechnic University of Catalonia:

UPC-Terrassa Campus, is an urban campus, integrated in the city of Terrassa, Vallès Occidental region, Barcelona province, which generates the volume of industrial and economic activity higher of Catalonia. Therefore, the relation between the companies and the UPC in this territory is narrow and fluid.



In Terrassa Campus are located 3 study centres:

- ESEIAAT: school of Industrial, Aerospace and Audio-visual Engineering of Terrassa
- FOOT: Terrassa school of Optics and Optometry
- CITM: Image Processing and Multimedia Technology Center

Involving: 5000 students – 400 professors/investigators

Also, on Terrassa Campus there are 6 researcher's centers, located on GAIA building, one of them **SEER**: *research center on Renewable Electrical Energy Systems* that promotes Solar Campus with ESEIAAT students.

Under Solar Campus project, UPC collaborates with CCIT on Pilots development with 2 photovoltaics plants to be installed on 2 buildings, TR11 (Robotic Faculty and Library)

Solar Campus is an initiative created by students of all the fields of engineering of the UPC in Terrassa that wants to convert the campus in a Smart Energy Campus, creating projects of renewable energies that help to improve the image and the efficiency of the university.



**Background:**

SEER: installed on GAIA building a photovoltaic plant makes this building the greater plant of self-consumption of the UPC, accumulating more than 83% of the renewable generation to the UPC, saving 6.000€ /year on electricity consumption.

**Objectives of Project SOLAR CAMPUS 2017:**

- ✓ Reduction on energy consumption.
- ✓ 40 students from engineering degree courses getting experience on energy field
- ✓ Disseminate the activities and results
- ✓ Make the Campus in a Smart Energy Campus
- ✓ Promote another projects under the Smart Energy Campus idea

**Objectives on collaboration with GRASPINNO as one of CCIT Pilots:**

- ✓ Promote the visibility to be replicated on another buildings
- ✓ Learn about eGPP
- ✓ Experience

| Title:                             | <b>SOLAR CAMPUS:<br/>Installation of Photovoltaic plant in<br/>two university buildings.</b>                                             |
|------------------------------------|------------------------------------------------------------------------------------------------------------------------------------------|
| <b>Pilot Site</b>                  | UPC Campus: located at Terrassa city:<br>✓ Library<br>✓ Robotic Faculty – TR11                                                           |
| <b>Objectives</b>                  | <ul style="list-style-type: none"> <li>✓ Reduce the consumption of power coming from the grid.</li> <li>✓ Publish the results</li> </ul> |
| <b>EE/Category and Subcategory</b> | Renewable energy: RES<br>Energy source: Solar energy<br>Photovoltaic system                                                              |

## 2.- CCIT: Terrassa building (headquarter)

The CCIT develop the activities on the central headquarters in Terrassa (5.000m<sup>2</sup>), and on an office in Sant Cugat the Vallès (100m<sup>2</sup>). The activities in both of the installations are developed with a low impact in regarding risks of pollution and are ranged to the surroundings centric and urban of the city.

The GRASPINNO pilot is focused on CCIT Headquarters in Terrassa.



Building: 5000 m<sup>2</sup> distributed:

- ✓ Parking (-2)
- ✓ Floor -1
- Storage of Historical documents, Logistic department, machines room, staff place
- 2 rented offices
- ✓ Principal: staff offices and classroom
- ✓ 1<sup>st</sup>. Floor: Classrooms, Conferences room
- ✓ 2<sup>nd</sup>.Floor: Rented Offices, Plenary room
- ✓ 3<sup>rd</sup>. Floor: Meeting Rooms

The GRASPINNO pilot is focused on CCIT Headquarters in Terrassa. That building was built between 1989 and 1991. After that on 2007-2008 CCIT did a big refurbishment to expand the 3rd. floor, gaining 2 classrooms and 2 meetings room more. Under that refurbishment the air-condition system was renovated by one more efficient.

The use of the building is for offices, classrooms for training courses, meeting rooms, events rooms, and offices rented by external companies.

The energy used is electricity, and the consumption control is centralised for this reason is not possible to have data about the energy consumption on a separate way.

**Objectives:**

- ✓ Reduction on energy consumption: 10%
- ✓ Reduction of IND\_12: 5% (KPI)
- ✓ Improve the health conditions for people increasing the light lumens and quality at each workstation.
- ✓ To Continue with the plan for change all light system for LED technology

| Title:                      | Installation of Leds lights                                                                                                                                                                                                 |
|-----------------------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| Pilot Site                  | Terrassa building                                                                                                                                                                                                           |
| Objectives                  | <ul style="list-style-type: none"> <li>✓ Reduce the consumption of power coming from the grid.</li> <li>✓ Improve the health conditions for workers increasing the light lumens and quality at each workstation.</li> </ul> |
| EE/Category and Subcategory | Energy Efficiency: EE<br>Building renovation                                                                                                                                                                                |

## 2. PILOT SITES INITIAL CONDITION

### 2.1 Audits of pilot sites

#### UPC Pilots

UPC did a preliminary study on Building PV plants on the roof of Buildings TR11 and library. (**Annex 1**). This report contains layout designs for panel placements, and total power calculations and inverter selection. This studies goal is to define number of solar panels needed, where they are placed and what the total power is.

This study was elaborated under the student final thesis of degree.

Both buildings have an official audit with the energy classification.



#### TR11

Edifici TR11 CD6. Centre de Desenvolupament de Sensors, Instrumentació i Sistemes

|   |     |    |
|---|-----|----|
| D |     | 48 |
| E | 274 |    |



#### Library

Edifici TR9. Biblioteca

|   |     |    |
|---|-----|----|
| C |     | 56 |
| D | 333 |    |

#### CCIT Pilot

Under environmental management system certified by ISO 14001:2015, different KPIs are defined in order to measure the impact of CCIT activities on environment.

The energy used is electrical, and the consumption control is centralised for this reason is not possible to have data about the energy consumption on a separate way.

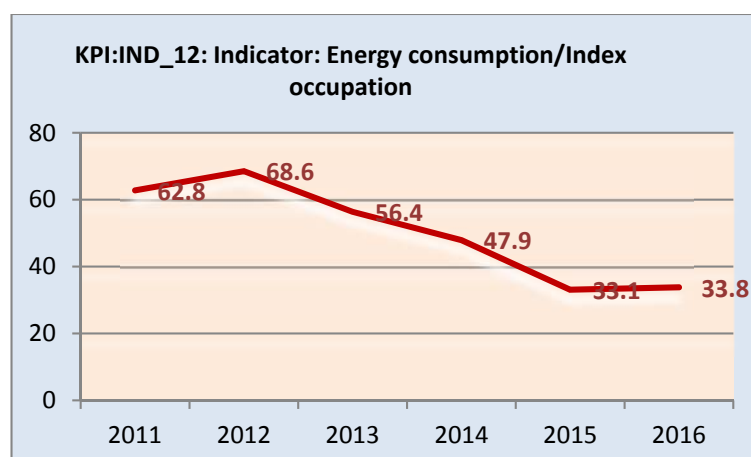
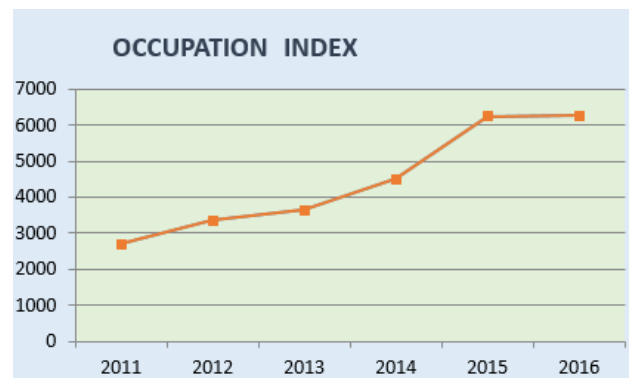
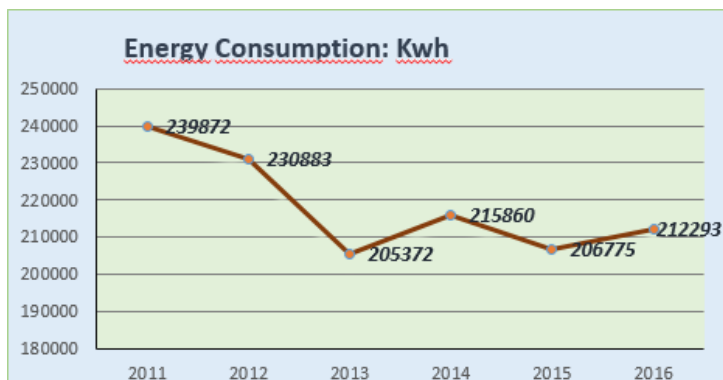
For this reason, concretely for energy CCIT establish an indicator of consumption related to an occupation index.

That KPI have two components, one is the global consumption of electricity by kWh and the second is the activities expressed as occupation index.

This Index is calculated considering the activities on a different place (offices, rent offices, classrooms, meeting rooms), information provided by an internal APP used for organised the occupation on a different place.

Considering the global consumption and the Consumption indicator, is possible to planning improvement on the infrastructures.

The evolution of that KPI on the last years.



Energy consumption increase **3%** on 2016

IND\_12: increase **2%**

NOTE: Graphics: just before GRASPINNO beginning.

On 2011 CCIT began the renovation of light system changing traditional devices by Leds in addition with good practices implemented under environmental management system.

| Installation            | Year         | Project scope                                                                |
|-------------------------|--------------|------------------------------------------------------------------------------|
| Parking                 | 2011         | Pàrquing: 1000 m <sup>2</sup>                                                |
| 2 <sup>nd</sup> . Floor | 2012-2013    | 4 rented offices:<br>28 m <sup>2</sup> each one                              |
| Principal floor         | 2012-2013    | President's office<br>Secretary General's office<br>General Manager's office |
|                         | 2015-2016    | Exposition local: 100 m <sup>2</sup>                                         |
|                         | January 2017 | Offices: 500 m <sup>2</sup>                                                  |

For the Pilot: in function of the budget

| Installation            | Year      | Project scope                                                            |
|-------------------------|-----------|--------------------------------------------------------------------------|
| -1 Floor                | 2017-2018 | 1-Rented office: 90 m <sup>2</sup><br>2-Rented office: 40 m <sup>2</sup> |
| 2 <sup>nd</sup> . Floor | 2017-2018 | 1 rented offices: 50 m <sup>2</sup>                                      |
| 1 <sup>st</sup> . Floor | 2018      | 5 classrooms/meeting rooms                                               |

Considering the improvement achieve on consumption since 2010 until the last work (showed on graphics), the conclusion is: changing the traditional light system by Leds is possible to achieve a reduction on the energy consumption **around 10 %**.

## 2.2 Identification of KPIs

### UPC:

- ✓ Reduction on energy consumption in a range of 10% in each building.
- ✓ Energy productions in kWh
- ✓ Energy class after refurbishment (official certificate)

### CCIT:

- ✓ Energy consumption
- ✓ IND\_12: Energy consumption/Occupation Index  
(Environmental Management System: ISO 14001)
- ✓ Evaluation of the improvement health conditioning under annual system revision

## 2.3 KPIs implementation

### UPC:

- ✓ Reduction on energy consumption in a range of 10% in each building.
- ✓ Energy productions in kWh
- ✓ Energy class after refurbishment (official certificate)

### CCIT:

#### **Monthly**

- ✓ Energy consumption: register using invoice (monthly)

#### **Each 3 months:**

- ✓ IND\_12: Energy consumption/Occupation Index  
(Environmental Management System: ISO 14001)

The installation is not ready at the moment of Final report redacting, but considering the historic data, is possible to estimate the reduction on energy consumption in terms of kWh expressed by 2 KPI.

The last big renovation was at the beginning of 2017 /Principal offices:500 m<sup>2</sup> ), the energy consumption decrease on **16 % (Annex 2)**.

**Annex 2** shows the last report on KPIs, global energy consumption and IND\_12 (occupation index).

### 3. TENDERS

#### 3.1 Preparation using the eGPP platform

##### UPC:

The GRASPINNO pilot is focused on solar panels materials.

(3 offers if the amount is  $\geq 5.000\text{€}$ ).

- ✓ Different suppliers
- ✓ Homologated Suppliers
- ✓ Contribution of local enterprises
- ✓ **Process:**
  - Until 18.000€: 3 offers / material
  - Technical specification document \_ Preliminary Study (**Annex 1**)
  - Adjudication body: Department director (SEER)

The product type:

- ✓ **Solar panels**
- ✓ **Solar blocs**
- ✓ **Inverter**
- ✓ **Electrical material**
- ✓ **Energy measuring equipment**

Each material has to be buy on an individual way. Each potential provider receives the technical specifications with the preliminary study document where the different kind of material and characteristics were defined.

Information already upload on GRASPINNO database used as reference:

### Photovoltaic panels:

| NAME                                  | Description                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                    | Model #                               | Brand name     | Options                                         |
|---------------------------------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|---------------------------------------|----------------|-------------------------------------------------|
| Panel Fotovoltaico Canadian 270       | Module 60 poly cells. 270 W and positive tolerance. Canadian Solar is the world's second largest manufacturer of photovoltaic modules. International quality, safety and performance certifications. High efficiency with low solar radiation.                                                                                                                                                                                                                                                                                                                                                                                                                                                                 | Canadian 270                          | CANADIAN SOLAR | <a href="#">View</a><br><a href="#">Compare</a> |
| Photovoltaic modules HIT® VBHN245SJ25 | High efficiency: With a Module efficiency of 19.4 % and a cell conversion efficiency of 22 %, the HIT® N245 ranks high on the level of efficiency in the market. With its very low temperature coefficient of only -0.29%/°C, the HIT® offers better performance than conventional cells in normal operating conditions. 2. Water-drainage frame: drainage corners in the Module frame allow for constant discharging of accumulated water. As water is not able to dry on the Module, there are no drying stains, and any build-up of humidity inside the panel is effectively prevented. A welcome side-effect is that the water-drainage frames help to keep modules clean even in low-angle installations. | Photovoltaic modules HIT® VBHN245SJ25 | PANASONIC      | <a href="#">View</a><br><a href="#">Compare</a> |
| POLYCRYSTALLINE SOLAR PANEL ND-R245A5 | "Loading... ND-R245A5 Image Details High-performance photovoltaic modules made of polycrystalline (156.5 mm)² silicon solar cells with module efficiencies of 14.9%. 3 busbar technology for enhancing the power output. Anti-reflex coating to increase light absorption. Production controlled positive power tolerance from 0 to 5 %. Only modules will be delivered that have the specified power or more for high energy yield. Delivery of modules in 5-watt intervals. Improved temperature coefficient to reduce power losses at higher temperatures. High power performance even at lower irradiances. Nominal Output (Wp) 245 Module Efficiency (%) 14.9 "                                           | ND-R245A5                             | sharp          | <a href="#">View</a><br><a href="#">Compare</a> |

Showing 1 to 3 of 3 entries (filtered from 288 total entries)

### Inverters:

| NAME                            | Description                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                              | Model #         | Brand name  | Options                                         |
|---------------------------------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-----------------|-------------|-------------------------------------------------|
| Air cooled heat pump EWYQ16BAWP | Inverter chiller • High efficiency with leader-of-class ESEER (up to 4.75) • Minimal starting currents and short payback times • No buffer tank required for standard applications • Daikin scroll compressor • Large operation range (ambient temperature up to 43°C) • Digital remote controller EER 3.11                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                              | EWYQ16BAWP      | DAIKIN      | <a href="#">View</a><br><a href="#">Compare</a> |
| Inversor Trifásico              | Fronius Eco three-phase inverter with power ratings of 25.0, has been specially designed for high power installations                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                    | ECO 25 KW       | FRONIUS ECO | <a href="#">View</a><br><a href="#">Compare</a> |
| Inverter MIC 350 -1500          | This inverter is produced by conergy, the biggest company in Europe. Voltage converters, inverters, DC / AC Converters are the vital element of each photovoltaic system. They convert the direct current produced by the photovoltaic generator into alternating current and then feed with this power grid. Conergy inverters impress thanks to their extremely high output and their small external dimensions. The high quality of Conergy inverters and all Conergy products is a result of its many years of experience.                                                                                                                                                                                                                                                                                                                                                           | Mic 350         | Conergy     | <a href="#">View</a><br><a href="#">Compare</a> |
| PV Inverter Kstar               | Omega KSG 5M / DM Single Phase String-Type Inverter Series. Is the ideal solution for roof-top solar system solutions. With the characteristics of high efficiency and reliability, compact design and easy installation, it is applicable to distribute power generation system. Highlighted Features: Transformer-less design and compact in size Harsh test IP65 industrial protection Provides single and double MPPT trackers for different application demands. Firmware is upgradeable via RS232 port. Parallel up to 50 units via RS485 port. Comply with latest VDE AR N4105 standard. MPP efficiency > 99.9% Maximum efficiency > 97.9% Mimic LCD display. Versatile communication interface options, standard RS485, RS485/WiFi and Ethernet/WiFi may reach up to your utmost request. Monitoring software provided offers operational status and electricity generated data. | KSG- 3000SM 3KW | Kstar       | <a href="#">View</a><br><a href="#">Compare</a> |
| PV Inverter Kostal              | Single-phase feed-in Transformerless converting integrated electronic DC switch Broad input voltage range Standard integrated communication package with data logger, web server, solar portal and the following interfaces: 2x Ethernet, RS485, 50, 4x analogue inputs (e.g. for ripple control receivers or PIKO Sensor) Integrated switch contact for self-consumption optimisation Smart Home-ready, EEBus 1.0-ready                                                                                                                                                                                                                                                                                                                                                                                                                                                                 | KOSTAL PIKO 3   | KOSTAL      | <a href="#">View</a><br><a href="#">Compare</a> |

Showing 1 to 5 of 5 entries (filtered from 288 total entries)

## CCIT

The GRASPINNO pilot is focused on **different size of Tubs Leds**.

