HOUSING´S DESCRIPTION

1. PROJECT BACKGROUND AND PURPOSE.

This project "Implementation of renewable resources in houses" in the application of the Learning Agreement pertaining to the degree of Industrial Engineering electrical, whose tutor Dr. Kádár Péter of the Óbudai Egyetem, revised and corrected writing listed data of this project.

The project consists of renewable and sustainable type facilities with the environment, for the comfort and use in a home, these facilities take advantage of renewable energy as: solar power (thermal and photovoltaic) and geothermal energy. Facilities and corresponding applications are listed in their respective sections.

2. PROJECT FEATURES

2.1. SITUATION AND LOCATION

The house which we apply this project is an “isolated single-family house” built on a plot of approx. 3000 m^2. Located in Alcañiz (Teruel), on the outskirts of the town, located within heading "Saints Plana" marked on the map PFC_01 LOCATION.

The urbanization constituted by similar chalets or houses located in the midst of nature, located at 30 meters from Guadalope River. There are not wide unevennesses of the land in the area, between the different plots and even within the same plot.

2.2. HOUSING DISTRIBUTION

The house has four floors, two of them destined for housing, a cover plant destined to placing the solar panels and a basement for accommodating the machines and devices of several installations.

Distribution of the main plants is as follows:

Down floor: Living room, kitchen, toilet, access, guest room, guest bathroom, laundry, gallery, stairs to first floor, porch and garage.

First floor: Three bedrooms, two doubles rooms and one main bedroom, two bathrooms, one of them incorporated in the main bedroom, study, living room and two terraces.

Basement: The house has a basement, which is accessed from the garage and is used as a machine room and cellar.

The table of house areas is as follows:

	USEFULL	BUILT
Down Floor		
Living-Room	21,56	
Dining-Room	12,69	
Kitchen	11,87	
Toilette	2,08	
Visitor Room	5,42	
Visitor Bath	1,91	
Laundry	6,16	
Stairs	2,12	
Entry - Hall	24,49	
	88,30	101,88
	USEFULL	BUILT
First Floor		
Main Room	16,16	
Wardrobe	5,02	
Bath MainRoom	5,47	
Room 1	14,55	
Room 2	14,55	
Main Bath	4,98	
Studio	6,55	
Hall	14,18	
Living-Room	11,36	
	92,82	122,29

	USEFULL	BUILT
Terraces		
Roof	100,90	
Terrace 1	21,13	
Terrace 2	36,35	
Porch	23,30	
Balcony	6,47	
	188,15	188,15
	USEFULL	BUILT
Cellar	41,25	45,93
Foundations		
Sanitary forging	107,60	107,60
	148,85	153,53
	USEFULL	BUILT
Down Floor	88,30	101,88
First Floor	92,82	122,29
Cellar	41,25	45,93
Terraces	188,15	188,15
	410,52	458,25

Table 1. Surfaces.

3. OBJETIVE OF PROJECT

Below is a summary of the proposed objectives in this project:

- Study of the available renewable energy systems, applied to the air conditioning, sanitary hot water and power electrical energy production.
- Evaluate housing energy needs for heating, cooling and electricity consumption.
- Compute surfaces and necessary elements for the implementation of the aforementioned systems in single-family housing.
- Evaluate economically the installations to build.

4. APPLICABLE RULES.

Below are the rules we have used in development of this project.

- Código Técnico de la Edificación (C.T.E.), aprobado por el R.D. 314/2006 del 17 de Marzo.
- Reglamento de Instalaciones Térmicas en los Edificios (R.I.T.E.), aprobado por el R.D. 1027/2007 del 20 de Julio.
- Decisión de la Comisión Europea 2007/742/CE por la que se Establecen los Criterios Ecológicos para la Concesión de la Etiqueta Ecológica Comunitaria a las Bombas de Calor Accionadas Eléctricamente ó por Gas ó de Absorción a Gas.
- Directiva 2009/28/CE Relativa al fomento del Uso de energía Procedente de Fuentes Renovables.
- Pliego de Condiciones Técnicas de Baja Temperatura para Instalaciones de Energía Solar Térmica, publicado por el Instituto para la Diversificación y Ahorro de la Energía (IDAE).
- Normas UNE que son de aplicación al proyecto.
- Reglamento electrotécnico para Baja Tensión.
- Reglamento de Aparatos a Presión.
- Real Decreto 436/2004 sobre la producción de energía eléctrica mediante energías renovables.
- Real Decreto 1663/2000 del 29 de Septiembre sobre la conexión de la instalación fotovoltaica a la red de baja Tensión.
- Real Decreto 3490/2000 de 20 de Septiembre sobre los derechos de verificación de la compañía eléctrica.

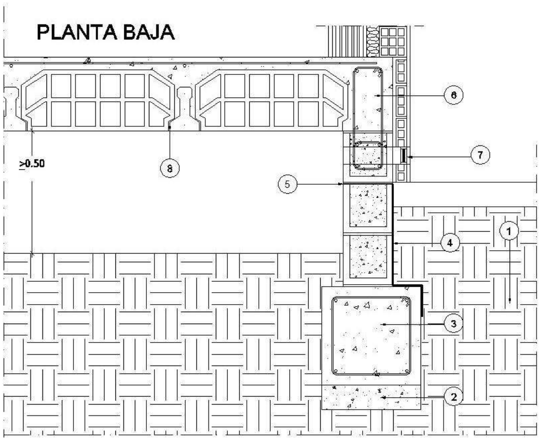
5. PROJECT DESCRIPTION

5.1. STRUCTURE

It describes below the construction elements of the housing that affect the development of this project.

5.1.1 Foundations and Structure

Foundation formed by reinforced concrete isolated footings. And structure based on reinforced concrete columns, beams and straps. The housing is built on a sanitary floor slab with an edge of 30 cm. Supported on concrete walls.

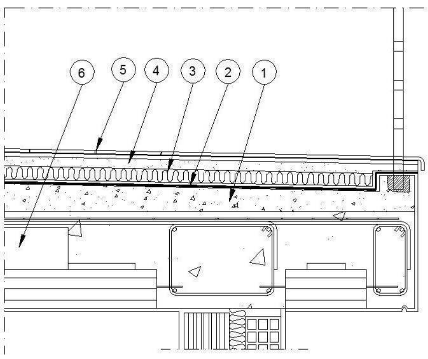


1. Natural terrain.
2. Concrete for cleaning.
3. Reinforced concrete beam.
4. Bitumen´s waterproof sheet lbm-40.
5. Moisture barrier.
6. Hook for tying.
7. Ventilation grille of sanitary floor slab.
8. Prefabricated concrete beams.

Figure 1. Foundations and sanitary floor slab.

5.1.2. Roofs and Covers

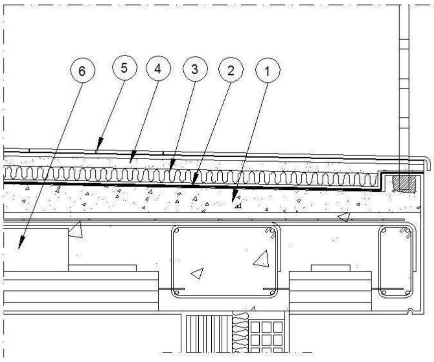
The house has a type of walkable cover that coincides with the bedroom´s terraces.



1. Cellular concrete for formation of slopes (12 cm).
2. Modified bitumen´s waterproof sheet lbm-40 (1cm).
3. Extruded polystyrene isolation (5 cms).
4. Regularization layer paving (2cm).
5. Paved of gres for outdoor (2cm)
6. Reinforced concrete slab and beams (30 cm).

Figure 2. Roofs corresponding on the first floor.

The house has a type of non-walkable cover that coincides with the housing cover.

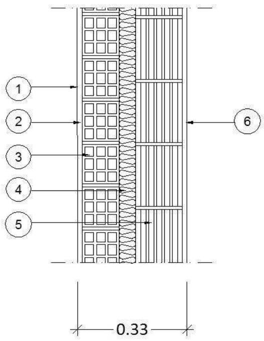


1. Cellular concrete for formation of slopes (12 cm).
2. Modified bitumen´s waterproof sheet lbm-40 (1cm).
3. Extruded polystyrene isolation (5 cms).
4. Regularization layer paving (2cm).
5. Gravel (2cm)
6. Reinforced concrete slab and beams (30 cm).

Figure 3. Roofs corresponding on the cover.

5.1.3. Masonry

All interior walls are made of factory bricks of 7 cm thick to lining. The outer walls are part of the building structure and are according to the following scheme:



1. Layer transpirable stone.
2. Plastering of lime mixed mortar (1,5 cm).
3. Hollow ceramic brick 24 x 11,5 x 11 cm
4. Heat and acoustic insulation panels of napa (4 cm)
5. Thermoclay walls (14 cm).
6. Laying of plaster projected (1,5 cm).

Figure 4. Exterior wall facade

5.2. HOUSING´S FINISHES

5.2.1. Continuous Coatings

Plaster´s finish in indoor zones of 1.5 mm thickness. External enclosures, vertical and horizontal surfaces garage, vaulted stairs and cover´s railings are coated with cement mortar plastering.

Plaster ceiling in bathrooms, kitchen and hallways.

5.2.2. Tiles and Veneered

The bathrooms and kitchen with ceramic tiles, with borders perimeter in both case.

5.2.3. Pavements

The housing is paved with stoneware tiles. Humid zones are also paved with stoneware. The terraces are paved with antiskid stoneware tiled for outdoor.

5.2.4. External Carpentry

The living room and bedrooms are made of treated wood, louvered incorporated monoblock system. The windows are sliding and folding, and double-leaf sliding the balcony doors.

The gateway to the housing will be sheet metal, pressed and injected with safety lock.

5.2.5. Wood Carpentry

The interior doors are made of chipboard and blind, except for the kitchen door which has a glazed part.

5.2.6. Paints

The walls and ceilings are painted with smooth transpirable paint and the outside walls are coating with smooth stone for outdoor.

External elements enamelled or varnish finishes on primer layer.

5.2.7. Glazing

The glazing of all exterior carpentry are made of double insulated glass climalit type 4/8/4.

5.3. INSTALLATIONS

5.3.1. Plumbing, Sanitary Fittings and Taps

All water distribution net, hot and cold, of the housing is made of PVC pipes. The mains drainages and rainwater network include downpipes and collectors alike PVC.

This installation is ready to collect dirty water that contains soaps, grease and non-solid wastes produced in the housing, in addition to collecting rainwater.

The installation consists of a water treatment plant capable of cleaning 250 l / h of water, where this water is then stored in a tank of 500 l for later use in cisterns and gardering.

The full description of this installation is described in its corresponding section.

5.3.2. Electrical Installation

The electrical installation of the housing has a general protection box (CGP) next to the plot boundary fence. From this box leaves the splitter line to reach the housing.

The indoor installation is made of insulated conductors under protective tubes embedded in walls, ceilings. It has a high degree of electrification of 9200 W and 16 circuits.

The full description of this installation is described in its corresponding section.

5.3.3. Heating and Sanitary Heated Water Installations

The solar thermal systems consists in a solar collector with 2.6 m2 of area, able to capture solar heat in a fluid and then are stored in a 160 l tank, enough for housing consumption.

The disadvantage of this system is that we can only get 60% of the hot water demand in winter and 90% of demand in summer. So this energy deficit is obtained by using the geothermal pump system.

Regarding geothermal system has been chosen a geothermal pump 13,4 kWth with a 2800W electric support, both for heating and for cooling housing. The distribution system inside the home is through the floor heating system because it operates at low temperatures. For the system of external exchange with the terrain is to install two probes 70 m depth according to calculations obtained.

The full description of these installations is described in their corresponding sections.

5.3.4. Solar Photovoltaic Installation

The solar photovoltaic system consists of 18 solar panels with peak power 175 W each one, connected to an inverter of 3150 W. This installation has 4 batteries of 2500 Ah for energy storage in addition to being connected to the electricity grid to sell excess energy that is produced.

The full description of this installation is described in its corresponding section.

6. DRAWINGS

The documentation of drawings is in the correspondent document, DOC_02 DRAWINGS. In this document can be found the documentation of: geographical location, plants distribution, facades, sections and construction details of the housing.

7. CONCLUSION

Exposed the purpose and usefulness of this project, we hope that it deserves the approval of the Administration, giving us the necessary approvals for processing and commissioning.

Budapest, June 2013

The Student of Electrical Engineering

Signed: Enrique Esteve Martínez

ID code: IF1VX7

WATER INSTALLATION´S DESCRIPTION

1. PROJECT BACKGROUND AND PURPOSE

The plumbing installation born as necessity of water supply to fulfill their hygienic mission to people who using the housing.

The network of sewage disposal is carried out as a complementary requirement to the water network since after that entering water into the building and complete its hygienic mission in the different places of the same, these waters must be cleaned for reuse or elimination, which implies the necessity of water evacuation progressively in the housing. Mainly this installation constitute in collecting and unification different points to an only point, to be reused by a purification system or elimination to another network, which is the sewer.

1.1. WATER EVACUATION

With this name, is called the gathered waters which are spill into the sewage network. The differences that are in the water classification are numerous, but according to their origin and transport of organic materials, can be divided into three categories, so the waters of evacuation of housing normally are:

- Water used or dirty: This water coming from the set of sanitary fittings of the housing (sinks, loos, bidets, etc...) except toilet or turkish plates. These waters are relatively dirty and drag many elements dissolved as fats, soaps, detergents, etc..
- Water sewage or blacks: This water drags feces and urine from toilets and turkish plates. Waters are high in bacterias and high solids content and organic elements.
- Storm water or white: This water coming from the rain or snow, runoff or drainage. The waters are generally quite clean.

Onwards it will distinguish between sewage and grays, encompassing those used with rainwater for recycling, and sewage to be removed.

2. PROJECT FEATURES

From all above, it follows that the interior evacuation network is subject to two types of wastes of very different nature and origin, which requires a very careful and meticulous installation, with high quality in different materials and a rigorous design. So that wastes are retained in the shortest possible time and give them quick exit out of the building, as this is the most important order that must meet this network, to get its mission successfully.

We cannot forget the troubled nature of this network that despite all foreseeable considerations, being an open network, is always subject to unexpected admission that many times originates jams and breakdowns. To avoid such effects should be taken into account a number of recommendations when performing this type of installation:

- Should be arranged in the installation, hydraulic seals to prevent that the airflow go into the premises occupied it without affecting the waste stream.
- Pipes of evacuation network must take the simplest path possible, with distances and slopes that facilitate the removal of waste and be self-cleaning. Should avoid water retention inside.
- The diameters of the pipes should be appropriate to transport predictable flows safely.
- Piping must be designed to be accessible for maintenance and repair, for which they must be willing to look at housed bands or holes or hatches. Otherwise, should have chests for reparation with the lowest incidence to other units of work, otherwise, their impact can be very important, since both from a technical standpoint and economically.
- Ventilation systems are arranged adequately to enable the operation of the hydraulic seal and evacuation of sewer gas.
- The installation should not be used for disposal of waste other than sewage or storm water.
- Building´s collectors must drain, preferably by gravity, in the well or pit which is generally the connection point between the store facility and the public sewer through the corresponding rush.
- Before the general manhole and after manhole siphon the building generally must put a check valve to prevent water from backing up into the same and charge entry into sewer pipe in case of flooding, heavy rain , collapse, jam, etc.

3. OBJECTIVE OF PROJECT

Below are shown in summary the objectives that arise in the realization of this facility.

– Size and calculate the elements needed for the implementation of this system in the housing.

– Economical estimation of installation to perform.

4. APPLICABLE RULES

The new legislation makes explicit reference to disposal facilities, and to be taken into account when designing these facilities is:

– The Technical Building Code (CTE) in the health section (HS) has a specific section for that installation, entitled Waste water, specifying the scope of that law, characterize and quantify the level of demand that is required for the installation, the design and the parts that make up the installation, sizing and how to implementation of the construction.

Others regulations that are taken into account:

– Municipal Ordinances refer to the form of wastewater disposal and the status of the wastes, which should arrive in the best condition possible to the sewage network, and systems such as drains of garages and parkings should carry fat purification system prior to the rush overall network to avoid congestion and jam. This regulation has an important weight when installing with the CTE.

– NTE (Rules of building). It is a valuable documentation for the project, for its simplicity and clarity to be found the fundamentals of all facilities, not just disposal facilities and sanitation. And although these rules, as indicated on other occasions, it is not obligatory and usually quite useful in many cases.

– NBIA (Basic Standards Indoor Water Facility), which indicated in its title second, the prohibition of a direct connection of water supply installation with any water discharge line.

– RITE (Regulation of Thermal Installations in Buildings).

5. EVACUATION AND SANITARY NETWORKS DESCRIPTION.

As already indicated above the evacuation network and housing sanitation entails the waters used treatment in its various forms.

So we have, in the absence of a sewage waste water for the building. The wastewater will be evacuated to a septic tank located in the terrain, while the gray water will be treated for reuse in toilets and gardening.

The sanitary network of the housing is conceived through semiseparative system that is implementation of the downpipes in two pipe networks designed to collect graywater and rainwater and other to collection of sewage from the housing. The two end pipes networks at different points in the basement will be located a plant for the treatment and storage of water.

5.1. COLLECTION STORMWATER

The Basic Rule of Edification, "Covers with Bituminous Materials" (NBE, QB-90), does not make clear the limitations on the measures of the "drop cloths" depending on the material or the constructive solution to adopt for waterproofing.

To carry out this section is recommended:

– Do not overload the structure with thick excessive. A length "a" above than 7 m, with a slope of 2% results in an increase over than 200 kg/m2.
– Considering that drop cloths having the waterproof layer welded to the base, and their high coefficient of expansion, is proposed:

- Drop cloths not exceed 100 m2.
- In drop cloths not are b> 3 c, in order not to favor dilatation in only one direction.

Also considered:

– Avoiding controversial points in the water collection.
– Ensure that bowl, detours and downspipes not interfere with structural elements such as capitals (in waffle slabs), edge beams and nerves.
– For drainage of terraces and balconies inward, is recommend a solution with a single slope and gutter.
– In big passable terraces is often that water collection is carried out under the pavement, this is placed horizontally, either slotted or with open joints, by height adjusters. Nowadays is marketed such solutions, avoiding their problems to do handmade.

As a general recommendation has to be assumed, for any type of building, its expansion joints must match with roof beams on the cover.

5.2 COLLECTION GRAY WATER

The system to implant requires connect the drains of sinks, baths, bidets, washing machine and dishwasher to a tank, where there are two purification treatments:

– One physical, using filters that avoiding the passage of solid particles: these filters must be specific sized to retain those particles that can appear in the drains.

– Another chemical treatment of water by chlorination with sodium hypochlorite with automatic dispenser, which leave ready to be reused.

– To return the water to the tank is used a low-power pump that carry water since the tank to the cisterns when they, after use, should be filled again.

– To size the system, is essential tank. Depending on the number of people that living in the home, its size is estimated to reach a balance between the space used and the capacity thereof. For our housing, the tank of 0.5 m3 is the most common. Usually is of fiberglass or plastic, being the usual place location the basement of the house.

– If for some reason there is no gray water supply or there is a very high consumption in the toilets, the tank has a mechanism of valves and buoys which supplies this lack taking water from the supply network general. If, instead, there is a very high production of gray water and produces a tank overfilling, the latter has an overflow that collects and carries the waste to a watering garden network.

5.3. COLLECTION SEWAGE WATER

The system to implant, only requires connect the drains from toilets to a septic tank, where pours the sewage.

5.4 TYPES OF MATERIALS USED

5.4.1 Materials Used in Pipes

Therefore material used, following the rules for the canalization of the evacuation network is plastic material, since it is a material commonly used in the entire system. The compounds used for the manufacture of pipes and pieces for water pipes belong to the thermoplastic range. This property means that after softening by the action of heat, the material recovers their organoleptic after cooling.

– Polyvinylchloride (PVC).

It is light, cheap, and today, with a lot of pieces and accessories to facilitate rapid assembly, and allows excellent and safe sanitary installations.

There are two kinds of tubes of this material:

– Series "F"; usable for networks vents, several wastewater and stormwater networks.
– Series "C", usable for all types of wastewater, both branches as downpipes and collectors.

Its characteristics and required behaviors are regulated by the UNE Rule indicated in CTE DB-HS 5 6.2. Accessories are designated similarly to tubes, noting that cited nominal diameters of the tubes correspond to those serving.

– Disadvantages of PVC

The high coefficient of expansion, which can be problematic from a certain temperature. However, constructive practice indicates that whenever is reinforced, ie 3.2 mm thick, there is no objection to make the entire network without exception through these thermoplastic materials. It will be necessary placement of dilators every few meters:

- Branches: 2 m.
- Downpipes: 3 m.
- Collectors: 6 m.

5.3.2. Materials Used in Accessories

Must meet the following conditions:

– Any metallic element or not necessary to the perfect execution of these facilities meet the same conditions required for the pipeline to be inserted.
– The casting pieces intended for tapas, sinks, valves, etc.., Meet the requirements for casting´s pipes.
– The flanges, clips and other material intended to fixing downpipes will be metallic or galvanized iron.

– In the case of the plastic downpipes are inserted between the clamp and the downpipe a plastic sleeve.