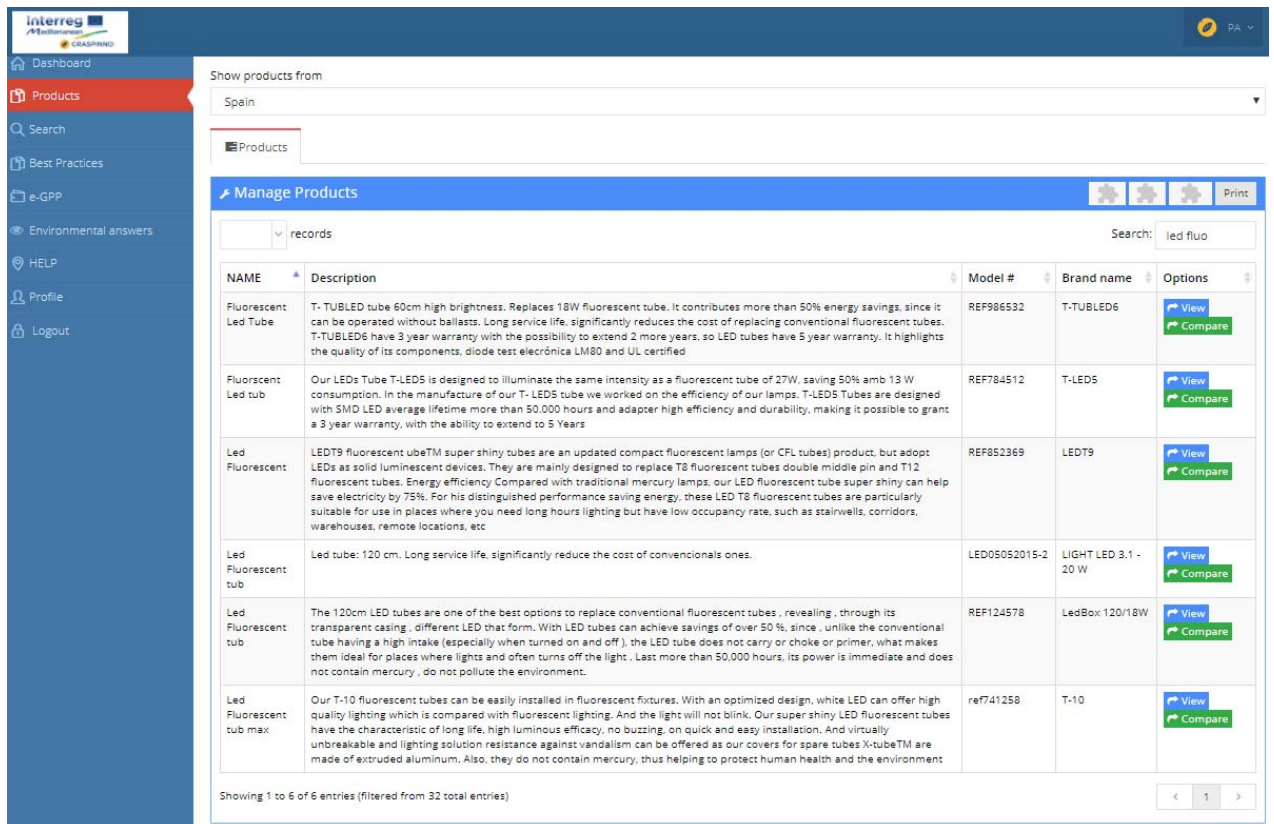
Under CCIT contracting official procedure the amount doesn't exceed 18.000€:

- ✓ The procedure is negotiating, if the amount is  $\geq 5.000\text{€}$ : 3 offers
- ✓ Following the internal instruction, CCIT develop an internal document with all relevant information and the evaluation criteria.
- ✓ This offers will be evaluated with LCC tool as defined on internal document
- ✓ Publish is not mandatory in this case, some local providers were invited.

## eGPP Platform

|             |                           |                     |            |                                              |        |                                                                                     |                        |                                                                                     |
|-------------|---------------------------|---------------------|------------|----------------------------------------------|--------|-------------------------------------------------------------------------------------|------------------------|-------------------------------------------------------------------------------------|
| Leds system | Design of indoor lighting | Direct Adjudication | 30/12/2017 | Chamber of Commerce and Industry of Terrassa | Closed |  | <a href="#">Delete</a> |  |
|-------------|---------------------------|---------------------|------------|----------------------------------------------|--------|-------------------------------------------------------------------------------------|------------------------|-------------------------------------------------------------------------------------|

## Searching products on database:



The screenshot shows the eGPP Platform interface. On the left is a sidebar with navigation links: Dashboard, Products (selected), Search, Best Practices, e-GPP, Environmental answers, HELP, Profile, and Logout. The main area displays a search results table for 'led fluo'.

**Search results table:**

| NAME                    | Description                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                  | Model #       | Brand name           | Options                                         |
|-------------------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|---------------|----------------------|-------------------------------------------------|
| Fluorescent Led Tube    | T-TUBLED tube 60cm high brightness. Replaces 18W fluorescent tube. It contributes more than 50% energy savings, since it can be operated without ballasts. Long service life, significantly reduces the cost of replacing conventional fluorescent tubes. T-TUBLED6 have 3 year warranty with the possibility to extend 2 more years, so LED tubes have 5 year warranty. It highlights the quality of its components, diode test electrónica LM80 and UL certified                                                                                                                                                                                           | REF986532     | T-TUBLED6            | <a href="#">View</a><br><a href="#">Compare</a> |
| Fluorescent Led tub     | Our LEDs Tube T-LED5 is designed to illuminate the same intensity as a fluorescent tube of 27W, saving 50% amb 13 W consumption. In the manufacture of our T-LED5 tube we worked on the efficiency of our lamps. T-LED5 Tubes are designed with SMD LED average lifetime more than 50,000 hours and adapter high efficiency and durability, making it possible to grant a 3 year warranty, with the ability to extend to 5 Years                                                                                                                                                                                                                             | REF784512     | T-LED5               | <a href="#">View</a><br><a href="#">Compare</a> |
| Led Fluorescent         | LEDT9 fluorescent ubeTM super shiny tubes are an updated compact fluorescent lamps (or CFL tubes) product, but adopt LEDs as solid luminescent devices. They are mainly designed to replace T8 fluorescent tubes double middle pin and T12 fluorescent tubes. Energy efficiency Compared with traditional mercury lamps, our LED fluorescent tube super shiny can help save electricity by 75%. For his distinguished performance saving energy, these LED T8 fluorescent tubes are particularly suitable for use in places where you need long hours lighting but have low occupancy rate, such as stairwells, corridors, warehouses, remote locations, etc | REF852369     | LEDT9                | <a href="#">View</a><br><a href="#">Compare</a> |
| Led Fluorescent tub     | Led tube: 120 cm. Long service life, significantly reduce the cost of conventionals ones.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                    | LED05052015-2 | LIGHT LED 3.1 - 20 W | <a href="#">View</a><br><a href="#">Compare</a> |
| Led Fluorescent tub     | The 120cm LED tubes are one of the best options to replace conventional fluorescent tubes, revealing, through its transparent casing, different LED that form. With LED tubes can achieve savings of over 50%, since, unlike the conventional tube having a high intake (especially when turned on and off), the LED tube does not carry or choke or primer, what makes them ideal for places where lights and often turns off the light. Last more than 50,000 hours, its power is immediate and does not contain mercury, do not pollute the environment.                                                                                                  | REF124578     | LedBox 120/18W       | <a href="#">View</a><br><a href="#">Compare</a> |
| Led Fluorescent tub max | Our T-10 fluorescent tubes can be easily installed in fluorescent fixtures. With an optimized design, white LED can offer high quality lighting which is compared with fluorescent lighting. And the light will not blink. Our super shiny LED fluorescent tubes have the characteristic of long life, high luminous efficacy, no buzzing, on quick and easy installation. And virtually unbreakable and lighting solution resistance against vandalism can be offered as our covers for spare tubes X-tubeTM are made of extruded aluminum. Also, they do not contain mercury, thus helping to protect human health and the environment                     | ref741258     | T-10                 | <a href="#">View</a><br><a href="#">Compare</a> |

Showing 1 to 6 of 6 entries (filtered from 32 total entries)



|                                                                                                                                   |                             |        |
|-----------------------------------------------------------------------------------------------------------------------------------|-----------------------------|--------|
| <br>La Cambra<br>Cambra de Comerç<br>de Terrassa | FITXA DE PROJECTE DE COMPRA | Pàgina |
|                                                                                                                                   |                             | 3 de 4 |

Pg-03/16 Ed.1

| <b>RESOLUCIÓ DE L'ÒRGAN DE CONTRACTACIÓ (omplir per l'òrgan de contractació)</b>                                                                                                 |                                                                                                                                                                                                                                                                                |              |              |                                          |  |                                   |  |
|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|--------------|--------------|------------------------------------------|--|-----------------------------------|--|
| <b>LICTACIÓ</b>                                                                                                                                                                  | <b>PROVEIDORS:</b><br><table border="1"> <thead> <tr> <th>PROVEIDOR</th> <th>Observacions</th> </tr> </thead> <tbody> <tr> <td>A.- ORVISER SL: instal·lació i productes</td> <td></td> </tr> <tr> <td>B.- MaxLed Egara, S.L.: productes</td> <td></td> </tr> </tbody> </table> | PROVEIDOR    | Observacions | A.- ORVISER SL: instal·lació i productes |  | B.- MaxLed Egara, S.L.: productes |  |
|                                                                                                                                                                                  | PROVEIDOR                                                                                                                                                                                                                                                                      | Observacions |              |                                          |  |                                   |  |
|                                                                                                                                                                                  | A.- ORVISER SL: instal·lació i productes                                                                                                                                                                                                                                       |              |              |                                          |  |                                   |  |
|                                                                                                                                                                                  | B.- MaxLed Egara, S.L.: productes                                                                                                                                                                                                                                              |              |              |                                          |  |                                   |  |
| <table border="1"> <thead> <tr> <th>PROVEIDOR</th> <th>PUNTUACIÓ</th> </tr> </thead> <tbody> <tr> <td> </td> <td> </td> </tr> <tr> <td> </td> <td> </td> </tr> </tbody> </table> | PROVEIDOR                                                                                                                                                                                                                                                                      | PUNTUACIÓ    |              |                                          |  |                                   |  |
| PROVEIDOR                                                                                                                                                                        | PUNTUACIÓ                                                                                                                                                                                                                                                                      |              |              |                                          |  |                                   |  |
|                                                                                                                                                                                  |                                                                                                                                                                                                                                                                                |              |              |                                          |  |                                   |  |
|                                                                                                                                                                                  |                                                                                                                                                                                                                                                                                |              |              |                                          |  |                                   |  |
| <b>OBSERVACIONS:</b><br>                                                                                                                                                         |                                                                                                                                                                                                                                                                                |              |              |                                          |  |                                   |  |
| <b>RESOLUCIÓ:</b>                                                                                                                                                                |                                                                                                                                                                                                                                                                                |              |              |                                          |  |                                   |  |

|                                                  |
|--------------------------------------------------|
| Vist-i-plau,<br>Director Gerent<br>(adjudicació) |
| Data: 27/03/2017 - Josep Prieto                  |

## 3.2 Publication of the real tender

For both Pilots:

- Not mandatory for this kind of tender
- Invite 3 or more potential provider
- Technical Specification document

**UPC:** Preliminary Study\_ Annex 1

**CCIT:**

- Technical Specification document (selection criteria are included on that document).

## Condiciones tècniques: LEDS – PC 17-002

### QUADRE RESUM DE CARACTERÍSTIQUES DEL CONTRACTE

A.- PRESSUPOST: Màxim de 6.000 €

B.- DURADA DEL CONTRACTE: Duració del treball d'instal·lació

C.- ADMISSIÓ DE SOL·LICITUDS DE PARTICIPACIÓ:

Marianna Pereira: [mpereira@cambraterassa.org](mailto:mpereira@cambraterassa.org)

German Fortet: [gfortet@cambraterassa.org](mailto:gfortet@cambraterassa.org)

TRAMITACIÓ: Ordinària

PROCEDIMENT: Negociat

### OBJECTE I CARACTERÍSTIQUES

#### Fase 1

|            |                                                  | Nº Tubs | Mida   |
|------------|--------------------------------------------------|---------|--------|
| Planta -1  | Oficina llogada STINGBYE SL                      | 48      | 1500mm |
|            | Oficina llogada Agents<br>Comercials de Terrassa | 16      | 1500mm |
| 2a. Planta | Oficina llogada NB Webs                          | 20      | 1200mm |

#### Fase 2

|            |                  |      |        |
|------------|------------------|------|--------|
| 1a. Planta | Aules. A-B-C-D-E | 20X5 | 1200mm |
| 2a. Planta | Aula 6           | 20   | 1200mm |

**NOTA:** Les ofertes han d'estar acompanyades de Full  
d'especificacions tècniques.

Exp. 17-002

Cerdanyola – Galdà – Matadepera – Cerdà de Montornès – Molins – Rubí – Sant Cugat del Valles – Sant Llorenç Savall – Terrassa – Llímadell – Vicennesa

### CRITERIS DE SELECCIÓ DE PROVEÏDOR:

| CRITERIS                                                                                                                            | PUNTUACIÓ                                     |
|-------------------------------------------------------------------------------------------------------------------------------------|-----------------------------------------------|
| Experiència: anys, referències. – Proveïdor històric<br>Proveïdor Puntual: 1-3<br>Homologat: 4-5<br>(Sistema de Gestió de Qualitat) | 1 A 5                                         |
| GRASPINNO LCC tool                                                                                                                  | Resultat<br>0-50% –1<br>50-70% –2<br>>70% – 3 |
| Cost i condicions<br>Productes + Instal·lació                                                                                       | 1 A 5                                         |

/

### 3.3 Tenders evaluation system

#### UPC:

The technical criteria were fixed on preliminary study.

Following the study recommendation, the criteria was to present the same material (brand) or equivalent with better economic conditions, considering this project is part of students final works.

Using GRASPINNO platform, another kind of material with similar technical characteristics were evaluated.

#### CCIT:

In this kind of procurement, the evaluation system is defined on the Internal Contracting document and is communicated with the specification document.

**Methodology:** evaluation using ponderation with criteria pre-fixed.

On this case the criteria are:

| CRITERIA                                                                                                                                                                                                             | SCORE  |
|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|--------|
| <i>Years of experience _ CCIT homologated provider</i><br><i>Considering:</i> <ul style="list-style-type: none"> <li>✓ Punctual provider: 1-3</li> <li>✓ Homologated under Quality Management System: 4-5</li> </ul> | 1 - 5  |
| <i>GRASPINNO LCC tool</i><br><i>Difference:</i> <ul style="list-style-type: none"> <li>✓ 0-50%--1</li> <li>✓ 50-70%--2</li> <li>✓ &gt;70%-- 3</li> </ul>                                                             | 1,2, 3 |
| <i>Price and Conditions</i><br><i>Products, prices, installation, services included</i>                                                                                                                              | 1 - 5  |

### 3.4 Results of the tenders

#### UPC:

The product type:

- ✓ **Solar panels:** 2 providers evaluated offering the similar product.

##### Provider\_1:

Luxor 100 M M-21-006 100 Wp 36 cel. Mono 0+SW 12 V I<sub>max</sub> 5,87 A 7,8Kg 1194 x 542 x 35 mm. MC4 162 145

##### Provider\_2:

| Nombre del producto                    |                  | SCHOTT ASI™ 81   |                          |
|----------------------------------------|------------------|------------------|--------------------------|
|                                        |                  | Potencia nominal | Potencia nominal inicial |
| Potencia nominal                       | P <sub>nom</sub> | 81 Wp            | 98,8 Wp aprox.           |
| Tensión en el punto de potencia máx.   | U <sub>mpp</sub> | 17,1 V           | 19,0 V aprox.            |
| Corriente en el punto de potencia máx. | I <sub>mpp</sub> | 4,73 A           | 5,20 A aprox.            |
| Tensión en circuito abierto            | U <sub>oc</sub>  | 23,0 V           | 24,0 V aprox.            |
| Corriente de cortocircuito             | I <sub>sc</sub>  | 5,82 A           | 6,00 A aprox.            |

- ✓ The winner is the provider who present the low price following the preliminary study recommendation.
- ✓ The winner is **Provider\_2**: low price offering exactly the product recommended on study.  
This provider offered a very low price considering the project will be developed by student.

#### CCIT:

- ✓ 4 Potential providers applied the request to present offer
- ✓ 2 of them only presents a catalog of products and prices
- ✓ 2 presents complete offers and their products were introduced on GRASPINNO) on data base, during the Training course (April 2017).

Using GRASPINNO unified platform:

### Life Cycle Cost

#### PROVIDER n\_1

| INSTALLATION |                               | INDEX<br>2015 | INDEX<br>2016 | Units | TRADITIONAL |            | TUBS LEDS |            | LCC         |            |
|--------------|-------------------------------|---------------|---------------|-------|-------------|------------|-----------|------------|-------------|------------|
|              |                               |               |               |       | W           | Import     | W         | Import     | TRADITIONAL | LEDS       |
| Floor: -1    | RENTED OFFICE                 | 1000          | 1008          | 48    | 58          | 288.00 €   | 21        | 729.60 €   | 6,187.27 €  | 1,934.09 € |
|              | RENTED OFFICE                 | 500           | 504           | 16    | 58          | 96.00 €    | 21        | 243.20 €   | 2,062.42 €  | 644.70 €   |
| 2nd. Floor   | RENTED OFFICE                 | 500           | 358           | 20    | 36          | 100.00 €   | 18        | 259.00 €   | 2,013.41 €  | 747.92 €   |
|              | Aula 6 - rented in mid-term   | 384           | 288           | 20    | 36          | 100.00 €   | 18        | 259.00 €   | 1,178.17 €  | 346.62 €   |
| 1st. Floor   | Aules. A - rented in mid-term | 148           | 248           | 20    | 58          | 120.00 €   | 21        | 304.00 €   | 4,161.56 €  | 1,213.12 € |
|              | Aules. B                      | 128           | 206           | 20    | 58          | 120.00 €   | 21        | 304.00 €   | 4,161.56 €  | 1,213.12 € |
|              | Aules. C-D                    | 336           | 316           | 60    | 58          | 360.00 €   | 21        | 912.00 €   | 4,340.18 €  | 1,273.35 € |
|              | Aules.E                       |               |               |       |             |            |           |            |             |            |
|              |                               |               |               |       |             | 1,184.00 € |           | 3,010.80 € | 24,104.57 € | 7,372.92 € |

#### PROVIDER n\_2

| INSTALLATION |                               | INDEX<br>2015 | INDEX<br>2016 | Units | TRADITIONAL |            | TUBS LEDS |            | LCC         |            |
|--------------|-------------------------------|---------------|---------------|-------|-------------|------------|-----------|------------|-------------|------------|
|              |                               |               |               |       | W           | Import     | W         | Import     | TRADITIONAL | LEDS       |
| Floor: - 1   | RENTED OFFICE                 | 1000          | 1008          | 48    | 58          | 288.00 €   | 22        | 979.20 €   | 6,187.27 €  | 2,247.69 € |
|              | RENTED OFFICE                 | 500           | 504           | 16    | 58          | 96.00 €    | 22        | 326.40 €   | 2,062.42 €  | 749.23 €   |
| 2nd. Floor   | RENTED OFFICE                 | 500           | 358           | 20    | 36          | 100.00 €   | 20        | 408.00 €   | 2,013.41 €  | 897.26 €   |
|              | Aula 6 - rented in mid-term   | 384           | 288           | 20    | 36          | 100.00 €   | 20        | 408.00 €   | 1,178.17 €  | 447.74 €   |
| 1st. Floor   | Aules. A - rented in mid-term | 148           | 248           | 20    | 58          | 120.00 €   | 22        | 400.00 €   | 4,161.56 €  | 1,541.12 € |
|              | Aules. B                      | 128           | 206           | 20    | 58          | 120.00 €   | 22        | 400.00 €   | 4,161.56 €  | 1,541.12 € |
|              | Aules. C-D                    | 336           | 316           | 60    | 58          | 360.00 €   | 22        | 1,224.00 € | 4,340.18 €  | 1,604.55 € |
|              | Aules.E                       |               |               |       |             |            |           |            |             |            |
|              |                               |               |               |       |             | 1,184.00 € |           | 4,145.60 € | 24,104.57 € | 9,028.71 € |

Annex 3 shows the individual calculus of LCC by each kind of installation.