6. DRAWINGS

The documentation of drawings is in the correspondent document, DOC_02 DRAWINGS. In this document can be found the documentation of: plants distribution, sections and construction details of the housing.

7. CONCLUSION

Exposed the purpose and usefulness of this project, we hope that it deserves the approval of the Administration, giving us the necessary approvals for processing and commissioning.

Budapest, June 2013
The Student of Electrical Engineering

Signed: Enrique Esteve Martínez
ID code: IF1VX7

THERMAL INSTALLATION DESCRIPTION

1. PROJECT BACKGROUND AND PURPOSE

Most of the energy consumption in housings is attributed to heating and cooling requirements by the occupants for comfort conditions.

The most widespread techniques currently require use of fossil fuels, resulting in emission of greenhouse gases and a rise in energy bills. Therefore, it has made a great effort to reduce dependence on external energy in order to have alternative sources of energy consumption and more efficient systems capable of reducing dependence on external energy and emissions of pollutants and greenhouse gases emissions.

Between of minority renewable energies, Geothermal Energy is defined as the energy stored as heat in the Earth's interior. This energy with the use of heat pumps offers an alternative to conventional air conditioning systems to supply the needs of demanding heating and cooling residential housings. Also, Solar Thermal able to capture the heat of solar radiation also presents an alternative to consider.

To improve the housings, in this sense we have to act in two main directions:

- Improve home insulation to the outside environment to minimize heat exchanges.
- Improve the performance of equipment and facilities, so that we supply more energy with minimum energy consumption.

2. PROJECT FEATURES

In Spain the most common form of water heating is by radiators, fed from individual or collective boilers. These radiators need to function effectively a relatively high temperature, between 70 and 90 ° C. This temperature is easy to achieve and maintain with conventional energy systems but not for a solar thermal system or shallow geothermal. The only way to get a good heating using a combination of solar thermal and geothermal energy is using underfloor heating, since the system works effectively at a temperature around 40 °C, this being an optimum performance range for collectors solar and geothermal pump.

The thermal emitter is the entire floor area to be heated. This results in that the thermal emission is uniform throughout the surface. This phenomenon is opposed to the hot zones and cold zones you get with other heating systems in which there is a limited number of heat emitters.

For uses relating to domestic housing using geothermal energy with low and very low temperature. The use of geothermal energy is directed primarily to air conditioning (hot/cold) with heat pumps, as well as the production of hot water in combination with the solar collector system.

No makes use of the energy surplus in summer seasons where we do not need heating, and hot water needs decrease, this will dissipate to avoid overheating of the system.

2.1. WEATHER CONDITIONS

For the determination of the average temperatures and relative humidity of the municipality of Alcaniz, average temperatures are taken from the weather station AEMET specifically located in Alcaniz station with geographic coordinates: Latitude: 41.058056 and Longitude: -0.137778), approx. 320 m above sea level.

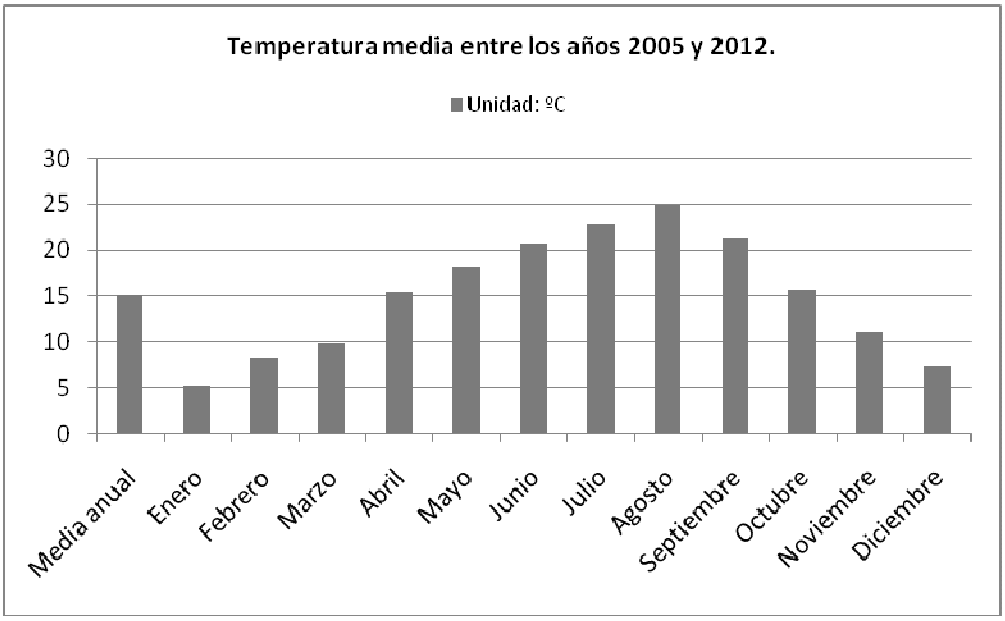


Table 1. Average temperatures in the location.

Below is a graphic in that sampled, mean solar radiation recorded between the years 2005-2012.

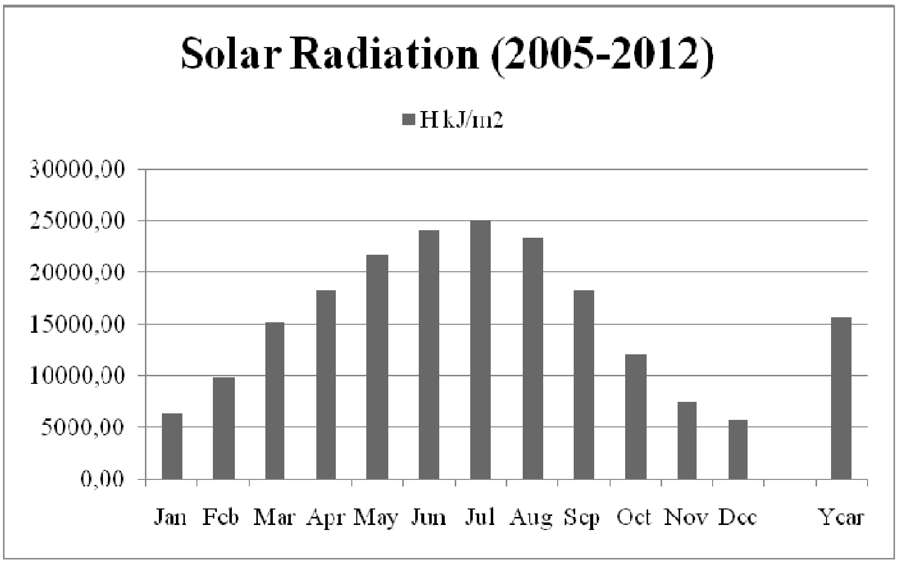


Table 2. Solar radiation at the location.

2.2. GEOTHERMAL INSTALLATION FEATURES.

In Spain the temperature of the ground in the first few meters is approx. about 15 ° C depending on the climate zone.

The air conditioning geothermal system to install is the vertical duct system, because it uses the thermal inertia of the earth to depths of 150 m. This system is done by utilizing the difference of temperature between ground and the outside environment through a manifold installed underground, in winter uses the high ground temperature for heating, and in summer the lowest temperature for cooling.

This installation is considered primarily to the housing climate, favorable characteristic inasmuch as that have about solar power is that this system is not affected by seasonal weather conditions and because the ground temperature remains constant throughout the year.

Geothermal collection system to install and operates in closed loop is formed by three main subsystems:

– An underground heat exchanger, also called underground loop. It is a vertical pipe network buried in the ground, with water flowing inside through a pump. The network acts as a heat exchanger which takes relative heating from the earth on winter, and the relative cooling on summer.

– A geothermal heat pump with refrigerant in an intermediate circuit which transfers the heat from the underground heat exchanger to housing distribution system. The warm side of the circuit compresses the gas and increases its temperature, which is transmitted to the heat distribution circuit of the housing, while the cold side circuit acts in reverse.

– An underfloor distribution system that distributes the heat or cold generated by the exchanger buried in the earth, in different rooms of the house.

2.3. SOLAR THERMAL INSTALLATION FEATURES

A solar heating system is composed of the elements to capture sunlight, turning it into usable heat energy for a system with a working fluid and storing this efficiently, usually in another fluid suitable for consumption. The accumulation is performed by accumulation tanks to use at the time consumption with the lowest possible losses.

This system is supplemented by a thermal energy production by geothermal energy system will be integrated into the installation.

Collector be found anchored on the roof using an adequate support (REF_DRAWINGS). The connection between the collectors will be flexible to prevent expansions caused by temperature gradients.

Protect the system against frost and therefore will set the minimum temperature of the system. All parts of the system that are exposed to the outside must be able to withstand the specified temperature without permanent damage to the system. To avoid overheating should provide automatic devices or manual control to prevent damage to equipment and to penalize the quality of energy supply.

The systems that comply the solar thermal installation for hot water are:

– Capture system: is formed by the solar collectors, responsible for transforming the incident solar radiation over them and usable thermal energy transported by a working fluid.

– Accumulation system: formed by one reservoir, which store the hot water until their use is required.

– Hydraulic circuit: consists of pipes, pumps, valves, etc.., which is responsible for transporting thermal energy through the hot fluid to the accumulation.

– Exchange systems: performing the transfer of thermal energy from the collector circuit to consumption.

– Regulation and Control System: who is responsible, on the one hand secure the correct equipment operation to provide maximum possible solar energy and on the other hand, acts as a protection against the action of multiple factors such as over overheating system risks of freezing, etc..

3. OBJECTIVE OF PROJECT

The objective of this project is to design measure and test the feasibility of an air conditioning system in a house to ensure approximately 90% of the heating requirements of the building by using geothermal and solar collectors.

In summer, with the irradiation available it can cover 100% of the energy consumption in hot water, but in winter there is a significant energy deficit to be covered by the combination of the two systems.

Below are shown in summary the objectives that arise in the realization of this facility.

– Calculation of building thermal loads.
– Dimensioning of the underfloor heating installation.
– Dimensioning of the geothermal heat pump and solar collection system.
– Selection of equipment and materials to install.

4. APPLICABLE RULES

It follows the rules that we used in the writing of this facility.

– Código Técnico de la Edificación (C.T.E.), aprobado por el R.D. 314/2006.
– Reglamento de Instalaciones Térmicas en los Edificios (R.I.T.E.), aprobado por el R.D. 1027/2007.
– Normas UNE que son de aplicación al proyecto
– Reglamento de Aparatos a Presión
– Directiva 2009/28/CE Relativa al fomento del Uso de energía Procedente de Fuentes Renovables.