The final results:

| PROVIDER n_1                                    |       | PROVIDER n_2                                    |       |
|-------------------------------------------------|-------|-------------------------------------------------|-------|
| CRITERIA                                        | SCORE | CRITERIA                                        | SCORE |
| Years of experience _ CCIT homologated provider | 4     | Years of experience _ CCIT homologated provider | 3     |
| GRASPINNO LCC tool                              | 3     | GRASPINNO LCC tool                              | 2     |
| Price and Conditions                            | 4     | Price and Conditions                            | 2     |
|                                                 | 11    |                                                 | 7     |

The provider winner is PROVIDER\_1.

## 4. INSTALLATION OF SUPPLIED PRODUCT / SERVICES

### UPC:

With this kind of material and considering the climatological situation is possible to estimate:

|           |              |
|-----------|--------------|
| Objective | 18400 kWh    |
| Achieved  | 17118.09 kWh |

The achieved is little less than the initial objective, but the economical result is a 2.396 €/year by Building.

The students have begun the works on both buildings and the prevision is to finish on the first semester of 2018.



## CCIT:

The installation is not finish at the date of this report.

To have quantitative data is necessary to evaluate 1 complete year realizing a comparison with data of years before.

Is possible to do an estimation, considering the occupation index will be similar, the reduction on light consumptions on this places will be reflected on the overall electricity consumption, around of 10% achieving objectives.

## 5. CONCLUSION

From two point of view, after GRASPINNO Pilot implementation is possible to conclude:

- ✓ From the benefit won on public buildings improving the energy management. Public buildings are among the largest consumers of energy, many of them with old facilities that require refurbishment, not only to comply with current regulations but primarily to optimize the use of energy resources.  
GRASPINNO provides a successful example to be replicated on others kinds of buildings, not only public ones, where the energy consumption is a relevant part on budget, promoting green technology through good practices.
- ✓ On green public procurement, GRASPINNO facilitates the process promoting the knowledge on green technology, green criteria, good practices examples centralized on an integrated platform where is possible to find information and recommendations on energy efficiency and renewable energy sources.

### NOTES:

Solar Campus Project:

[https://www.youtube.com/watch?time\\_continue=20&v=Ci4ychEmw8A](https://www.youtube.com/watch?time_continue=20&v=Ci4ychEmw8A)

## 6. ANNEX

Annex 1.- UPC: Preliminary study

Annex 2.- CCIT\_last report on KPIs

Annex 3- LCC tool study

## Preliminary study on building PV plants at the roof of TR11 and library

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**Project:** Building PV plants on TR11 and library  
**Date:** 18 july 2016  
**Version:** 02

---

# 1 - Introduction

This is preliminary study on Building PV plants on the roof of Buildings TR11 and library. This report contains layout designs for panel placements, and total power calculations and inverter selection. This study's goal is to define number of solar panels needed, where they are placed and what is the total power. Some of the values on this report is based on final thesis of Marc Serrano Rodriguez.

## 1.1 Solar panels

Solar panels that will be used in this project is SCHOTT ASI 81.

| Solar panels          |                             |
|-----------------------|-----------------------------|
| SCHOTT ASI 81         |                             |
| Size                  | 1,108x1,308 mm <sup>2</sup> |
| Thickness             | 50 mm                       |
| Weight                | 19 kg                       |
| Nominal output        | 81 Wp                       |
| Nominal Voltage       | 17,1 V                      |
| Nominal current       | 4,73 A                      |
| Open circuit voltage  | 23 V                        |
| Short circuit current | 5,82 A                      |
| Max voltage system    | 1000V                       |



SCHOTT ASI™ 78/81/86/89

Figure 1 SCHOTT ASI 81

## 1.2 Supporting panels

For supporting the panels will be used Solarblocks that are concrete blocks with 34degree angle.

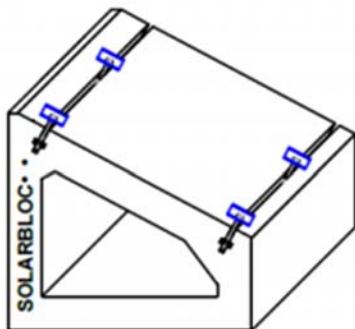


Figure 2 SolarBlock

| Características | SolarBloc      |
|-----------------|----------------|
| Altura 1        | 500 mm         |
| Altura 2        | 300 mm         |
| Ancho           | 500 mm         |
| Peso            | 76 kg          |
| inclinación     | 34 °           |
| Composición     | Hormigón HM-30 |

## 2 – Roof of TR11

### 2.1 Characteristic of the roof of TR11

The roof is divided in three areas that are named A, B and C as in the Figure 3.



Figure 3 TR11 roof

Roof is in two levels so that area C is higher than A and B. The roof is surrounded by wall that is

0,83m tall at areas A and B also dividing them, and 0,3m at area C.



Figure 4 Wall between area A and B

These walls has to be considered as calculating the distance to the wall.

## 2.2 Shadow calculations

The roof has 0,83m high edge at areas A, B and 0,3m at area C. Per meter of height projected shadow is 2,63m

The minimum distance from the edge at area A and B is:

$$h \cdot k = 0,83m \cdot 2,63m = 2,1m$$

The minimum distance from the edge at area C

$$h \cdot k = 0,3m \cdot 2,63m = 0,79m$$

Where k is latitude factor 2,63m

h is height of the wall.

These values are based on final thesis of Marc Serrano Rodriguez.

### 2.2.1 Panels installed standing vertical

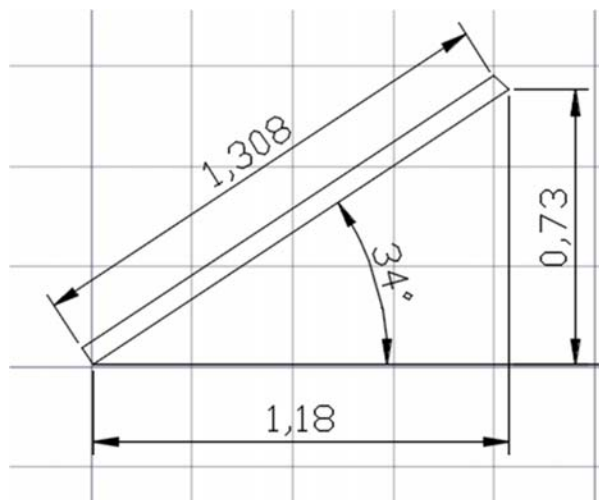


Figure 5 Solar panel installed upright

The spacing between the back of a row and the start of the next, will be  $h \cdot k$  below, where  $h$  is the height difference between the top of a row with the lower part of the next.

The minimum distance between plates, with reference to the type of plate, disposition and inclination of  $34^\circ$ , is:

$$h \cdot k = 0,73m \cdot 2,63 = 1,9m$$

Squeezing to 1,8m is possible.

## 2.2.2 Panels installed standing horizontal

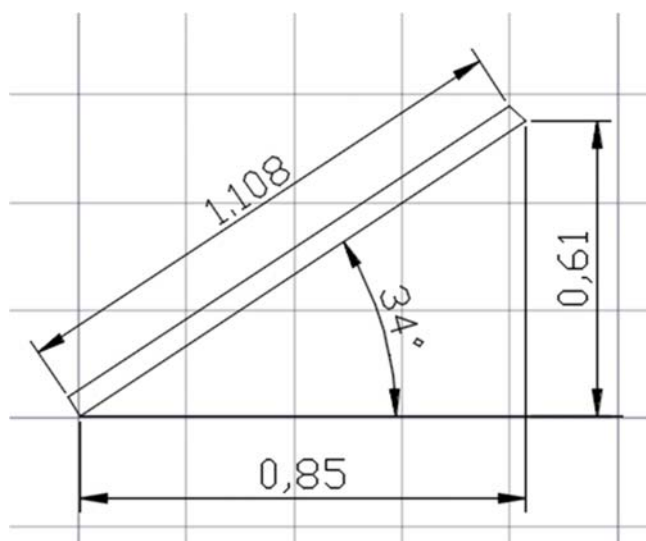
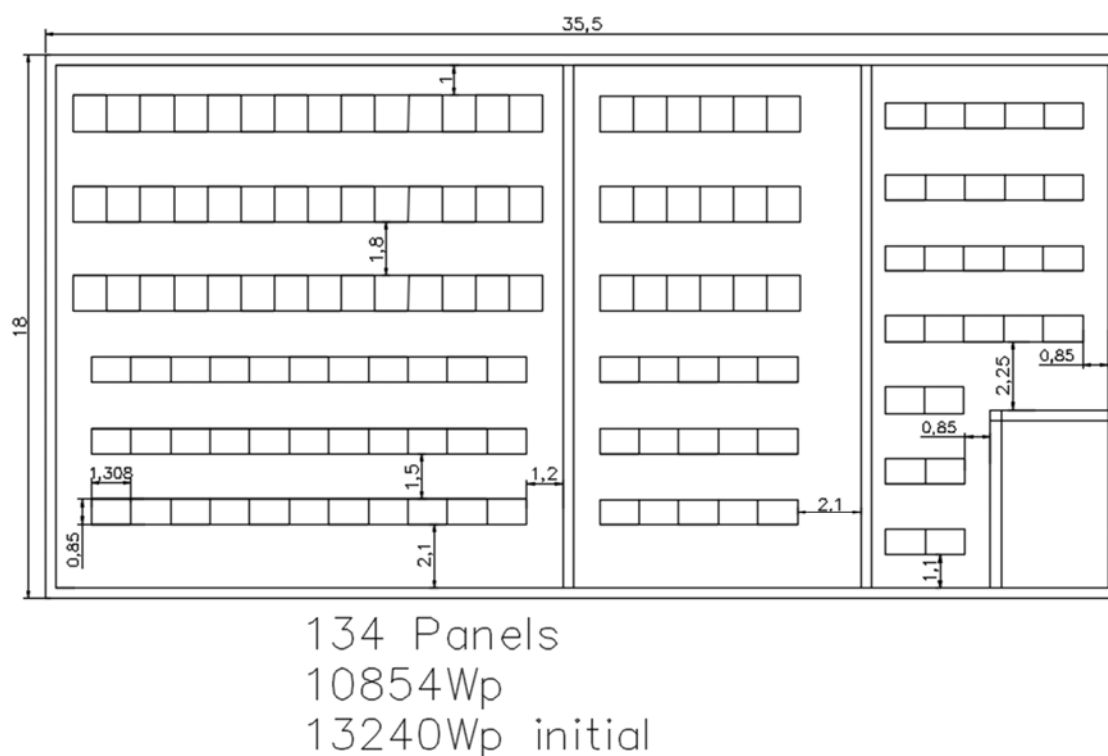


Figure 6 Option 2



Table 2 Layout TR11 option 2



## 2.5 Conclusion

With option 1 layout it is possible to install 138 panels with total of 11,2kWp on the roof of TR11. These layouts are designed very tight to place more power but having some "acceptable shadows" in winter.

## 3 Roof of Library

### 3.1 Characteristic of the roof of Library

Total area of the roof is about 26,81 m x 14,4 m. On one corner of the roof there is air condition systems that takes requires about 7m x 6m space around that cannot be used for solar panels.

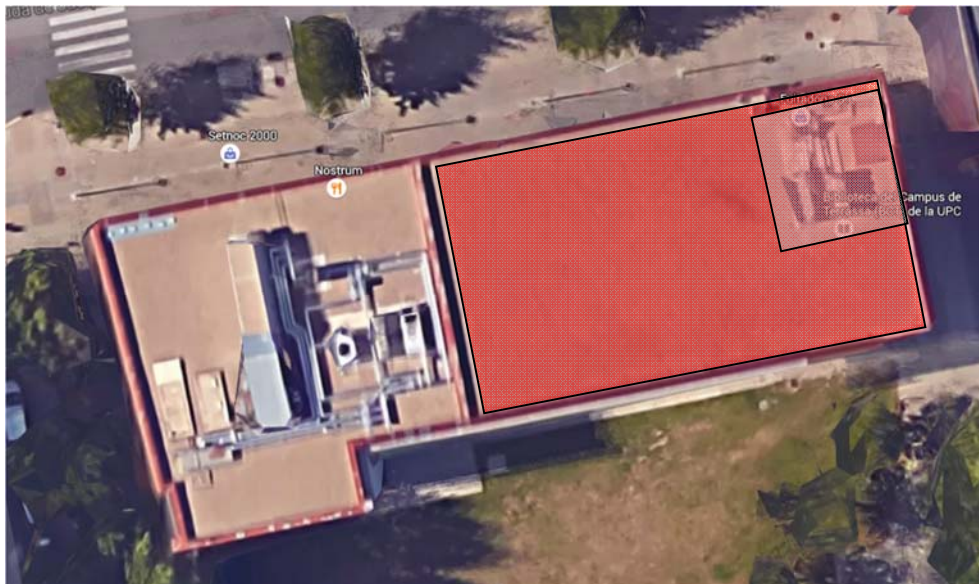


Figure 6 Roof of library

The roof is surrounded by wall that is 0,4m tall.



Figure 7 The roof, walls and AC equipment of library

### 3.2 Shadow calculation

The roof has 0,4m high wall edge.

The minimum distance from the edge is:

$$h \cdot k = 0,4m \cdot 2,63 = 1m$$

Can be squeezed to 1m

Where k is latitude factor 2,63

h is height of the wall.

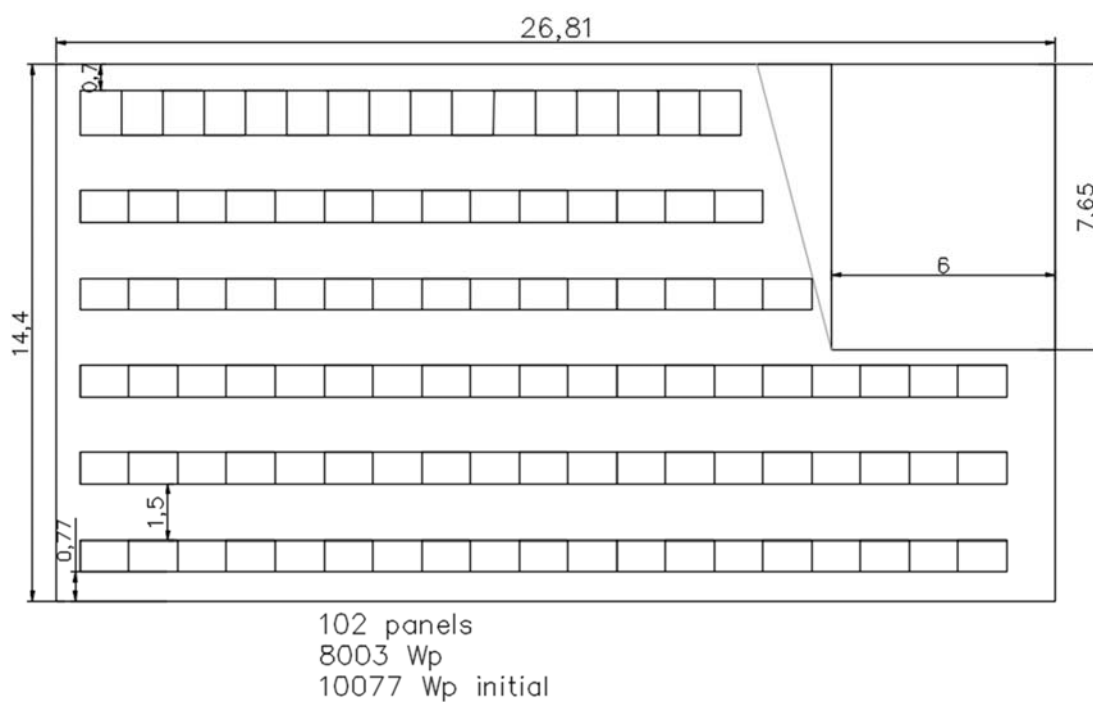
Also the AC equipments shadow has to be considered.

Distances between the rows of panels are same as in the calculations of building TR11 that are

- Panels standing vertically: 1,8m
- Panels standing on horizontal: 1,5m

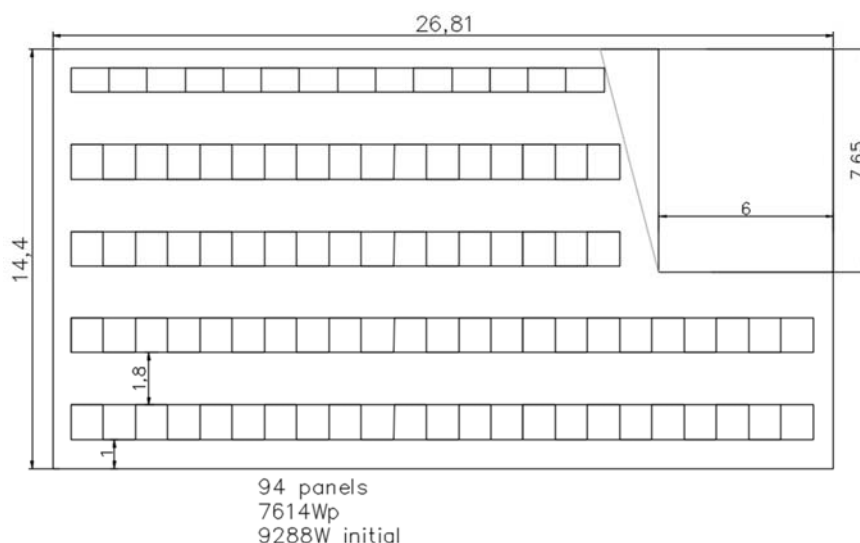
### 3.3 Layout design Library Option 1

Table 3 Library layout option1



### 3.4 Layout design Library option 2

Table 4 Library layout option 2



### 3.5 Conclusion

With option1 layout it is possible to install 102 panels with total of 8kWp on the roof of library. This layout is designed very tight to place more power but having some "acceptable shadows" in winter. With this design work safety has to be considered as installing the panels.

## 4 Inverters

The system needs inverters to assemble and transform the DC to AC and to input power to grid. Calculations has to be done with initial values because of the stabilizing of the amorphous silicon. The total number of panels has to be divided to few connection series so that the voltage will not be too much for the inverter which is usually 1000V per string. Also the power input has to be limited depending on the inverter. Inverters for this project will be provided by Schneider Electric.

### 4.1 TR11 inverter study

The initial values of 138 panels are at the table below. There is also presented the values with different amount of strings. Operating voltage range is usually 200-100V so 400-600V would be optimal.

Table 5 Initial values of TR11

| Initial values       |           |          |         |
|----------------------|-----------|----------|---------|
|                      | Voltage V | Power W  | Current |
| Total/134panels      | 2546V     | 13239,2W | 5,2A    |
| 4 strings/33,5panels | 636,5V    | 3309,8W  | 5,2A    |
| 5 strings/26,8panels | 509,2V    | 2647,8W  | 5,2A    |
| 6 strings/22,3panels | 424,3V    | 2206,5W  | 5,2A    |

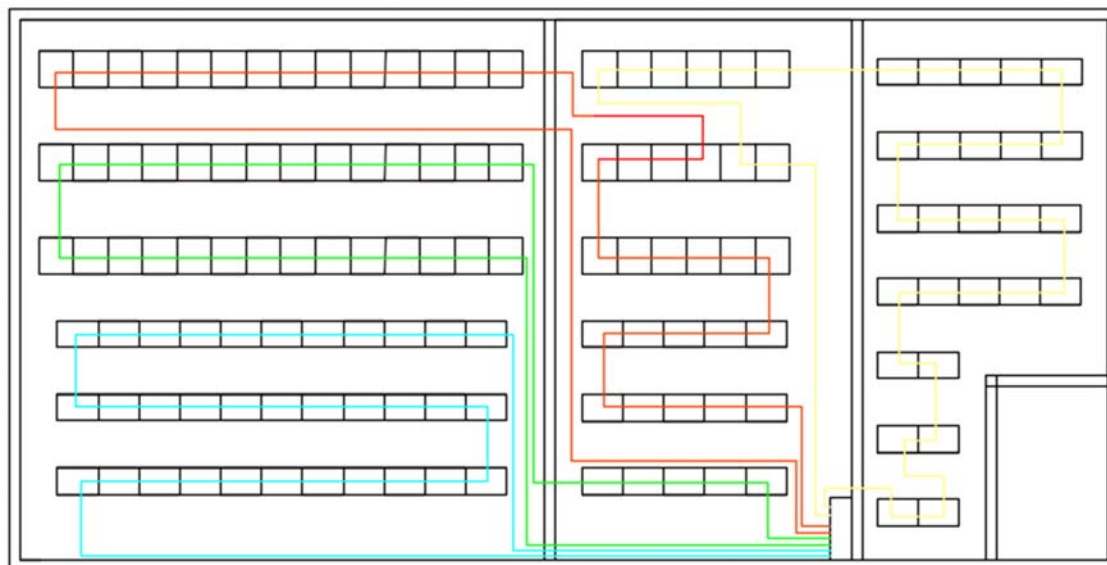
Optimal number of strings would be 6 strings.

#### 4.1.1 TR11 inverter Option 1 Conext TL15000E

One option for inverter would be to install four strings and for inverter to choose Conext TL 15000E. It has with four strings. The voltage and the power is in the limits. The requirement is 13,2kW so it is a little bit oversized but it is closest to total power available.

| Conext TL series                     |                          |                          |
|--------------------------------------|--------------------------|--------------------------|
| Device short name                    | TL 15000 E               | TL 20000 E               |
| <b>Electrical specifications</b>     |                          |                          |
| <b>Input (DC)</b>                    |                          |                          |
| MPPT voltage range, full power       | 350 - 800 V              | 350 - 800 V              |
| Operating voltage range              | 200 - 1000 V             | 200 - 1000 V             |
| Starting voltage                     | 250 V                    | 250 V                    |
| Max. input voltage, open circuit     | 1000 V                   | 1000 V                   |
| Number of MPPT                       | 2                        | 2                        |
| Max. input current per MPPT          | 23 A                     | 30 A                     |
| Nominal input power ( $\cos\phi=1$ ) | 15.6 kW                  | 20.8 kW                  |
| Max. DC input power per MPPT         | 8.5 kW                   | 11.0 kW                  |
| DC connection type                   | MC4, 4 pairs (2+2)       | MC4, 4 pairs (2+2)       |
| DC switch                            | Integrated               | Integrated               |
| <b>Output (AC)</b>                   |                          |                          |
| Nominal output power                 | 15 kVA                   | 20 kVA                   |
| Max. AC output power                 | 15.8kVA                  | 21.0 kVA                 |
| Nominal output voltage               | 230 / 400 V, three-phase | 230 / 400 V, three-phase |
| Isolation                            | Transformerless          | Transformerless          |
| AC voltage range                     | 184 - 276 V              | 184 - 276 V              |
| Frequency                            | 50 / 60 Hz               | 50 / 60 Hz               |
| Frequency range                      | 50 / 60 +/- 3 Hz         | 50 / 60 +/- 3 Hz         |
| Max. output current                  | 24.0 A                   | 32.0 A                   |
| Total harmonic distortion            | < 3 %                    | < 3 %                    |
| Power factor (adjustable)            | 0.8 lead to 0.8 lag      | 0.8 lead to 0.8 lag      |
| AC connection type                   | IP67 connector           | IP67 connector           |
| <b>Efficiency</b>                    |                          |                          |
| Peak                                 | 98.0%                    | 98.0 %                   |
| European                             | 97.3 %                   | 97.5 %                   |

Figure 8 Conext TL15000E



134 Panels 171m cable 153 Solarblocs

String 1: 33 panels 46m

String 2: 33 panels 35m

String 3: 34 panels 50m

String 4: 34 panels 40m

#### 4.1.2 TR11 inverter Option 2 Conext TL8000E

Option 2 is to install four strings and for inverter to choose two Conext TL8000E inverters and divide two strings to each inverters. Nominal input in one inverter is 8,3kW and combined 16,6kW. The requirement is 13,2kW so this option is also a bit oversized.

## Conext TL series

| Device short name                | TL 8000 E                | TL10000 E                |
|----------------------------------|--------------------------|--------------------------|
| <b>Electrical specifications</b> |                          |                          |
| <b>Input (DC)</b>                |                          |                          |
| MPPT voltage range, full power   | 350 - 850 V              | 350 - 850 V              |
| Operating voltage range          | 200 - 1000 V             | 200 - 1000 V             |
| Starting voltage                 | 250 V                    | 250 V                    |
| Max. input voltage, open circuit | 1000 V                   | 1000 V                   |
| Number of MPPT                   | 2                        | 2                        |
| Max. input current per MPPT      | 17 A                     | 17 A                     |
| Nominal input power (cosφ=1)     | 8.3 kW                   | 10.4 kW                  |
| Max. DC input power per MPPT     | 5.5 kW                   | 7.0 kW                   |
| DC connection type               | MC4, 4 pairs (2+2)       | MC4, 4 pairs (2+2)       |
| DC switch                        | Integrated               | Integrated               |
| <b>Output (AC)</b>               |                          |                          |
| Nominal output power             | 8 kVA                    | 10 kVA                   |
| Max. AC output power             | 8.4 kVA                  | 10.5 kVA                 |
| Nominal output voltage           | 230 / 400 V, three-phase | 230 / 400 V, three-phase |
| Isolation                        | Transformerless          | Transformerless          |
| AC voltage range                 | 184 - 276 V              | 184 - 276 V              |
| Frequency                        | 50 / 60 Hz               | 50 / 60 Hz               |
| Frequency range                  | 50 / 60 +/- 3 Hz         | 50 / 60 +/- 3 Hz         |
| Max. output current              | 12.8 A                   | 16.0 A                   |
| Total harmonic distortion        | < 3 %                    | < 3 %                    |
| Power factor (adjustable)        | 0.8 lead to 0.8 lag      | 0.8 lead to 0.8 lag      |
| AC connection type               | IP67 connector           | IP67 connector           |
| <b>Efficiency</b>                |                          |                          |
| Peak                             | 98.2 %                   | 98.3 %                   |
| European                         | 97.4 %                   | 97.7 %                   |

## 4.2 Library inverter study

The initial values of 102 panels are at the table below. There is also presented the values with different amount of strings. Operating voltage range is usually 200-100V so 400-600V would be optimal.

Table 6 Library inverter

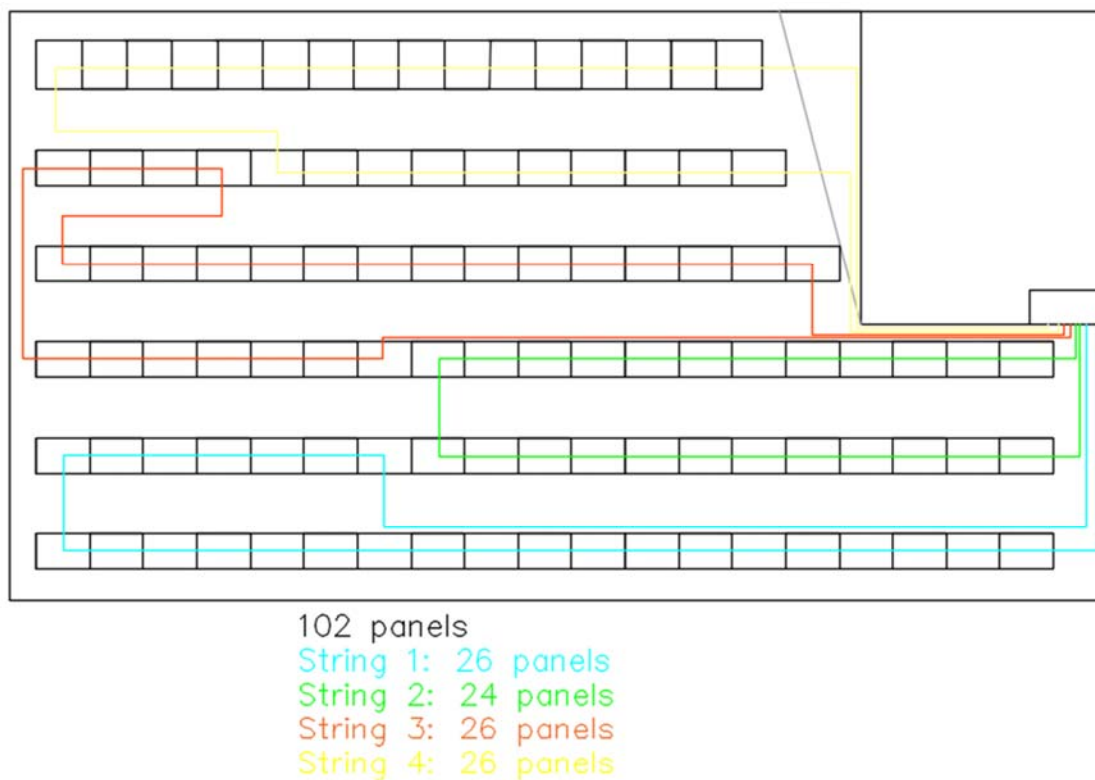
| Initial values       |           |          |         |
|----------------------|-----------|----------|---------|
|                      | Voltage V | Power W  | Current |
| Total/102panels      | 1938V     | 10077,6W | 5,2A    |
| 4 strings/25,5panels | 484,5V    | 2519,4W  | 5,2A    |
| 5 strings/20,4panels | 387,6V    | 2015,52W | 5,2A    |
| 6 strings/17panels   | 323V      | 1679,6W  | 5,2A    |

### 4.2.1 Library inverter Option 1 Conext TL1000E

One option for inverter would be to install four strings and for inverter to choose Conext TL 10000E. It has with four strings. The voltage and the power is in the limits. It is closest to total needed power available as demand is 10,07kWp and nominal input is 10,4kW.

#### Conext TL series

| Device short name                    | TL 8000 E                | TL10000 E                |
|--------------------------------------|--------------------------|--------------------------|
| <b>Electrical specifications</b>     |                          |                          |
| <b>Input (DC)</b>                    |                          |                          |
| MPPT voltage range, full power       | 350 - 850 V              | 350 - 850 V              |
| Operating voltage range              | 200 - 1000 V             | 200 - 1000 V             |
| Starting voltage                     | 250 V                    | 250 V                    |
| Max. input voltage, open circuit     | 1000 V                   | 1000 V                   |
| Number of MPPT                       | 2                        | 2                        |
| Max. input current per MPPT          | 17 A                     | 17 A                     |
| Nominal input power ( $\cos\phi=1$ ) | 8.3 kW                   | 10.4 kW                  |
| Max. DC input power per MPPT         | 5.5 kW                   | 7.0 kW                   |
| DC connection type                   | MC4, 4 pairs (2+2)       | MC4, 4 pairs (2+2)       |
| DC switch                            | Integrated               | Integrated               |
| <b>Output (AC)</b>                   |                          |                          |
| Nominal output power                 | 8 kVA                    | 10 kVA                   |
| Max. AC output power                 | 8.4 kVA                  | 10.5 kVA                 |
| Nominal output voltage               | 230 / 400 V, three-phase | 230 / 400 V, three-phase |
| Isolation                            | Transformerless          | Transformerless          |
| AC voltage range                     | 184 - 276 V              | 184 - 276 V              |
| Frequency                            | 50 / 60 Hz               | 50 / 60 Hz               |
| Frequency range                      | 50 / 60 +/- 3 Hz         | 50 / 60 +/- 3 Hz         |
| Max. output current                  | 12.8 A                   | 16.0 A                   |
| Total harmonic distortion            | < 3 %                    | < 3 %                    |
| Power factor (adjustable)            | 0.8 lead to 0.8 lag      | 0.8 lead to 0.8 lag      |
| AC connection type                   | IP67 connector           | IP67 connector           |
| <b>Efficiency</b>                    |                          |                          |
| Peak                                 | 98.2 %                   | 98.3 %                   |
| European                             | 97.4 %                   | 97.7 %                   |



#### 4.2.2 Library inverter Option 2 Conext TL8000E

Option 2 is to install four strings and for inverter to choose two Conext TL8000E inverters and divide two strings to each inverters. Nominal input in one inverter is 8,3kW and combined 16,6kW. The requirement is 10,07kW so this option is a lot oversized.

## 5 PVsyst study

PVsyst Photovoltaic Software is a designing tool for calculating and simulating photovoltaic system power production and losses.

### 5.1 TR11 PVsyst study

With 136 solar panels total produced energy is 18,36MWh/year.

|                                              |  |                       |                                   |                    |                  |
|----------------------------------------------|--|-----------------------|-----------------------------------|--------------------|------------------|
| PVSYST V6.44                                 |  | 21/06/16              |                                   | Page 1/3           |                  |
| Grid-Connected System: Simulation parameters |  |                       |                                   |                    |                  |
| Project :                                    |  | Library               |                                   |                    |                  |
| Geographical Site                            |  | Barcelona             | Country                           | Spain              |                  |
| Situation                                    |  | Latitude              | 41.4°N                            | Longitude          | 2.1°E            |
| Time defined as                              |  | Legal Time            | Time zone UT+1                    | Altitude           | 273 m            |
|                                              |  | Albedo                | 0.20                              |                    |                  |
| Meteo data:                                  |  | Barcelona             | MeteoNorm 7.1 station - Synthetic |                    |                  |
| Simulation variant :                         |  | TR11                  |                                   |                    |                  |
|                                              |  | Simulation date       | 21/06/16 11h16                    |                    |                  |
| Simulation parameters                        |  |                       |                                   |                    |                  |
| Collector Plane Orientation                  |  | Tilt                  | 34°                               | Azimuth            | -17°             |
| Models used                                  |  | Transposition         | Perez                             | Diffuse            | Perez, Meteonorm |
| Horizon                                      |  | Free Horizon          |                                   |                    |                  |
| Near Shadings                                |  | No Shadings           |                                   |                    |                  |
| PV Array Characteristics                     |  |                       |                                   |                    |                  |
| PV module                                    |  | a-Si:H tandem         | Model                             | ASI-TM 81          |                  |
| Original PVsyst database                     |  | Manufacturer          | Schott Solar AG                   |                    |                  |
| Number of PV modules                         |  | In series             | 34 modules                        | In parallel        | 4 strings        |
| Total number of PV modules                   |  | Nb. modules           | 136                               | Unit Nom. Power    | 81 Wp            |
| Array global power                           |  | Nominal (STC)         | 11.02 kWp                         | At operating cond. | 10.50 kWp (50°C) |
| Array operating characteristics (50°C)       |  | U mpp                 | 557 V                             | I mpp              | 19 A             |
| Total area                                   |  | Module area           | 197 m²                            |                    |                  |
| Inverter                                     |  |                       |                                   |                    |                  |
| Original PVsyst database                     |  | Model                 | Conext TL 15000 E                 |                    |                  |
| Characteristics                              |  | Manufacturer          | Schneider Electric                |                    |                  |
| Inverter pack                                |  | Operating Voltage     | 350-850 V                         | Unit Nom. Power    | 15.0 kWac        |
|                                              |  | Nb. of inverters      | 2 * MPPT 50 %                     | Total Power        | 15.0 kWac        |
| PV Array loss factors                        |  |                       |                                   |                    |                  |
| Thermal Loss factor                          |  | Uc (const)            | 20.0 W/m²K                        | Uv (wind)          | 0.0 W/m²K / m/s  |
| Wiring Ohmic Loss                            |  | Global array res.     | 507 mOhm                          | Loss Fraction      | 1.5 % at STC     |
| Module Quality Loss                          |  |                       |                                   | Loss Fraction      | -0.8 %           |
| Module Mismatch Losses                       |  |                       |                                   | Loss Fraction      | 0.8 % at MPP     |
| Incidence effect, ASHRAE parametrization     |  | IAM =                 | 1 - bo (1/cos i - 1)              | bo Param.          | 0.05             |
| User's needs :                               |  | Unlimited load (grid) |                                   |                    |                  |

PV Field Orientation

PV modules

PV Array

Inverter

User's needs

DIT 34°

Model ASI-TM 81

Nb. of modules 136

Model Conext TL 15000 E

Unlimited load (grid)

azimuth -17°

Pnom 81 Wp

Pnom total 11.02 kWp

Pnom 15.00 kW a

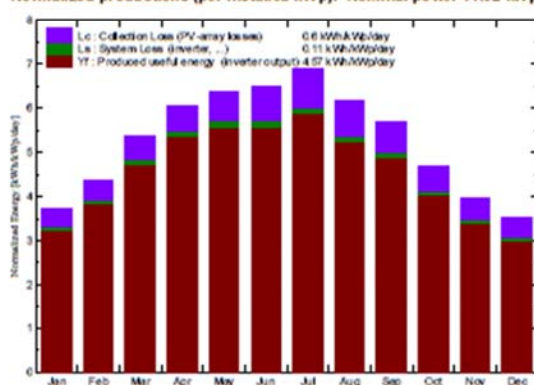
### Main simulation results

System Production

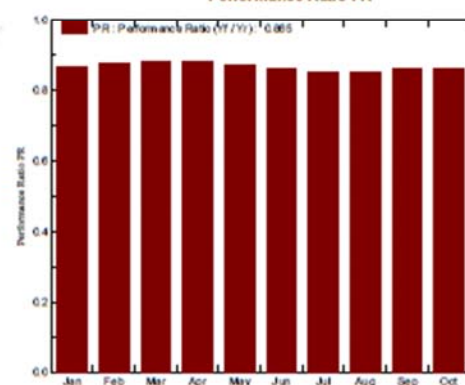
Produced Energy **18.36 MWh/year**  
Performance Ratio PR **86.5 %**