– Decisión de la Comisión Europea 2007/742/CE por la que se Establecen los Criterios Ecológicos para la Concesión de la Etiqueta Ecológica Comunitaria a las Bombas de Calor Accionadas Eléctricamente ó por Gas ó de Absorción a Gas.

– Real decreto 1027/2007 del 20 de Julio (RITE).

– Real Decreto 314/2006 del 17 de Marzo (CTE).

5. THERMAL NETWORKS DESCRIPTION.

Taking as reference data that we have of the housing such as climatology, structural characteristics, areas and volumes, as well as preset comfort conditions; are evaluated and calculated the thermal needs of housing, both heating and cooling and SHW consumption necessary for sizing the geothermal and solar installation.

5.1. GEOTHERMAL INSTALLATION´S DESCRIPTION

Once the calculation of the needed energy demand for Climatization, we need to dimension and choose the elements that formed the geothermal installation.

5.1.1. Geothermal Heat Pump

The geothermal heat pump exchanges heat with the ground, which maintains an even temperature of 15 ° C throughout the year. In the closed loop system, used in our project, circulates an antifreeze solution, such as fluid transfer through pipes buried vertically.

As of the data of energy demand necessary for proper housing climate has been sought a device that complies with the requirements of our installation.

– Minimum power of 9 kW for heating and 7.5 kW cooling.

– Ground-water type system. Take ground heat and transmits it to the house by water through a network of pipes.

We selected a geothermal heat pump that fits our installation; brand TERRA 12 S/W-HGL-P.

It will be necessary to install several local grilles for permanent ventilated.

The heat pump will be located in the basement of the house as indicated (PFC_04).

Characteristics of the geothermal pump in TECHNICAL SHEET

5.1.2. Pipe System

5.1.2.1. Buried pipe network

The buried pipe network contains an antifreeze liquid that is driven by the pump. As the ground temperature is constant there is a transfer of heat in winter or cold in summer by heat pump that is transferred to housing.

The system of pipes or collectors, is copper coated cross-linked polyethylene (PER), and implanted by drilling.

The pipes are buried through drillings which are 70 m of depth.

The fluid used in the geothermal circuit will be water with an antifreeze solution in proportion of 15% of propylene to prevent freezing.

5.1.2.2. Underfloor network of the housing

.

Heating or cooling energy will be distributed for housing through a network of pipes. The geothermal heat pump of low temperature, from the basement, would improve hot or cold water (depending on time of year) vertically.

Is formed by multiple pipes of polyethylene inside the concrete floor and separated into rooms, with independent temperature control.

For correct operation of the installation must be ensured that the difference in temperature between the closed loop system and hot water distribution is adequate to obtain maximum performance of heat pump. A greater difference produces less performance.

5.2. SOLAR THERMAL INSTALLATION´S DESCRIPTION

The solar installation is designed to work with the geothermal system in the supply of for total sanitary hot water housing demand and heating load.

The installation was designed so harness the maximum energy taked by the sensors. We evaluated several design options, taking this design to be the most energetically efficient and lower cost to have fewer elements, which increase the cost of installation.

Both the distribution of the collectors on the roof, as storage tanks have been arranged for the best maneuverability, maintenance and repair of the system.

Our solar system can be classified based on some criteria:

– By circulating principle is classified as forced circulation system, since there are circulation pumps that move the heat transfer fluid along the various circuits of the facility.
– For the heat transfer system is classified as an indirect installation with separate heat exchanger.
– For system expansion, installation is classified as a closed system, because the working fluid is not in contact with the outside and operates at a pressure above atmospheric.
– According coupling shaped, installation is classified as a broken installation; to be physically separated from the collector and the tank.

5.2.1 Capture System

After verifying all specifications, qualities and appropriateness to our system is selected a collector model TERMOCAN 2.6A of TEICAN.

Characteristics of the Solar Collector in TECHNICAL SHEET

5.2.2. Accumulation System

The solar system should be conceived in terms of the energy provided throughout the day and not depending on generator power (solar collectors), so it should provide an accumulation according to demand as it is not simultaneous with the generation.

Accumulating system facilitates the operating temperature limitation maintaining performance of the sensors to an acceptable level, so it is vital for correct sizing. Excessive accumulation but increase the collection system performance causing unacceptable heat losses and non reach the consume temperature, however insufficient accumulation system could represent an excessive operating temperature or higher consumption of the auxiliary system.

Is intended to become independent the SHW storage system with storage system of heating, so will use two separate storage. Although with this solution increase the cost of installing the performance will be greater.

In order to maximize energy and prevent delamination the connectors of deposits are located in the following points:

- Injecting of hot water from exchanger: between 50 and 75% of the height.
- Extraction of water for the exchanger: at the bottom of the tank.
- Output hot water for consumption: on the top of the tank.

Characteristics of the Accumulation system in TECHNICAL SHEET

5.2.3. Exchange System

The exchange system is responsible of transfer the energy that solar collectors have been able to get and transfer it to the storage system. The solution chosen for the energy exchange between the primary circuit and the secondary is an external plate exchanger that connects both circuits known as indirect heat transfer system.

At no time, in the system of exchange must mix heat transfer fluid with accumulation water.

The lower efficiency of the heat exchanger should be increased inlet temperature in the collectors, decreasing the performance of these and therefore the installation.

The exchanger selected for the SHW system belongs to the brand Daikin Alterna, model EKSOLHWAV1.

5.2.4. Hydraulic Circuit

The hydraulic circuit is made of copper, complying with ISO / TR 10217 and UNE-EN 806-1, material that has been chosen to have a high performance in terms of corrosion resistance, malleability, ductility and innocuousness as well as being economically very competitive.

In the design of the pipe network is sought to limit the maximum thermal losses, looking for shorter paths and limit as much as possible the load losses avoiding bends or unnecessary accessories.

The design values of the primary circuit that have been considered are:

- Rate in pipes < 1.5 m/s.
- Caudal approximately 45 l/h per m^2
- Allowable pressure drop in pipes per meter < 40 mm.ca of collector surface.

In those horizontal segments always will have a minimum slope of 1% in direction of flow, to favor this.

Will be used for water distribution network, which acts as a copper pipe welded by capillarity inner diameters of 16, 20, 26, 32 and 40 mm.

In the installation can differentiate the following circuits:

- Primary circuit: this is the circuit of the solar system, which circulates the heat transfer fluid. This circuit is closed and the fluid runs through the installation driven circulation pumps.
- SHW secondary circuit: this circuit is the consumption, by circulating water from the network for hot water consumption.

Isolates not allow visible areas of pipe or fittings, remaining only the outside elements that are necessary for the proper functioning and operation of the components.

5.2.5. Control System

The primary object of the regulating and control systems is to optimize the performance of the system and prevent it reaching extreme conditions that may cause damage, so its purpose will be to act on the operation of:

- Circulation pumps.
- Frost system activation.
- Maximum temperature control in accumulator.

The control system will act and adjusted so that the pumps are not running when the difference in temperature is less than 2 °C and non are stopped when the difference is greater than 7 °C. The temperature difference between the points of starting and stopping of differential thermostat shall not be less than 2 °C.

The temperature sensor of accumulation is preferably placed at the bottom in an area not influenced by the flow of the secondary circuit or the heating exchanger if this is incorporated.

The control system will ensure that in no case reach temperatures above the maximum supported by the materials, components and circuits treatments. Also ensure that at any point the working fluid temperature drops below a temperature of three degrees higher than the freezing fluid.

Alternatively to differential control, can be operated using control systems based on solar radiation.

The three main elements of a system of regulation and control are:

- Sensors: They are responsible for measuring control variables in the system, temperatures.
- Controller: The device that generates a control signal from the controlled variable value and the setpoint. Can be thermostats or proportional controllers.
- Actuator: This element to receive the control signal acts on the operating variable, generally regulating the flow of matter or energy. They can be relays, contactors, control valves, etc..

6. JUSTIFICATORY CALCULATION

6.1. CHARACTERISTICS ENERGETIC OF HOUSING

The housing where shall be do these installations, is located on a long terrain, with north-south orientation, the roof of this housing is of flat surface so that our collectors have south orientation, with this and the climatic characteristics of the site favor the suitability of these type installations.

Also the location of the house is quite suitable for this type of installation because there are not buildings or objects around that and may cast shadow over our collection system and cause important losses in this.

6.1.1. Location Details

The building is located in Alcañiz, province Teruel, locality with the following geographic and climatological data:

- Height: 323 m
- Latitude: 41 ° 1'46" N
- Long: 0 ° 8'37" W
- Historical minimum temperature: -11 ° C
- Annual average temperature during sunlight hours: 16.8 ° C
- Average relative humidity: 40%
- Average number of days of fog: 28 days
- Average number of clear days: 80 days
- Average number of sunshine hours: 2614 hours

For the design of the system it has been taken into account other weather data such as data of ambient temperature and also data of solar radiation, typical of the climatic zone of the Alcañiz city.

These data have been obtained from various sources: CENSOLAR (Center for Solar Energy Studies), AEMET (Meteorological Agency) and JRC (Joint Research Center).

The weather data can be found in TECHNICAL SHEET.

6.1.2. Climatic zone

The climate zone where the housing is located is determined from tabulated values in the DB-HE1. They are classified into 12 climate zones identified by a letter corresponding to the winter division and for a number corresponding to the summer division.

The corresponding climate zone Alcaniz, is the IV, with a reference height of 323 m above sea level, the house is far from the capital at a height above about the reference climate zone, but for the purposes calculation no abrupt changes.

The following graph shows the distribution of climatic zones in Spain according to CTE HE-4.

Picture 3. Spanish´s Climate Areas.

6.2. SHW NEEDS

Thermal solar system pursues an increase in the network water temperature to consumption temperature or close to it. The sanitary hot water needs are very variable throughout the day and depend on many factors so estimate them at specific times is complicated therefore recourse is had to estimate them on a daily basis.

The temperature distribution of hot water which has been considered in the design of the installation is 45 ° C at the point of consumption and the accumulation of 60 ° C, calculated according to the requirements stated in the CTE HE-4.

The occupancy percentage employed on the housing is 100%.

Data for SHW liters per person at a temperature of 60 ° C have been obtained from CTE-DB HE-4.

Número de dormitorios	1	2	3	4	5	6	7	más de 7
Número de personas	1,5	3	4	6	7	8	9	Número de dormitorios

Table 3. Nº of people in function of Nº of rooms.

According to the Technical Building Code in its Basic Document HE-4, minimum solar contribution of sanitary hot water for single family homes is estimated a consumption of 30 liters/person of DHW per day at 60 ° C.

Number of people (4 bedrooms) = 6 people

DHW = 30 (liters/person day at 60 °C) x 6 (people) = 180 l/day

6.2.1. Solar Minimum Contribution

The objectives of the solar installation satisfy most energy demand possible. So in summer we could cover 80-90% of the hot water consumption on housing due to irradiation available, but in winter there will be a significant energy deficit, which cover only 60%, so this deficit will be covered by the geothermal installation.