Specific prod. 1667 kWh/kWp

Normalized productions (per installed kWp): Nominal power 11.02 kWp



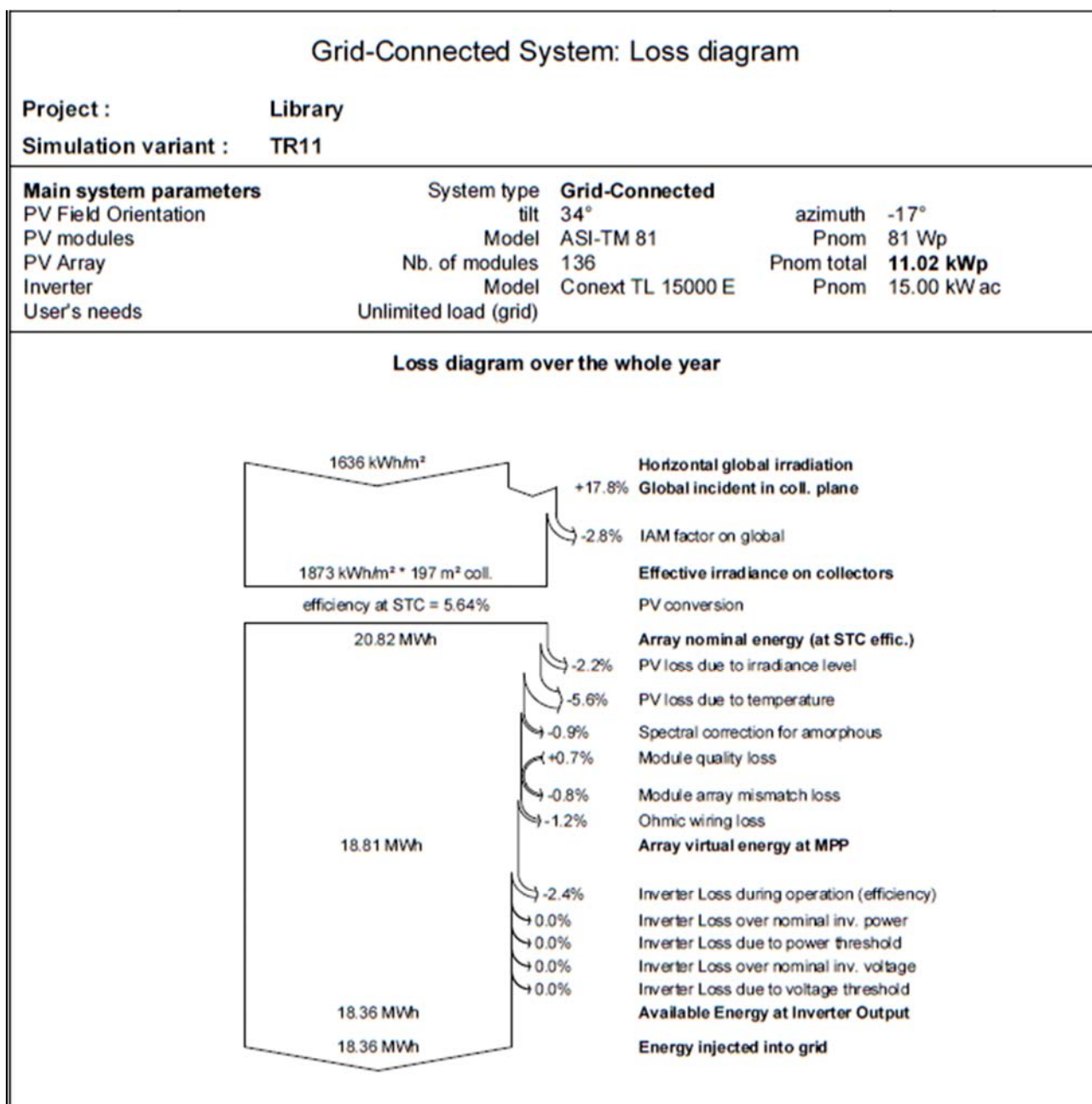
Performance Ratio PR



TR11

### Balances and main results

|           | GlobHor<br>kWh/m² | T Amb<br>°C | GlobInc<br>kWh/m² | GlobEff<br>kWh/m² | EArray<br>MWh | E_Grid<br>MWh | EffArrR<br>% | EffS<br>% |
|-----------|-------------------|-------------|-------------------|-------------------|---------------|---------------|--------------|-----------|
| January   | 67.4              | 8.03        | 115.6             | 112.6             | 1.133         | 1.106         | 4.97         | 4.97      |
| February  | 82.4              | 9.15        | 122.5             | 119.3             | 1.213         | 1.184         | 5.02         | 4.97      |
| March     | 131.1             | 11.95       | 166.0             | 161.9             | 1.651         | 1.611         | 5.04         | 4.97      |
| April     | 166.5             | 14.15       | 181.9             | 176.9             | 1.813         | 1.770         | 5.06         | 4.97      |
| May       | 198.9             | 17.92       | 197.8             | 191.7             | 1.950         | 1.903         | 5.00         | 4.97      |
| June      | 205.5             | 22.11       | 194.3             | 188.4             | 1.890         | 1.844         | 4.93         | 4.97      |
| July      | 222.4             | 24.47       | 213.4             | 206.9             | 2.054         | 2.005         | 4.88         | 4.97      |
| August    | 183.0             | 24.54       | 190.9             | 185.5             | 1.839         | 1.794         | 4.89         | 4.97      |
| September | 142.2             | 20.70       | 170.3             | 165.8             | 1.652         | 1.612         | 4.92         | 4.97      |
| October   | 105.2             | 17.52       | 145.0             | 141.2             | 1.410         | 1.376         | 4.93         | 4.97      |



## 5.2 Library PVsyst study

With 96 solar panels total produced energy is 12,84MWh/year.

## Grid-Connected System: Simulation parameters

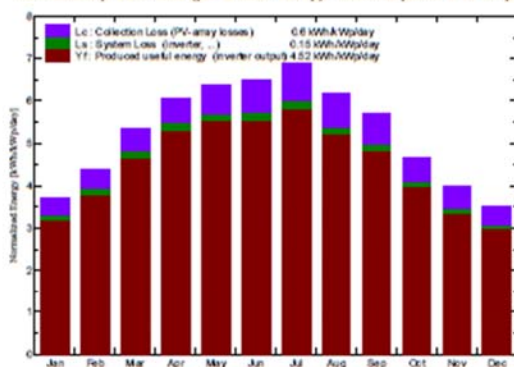
|                                          |                   |                                   |                    |                  |
|------------------------------------------|-------------------|-----------------------------------|--------------------|------------------|
| Project :                                | Library           |                                   |                    |                  |
| Geographical Site                        | Barcelona         |                                   | Country            | Spain            |
| Situation                                | Latitude          | 41.4°N                            | Longitude          | 2.1°E            |
| Time defined as                          | Legal Time        | Time zone UT+1                    | Altitude           | 273 m            |
|                                          | Albedo            | 0.20                              |                    |                  |
| Meteo data:                              | Barcelona         | MeteoNorm 7.1 station - Synthetic |                    |                  |
|                                          |                   |                                   |                    |                  |
| Simulation variant :                     | Library           |                                   |                    |                  |
|                                          | Simulation date   | 21/06/16 11h17                    |                    |                  |
|                                          |                   |                                   |                    |                  |
| Simulation parameters                    |                   |                                   |                    |                  |
| Collector Plane Orientation              | Tilt              | 34°                               | Azimuth            | -17°             |
| Models used                              | Transposition     | Perez                             | Diffuse            | Perez, Meteonorm |
| Horizon                                  | Free Horizon      |                                   |                    |                  |
| Near Shadings                            | No Shadings       |                                   |                    |                  |
|                                          |                   |                                   |                    |                  |
| PV Array Characteristics                 |                   |                                   |                    |                  |
| PV module                                | a-Si:H tandem     | Model                             | ASI-TM 81          |                  |
| Original PVsyst database                 | Manufacturer      | Schott Solar AG                   |                    |                  |
| Number of PV modules                     | In series         | 24 modules                        | In parallel        | 4 strings        |
| Total number of PV modules               | Nb. modules       | 96                                | Unit Nom. Power    | 81 Wp            |
| Array global power                       | Nominal (STC)     | 7.78 kWp                          | At operating cond. | 7.41 kWp (50°C)  |
| Array operating characteristics (50°C)   | U mpp             | 393 V                             | I mpp              | 19 A             |
| Total area                               | Module area       | 139 m²                            |                    |                  |
|                                          |                   |                                   |                    |                  |
| Inverter                                 | Model             | Conext TL 10000 E                 |                    |                  |
| Original PVsyst database                 | Manufacturer      | Schneider Electric                |                    |                  |
| Characteristics                          | Operating Voltage | 350-850 V                         | Unit Nom. Power    | 10.0 kWac        |
| Inverter pack                            | Nb. of inverters  | 2 * MPPT 50 %                     | Total Power        | 10.0 kWac        |
|                                          |                   |                                   |                    |                  |
| PV Array loss factors                    |                   |                                   |                    |                  |
| Thermal Loss factor                      | Uc (const)        | 20.0 W/m²K                        | Uv (wind)          | 0.0 W/m²K / m/s  |
| Wiring Ohmic Loss                        | Global array res. | 358 mOhm                          | Loss Fraction      | 1.5 % at STC     |
| Module Quality Loss                      |                   |                                   | Loss Fraction      | -0.8 %           |
| Module Mismatch Losses                   |                   |                                   | Loss Fraction      | 0.8 % at MPP     |
| Incidence effect, ASHRAE parametrization | IAM =             | 1 - bo (1/cos i - 1)              | bo Param.          | 0.05             |

|                      |                       |                   |            |             |
|----------------------|-----------------------|-------------------|------------|-------------|
| PV Field Orientation | tilt                  | 34°               | azimuth    | -17°        |
| PV modules           | Model                 | ASI-TM 81         | Pnom       | 81 Wp       |
| PV Array             | Nb. of modules        | 96                | Pnom total | 7.78 kWp    |
| Inverter             | Model                 | Conext TL 10000 E | Pnom       | 10.00 kW ac |
| User's needs         | Unlimited load (grid) |                   |            |             |

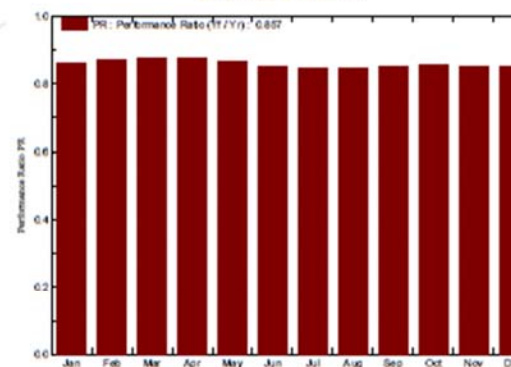
### Main simulation results

|                   |                      |                |                |                   |
|-------------------|----------------------|----------------|----------------|-------------------|
| System Production | Produced Energy      | 12.84 MWh/year | Specific prod. | 1652 kWh/kWp/year |
|                   | Performance Ratio PR | 85.7 %         |                |                   |

Normalized productions (per installed kWp): Nominal power 7.78 kWp



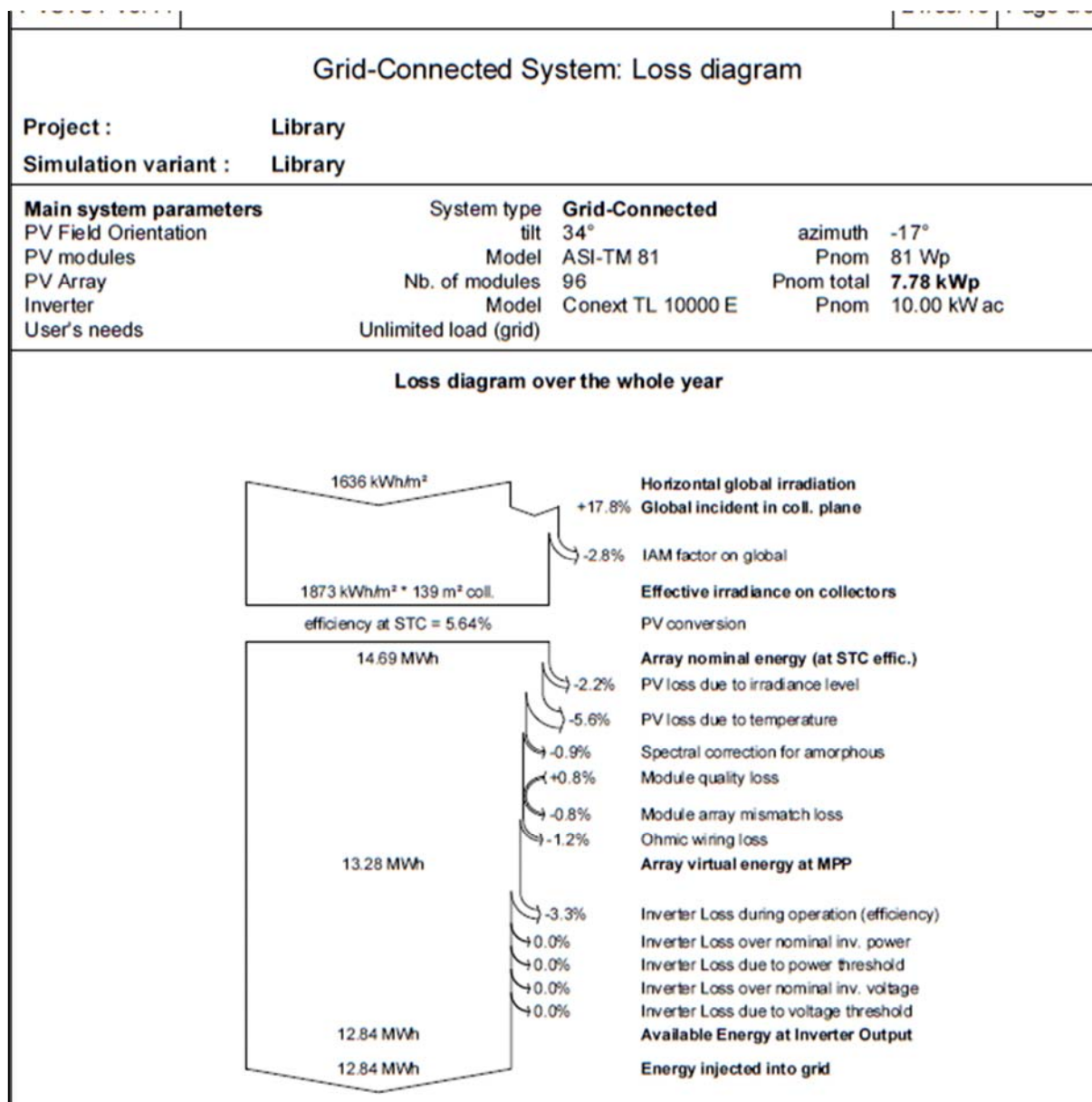
Performance Ratio PR



### Library

#### Balances and main results

|           | GlobHor | T Amb | GlobInc | GlobEff | EArray | E_Grid | EffArrR | EffSysR |
|-----------|---------|-------|---------|---------|--------|--------|---------|---------|
|           | kWh/m²  | °C    | kWh/m²  | kWh/m²  | MWh    | MWh    | %       | %       |
| January   | 67.4    | 8.03  | 115.6   | 112.6   | 0.800  | 0.774  | 4.97    | 4.82    |
| February  | 82.4    | 9.15  | 122.5   | 119.3   | 0.856  | 0.829  | 5.02    | 4.86    |
| March     | 131.1   | 11.95 | 166.0   | 161.9   | 1.165  | 1.128  | 5.04    | 4.88    |
| April     | 166.5   | 14.15 | 181.9   | 176.9   | 1.280  | 1.239  | 5.06    | 4.90    |
| May       | 198.9   | 17.92 | 197.8   | 191.7   | 1.377  | 1.331  | 5.00    | 4.84    |
| June      | 205.5   | 22.11 | 194.3   | 188.4   | 1.334  | 1.289  | 4.93    | 4.77    |
| July      | 222.4   | 24.47 | 213.4   | 206.9   | 1.450  | 1.401  | 4.88    | 4.72    |
| August    | 183.0   | 24.54 | 190.9   | 185.5   | 1.298  | 1.254  | 4.89    | 4.72    |
| September | 142.2   | 20.70 | 170.3   | 165.8   | 1.166  | 1.127  | 4.92    | 4.76    |
| October   | 105.2   | 17.52 | 145.0   | 141.2   | 0.995  | 0.962  | 4.93    | 4.77    |



## 6 Electrical connections and protections

Determine where to put the fuses, its shape, the overvoltage protections, size of the magneto-thermic protections and the section of the cables.

### 6.1 Cables

For the calculation of the cable cross sections they have been taken into account the following criteria:

- Criterion of the maximum ampacity or heating:

The conductor temperature Cable, working at full load and at steady state, shall not exceed in any time allocated the maximum allowable temperature of the materials used for the cable insulation. This temperature is specified in the particular rules of cables and usually 70 ° C for cables with thermoplastic insulation and 90 ° C for cable thermoset insulations.

- Criteria voltage drop:

The current flow through conductors, causes a loss of power carried by the cable, and a voltage drop or difference tensions in the origin and end of pipe.

### 6.1.1 D.C. wiring section part

Drivers must be designed for an intensity not less than 125% of the maximum intensity of the PV generator, which corresponds to the short circuit current conditions SCT.

$$I_{max} = 1.25 \times I_{cc} = 6.5 \text{ A}$$

In our case, we will take as maximum intensity corresponding will be 5.2 A.

The cross section of the cable will be one whose maximum allowable current  $I_z$  is greater or equal to the  $I_{max}$  calculated:

In addition, through the following table, we can tell at first glance an order magnitude of the conductor cross section.

We apply a correction factor in calculating maximum intensity permissible, according to Table E of the technical guide for the application of REBT based the number of circuits that go by the tray. Apply a factor of 0.75 by a 6 grouping circuits as in parts several circuits are grouped.

For a first estimate of the calculation of the cable section:

$$I_z \geq I_{max}$$

|       |                                                                                   |                                                                                |        |        |               |               |        |               |               |               |               |     |
|-------|-----------------------------------------------------------------------------------|--------------------------------------------------------------------------------|--------|--------|---------------|---------------|--------|---------------|---------------|---------------|---------------|-----|
| A     |  | Conductores aislados en tubos empotrados en paredes aislantes                  | 3x PVC | 2x PVC | 3x XLPE o EPR | 2x XLPE o EPR |        |               |               |               |               |     |
| A2    |  | Cables multiconductores en tubos empotrados en paredes aislantes               | 3x PVC | 2x PVC | 3x XLPE o EPR | 2x XLPE o EPR |        |               |               |               |               |     |
| B     |  | Conductores aislados en tubos en montaje superficial o empotrados en obra.     |        |        | 3x PVC        | 2x PVC        |        | 3x XLPE o EPR | 2x XLPE o EPR |               |               |     |
| B2    |  | Cables multiconductores en tubos en montaje superficial y empotrados en obra.  |        |        | 3x PVC        | 2x PVC        |        | 3x XLPE o EPR | 2x XLPE o EPR |               |               |     |
| C     |  | Cables multiconductores directamente sobre la pared                            |        |        | 3x PVC        | 2x PVC        |        | 3x XLPE o EPR | 2x XLPE o EPR |               |               |     |
| E     |  | Cables multiconductores al aire libre. Distancia a la pared no inferior a 0,3D |        |        |               | 3x PVC        |        | 2x PVC        | 3x XLPE o EPR | 2x XLPE o EPR |               |     |
| F     |  | Cables unipolares en contacto mutuo. Distancia a la pared no inferior a D      |        |        |               |               | 3x PVC |               |               | 3x XLPE o EPR |               |     |
| G     |  | Cables unipolares separados mínimo D                                           |        |        |               |               |        |               | 3x PVC        |               | 3x XLPE o EPR |     |
| Cobre | mm <sup>2</sup>                                                                   | 1                                                                              | 2      | 3      | 4             | 5             | 6      | 7             | 8             | 9             | 10            | 11  |
|       | 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           | 164           | 205 |
|       | 50                                                                                | 94                                                                             | 103    | 117    | 125           | 133           | 145    | 159           | 175           | 188           | 200           | 250 |
|       | 70                                                                                |                                                                                |        | 149    | 160           | 171           | 188    | 202           | 224           | 244           | 264           | 321 |
|       | 95                                                                                |                                                                                |        | 180    | 194           | 207           | 230    | 245           | 271           | 296           | 321           | 391 |
|       | 120                                                                               |                                                                                |        | 208    | 225           | 240           | 267    | 284           | 314           | 348           | 381           | 455 |
|       | 150                                                                               |                                                                                |        | 236    | 260           | 278           | 310    | 338           | 363           | 404           | 445           | 525 |
|       | 185                                                                               |                                                                                |        | 268    | 297           | 317           | 354    | 386           | 415           | 464           | 501           | 601 |
|       | 240                                                                               |                                                                                |        | 315    | 350           | 374           | 419    | 455           | 490           | 552           | 601           | 711 |
|       | 300                                                                               |                                                                                |        | 360    | 404           | 423           | 484    | 524           | 565           | 640           | 681           | 821 |

Intensidades en Amperios para conductores de cobre

| Ref.                                                                                                                                                                                                                                                                                                                                    | Disposición de cables contiguos                                           | Número de circuitos o cables multiconductores |      |      |      |      |      |      |      |      |                                                                            |      |      |
|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|---------------------------------------------------------------------------|-----------------------------------------------|------|------|------|------|------|------|------|------|----------------------------------------------------------------------------|------|------|
|                                                                                                                                                                                                                                                                                                                                         |                                                                           | 1                                             | 2    | 3    | 4    | 5    | 6    | 7    | 8    | 9    | 12                                                                         | 16   | 20   |
| 1                                                                                                                                                                                                                                                                                                                                       | Agrupados en una superficie empotrados o embutidos                        | 1,00                                          | 0,80 | 0,70 | 0,65 | 0,60 | 0,55 | 0,55 | 0,50 | 0,50 | 0,45                                                                       | 0,40 | 0,40 |
| 2                                                                                                                                                                                                                                                                                                                                       | Capa única sobre pared, suelo o superficie sin perforar                   | 1,00                                          | 0,85 | 0,80 | 0,75 | 0,75 | 0,70 | 0,70 | 0,70 | 0,70 | Sin reducción adicional para más de 9 circuitos o cables multiconductores. |      |      |
| 3                                                                                                                                                                                                                                                                                                                                       | Capa única en el techo                                                    | 0,95                                          | 0,80 | 0,70 | 0,70 | 0,65 | 0,65 | 0,65 | 0,60 | 0,60 |                                                                            |      |      |
| 4                                                                                                                                                                                                                                                                                                                                       | Capa única en una superficie perforada vertical u horizontal              | 1,00                                          | 0,90 | 0,80 | 0,75 | 0,75 | 0,75 | 0,75 | 0,70 | 0,70 |                                                                            |      |      |
| 5                                                                                                                                                                                                                                                                                                                                       | Capa única con apoyo de bandeja escalera o abrazaderas (collarines), etc. | 1,00                                          | 0,85 | 0,80 | 0,80 | 0,80 | 0,80 | 0,80 | 0,80 | 0,80 |                                                                            |      |      |
| Nota 1. Estos factores son aplicables a grupos homogéneos de cables cargados por igual.                                                                                                                                                                                                                                                 |                                                                           |                                               |      |      |      |      |      |      |      |      |                                                                            |      |      |
| Nota 2. Cuando la distancia horizontal entre cables adyacentes es superior al doble de su diámetro exterior, no es necesario factor de reducción alguno.                                                                                                                                                                                |                                                                           |                                               |      |      |      |      |      |      |      |      |                                                                            |      |      |
| Nota 3. Los mismos factores se aplican para grupos de dos o tres cables unipolares que para cables multiconductores.                                                                                                                                                                                                                    |                                                                           |                                               |      |      |      |      |      |      |      |      |                                                                            |      |      |
| Nota 4. Si un sistema se compone de cables de dos o tres conductores, se toma el número total de cables como el número de circuitos, y se aplica el factor correspondiente a las tablas de dos conductores cargados para los cables de dos conductores y a las tablas de tres conductores cargados para los cables de tres conductores. |                                                                           |                                               |      |      |      |      |      |      |      |      |                                                                            |      |      |
| Nota 5. Si un número se compone de "n" conductores unipolares cargados, también pueden considerarse como "n/2" circuitos de dos conductores o "n/3" circuitos de tres conductores cargados.                                                                                                                                             |                                                                           |                                               |      |      |      |      |      |      |      |      |                                                                            |      |      |

$$I_{max} \leq I_z \rightarrow 6,5A \leq 0,75 \cdot 21A \rightarrow 1,5 \text{ mm}^2$$

### 6.1.2 Section wiring part A.C.

The section covering is part of the installation transfer from the three-phase inverter output to the grid connection point.

The rated current that can pour the inverter will:

$$I = \frac{P}{\sqrt{3} \cdot V_L \cdot \cos\varphi} = \frac{13000W}{\sqrt{3} \cdot 400V} = 18,7A$$

$$I_{max} = 1,25 \cdot I = 23,3A$$

|       |                                                                                     |                                                                                             |                 |        |        |               |               |               |               |                     |                            |               |     |     |
|-------|-------------------------------------------------------------------------------------|---------------------------------------------------------------------------------------------|-----------------|--------|--------|---------------|---------------|---------------|---------------|---------------------|----------------------------|---------------|-----|-----|
| A     |    | Conductores aislados en tubos empotrados en paredes aislantes                               |                 | 3x PVC | 2x PVC |               | 3x XLPE o EPR | 2x XLPE o EPR |               |                     |                            |               |     |     |
| A2    |    | Cables multiconductores en tubos empotrados en paredes aislantes                            | 3x PVC          | 2x PVC |        | 3x XLPE o EPR | 2x XLPE o EPR |               |               |                     |                            |               |     |     |
| B     |   | Conductores aislados en tubos en montaje superficial o empotrados en obra                   |                 |        |        | 3x PVC        | 2x PVC        |               | 3x XLPE o EPR | 2x XLPE o EPR       |                            |               |     |     |
| B2    |  | Cables multiconductores en tubos en montaje superficial o empotrados en obra                |                 |        | 3x PVC | 2x PVC        |               | 3x XLPE o EPR | 2x XLPE o EPR |                     |                            |               |     |     |
| C     |  | Cables multiconductores directamente sobre la pared                                         |                 |        |        |               | 3x PVC        | 2x PVC        | 3x XLPE o EPR | 2x XLPE o EPR       |                            |               |     |     |
| E     |  | Cables multiconductores al aire libre. Distancia a la pared no inferior a 0.3D <sup>b</sup> |                 |        |        |               |               | 3x PVC        | 2x PVC        | 3x XLPE o EPR       | 2x XLPE o EPR              |               |     |     |
| F     |  | Cables unipolares en contacto mutuo. Distancia a la pared no inferior a D <sup>b</sup>      |                 |        |        |               |               | 3x PVC        |               |                     | 3x XLPE o EPR <sup>c</sup> |               |     |     |
| G     |  | Cables unipolares separados mínimo D <sup>b</sup>                                           |                 |        |        |               |               |               |               | 3x PVC <sup>c</sup> |                            | 3x XLPE o EPR |     |     |
| Cobre |                                                                                     |                                                                                             | mm <sup>2</sup> | 1      | 2      | 3             | 4             | 5             | 6             | 7                   | 8                          | 9             | 10  | 11  |
|       |                                                                                     |                                                                                             | 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 | 206 |
|       |                                                                                     |                                                                                             | 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           | 249           | 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 |

Tabla E. Factores de reducción para agrupamiento de varios circuitos (Tabla A.52-3 de la norma UNE 20 460-5-523:2004)

| Ref. | Disposición de cables contiguos                                          | Número de circuitos o cables multiconductores |      |      |      |      |      |                                                                            |      |      |
|------|--------------------------------------------------------------------------|-----------------------------------------------|------|------|------|------|------|----------------------------------------------------------------------------|------|------|
|      |                                                                          | 1                                             | 2    | 3    | 4    | 6    | 9    | 12                                                                         | 16   | 20   |
| 1    | Empotrados o embutidos                                                   | 1,00                                          | 0,80 | 0,70 | 0,70 | 0,55 | 0,50 | 0,45                                                                       | 0,40 | 0,40 |
| 2    | Capa única sobre pared, suelo o superficie sin perforar                  | 1,00                                          | 0,85 | 0,80 | 0,75 | 0,70 | 0,70 | Sin reducción adicional para más de 9 circuitos o cables multiconductores. |      |      |
| 3    | Capa única fijada bajo techo                                             | 0,95                                          | 0,80 | 0,70 | 0,70 | 0,65 | 0,60 |                                                                            |      |      |
| 4    | Capa única en una bandeja perforada vertical u horizontal                | 1,00                                          | 0,90 | 0,80 | 0,75 | 0,75 | 0,70 |                                                                            |      |      |
| 5    | Capa única con apoyo de bandeja escalera o abrazaderas (collarines) etc. | 1,00                                          | 0,85 | 0,80 | 0,80 | 0,80 | 0,8  |                                                                            |      |      |

Nota 1. Estos factores son aplicables a grupos homogéneos de cables cargados por igual.  
 Nota 2. Cuando la distancia horizontal entre cables adyacentes es superior al doble de su diámetro exterior, no es necesario factor de reducción alguno.  
 Nota 3. Los mismos factores se aplican para grupos de dos o tres cables unipolares que para cables multiconductores.  
 Nota 4. Si un sistema se compone de cables de dos o tres conductores, se toma el número total de cables como el número de circuitos, y se aplica el factor correspondiente a las tablas de dos conductores cargados para los cables de dos conductores y a las tablas de tres conductores cargados para los cables de tres conductores.  
 Nota 5. Si la instalación se compone de "n" conductores unipolares cargados, también pueden considerarse como "n/2" circuitos de dos conductores o "n/3" circuitos de tres conductores cargados.

En la tabla F se indican los factores de reducción por agrupamiento de circuitos en varias capas que multiplicarán al factor de reducción de la tabla E anterior.

Tabla F – Factor de reducción adicional para cables instalados en varias capas

| Nº de capas | 2   | 3    | 4 ó 5 | 6 a 8 | 9 o más |
|-------------|-----|------|-------|-------|---------|
| Factor      | 0,8 | 0,73 | 0,70  | 0,68  | 0,66    |

$$I_{\max} \leq I_Z \rightarrow 18,7A \leq 0,75 \cdot 0,70 \cdot 37A \rightarrow 6 \text{ mm}^2$$

Cable length to grid connection point is unknown.

## 6.2 Fuses

### 6.2.1 D.C. side protections

Voltage, overload device protects a driver if the following are verified terms:

$$I_B \leq I_N \leq I_Z$$

$$I_2 \leq 1,45 \cdot I_Z$$

Where:

- IB Is the current job or use.
- IN is the nominal current of the protective device.
- IZ is the maximum permissible current for the element to be protected.
- I2 is the conventional operating current of the protective device. (Melting fuses and tripping of circuit breakers).

$$I_2 = 5,2A$$

$$I_Z = 21A$$

The fuses to be used are 16A.

Fuses installed will be DF2CN16 Schneider.

### 6.2.2 D.C. overvoltage protection

The highest operating voltage of the PV strings, in our case 636 V. Therefore chosen is a varistor whose voltage steady discharge exceeds this value.  
CIRPROTEC PSM3 40/1000.

### 6.2.3 A.C. protection

$$\begin{aligned} I_B &\leq I_N \leq I_Z \\ I_2 &\leq 1,45 \cdot I_Z \end{aligned}$$

$I_Z = 37A$

$$I = \frac{P}{\sqrt{3} \cdot V_L \cdot \cos\varphi} = \frac{13000W}{\sqrt{3} \cdot 400V} = 18,7A$$

Therefore the switch rated current is 32 A

Chosen switch:

Merlin Gerin Multi 9 C32A

At the point of connection low voltage network 300mA differential will be connected to protect from direct and indirect contacts.

The differential switch:

IID 63 300mA

Element of overcurrent protection and overvoltage will install another three-phase magneto device, four poles, calibrated for total current generation.

In this case the device is installed

IC60N 40A

For this part of the circuit is protected, analogously to the above calculations installed a circuit breaker rated current 32 A, as described above, and a differential switch 30mA for output branch inverter.

## 7 Market list

| Market list |                  |                          |      |         |       |         |
|-------------|------------------|--------------------------|------|---------|-------|---------|
|             |                  |                          | TR11 | Library | Total | Price € |
| 1           | Supply equipment |                          |      |         |       |         |
| 1.1         | Solar panel      | Schott ASI 81            | 134  | 94      | 228   |         |
| 1.2         | Solarbloc        | Solarbloc 34degree angle | 153  | 99      | 252   |         |
| 1.3         | Inverter         | Conext TL10000E          | -    | 1       | 1     |         |

|     |                                              |                                                                                                                                                                                                    |      |      |       |  |
|-----|----------------------------------------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|------|------|-------|--|
| 1.4 | Inverter                                     | Conext TL15000E                                                                                                                                                                                    | 1    | -    | 1     |  |
|     |                                              |                                                                                                                                                                                                    |      |      |       |  |
| 2   | Cables                                       |                                                                                                                                                                                                    |      |      |       |  |
| 2.1 | String connection cables D.C.                | Unipolar copper cable 4mm <sup>2</sup> 0,6/1kV Xlpe PVC coating (red and black)                                                                                                                    | 200m | 150m | 350m  |  |
| 2.2 | Structure earth                              | Unipolar copper cable 4mm <sup>2</sup> 0,6/1kV Xlpe PVC coating                                                                                                                                    | 20m  | 20m  | 40m   |  |
| 2.3 | Main earth                                   | Unipolar copper cable 4mm <sup>2</sup> 0,6/1kV Xlpe PVC coating                                                                                                                                    | 50m? | 50m? | 100m? |  |
| 2.4 | Cable injection internal power network A.C.  | Supply Cable 5-pole 6mm <sup>2</sup> of copper 0.6 / 1kV PVC coated Xlpe                                                                                                                           | 50m? | 50m? | 100m? |  |
| 2.5 | Cable interconnection Inverter Box A.C.      | Unipolar copper cable 4mm <sup>2</sup> 0,6/1kV Xlpe PVC coating                                                                                                                                    | 25m? | 25m? | 50m?  |  |
| 2.6 | Connection Cables to devices and boxes.      | Supply devices for connection cables, protection and boxes. (Surge protector MC3 and 4, terminal blocks, ferrules, stuffing ....)                                                                  | 200? | 200? | 400?  |  |
|     |                                              |                                                                                                                                                                                                    |      |      |       |  |
| 3   | Connection and protection boxes              |                                                                                                                                                                                                    |      |      |       |  |
| 3.1 | Junction boxes                               | Thalassa PLM NSYPLM3025 box, IP66 UNE for modular installation. 13 terminals 4mm <sup>2</sup> .                                                                                                    | 1    | 1    | 2     |  |
| 3.2 | Protection boxes D.C.                        | Schneider's NSYCRN54200 box, IP66 UNE for modular installation. 4 fuses 16A DF2CN16 Schneider 4 modular fuse holders 6 varistors discharge PSM3 CIRPROTEC 40/1000, 1000 Vcc. 3 terminals for land. | 1    | 1    | 2     |  |
| 3.3 | Measurement box                              | Kaedra 13182 protection box 4 digital voltmeter panels Chint600Vcc 4 digital ampmeter panels Chint600Vcc 8 16A fuses DF2CN16 Schneider 8 modular fuse holders                                      | 1    | 1    | 2     |  |
| 3.4 | A.C. output box                              | Kaedra 13990 protection box IP66 1 A.C. output PKF16F435 Schneider 380/400 V 2 Magneto thermic protections Multi9 C32A three phase 4-pole 1 differential interrupter 30mA liD 40A 4-pole           | 1    | 1    | 2     |  |
| 3.5 | D.C. output box                              | Kaedra 13179 protection box IP66 2 D.C. output PKY16F423 Schneider 380/400 V 4 16A fuses DF2CN16 Schneider 4 modular fuse holders                                                                  | 1    | 1    | 2     |  |
| 3.6 | Differential protection power line injection | Schneider 4-pole differential switch 63A IID. of 300mA                                                                                                                                             | 1    | 1    | 2     |  |
| 3.7 | Thermomagnetic protection power              | Schneider 4-pole thermomagnetic switch IC60N 40A                                                                                                                                                   | 1    | 1    | 2     |  |

|     |                                       |                                                                                                                       |      |      |      |  |
|-----|---------------------------------------|-----------------------------------------------------------------------------------------------------------------------|------|------|------|--|
|     | line injection                        |                                                                                                                       |      |      |      |  |
|     |                                       |                                                                                                                       |      |      |      |  |
| 4   | Energy measuring equipment            |                                                                                                                       |      |      |      |  |
| 4.1 | Network analyzer to counter mode      | A network analyzer house Circutor CVM-MINI-ITFRS-485-C2 4-wire.<br>3 Measuring transformers TC 5 thereof 40/5 A. home | 1    | 1    | 2    |  |
|     |                                       |                                                                                                                       |      |      |      |  |
| 5   | Cable canalization                    |                                                                                                                       |      |      |      |  |
| 5.1 | D.C. part channeling                  | Rejiband 60x600mm and connecting elements                                                                             | 60m  | 70m  | 130m |  |
| 5.2 | Ground wire channeling                | Channeling halogen-free rigid tube Gaestopa H-20 TLH and connecting elements.                                         | 20m? | 20?m | 40?m |  |
| 5.3 | Channeling surface multiple locations | Unex23 30 X 60 PVC and connection elements.                                                                           | 10m? | 10?m | 20?m |  |
|     |                                       |                                                                                                                       |      |      |      |  |
|     |                                       |                                                                                                                       |      |      |      |  |