According to the CTE-HE 4, the minimum solar contribution to cover the installation will depend on the energy source of support, SHW consumption and climate zone of the city.

In the following table we have that the minimum solar contribution to our data is 70%.

Demanda total de ACS del edificio (l/d)	Zona climática I	II	III	IV	V
50-1.000	50	60	70	70	70
1.000-2.000	50	63	70	70	70
2.000-3.000	50	66	70	70	70
3.000-4.000	51	69	70	70	70
4.000-5.000	58	70	70	70	70
5.000-6.000	62	70	70	70	70
> 6.000	70	70	70	70	70

Table 4. SHW Minimum solar contribution in%. Case Joule Effect

6.2.2. DHW Demand

The criteria for determining the collector surface are energy consumption and solar contributions. It desired is that these data provide best fit for no excess or energy deficiencies.

To study this indicative parameter is determined the fraction Contribution/Consumption, which is intended to oscillate as close to unity. In this case it is intended to cover 75% of the annual demand for SHW in the housing through the solar system; the rest should be covered by the energy of support.

The heat loads determine the monthly amount of heat required to heat water for domestic consumption, calculated by the expression:

$$Q_a = C_e.C.N.(t_{ac}-t_r)$$

The following table shows the calculation results of energy demand estimates for each month of the year:

Month	Ce (kJ/kg ºC)	N	M (l/day)	Tª Accumul.	Tª Net	QSHW (kJ)	QSHW (W)
	Specific Heat Water	days/month	Diary Consum				
Jan	4,187	31	180	60	5	1284990,300	356,942
Feb	4,187	28	180	60	6	1139533,920	316,537
Mar	4,187	31	180	60	8	1214899,920	337,472
Apr	4,187	30	180	60	10	1130490,000	314,025
May	4,187	31	180	60	11	1144809,540	318,003
Jun	4,187	30	180	60	12	1085270,400	301,464
Jul	4,187	31	180	60	13	1098082,620	305,023
Aug	4,187	31	180	60	12	1121446,080	311,513
Sep	4,187	30	180	60	11	1107880,200	307,745
Oct	4,187	31	180	60	10	1168173,000	324,493
Nov	4,187	30	180	60	8	1175709,600	326,586
Dec	4,187	31	180	60	5	1284990,300	356,942
Year	4,187	365	180	60	9,25	**13956275,880**	**3876,746**

Table 5. Demand Sanitary Hot Water.

6.2.2.1. Pre-dimensioning surface catchment and accumulation volume

For the pre-dimensioning of the collector surface must take into account the conditions that expose the CTE (DB HE-4) and the RITE (ITE 10.1.3.2).

According RITE (ITE 10.1.3.2), the total area of the manifolds have a value such that the condition is fulfilled:

$$1,25 \leq 100A/M \leq 2$$

Where:

- ***A***: the sum of the areas of the collectors, expressed in m^2
- **M**: average daily consumption of the summer months, expressed in l/d
- **V**: accumulator tank volume, expressed in liters

In addition, installations whose consumption is constant throughout the year, the volume of the storage tank to satisfy the condition:

$$0,8M \leq V \leq M$$

Moreover, the CTE (HE-4 DB 3.3.3.1) states that for applications with DHW the total area of sensors have a value such that condition is met:

$$50 < V/A < 180$$

Taking into account the above conditions and that the average daily consumption is 180 liters/day, determine the proportions both the collector surface to use as storage volume:

$$V_{mín} = 144,0 \leq V \leq 180,0 = V_{máx}$$

$$A_{mín} = 2,25 \leq A \leq 3,60 = A_{máx}$$

6.2.2.2. Theoretical energy available

For the calculation of the available energy incident on an average day of each month on every square meter inclined surface of the sensors, R, is necessary to go to a table of average horizontal irradiance H of the province considered and correct these values based to inclination.

For the correctness of these values we resort to the following expression:

$$R = K \cdot H$$

Where:

- ***R***: radiation incident on an average day of each month on square meter inclined surface (KJ.día/m2)
- **K**: correction factor depending on the inclination of the collectors and latitude of where the facility is available. For Alcaniz, latitude 41 ° and had a inclination of the collectors of 41 º.
- **H**: average daily radiation incident on a horizontal surface m2 (KJ . día/m2).

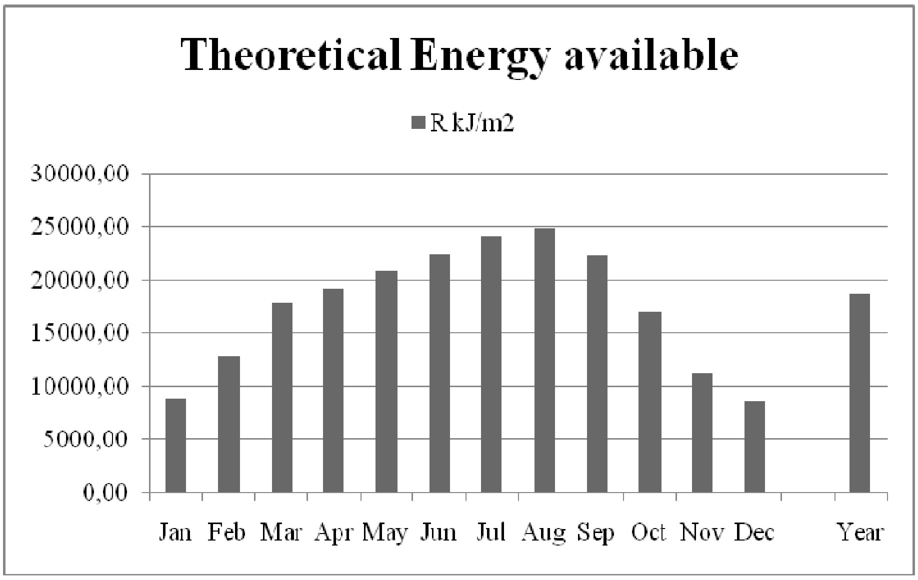
The inclination of the sensors has been chosen as the RITE (ITE 10.1.3.1).

The data used in performing the calculation and shown in the following table were obtained from the tables of the IDEA and JRC.

Month	K	H (kJ/m2)	R (kJ/m2)
Jan	1,42	3870,00	19783,44
Feb	1,30	5100,00	23868,00
Mar	1,14	5760,00	23639,04
Apr	0,99	5840,00	20813,76
May	0,88	6160,00	19514,88
Jun	0,84	7290,00	22044,96
Jul	0,88	8110,00	25692,48
Aug	1,01	6860,00	24942,96
Sep	1,19	6070,00	26003,88
Oct	1,41	4710,00	23907,96
Nov	1,56	3710,00	20835,36
Dec	1,54	3070,00	17020,08
Year	1,18	5410,00	22981,68

Table 6. Theoretical Energy Available.

The following graph shows the variation of the incident radiation on an average day per m^2 of surface in different months of the year.



Picture 4. Theoretical Energy Available.

In the above chart we can see the availability of energy is inverse to the consumption of hot water and heating facilities.

The intensity incident on the surface of the collectors will vary according elapses day. It works, then, with an average intensity that is the ratio of useful energy R incident throughout the day and the time useful day, the time that the sun is above the horizon, discounting the times of beginning and end, when the height of the sun is so low and the intensity is below the threshold.

6.2.2.3. Study of annual solar coverage. F-Chart method

The calculation method used is the of the curves f (F-Chart), which is recommended by the "CTE" (Technical Building Code) and the "Technical Specification for solar thermal low temperature" of IDEA, as it is widely accepted by a sufficiently accurate calculation process for long estimates, as in our case.

The F-Chart system, allows the calculation of the coverage of a solar system, i.e., its contribution to the total heat input required to meet thermal loads and its average performance over a long period of time.

The equation used in the following method is as follows:

$$f = 1{,}029 * D_1 - 0{,}065 * D_2 - 0{,}245 * D_1^2 + 0{,}0018 * D_2^2 + 0{,}0215 * D_1^3$$

D1 parameter expresses the relationship between the energy absorbed by the collector flat and the total heat load heating for a month:

$$D_1 = \frac{\text{energía absorbida por el captador}}{\text{carga calorífica mensual}}$$

The energy absorbed by the collector is given by the expression:

$$E_a = S_c.F_r'(\tau\alpha).R_1.N$$

Where:

- **Sc**: the collector surface (m2).
- **R1**: Monthly average daily radiation incident on the collector surface per unit area (kJ/m2).
- **N**: number of days in the month.
- **Fr**'(τa): dimensionless factor is given by the following expression.

$$F_r'(\tau\alpha) = F_r(\tau\alpha)_n.\left[\frac{\tau\alpha}{(\tau\alpha)_n}\right].\left(\frac{F_r'}{F_r}\right)$$

Where:

- ***Fr***(τa)***n***: optical efficiency factor the collector, ie, the ordinate at the origin of the characteristic curve of the sensor.
- τa/(τa)**n**: changing the angle of incidence. In general it can be taken as constant: 0.96 (simple transparent surface) or 0.94 (double transparent surface).
- **Fr**'/**Fr**: Correction factor gauge-exchanger assembly. We recommend taking the value of 0.95.

D2 parameter expresses the ratio of energy losses in the collector, for a given temperature and heat load of heating for a month:

$$D_2 = \frac{\text{Energía perdida por el captador}}{\text{carga calorífica mensual}}$$

The energy lost by the collector is given by the following expression:

$$E_P = S_c.F_r'U_L(100 - t_a).\Delta t.K_1.K_2$$

$$F_r'U_L = F_rU_L(F_r'/F_r)$$

Where:

- **FrUL**: slope of the characteristic curve the collector (overall loss coefficient the collector).
- **ta**: monthly average ambient temperature (° C).

- **Δt**: considered time period in seconds (s).
- **K1**: storing correction factor, this is obtained from the following equation:

$$K_1 = [\text{Kg de acumulación}/(75S_c)]^{-0,25}$$

$$37,5 < (\text{Kg de acumulación})/(\text{m}^2 \text{ de captador}) < 300$$

- **K2**: correction factor for DHW, which relates the minimum temperature of DHW, the water network and the monthly average temperature, given by the following expression:

$$K_2 = 11,6 + 1,18t_{ac} + 3,86t_r - 2,32\, t_a/(100 - t_a)$$

Where:

- **ta**c: minimum temperature of DHW.
- **tr**: network water temperature.
- **ta**: monthly average temperature of the environment.