# INDICADORS MEDIAMBIENTALS - version 2017

## INDICADOR: CONSUM ENERGIA ELÈCTRICA

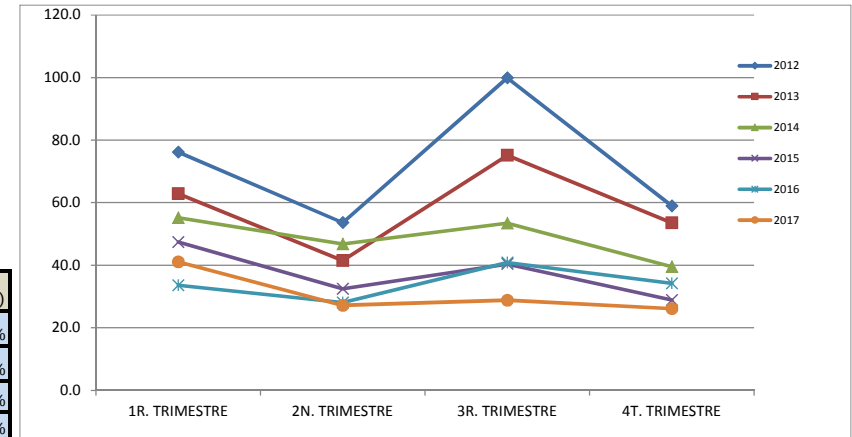
### A= consum ENERGIA ELÈCTRICA

|          | 2012                | 2013           | 2014           | 2015           | 2016           | 2017           |
|----------|---------------------|----------------|----------------|----------------|----------------|----------------|
| GENER    | 24,259              | 23,957         | 19,766         | 22,456         | 19,236         | 27,752         |
| FEBRER   | 26,664              | 21569          | 18,839         | 23,430         | 19,334         | 18,003         |
| MARÇ     | 17,764              | 17866          | 17,060         | 19,055         | 19,273         | 17,033         |
| ABRIL    | 14,810              | 14164          | 15,217         | 13,244         | 15,202         | 11,715         |
| MAIG     | 17,139              | 13296          | 14,132         | 17,449         | 15,506         | 11,957         |
| JUNY     | 19,383              | 14476          | 16,458         | 19,256         | 17,048         | 15,261         |
| JULIOL   | 19,229              | 17472          | 20,349         | 20,857         | 20,074         | 14,754         |
| AGOST    | 17,657              | 14882          | 17,061         | 15,454         | 15,217         | 12,875         |
| SETEMBRE | 16,282              | 15813          | 19,389         | 15,505         | 18,384         | 12,762         |
| OCTUBRE  | 17,888              | 16028          | 18,273         | 14,007         | 14,626         | 6,919          |
| NOVEMBRE | 19,240              | 16369          | 18,635         | 13,040         | 18,891         | 15,814         |
| DESEMBRE | 20,568              | 19480          | 20,681         | 13,022         | 19,502         | 10,747         |
|          | <b>230,883</b>      | <b>205,372</b> | <b>215,860</b> | <b>206,775</b> | <b>212,293</b> | <b>177,609</b> |
|          | $\Delta(2012-2013)$ |                | <b>-11 %</b>   |                |                |                |

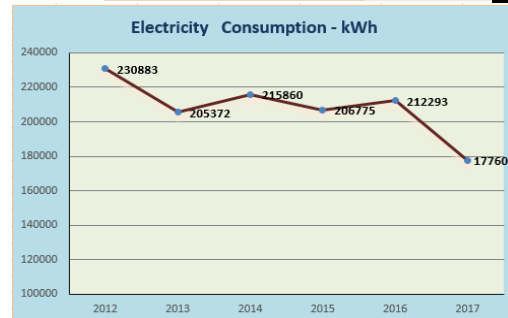
$\Delta(2017-2016)$   
-16 %

### R=A/B

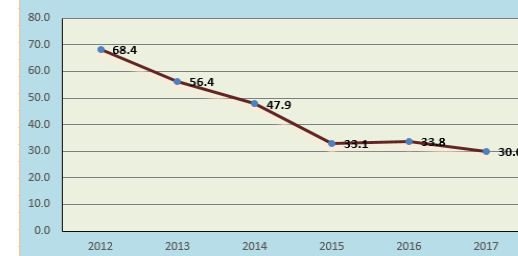
|               | 2012        | 2013        | 2014        | 2015        | 2016        | 2017        | (2016-2015)  |
|---------------|-------------|-------------|-------------|-------------|-------------|-------------|--------------|
| 1R. TRIMESTRE | 76.2        | 62.9        | 55.2        | 47.4        | 33.61       | 41.06       | 22 %         |
| 2N. TRIMESTRE | 53.6        | 41.5        | 46.8        | 32.5        | 28.09       | 27.17       | -3 %         |
| 3R. TRIMESTRE | 99.9        | 75.1        | 53.5        | 40.4        | 40.85       | 28.79       | -30 %        |
| 4T. TRIMESTRE | 59.0        | 53.6        | 39.6        | 28.9        | 34.27       | 26.13       | -24 %        |
| TOTAL         | <b>68.6</b> | <b>56.4</b> | <b>47.9</b> | <b>33.1</b> | <b>33.8</b> | <b>30.0</b> | <b>-11 %</b> |



|                 |               | B= Index d'activitat |             |             |             |             |             |                     |
|-----------------|---------------|----------------------|-------------|-------------|-------------|-------------|-------------|---------------------|
|                 |               | 2012                 | 2013        | 2014        | 2015        | 2016        | 2017        | $\Delta(2017-2016)$ |
| Index activitat | 1R. TRIMESTRE | 901                  | 1023        | 1008        | 1369        | 1721        | 1529        | -11%                |
|                 | 2N. TRIMESTRE | 957                  | 1010        | 978         | 1537        | 1700        | 1433        | -16%                |
|                 | 3R. TRIMESTRE | 532                  | 641         | 1062        | 1424        | 1314        | 1403        | 7%                  |
|                 | 4T. TRIMESTRE | 978                  | 968         | 1456        | 1923        | 1547        | 1546        | 0%                  |
|                 |               | <b>3368</b>          | <b>3642</b> | <b>4504</b> | <b>6253</b> | <b>6282</b> | <b>5911</b> | <b>-6%</b>          |



### KPI:IND\_12: Indicator: Energy consumption/Index occupation



# ANNEX 3

## LCC – Study Provider 1

Rented Office: -1

|                                          | Lowest Price |         | Environment-friendly Price |         |
|------------------------------------------|--------------|---------|----------------------------|---------|
| Price                                    |              |         |                            |         |
| Price per product [Euro/product]         | 6.00         | €       | 15.20                      | €       |
| Lifetime [years]                         | 1.14         | y       | 4.60                       | y       |
| Comparable number of replacements        | 4.04         | n       | 1.00                       | n       |
| Total Cost [€]                           | 1,162.11     | €       | 729.60                     | €       |
| Duration                                 |              |         |                            |         |
| Lifetime [years]                         | 5            | y       | 5                          | y       |
| Average yearly time usage [hours/year]   | 2,500        | h/y     | 2,500                      | h/y     |
| Total usage time [hours]                 | 11500        | h       | 11500                      | h       |
| Number of purchases                      | 48           | n       | 48                         | n       |
| Total [hours]                            | 552000       | h       | 552000                     | h       |
| Maintenance                              |              |         |                            |         |
| Number of years [years]                  | 5            | y       | 5                          | y       |
| Jnits per year [work hour, kwp, page...] | 42.11        | n       | 0.00                       | n       |
| Cost per unit [€]                        | 7.50         | €       | 0.00                       | €       |
| Total [€]                                | 1453         | €       | 0                          | €       |
| Energy costs                             |              |         |                            |         |
| Price of energy [€/Kwhe €/Kwh]           | 0.11         | €       | 0.11                       | €       |
| Energy consumption [Watt e/t]            | 58           | W       | 21                         | W       |
| Lifetime energy consumption [kWh e/t]    | 32,016.00    | kWh e/t | 11,592.00                  | kWh e/t |
| Total energy cost [€]                    | 3,572.54     | €       | 1,293.50                   | €       |
| Emissions                                |              |         |                            |         |
| Kg of CO2/kWh                            | 0.385        | kg      | 0.385                      | kg      |
| Total of CO2 avoided [ton]               | 0.000        | t       | 7.863                      | t       |
| Economic value of CO2 [€/ton]            | 11.32        | €       | 11.32                      | €       |
| Total economic value of avoided CO2      | 0.0          | €       | 89.0                       | €       |
| Total life cycle costs                   | 6,187.27     | €       | 1,934.09                   | €       |

DIF

5 years: -69% 4,253.18 €

10 hs/dia\_250 days

Price of electricity:0.111586 e-conecta2018 in P1

| Factor de emisión (Kg de CO2 eq/kWh) |                  |
|--------------------------------------|------------------|
| 0.385                                | Kg de CO2 eq/kWh |

Study

Price CO2

<http://markets.businessinsider.com/commodities/co2-emissionsrechte>

Rented Office: Agents Comercials

|                                          | Lowest Price |         | Environment-friendly Price |         |
|------------------------------------------|--------------|---------|----------------------------|---------|
| Price                                    |              |         |                            |         |
| Price per product [Euro/product]         | 6.00         | €       | 15.20                      | €       |
| Lifetime [years]                         | 1.14         | y       | 4.60                       | y       |
| Comparable number of replacements        | 4.04         | n       | 1.00                       | n       |
| Total Cost [€]                           | 387.37       | €       | 243.20                     | €       |
| Duration                                 |              |         |                            |         |
| Lifetime [years]                         | 5            | y       | 5                          | y       |
| Average yearly time usage [hours/year]   | 2,500        | h/y     | 2,500                      | h/y     |
| Total usage time [hours]                 | 11500        | h       | 11500                      | h       |
| Number of purchases                      | 16           | n       | 16                         | n       |
| Total [hours]                            | 184000       | h       | 184000                     | h       |
| Maintenance                              |              |         |                            |         |
| Number of years [years]                  | 5            | y       | 5                          | y       |
| Units per year [work hour, kwp, page...] | 14.04        | n       | 0.00                       | n       |
| Cost per unit [€]                        | 7.50         | €       | 0.00                       | €       |
| Total [€]                                | 484          | €       | 0                          | €       |
| Energy costs                             |              |         |                            |         |
| Price of energy [€/Kwh e/Kwh]            | 0.11         | €       | 0.11                       | €       |
| Energy consumption [Watt e/t]            | 58           | W       | 21                         | W       |
| Lifetime energy consumption [kWh e/t]    | 10,672.00    | kWh e/t | 3,864.00                   | kWh e/t |
| Total energy cost [€]                    | 1,190.85     | €       | 431.17                     | €       |
| Emissions                                |              |         |                            |         |
| Kg of CO2/kWh                            | 0.385        | kg      | 0.385                      | kg      |
| Total of CO2 avoided [ton]               | 0.000        | t       | 2.621                      | t       |
| Economic value of CO2 [€/ton]            | 11.32        | €       | 11.32                      | €       |
| Total economic value of avoided CO2      | 0.0          | €       | 29.7                       | €       |
| Total life cycle costs                   | 2,062.42     | €       | 644.70                     | €       |

DIF

5 years: -69% 1,417.73 €

10 hs/dia\_250 days

Price of electricity:0.111586 e-conecta2018 in P1

| Factor de emisión (Kg de CO2 eq/kWh) |                  |
|--------------------------------------|------------------|
| 0.385                                | Kg de CO2 eq/kWh |

Study

Price CO2

<http://markets.businessinsider.com/commodities/co2-emissionsrechte>

# Rented Office: NBWEBS

|                                          | Lowest Price |         | Environment-friendly Price |         |
|------------------------------------------|--------------|---------|----------------------------|---------|
| Price                                    |              |         |                            |         |
| Price per product [Euro/product]         | 6.00         | €       | 15.20                      | €       |
| Lifetime [years]                         | 1.14         | y       | 4.60                       | y       |
| Comparable number of replacements        | 4.04         | n       | 1.00                       | n       |
| Total Cost [€]                           | 484.21       | €       | 304.00                     | €       |
| Duration                                 |              |         |                            |         |
| Lifetime [years]                         | 5            | y       | 5                          | y       |
| Average yearly time usage [hours/year]   | 2,500        | h/y     | 2,500                      | h/y     |
| Total usage time [hours]                 | 11500        | h       | 11500                      | h       |
| Number of purchases                      | 20           | n       | 20                         | n       |
| Total [hours]                            | 230000       | h       | 230000                     | h       |
| Maintenance                              |              |         |                            |         |
| Number of years [years]                  | 5            | y       | 5                          | y       |
| Units per year [work hour, kwp, page...] | 17.54        | n       | 0.00                       | n       |
| Cost per unit [€]                        | 7.50         | €       | 0.00                       | €       |
| Total [€]                                | 605          | €       | 0                          | €       |
| Energy costs                             |              |         |                            |         |
| Price of energy [€/Kwhe €/Kwh]           | 0.11         | €       | 0.11                       | €       |
| Energy consumption [Watt e/t]            | 36           | W       | 18                         | W       |
| Lifetime energy consumption [kWh e/t]    | 8,280.00     | kWh e/t | 4,140.00                   | kWh e/t |
| Total energy cost [€]                    | 923.93       | €       | 461.97                     | €       |
| Emissions                                |              |         |                            |         |
| Kg of CO2/kWh                            | 0.385        | kg      | 0.385                      | kg      |
| Total of CO2 avoided [ton]               | 0.000        | t       | 1.594                      | t       |
| Economic value of CO2 [€/ton]            | 11.32        | €       | 11.32                      | €       |
| Total economic value of avoided CO2      | 0.0          | €       | 18.0                       | €       |
| Total life cycle costs                   | 2,013.41     | €       | 747.92                     | €       |

DIF

5 years: -63% 1,265.48 €

10 hs/dia\_250 days

Price of electricity:0.111586 e-conecta2018 in P1

| Factor de emisión (Kg de CO2 eq/kWh) |                        |
|--------------------------------------|------------------------|
| 0.385                                | Kg de CO2 eq/kWh Study |

Price CO2

<http://markets.businessinsider.com/commodities/co2-emissionsrechte>

## Training Courses

|                                          | Lowest Price |         | Environment-friendly Price |         |
|------------------------------------------|--------------|---------|----------------------------|---------|
| Price                                    |              |         |                            |         |
| Price per product [Euro/product]         | 6.00         | €       | 15.20                      | €       |
| Lifetime [years]                         | 1.14         | y       | 4.60                       | y       |
| Comparable number of replacements        | 4.04         | n       | 1.00                       | n       |
| Total Cost [€]                           | 484.21       | €       | 304.00                     | €       |
| Duration                                 |              |         |                            |         |
| Lifetime [years]                         | 5            | y       | 5                          | y       |
| Average yearly time usage [hours/year]   | 240          | h/y     | 240                        | h/y     |
| Total usage time [hours]                 | 1104         | h       | 1104                       | h       |
| Number of purchases                      | 20           | n       | 20                         | n       |
| Total [hours]                            | 22080        | h       | 22080                      | h       |
| Maintenance                              |              |         |                            |         |
| Number of years [years]                  | 5            | y       | 5                          | y       |
| Units per year [work hour, kwp, page...] | 17.54        | n       | 0.00                       | n       |
| Cost per unit [€]                        | 7.50         | €       | 0.00                       | €       |
| Total [€]                                | 605          | €       | 0                          | €       |
| Energy costs                             |              |         |                            |         |
| Price of energy [€/Kwhe €/Kwh]           | 0.11         | €       | 0.11                       | €       |
| Energy consumption [Watt e/t]            | 36           | W       | 18                         | W       |
| Lifetime energy consumption [kWh e/t]    | 794.88       | kWh e/t | 397.44                     | kWh e/t |
| Total energy cost [€]                    | 88.70        | €       | 44.35                      | €       |
| Emissions                                |              |         |                            |         |
| Kg of CO2/kWh                            | 0.385        | kg      | 0.385                      | kg      |
| Total of CO2 avoided [ton]               | 0.000        | t       | 0.153                      | t       |
| Economic value of CO2 [€/ton]            | 11.32        | €       | 11.32                      | €       |
| Total economic value of avoided CO2      | 0.0          | €       | 1.7                        | €       |
| Total life cycle costs                   | 1,178.17     | €       | 346.62                     | €       |

DIF

5 years: -71% 831.55 €

Occupation 2017 40\*6hs.=240h

Price of electricity:0.111586 e-conecta2018 in P1

| Factor de emisión (Kg de CO2 eq/kWh) |                        |
|--------------------------------------|------------------------|
| 0.385                                | Kg de CO2 eq/kWh Study |

Price CO2

<http://markets.businessinsider.com/commodities/co2-emissionsrechte>

C-D-E: training courses - presentations and meetings

|                                          | Lowest Price |         | Environment-friendly Price |         |
|------------------------------------------|--------------|---------|----------------------------|---------|
| Price                                    |              |         |                            |         |
| Price per product [Euro/product]         | 6.00         | €       | 15.20                      | €       |
| Lifetime [years]                         | 1.14         | y       | 4.60                       | y       |
| Comparable number of replacements        | 4.04         | n       | 1.00                       | n       |
| Total Cost [€]                           | 1,452.63     | €       | 912.00                     | €       |
| Duration                                 |              |         |                            |         |
| Lifetime [years]                         | 5            | y       | 5                          | y       |
| Average yearly time usage [hours/year]   | 600          | h/y     | 600                        | h/y     |
| Total usage time [hours]                 | 2760         | h       | 2760                       | h       |
| Number of purchases                      | 60           | n       | 60                         | n       |
| Total [hours]                            | 165600       | h       | 165600                     | h       |
| Maintenance                              |              |         |                            |         |
| Number of years [years]                  | 5            | y       | 5                          | y       |
| Units per year [work hour, kwp, page...] | 52.63        | n       | 0.00                       | n       |
| Cost per unit [€]                        | 7.50         | €       | 0.00                       | €       |
| Total [€]                                | 1816         | €       | 0                          | €       |
| Energy costs                             |              |         |                            |         |
| Price of energy [€/Kwhe €/Kwh]           | 0.11         | €       | 0.11                       | €       |
| Energy consumption [Watt e/t]            | 58           | W       | 21                         | W       |
| Lifetime energy consumption [kWh e/t]    | 9,604.80     | kWh e/t | 3,477.60                   | kWh e/t |
| Total energy cost [€]                    | 1,071.76     | €       | 388.05                     | €       |
| Emissions                                |              |         |                            |         |
| Kg of CO2/kWh                            | 0.385        | kg      | 0.385                      | kg      |
| Total of CO2 avoided [ton]               | 0.000        | t       | 2.359                      | t       |
| Economic value of CO2 [€/ton]            | 11.32        | €       | 11.32                      | €       |
| Total economic value of avoided CO2      | 0.0          | €       | 26.7                       | €       |
| Total life cycle costs                   | 4,340.18     | €       | 1,273.35                   | €       |