Once obtained D1 and D2, applying the initial equation calculates the fraction of the monthly heating load supplied by the solar system.

$$f = 1,029 * D_1 - 0,065 * D_2 - 0,245 * D_1^2 + 0,0018 * D_2^2 + 0,0215 * D_1^3$$

In this way the useful energy captured each month, Qu, has the value:

$$Q_u = f. Q_a$$

Where:

- **Qa**: DHW monthly heating load.

By the same procedure as that process developed for a month, it will operate for every month of the year. The relationship between the sum of the coverage and the amount of monthly heat loads, heat or monthly needs, annual determine coverage of the system:

$$\text{Covertura solar anual} = \sum_{u=1}^{n=12} Q_u \text{ necesaria} \Big/ \sum_{u=1}^{u=12} Q_a \text{ necesaria}$$

With the calculated data and following the calculation process detailed in the calculation bases will get the fraction of the monthly heating load supplied by the solar system.

6.2.2.4. Resume tables

Calculation of the D1 parameter.

MONTH	Area Collec	Fr (ta)n	Fr´(ta)	R1	Ea	D1
	(m2)			(kJ/m2)	(kJ)	
Jan	2,50	0,769	0,701	19783,44	1075287,73	0,837
Feb	2,50	0,769	0,701	23868,00	1171750,77	1,028
Mar	2,50	0,769	0,701	23639,04	1284850,85	1,058
Apr	2,50	0,769	0,701	20813,76	1094795,45	0,968
May	2,50	0,769	0,701	19514,88	1060690,71	0,927
Jun	2,50	0,769	0,701	22044,96	1159556,08	1,068
Jul	2,50	0,769	0,701	25692,48	1396461,31	1,272
Aug	2,50	0,769	0,701	24942,96	1355722,71	1,209
Sep	2,50	0,769	0,701	26003,88	1367793,69	1,235
Oct	2,50	0,769	0,701	23907,96	1299467,44	1,112
Nov	2,50	0,769	0,701	20835,36	1095931,60	0,932
Dec	2,50	0,769	0,701	17020,08	925091,05	0,720
Year	2,50	0,769	0,701	22981,68	14707397,30	1,054

Table 7. D1 Parameter

Calculation of the D2 parameter

MONTH	Fr U_L	Fr´U_L	Ta	Dt	Accum. Vol.	K1	K2	Ep	D2
	(W/m2 ºC)	(kW/m2 ºC)	ºC	(h radiation /day)	(l/m2)			(kJ)	
Jan	3,957	0,00376	8,8	8	160	1,040	0,891	709592,857	0,552
Feb	3,957	0,00376	10,3	9	160	1,040	0,910	724408,732	0,636
Mar	3,957	0,00376	13,7	9	160	1,040	0,944	800374,021	0,659
Apr	3,957	0,00376	15,7	9,5	160	1,040	1,003	848485,625	0,751
May	3,957	0,00376	19,4	9,5	160	1,040	0,991	827796,498	0,723
Jun	3,957	0,00376	24,1	9,5	160	1,040	0,959	730426,378	0,673
Jul	3,957	0,00376	26,2	9,5	160	1,040	0,973	744282,890	0,678
Aug	3,957	0,00376	26,2	9,5	160	1,040	0,921	704267,681	0,628
Sep	3,957	0,00376	22,6	9	160	1,040	0,936	688371,283	0,621
Oct	3,957	0,00376	18,8	9	160	1,040	0,953	759989,978	0,651
Nov	3,957	0,00376	12,6	8	160	1,040	0,962	710053,565	0,604
Dec	3,957	0,00376	8,7	7,5	160	1,040	0,893	667142,035	0,519
Year	3,957	0,00376	17,3	107,0	160	1,040	0,943	107189215,808	7,680

Table 8. D2 Parameter

Calculation of the Solar Coverage.

MONTH	f Chart	Q useful	Solar Coverage
Jan	0,667	856788,801	0,667
Feb	0,782	890915,942	0,782
Mar	0,798	969020,077	0,798
Apr	0,738	834858,565	0,738
May	0,714	817523,602	0,714
Jun	0,803	871513,566	0,803
Jul	0,913	1002945,929	0,913
Aug	0,884	991115,302	0,884
Sep	0,898	994582,290	0,898
Oct	0,830	969062,275	0,830
Nov	0,725	852521,460	0,725
Dec	0,589	756318,263	0,589
Year	0,444	6202386,101	**0,774**

Table 9. Solar Coverage

6.2.3. Collection system

After checking all specifications, qualities and suitability to our system, we selected the collector, model TERMOCAN 2.6A, TEICAN company. The technical characteristics of this sensor are in TECHNICAL SHEET.

Collector performance curve: $\boldsymbol{\mu} = 0{,}769 - 3{,}957\ (\boldsymbol{Te} - \boldsymbol{Ta})/\boldsymbol{I}$

6.2.3.1. Dimensioning of the catchment surface

Taking as a starting point for the dimensioned SHW system, knowing the sum of the demands of the system, and known also the unit area of collector selected we can get the number of collectors to be installed and total area of our installation.

Total catchment area:

$$A_{\text{Captación}} = \text{N}^{\text{o}}_{\text{Captadores}} \text{ x } A_{\text{Captador}} = 1 \text{ x } 2,\ 50 = 2,\ 50 \text{ m}^2$$

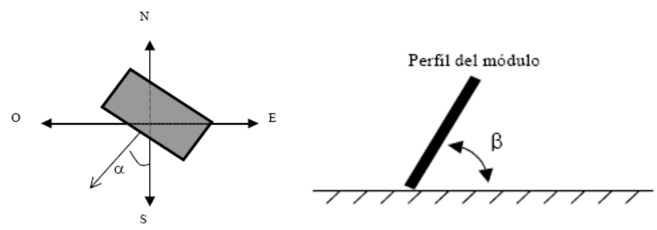
6.2.3.2. Inclination and orientation of collectors

Determine the limits of orientation and inclination of the modules according to the maximum admissible losses.

The losses for this item will be calculated according to:

– Angle of inclination β defined as the angle between the surfaces of the modules with the horizontal plane. It´s value is 51º.

– Azimuth angle, defined as the angle α between the projection onto the horizontal flat normal to the surface of the module and the meridian of the place. Its value is 30º.



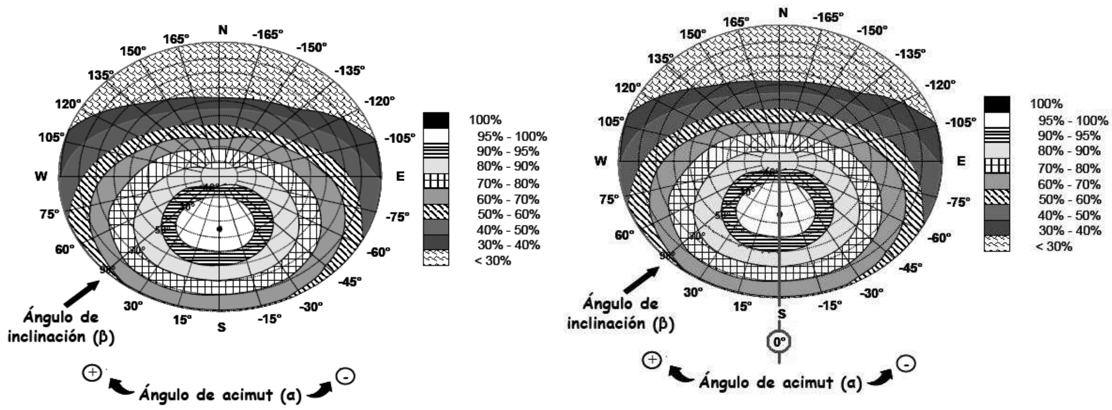
Picture 5. Orientation of collectors.

The maximum admissible loss in our case according to the CTE DB HE-4 is 10% (general case) by not having problems of proximity with buildings that we could cast a shadow on our collectors.

Case	Orientation & inclination	Shadow	Total
General	10%	10%	15%
Superposition	20%	15%	30%
Architectural Integration	40%	20%	50%

Table 10. Losses on shadows

Using the graph below we will determine the maximum and minimum inclination of our panels for the case of latitude 41 °. The intersection points of the loss limit of 10%, the edge of the region of 90% - 95%, the highest in our case and the azimuth line, we provide these values.



Picture 6. Losses on orientation.

For our azimuth α = 30 °, for the latitude of 41 °:

- Maximum Inclination: 60 º
- Minimum Inclination: 0 °

We correct for the latitude of the location:

Maximum Inclination = Inclination Max. (Latitude 41 °) - (41 º - Latitude)

$$\text{Maximum Inclination} = 60^{o} - (41^{o} - 37^{o}) = 56^{o}$$

Minimum Inclination = Inclination minimum (Latitude 41 °) - (41 °- Latitude) ≥ 5

$$\text{Minimum Inclination} = 7^{o} - (41^{o} - 37^{o}) = 3^{o} < 5^{o} = 5^{o}$$

Therefore, the inclination that we obtain must be between these two values to comply the requirements of orientation and inclination losses. RITE ITE 10.1.3.1 advises the following:

Type of Demand	Inclination
Annual Steady Demand	Geographic Latitude
Winter preferential demand	Latitude + 10º
Summer preferential demand	Latitude - 10º

Table 11. Recommended values of inclination by the RITE.

We will adopt a inclination of the modules of 45 °, as it is very close to the latitude and studied various factors we considered 45 º as the most suitable for our installation as irradiation better advantage in winter months.

$$\text{Pérdidas}(\%) = 100.\left(1{,}2.\,10^{-4}.\left(\beta - \beta_{opt}\right)^2 + 3{,}5.\,10^{-5}\alpha^2\right)$$

$$\text{Losses } (\%) = 100 \times (1{,}2 \times 10^{-4} \times (45-37)^2 + 3{,}5 \times 10^{-5} \times 30^2) = 3{,}918\ \%$$

Finally, we adopt the following orientations:

- Maximum Inclination: β = 45º
- Azimuth angle: α = 30º

6.2.4. Exchange System

6.2.4.1. Determining exchangers

Due to the large exchange of energy we have to make between the primary circuit or system sensors and DHW accumulation, will be used plate heat exchangers external to the storage systems as these provide higher performance us in the exchange, as well as higher efficiency. Besides for these systems, and the working fluid, the heat exchangers are most suitable due to its low cost and reduced space necessary for installation.

The minimum power of plate heat exchanger design will function of the collector area A (m2).

$$P\ (W) \geq 500 \times A\ (m^2)$$

6.2.4.2. Choosing Exchangers

The minimum power of the plate heat exchangers should be:

$$P_{mín.} = 500 \times 2{,}5 = 1250\ W$$

The maximum flow that will flow through the primary circuit of the exchanger will be:

$$Q_{máx.} = 2{,}5\ m^2 \times 46{,}8\ l/hm^2 = 117\ l/h$$

6.3. CLIMATIZATION, HEATING AND AIR-CONDITIONER

6.3.1. Classification of Areas

For estimation of energy demand classify living spaces depending on the amount of heat dissipated inside, due to the activity carried out and the period of use of each area, in low or high. Because the housing conditions of use is classified as low internal load.

The housing has 2 floors plus terrace and a basement dedicated to storage. Surface decomposition is:

	USEFULL	BUILT		USEFULL	BUILT
Down Floor			First Floor		
Living-Room	21,56		Main Room	16,16	
Dining-Room	12,69		Wardrobe	5,02	
Kitchen	11,87		Bath MainRoom	5,47	
Toilette	2,08		Room 1	14,55	
Visitor Room	5,42		Room 2	14,55	
Visitor Bath	1,91		Main Bath	4,98	
Laundry	6,16		Studio	6,55	
Stairs	2,12		Hall	14,18	
Entry - Hall	24,49		Living-Room	11,36	
	88,30	101,88		92,82	122,29

Table 12. Decomposition de superficies

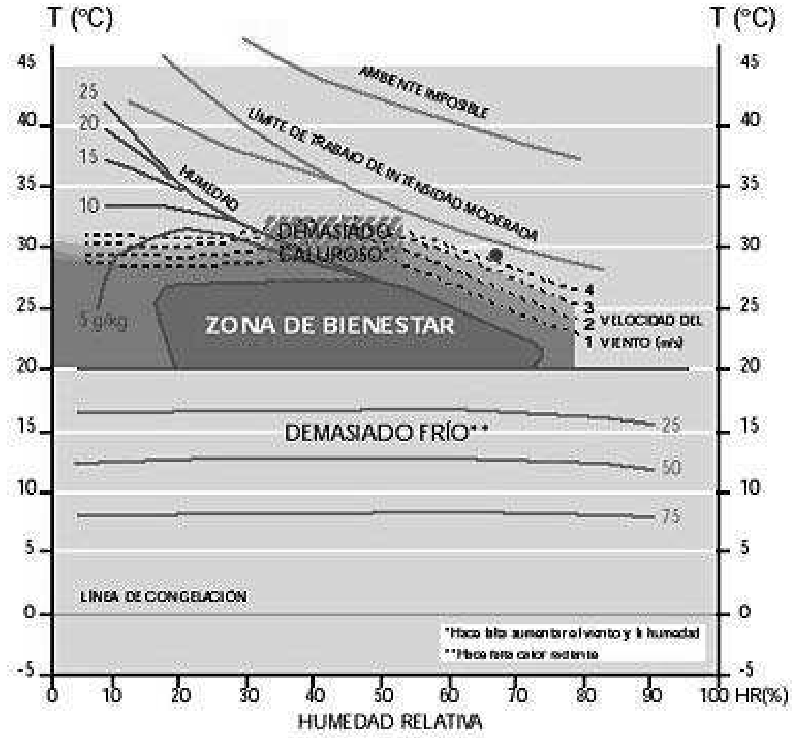
The total area to be conditioned is 125 m2 distributed in 2 floors dedicated to housing.

6.3.2. Comfort Point

The climate comfort or welfare depends on environmental and personal factors. The ISO 7730 defines it as "that condition of the human mind which expresses satisfaction with the thermal environment".

There must be a balance between the heat produced and lost by the body, which depends on many factors: temperature, pressure, wind, humidity, activity and clothing.

Environmental factors are the flow of air (wind), the temperature and humidity of air and radiation (solar or next hot objects). Combinations of the above parameters may not result in environmental stress on the human body are known as climatic comfort.



Picture 7. Comfort area or welfare (Olgyay´s model).

The objective is to get a good air healthy environmental condition that in addition does not involve unnecessary energy expenditure.

The internal conditions of comfort that will adopt which are recommended by the RITE.

Parámetros	Límite
Temperatura operativa en verano (°C)	$23 \leq T \leq 25$
Humedad relativa en verano (%)	$45 \leq HR \leq 60$
Temperatura operativa en invierno (°C)	$21 \leq T \leq 23$
Humedad relativa en invierno (%)	$40 \leq HR \leq 50$
Velocidad media admisible con difusión por mezcla (m/s)	$V \leq 0.14$

Table 13. Demand for environmental quality. 1.1.4.1 IT RITE

6.3.3. Energy Needs

The complete list of materials used, along with fiches justifying the limitation of the energy demand, basic requirement of CTE HE1, where you can see both the surfaces of the walls, floors, roofs and holes as their heat transfer coefficients are not done in this project, thus an estimate is made demand with standard values referred to a house of 180 m2.

6.3.3.1 Cooling needs

The estimation of required cooling loads in our housing is based on the heat gain of a room depends on the following parameters:

- Size of area to be cooled.
- Size and position of windows, and whether they are in the shade.
- Number of occupants.
- Heat generated by the equipment and machinery.
- Heat generated by lighting.

The installation is pre-dimensioned with appropriate factors external to different maximum temperatures between 32 and 43 ° C.

Consulting absolute maximum temperatures in the months of July and August recorded in the area over the past 25 years, we take as reference the average, which corresponds to 34 ° C, a temperature often exceeds in the month of July.

We estimate the power required to cool the house should be 7.5 kW.

6.3.3.2. Heating needs

It takes into account the parameters for surface area, volume, windows and walls exposed, people and electrical components that may affect the environment.

The method of operation is identical to the calculation of cooling.

Also estimated the demand needed for a heating power of 9 kW.

6.3.3.3. Zonification

The heat loads change throughout the day due to solar movement.

In housing, the four outer walls are oriented almost in the four cardinal points. This leads us to use this situation to zone the entire building into two or four separate networks, since it can take that at certain times of year is needed to cool a building area while another must be heated to bring the environments to desired conditions.

6.3.4. Calculation of the Installation

6.3.4.1 Buried pipe network

The buried pipe network contains antifreeze that is driven by the pump. The collector piping is cross linked polyethylene coated (PER), and implanted by drilling.

Is use the install closed loop vertical where the fluid is continuously circulated in a closed loop, without any contact with the soil surrounding the system.

For proper system operation, the fluid flowing through the closed loop must have a frost protection when the temperature drops below 4 ° C to leave the field and enter the building.

For the arrangement of the sensors in closed loop vertical calculation is made for disposition, with the arrangement of wells drilled and the spacing between them. The length of the sensors, and therefore vertical drilling to do, depends on two factors, the power required for cooling and the thermal conductivity of the ground.

Our geothermal collection system is sized to ensure 100% of the heating and cooling demand for housing.

The sensor power demanded for geothermal are 9 kW 7.5 kW heating and cooling. For calculating the length of the exchanger, will make the necessary calculations using the heating power of 9 kW.

$$L_{Sondas}[m] = \frac{P_{evaporador[W]}}{P_{específica\_de\_extracción[W/m]}}$$

To determine the type of terrain in the area of our house consult the geological survey done before the start of the project. Which indicate that the field is composed of gravel and sand wet, due to the proximity of the river.

$$L_{Probes} = 9000 \text{ W} / 65 \text{ W/m} = 138{,}46 \text{ m}$$

The necessary depth of the well and therefore the length of the exchangers is 140 linear meters. To reduce the distance can introduce, one U-tube in the well so that twice the length increase uptake and therefore can reduce the depth of the well to 70 m, half.

The wells have a diameter of between 150 - 200 mm. Before its implementation must ensure that there are no underground gas pipes, water, or any type of driving.

The holes site should be clearly reflected in a plane once installation is complete if necessary in the future to make any repair or maintenance work, in their own sensors or in the surrounding area to locate your position easily.

The recommended spacing between wells is 10 meters, to avoid coming into contact land areas affected either sensor. The minimum separation with respect to the building is 2 meters.

Is placed in total 140 m linear probe, placed in a well of 70 m depth. Geothermal probe will double U-type PE with a diameter of 32 mm (DN 32).

The fluid used in the circuit will geothermal water antifreeze solution in proportion of 15% (ethylene or propylene) to prevent freezing.

7. DRAWINGS

The documentation of drawings is in the correspondent document, DOC_02 DRAWINGS. In this document you can be found the documentation of: plants distribution, sections and construction details of the installation.

8. CONCLUSION

Exposed the purpose and usefulness of this project, we hope that it deserves the approval of the Administration, giving us the necessary approvals for processing and commissioning.

Budapest, June 2013
The Student of Electrical Engineering

Signed: Enrique Esteve Martínez
ID code: IF1VX7

ELECTRICAL INSTALLATION DESCRIPTION

1. PROJECT BACKGROUND AND PURPOSE.

The purpose of this project is to carry out the works necessary for the electrical and photovoltaic installations in a detached house in Alcaniz.

Regarding the PV system, we will calculate the energy demand needed daily in the home, since the mission of the solar photovoltaic installation will not be supply housing, but producing enough electricity to at least equate electricity costs, ie produce the same amount or more energy than needed for regular housing expenses.

Thus, on the one hand get back to the grid at least the same amount of electricity that we consume and that has created a clean renewable energy without harming the environment, and moreover financial gain.

So here our purpose is to design a solar photovoltaic installation occupying the maximum possible total area of the housing cover.

We should bear in mind that there are currently installed, and running, a solar heating panel on the roof, that supply hot water to the house.

Therefore shadows should be avoided cause or any other modification that alters its operation once our photovoltaic plant.

For the calculation of the solar photovoltaic take as a starting point, along with the geographical location and orientation of the house, cover the area available that we can use without causing nuisance to other elements or existing facilities.

2. PROJECT FEATURES

2.1. POWER FORECAST

Calculation on the basis of the electric power demand required to meet current needs and future expansion.

Installation has been divided according to the services to install, motive power and lighting:

Motive	C2	C3	C4	C5	C7	C8	C9	C11	C12	C15	C16
(W)	2850	5400	3500	3200	2100	2400	2500	2300	1380	690	345
Lighting		C1	C6	C13	C14						
(W)		1160	900	160	660						

Motive	26.665 W
Lighting	2.880 W
Total Installation	29.545 W

It is considered a simultaneity factor of 70% which will have a capacity of 29,545 W x 0.70 = 20,681 '5 W., contracting with the utility is 9,200 W of power.

2.2. PHOTOVOLTAIC SYSTEM

Connecting the output of the inverter to the grid, we injected that power to be consumed for anyone who demands at the time, becoming power producers and gaining economic benefits. To do this we place a counter before the connection to the network and bill the energy produced to corresponding electrical company.