DIF

5 years: -71% 3,066.83 €

Occupation 2017 100\*6hs.=600h

Price of electricity:0.111586 e-conecta2018 in P1

| Factor de emisión (Kg de CO2 eq/kWh) |
|--------------------------------------|
| 0.385                                |

Study

Price CO2

<http://markets.businessinsider.com/commodities/co2-emissionsrechte>

A/B: training courses - presentations and meetings

|                                          | Lowest Price |         | Environment-friendly Price |         |
|------------------------------------------|--------------|---------|----------------------------|---------|
| Price                                    |              |         |                            |         |
| Price per product [Euro/product]         | 6.00         | €       | 15.20                      | €       |
| Lifetime [years]                         | 1.14         | y       | 4.60                       | y       |
| Comparable number of replacements        | 4.04         | n       | 1.00                       | n       |
| Total Cost [€]                           | 1,452.63     | €       | 912.00                     | €       |
| Duration                                 |              |         |                            |         |
| Lifetime [years]                         | 5            | y       | 5                          | y       |
| Average yearly time usage [hours/year]   | 500          | h/y     | 500                        | h/y     |
| Total usage time [hours]                 | 2300         | h       | 2300                       | h       |
| Number of purchases                      | 60           | n       | 60                         | n       |
| Total [hours]                            | 138000       | h       | 138000                     | h       |
| Maintenance                              |              |         |                            |         |
| Number of years [years]                  | 5            | y       | 5                          | y       |
| Jnits per year [work hour, kwp, page...] | 52.63        | n       | 0.00                       | n       |
| Cost per unit [€]                        | 7.50         | €       | 0.00                       | €       |
| Total [€]                                | 1816         | €       | 0                          | €       |
| Energy costs                             |              |         |                            |         |
| Price of energy [€/Kwhe €/Kwh]           | 0.11         | €       | 0.11                       | €       |
| Energy consumption [Watt e/t]            | 58           | W       | 21                         | W       |
| Lifetime energy consumption [kWh e/t]    | 8,004.00     | kWh e/t | 2,898.00                   | kWh e/t |
| Total energy cost [€]                    | 893.13       | €       | 323.38                     | €       |
| Emissions                                |              |         |                            |         |
| Kg of CO2/kWh                            | 0.385        | kg      | 0.385                      | kg      |
| Total of CO2 avoided [ton]               | 0.000        | t       | 1.966                      | t       |
| Economic value of CO2 [€/ton]            | 11.32        | €       | 11.32                      | €       |
| Total economic value of avoided CO2      | 0.0          | €       | 22.3                       | €       |
| Total life cycle costs                   | 4,161.56     | €       | 1,213.12                   | €       |

DIF

5 years: -71% 2,948.43 €

Occupation 2017 500 H

Price of electricity:0.111586 e-conecta2018 in P1

| Factor de emisión (Kg de CO2 eq/kWh) |
|--------------------------------------|
| 0.385                                |

Study

Price CO2

<http://markets.businessinsider.com/commodities/co2-emissionsrechte>

## LCC – Study Provider 2

Rented Office: -1

|                                          | Lowest Price |         | Environment-friendly Price |         |
|------------------------------------------|--------------|---------|----------------------------|---------|
| Price                                    |              |         |                            |         |
| Price per product [Euro/product]         | 6.00         | €       | 20.40                      | €       |
| Lifetime [years]                         | 1.14         | y       | 4.60                       | y       |
| Comparable number of replacements        | 4.04         | n       | 1.00                       | n       |
| Total Cost [€]                           | 1,162.11     | €       | 979.20                     | €       |
| Duration                                 |              |         |                            |         |
| Lifetime [years]                         | 5            | y       | 5                          | y       |
| Average yearly time usage [hours/year]   | 2,500        | h/y     | 2,500                      | h/y     |
| Total usage time [hours]                 | 11500        | h       | 11500                      | h       |
| Number of purchases                      | 48           | n       | 48                         | n       |
| Total [hours]                            | 552000       | h       | 552000                     | h       |
| Maintenance                              |              |         |                            |         |
| Number of years [years]                  | 5            | y       | 5                          | y       |
| Jnits per year [work hour, kwp, page...] | 42.11        | n       | 0.00                       | n       |
| Cost per unit [€]                        | 7.50         | €       | 0.00                       | €       |
| Total [€]                                | 1453         | €       | 0                          | €       |
| Energy costs                             |              |         |                            |         |
| Price of energy [€/Kwh e/Kwh t]          | 0.11         | €       | 0.11                       | €       |
| Energy consumption [Watt e/t]            | 58           | W       | 22                         | W       |
| Lifetime energy consumption [kWh e/t]    | 32,016.00    | kWh e/t | 12,144.00                  | kWh e/t |
| Total energy cost [€]                    | 3,572.54     | €       | 1,355.10                   | €       |
| Emissions                                |              |         |                            |         |
| Kg of CO2/kWh                            | 0.385        | kg      | 0.385                      | kg      |
| Total of CO2 avoided [ton]               | 0.000        | t       | 7.651                      | t       |
| Economic value of CO2 [€/ton]            | 11.32        | €       | 11.32                      | €       |
| Total economic value of avoided CO2      | 0.0          | €       | 86.6                       | €       |
| Total life cycle costs                   | 6,187.27     | €       | 2,247.69                   | €       |

10 hs/dia\_250 days

Price of electricity:0.111586 e-conecta2018 in P1

| Factor de emisión (Kg de CO2 eq/kWh) |                  |
|--------------------------------------|------------------|
| 0.385                                | Kg de CO2 eq/kWh |

Study

Price CO2

<http://markets.businessinsider.com/commodities/co2-emissionsrechte>

DIF

5 years: -64% 3,939.58 €

Rented Office: Agents Comercials

|                                          | Lowest Price |         | Environment-friendly Price |         |
|------------------------------------------|--------------|---------|----------------------------|---------|
| Price                                    |              |         |                            |         |
| Price per product [Euro/product]         | 6.00         | €       | 20.40                      | €       |
| Lifetime [years]                         | 1.14         | y       | 4.60                       | y       |
| Comparable number of replacements        | 4.04         | n       | 1.00                       | n       |
| Total Cost [€]                           | 387.37       | €       | 326.40                     | €       |
| Duration                                 |              |         |                            |         |
| Lifetime [years]                         | 5            | y       | 5                          | y       |
| Average yearly time usage [hours/year]   | 2,500        | h/y     | 2,500                      | h/y     |
| Total usage time [hours]                 | 11500        | h       | 11500                      | h       |
| Number of purchases                      | 16           | n       | 16                         | n       |
| Total [hours]                            | 184000       | h       | 184000                     | h       |
| Maintenance                              |              |         |                            |         |
| Number of years [years]                  | 5            | y       | 5                          | y       |
| Units per year [work hour, kwp, page...] | 14.04        | n       | 0.00                       | n       |
| Cost per unit [€]                        | 7.50         | €       | 0.00                       | €       |
| Total [€]                                | 484          | €       | 0                          | €       |
| Energy costs                             |              |         |                            |         |
| Price of energy [€/Kwh e/€Kwh t]         | 0.11         | €       | 0.11                       | €       |
| Energy consumption [Watt e/t]            | 58           | W       | 22                         | W       |
| Lifetime energy consumption [kWh e/t]    | 10,672.00    | kWh e/t | 4,048.00                   | kWh e/t |
| Total energy cost [€]                    | 1,190.85     | €       | 451.70                     | €       |
| Emissions                                |              |         |                            |         |
| Kg of CO2/kWh                            | 0.385        | kg      | 0.385                      | kg      |
| Total of CO2 avoided [ton]               | 0.000        | t       | 2.550                      | t       |
| Economic value of CO2 [€/ton]            | 11.32        | €       | 11.32                      | €       |
| Total economic value of avoided CO2      | 0.0          | €       | 28.9                       | €       |
| Total life cycle costs                   | 2,062.42     | €       | 749.23                     | €       |

10 hs/dia\_250 days

Price of electricity:0.111586 e-conecta2018 in P1

| Factor de emisión (Kg de CO2 eq/kWh) |                  |
|--------------------------------------|------------------|
| 0.385                                | Kg de CO2 eq/kWh |

Study

Price CO2

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DIF

5 years: -64% 1,313.19 €

# Rented Office: NBWEBS

|                                          | Lowest Price |         | Environment-friendly Price |         |
|------------------------------------------|--------------|---------|----------------------------|---------|
| Price                                    |              |         |                            |         |
| Price per product [Euro/product]         | 6.00         | €       | 20.00                      | €       |
| Lifetime [years]                         | 1.14         | y       | 4.60                       | y       |
| Comparable number of replacements        | 4.04         | n       | 1.00                       | n       |
| Total Cost [€]                           | 484.21       | €       | 400.00                     | €       |
| Duration                                 |              |         |                            |         |
| Lifetime [years]                         | 5            | y       | 5                          | y       |
| Average yearly time usage [hours/year]   | 2,500        | h/y     | 2,500                      | h/y     |
| Total usage time [hours]                 | 11500        | h       | 11500                      | h       |
| Number of purchases                      | 20           | n       | 20                         | n       |
| Total [hours]                            | 230000       | h       | 230000                     | h       |
| Maintenance                              |              |         |                            |         |
| Number of years [years]                  | 5            | y       | 5                          | y       |
| Jnits per year [work hour, kwp, page...] | 17.54        | n       | 0.00                       | n       |
| Cost per unit [€]                        | 7.50         | €       | 0.00                       | €       |
| Total [€]                                | 605          | €       | 0                          | €       |
| Energy costs                             |              |         |                            |         |
| Price of energy [€/Kwhe €/Kwht]          | 0.11         | €       | 0.11                       | €       |
| Energy consumption [Watt e/t]            | 36           | W       | 20                         | W       |
| Lifetime energy consumption [kWh e/t]    | 8,280.00     | kWh e/t | 4,600.00                   | kWh e/t |
| Total energy cost [€]                    | 923.93       | €       | 513.30                     | €       |
| Emissions                                |              |         |                            |         |
| Kg of CO2/kWh                            | 0.385        | kg      | 0.385                      | kg      |
| Total of CO2 avoided [ton]               | 0.000        | t       | 1.417                      | t       |
| Economic value of CO2 [€/ton]            | 11.32        | €       | 11.32                      | €       |
| Total economic value of avoided CO2      | 0.0          | €       | 16.0                       | €       |
| Total life cycle costs                   | 2,013.41     | €       | 897.26                     | €       |

DIF

5 years: -55% 1,116.15 €

10 hs/dia\_250 days

Price of electricity:0.111586 e-conecta2018 in P1

| Factor de emisión (Kg de CO2 eq/kWh) |                        |
|--------------------------------------|------------------------|
| 0.385                                | Kg de CO2 eq/kWh Study |

Price CO2

<http://markets.businessinsider.com/commodities/co2-emissionsrechte>

## Training Courses

|                                          | Lowest Price |         | Environment-friendly Price |         |
|------------------------------------------|--------------|---------|----------------------------|---------|
| Price                                    |              |         |                            |         |
| Price per product [Euro/product]         | 6.00         | €       | 20.00                      | €       |
| Lifetime [years]                         | 1.14         | y       | 4.60                       | y       |
| Comparable number of replacements        | 4.04         | n       | 1.00                       | n       |
| Total Cost [€]                           | 484.21       | €       | 400.00                     | €       |
| Duration                                 |              |         |                            |         |
| Lifetime [years]                         | 5            | y       | 5                          | y       |
| Average yearly time usage [hours/year]   | 240          | h/y     | 240                        | h/y     |
| Total usage time [hours]                 | 1104         | h       | 1104                       | h       |
| Number of purchases                      | 20           | n       | 20                         | n       |
| Total [hours]                            | 22080        | h       | 22080                      | h       |
| Maintenance                              |              |         |                            |         |
| Number of years [years]                  | 5            | y       | 5                          | y       |
| Jnits per year [work hour, kwp, page...] | 17.54        | n       | 0.00                       | n       |
| Cost per unit [€]                        | 7.50         | €       | 0.00                       | €       |
| Total [€]                                | 605          | €       | 0                          | €       |
| Energy costs                             |              |         |                            |         |
| Price of energy [€/Kwhe €/Kwht]          | 0.11         | €       | 0.11                       | €       |
| Energy consumption [Watt e/t]            | 36           | W       | 20                         | W       |
| Lifetime energy consumption [kWh e/t]    | 794.88       | kWh e/t | 441.60                     | kWh e/t |
| Total energy cost [€]                    | 88.70        | €       | 49.28                      | €       |
| Emissions                                |              |         |                            |         |
| Kg of CO2/kWh                            | 0.385        | kg      | 0.385                      | kg      |
| Total of CO2 avoided [ton]               | 0.000        | t       | 0.136                      | t       |
| Economic value of CO2 [€/ton]            | 11.32        | €       | 11.32                      | €       |
| Total economic value of avoided CO2      | 0.0          | €       | 1.5                        | €       |
| Total life cycle costs                   | 1,178.17     | €       | 447.74                     | €       |

DIF

5 years: -62% 730.43 €

Occupation 2017 40\*6hs.=240h

Price of electricity:0.111586 e-conecta2018 in P1

| Factor de emisión (Kg de CO2 eq/kWh) |                        |
|--------------------------------------|------------------------|
| 0.385                                | Kg de CO2 eq/kWh Study |

Price CO2

<http://markets.businessinsider.com/commodities/co2-emissionsrechte>

C-D-E: training courses - presentations and meetings

|                                          | Lowest Price    |          | Environment-friendly Price |          |
|------------------------------------------|-----------------|----------|----------------------------|----------|
| <b>Price</b>                             |                 |          |                            |          |
| Price per product [Euro/product]         | 6.00            | €        | 20.40                      | €        |
| Lifetime [years]                         | 1.14            | y        | 4.60                       | y        |
| Comparable number of replacements        | 4.04            | n        | 1.00                       | n        |
| Total Cost [€]                           | 1,452.63        | €        | 1,224.00                   | €        |
| <b>Duration</b>                          |                 |          |                            |          |
| Lifetime [years]                         | 5               | y        | 5                          | y        |
| Average yearly time usage [hours/year]   | 600             | h/y      | 600                        | h/y      |
| Total usage time [hours]                 | 2760            | h        | 2760                       | h        |
| Number of purchases                      | 60              | n        | 60                         | n        |
| Total [hours]                            | 165600          | h        | 165600                     | h        |
| <b>Maintenance</b>                       |                 |          |                            |          |
| Number of years [years]                  | 5               | y        | 5                          | y        |
| Jnits per year [work hour, kwp, page...] | 52.63           | n        | 0.00                       | n        |
| Cost per unit [€]                        | 7.50            | €        | 0.00                       | €        |
| Total [€]                                | 1816            | €        | 0                          | €        |
| <b>Energy costs</b>                      |                 |          |                            |          |
| Price of energy [€/Kwhe €/Kwh]           | 0.11            | €        | 0.11                       | €        |
| Energy consumption [Watt e/t]            | 58              | W        | 22                         | W        |
| Lifetime energy consumption [kWh e/t]    | 9,604.80        | kWh e/t  | 3,643.20                   | kWh e/t  |
| Total energy cost [€]                    | 1,071.76        | €        | 406.53                     | €        |
| <b>Emissions</b>                         |                 |          |                            |          |
| Kg of CO2/kWh                            | 0.385           | kg       | 0.385                      | kg       |
| Total of CO2 avoided [ton]               | 0.000           | t        | 2.295                      | t        |
| Economic value of CO2 [€/ton]            | 11.32           | €        | 11.32                      | €        |
| Total economic value of avoided CO2      | 0.0             | €        | 26.0                       | €        |
| <b>Total life cycle costs</b>            | <b>4,340.18</b> | <b>€</b> | <b>1,604.55</b>            | <b>€</b> |

DIF

5 years: -63% 2,735.63 €

Occupation 2017 100\*6hs.=600h

Price of electricity:0.111586 e-conecta2018 in P1

| Factor de emisión (Kg de CO2 eq/kWh) | Kg de CO2 eq/kWh |
|--------------------------------------|------------------|
| 0.385                                | Study            |

Price CO2

<http://markets.businessinsider.com/commodities/co2-emissionsrechte>

A/B: training courses - presentations and meetings

|                                          | Lowest Price    |          | Environment-friendly Price |          |
|------------------------------------------|-----------------|----------|----------------------------|----------|
| <b>Price</b>                             |                 |          |                            |          |
| Price per product [Euro/product]         | 6.00            | €        | 20.40                      | €        |
| Lifetime [years]                         | 1.14            | y        | 4.60                       | y        |
| Comparable number of replacements        | 4.04            | n        | 1.00                       | n        |
| Total Cost [€]                           | 1,452.63        | €        | 1,224.00                   | €        |
| <b>Duration</b>                          |                 |          |                            |          |
| Lifetime [years]                         | 5               | y        | 5                          | y        |
| Average yearly time usage [hours/year]   | 500             | h/y      | 500                        | h/y      |
| Total usage time [hours]                 | 2300            | h        | 2300                       | h        |
| Number of purchases                      | 60              | n        | 60                         | n        |
| Total [hours]                            | 138000          | h        | 138000                     | h        |
| <b>Maintenance</b>                       |                 |          |                            |          |
| Number of years [years]                  | 5               | y        | 5                          | y        |
| Jnits per year [work hour, kwp, page...] | 52.63           | n        | 0.00                       | n        |
| Cost per unit [€]                        | 7.50            | €        | 0.00                       | €        |
| Total [€]                                | 1816            | €        | 0                          | €        |
| <b>Energy costs</b>                      |                 |          |                            |          |
| Price of energy [€/Kwhe €/Kwh]           | 0.11            | €        | 0.11                       | €        |
| Energy consumption [Watt e/t]            | 58              | W        | 22                         | W        |
| Lifetime energy consumption [kWh e/t]    | 8,004.00        | kWh e/t  | 3,036.00                   | kWh e/t  |
| Total energy cost [€]                    | 893.13          | €        | 338.78                     | €        |
| <b>Emissions</b>                         |                 |          |                            |          |
| Kg of CO2/kWh                            | 0.385           | kg       | 0.385                      | kg       |
| Total of CO2 avoided [ton]               | 0.000           | t        | 1.913                      | t        |
| Economic value of CO2 [€/ton]            | 11.32           | €        | 11.32                      | €        |
| Total economic value of avoided CO2      | 0.0             | €        | 21.7                       | €        |
| <b>Total life cycle costs</b>            | <b>4,161.56</b> | <b>€</b> | <b>1,541.12</b>            | <b>€</b> |

DIF

5 years: -63% 2,620.43 €

Occupation 2017 500 H

Price of electricity:0.111586 e-conecta2018 in P1

| Factor de emisión (Kg de CO2 eq/kWh) | Kg de CO2 eq/kWh |
|--------------------------------------|------------------|
| 0.385                                | Study            |

Price CO2

<http://markets.businessinsider.com/commodities/co2-emissionsrechte>