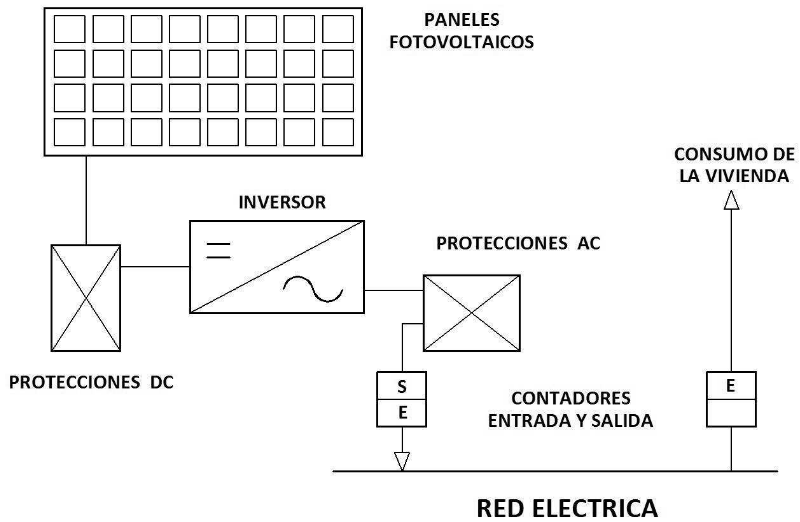


Figure 9. Diagram of grid connected photovoltaic system.

The photovoltaic system consists of solar panels, its support structure, inverter grid connection, and is complete with wiring and protections.

2.2.1. Photovoltaic panels.

The first characteristic of a panel or photovoltaic module is its peak power or rated power, which is the maximum amount of power that could get the panel in almost perfect condition radiation and temperature are not normally get to give. So called "peak", because in practice a maximum level. The peak power is given by the efficiency of the cells and the number of them, ie the size of the module.

Other important parameters are the panel losses temperature coefficients, which indicate the degree of loss of performance of the panel according warms. Heat is the higher enemy in photovoltaic generation.

2.2.2. Inverter Network

The inverter is the centerpiece of photovoltaic generation. In fact, his power is the power that marks the complete installation. Its mission is to transform the continuous current generated in photovoltaic field to alternate current ready to be consumed.

The inverter also incorporates a number of protections for both solar system and the grid, which are obligatory in Spanish legislation.

As all energy passes through the inverter, it is common cards also incorporate elements of communications or information on the status of the installation of energy generated or generate alarms in case of damage or malfunction.

2.2.3. Security and Wiring

The facility is complete with protection, wiring, grounding and accountants.

It installs an electrical panel in which are located the protections and switches required and the energy meter. In addition the installation must have its own ground.

The wiring runs must meet the low-voltage electrotechnical regulations in both sections, the DC from the field to the inverter, and AC from the inverter to the grid.

3. OBJETIVE OF PROJECT

Below are set out in summary the objectives posed in the realization of this project.

- Study and know the solar photovoltaic system, applied to the production of electricity.
- Size and calculate the necessary elements for the implementation of the above systems in single-family housing.
- Evaluate economically facilities to perform.

Its main applications are:

- Electrification: water pump systems, tv and telephone repeaters, etc..
- Electrification of isolated buildings: for lighting, small appliances, small and not intended for heating consumption.

4. APPLICABLE RULES.

- Reglamento Electrotécnico para Baja Tensión e Instrucciones Técnicas Complementarias (Real Decreto 842/2002 de 2 de Agosto de 2002).
- NBE CPI-96 de Protección contra Incendios en los Edificios.
- Ley 31/1995, de 8 de noviembre, de Prevención de Riesgos Laborales.
- Real Decreto 1627/1997 de 24 de octubre de 1.997, sobre Disposiciones mínimas de seguridad y salud en las obras.
- Real Decreto 436/2004 sobre la producción de energía eléctrica mediante energías renovables.
- Real Decreto 1663/2000 del 29 de Septiembre sobre la conexión de la instalación fotovoltaica a la red de baja Tensión.
- Real Decreto 3490/2000 de 20 de Septiembre sobre los derechos de verificación de la compañía eléctrica.

5. PROJECT DESCRIPTION

5.1. MAIN LINE

Is part of the distribution network installation, which feeds the general protection box (BGP). This line is regulated by the ITC-BT-11.

According to the installation system and the characteristics of the network, the connection will be: Underground. The copper wires will be isolated, rated voltage 0.6 / 1 kV, and can be installed directly buried, buried pipe.

Finally, note that the connection will be part of the installation consists of the Supplier Company therefore its design should be based on the particular rules of it.

5.2. LINK LINE

5.2.1. General Protection Box and Line Splitter

Its situation will be fixed by agreement between the subscriber and the energy supplier in an easily and free access. Will be of insulating material. Inside the box is installed with cartridges calibrated thermal fuses in each of the three phases of High Power Breaking and shall be sealable by avoidance of possible frauds, settling a Protection General Box of 63 A. with c.f.c. 63 A.

Reading devices measuring equipment must be located at a height of between 0.70 and 1.80 m.

In the niche, will be left the holes provided for used to accommodate the inlet ducts of the connection.

The boxes measure to use protection and correspond to one of the types listed in the technical specifications of the supplier that have been approved by the competent public authority, depending on the number and nature of the supply.

The envelope must have internal ventilation necessary to ensure no condensation formation. The transparent material for the reading will be resistant to the action of ultraviolet rays.

The general provisions of this type of case are set out in the ITC-BT-13.

5.2.2 Distribution Line

It is the part of the installation that starts from the protection and metering box, supplies electricity to a user installation. Includes safety fuses, all measuring and control devices and general protection. Is regulated by the ITC-BT-15.

Copper wires will XLPE 0.6 / 1 KV, fire retardant and non-smoke emission and opacity reduced, according to the UNE 21.123, part 4 or 5, 4 x 25 mm ² + TT and 1.5 mm ² for control wire, bind the enclosure and measuring equipment.

The maximum allowable voltage drop will be, in the case of supplies for a single user that there is no general line of food, of 1.5%.

5.2.3. Measuring Box

Be installed within double insulated modules at the entrance of the plot with the following devices:

- 2 Units. Counter III, 3 active threads, 3x10 (30) A. Be installed on the wall at a height of between 0.50 and 1.80 m.
- The cables shall be fire retardant with non-smoke emission and reduced opacity.

5.2.4. Protection Box.

General devices control and protection shall be located as close to the point of entry of the individual branch.

Individual devices control and protection of each of the circuits, which are the source of the interior installation, may be installed in separate boxes.

The installer will set permanently on a plaque switchboard, indelibly printed, stating his name or trademark, date of installation was performed and the rated automatic switch.

If the type or nature of the facility was installed a differential switch for each circuit or group of circuits, one could dispense with the general differential switch, provided that all circuits are protected. In the case of installing more than one circuit breaker in series, there will be a selectivity between them.

All masses of electrical equipment protected by the same protective device must be interconnected and linked by a protective conductor to the same outlet.

Omnipolar cutting devices intended for overload and short circuit protection of each of the internal circuits (according to ITC-BT-22).

Overvoltage protection device, according to ITC-BT-23, if is necessary.

C.G.D. be installed inside the house, in the entry area inside a closet with double insulation, at a height of at least one meter, the envelope shall conform to the standards UNE 20451 and UNE-EN 60439-3 and a degree of protection IP-30, and shall consist of:

Overcurrent protection:

- 1 Magneto-thermal switch IV de 32A. (I.G.A.)
- 3 Magneto-thermal switches IV de 16A. (I.G.A.)

- 5 Magneto-thermal switches II de 10A.
- 8 Magneto-thermal switches II de 16A.
- 1 Magneto-thermal switch II de 25A.
- 1 Magneto-thermal switch II de 20A.

Overvoltage protection

- 1 Differential switch IV de 40 A. 30 mA.
- 3 Differentials switches IV de 25 A. 30 mA.

5.3. INDOOR INSTALLATION

5.3.1. Cables.

The value of the voltage drop may be offset between the interior installation (3-5%) and of the individual branch (1.5%), so that the total voltage drop is less than the sum of the values limits specified for both (4.5-6.5%).

In interior installations, to take into account the harmonic currents caused by nonlinear loads and possible imbalances, unless justified by calculation, the section of the neutral conductor shall be at least equal to that of the phases. No one neutral conductor used for various circuits.

The current-carrying capacities shall be governed entirely by the indicated in the UNE 20.460-5-523 and its National Annex.

Protection cables have a section equal to the section of the phase conductor.

The copper cables will be below rated voltage 450/750 V and Ra ≥ 0.5 MΩ, and shall be under the protection of flexible plastic tubing degree of protection 7. The cables shall be fire retardant with non-smoke emission and reduced opacity.

5.3.2. Protection Tubes

Various circuits may be in the same tube or in the same compartment channel if all conductors are insulated higher rated voltage.

If electric conduits proximity to other non-electric, it shall be so arranged between the outer surfaces of both to maintain a minimum distance of 3 cm.

The electrical circuits shall not be located below other channellings that could lead to condensation, such as those for steam conduction, water, gas, etc..

Rigid plastic tubes will degree of protection 7 stapled recessed wall and ceilings.

5.3.2.1. Insulated conductors under protective tubes

The minimum outside diameter of the tubes is obtained from the tables shown in the ITC-BT-21.

For the execution of the pipelines under protective tubes are taken into account the following general requirements:

– The layout of the pipelines will follow horizontal or vertical lines parallel to the edges of the walls that limit the location where you are installing.

– Records may be intended solely to facilitate insertion and removal of tubes or cables serve both as junction boxes.

5.3.3. Overcurrent and Overload Protection in Small Receivers.

In the installation source and close to the feeding point to the same, is placed the general control and protection, which have overcurrent protection devices of each of the circuits that are based on said box.

The overcurrent protection for all conductors (phase and neutral) of each circuit is done with automatic circuit breakers or Omnipolar cutting, curved cutting thermal overload protection and electromagnetic cutting system for short circuit protection.

5.3.4. Lighting.

The circuits feeding discharge lamps or tubes will be expected to carry the load due to the receptors themselves, to their associated elements and their harmonic currents. The minimum load under volt-amperes shall be 1.8 times the wattage of the receivers. The neutral wire have the same section as the phase. The unipolar switches will cut 10 A.

The luminaries shall conform to the requirements of standards UNE-EN 60598 series. The mass of suspended luminaries’ exceptionally flexible cables should not exceed 5 kg.

Accessible metal parts of luminaries than Class II or Class III shall have a connector for grounding, which will be connected reliably and permanent conductor of the circuit.

In the case of receptors with discharge lamps is mandatory power factor compensation to a minimum value of 0.9.

5.4. GROUNDING.

It nailed the required number with pikes copper coated steel 2 m. in length, so as to obtain an earth resistance of less than 24 / 0.21 = 114 ohms, since the sensitivity of the differential switch is

0.21 A. The conductor will be easily identifiable (green yellow). The section of the buried conductor to the electrical box is 35 mm ² minimum.

The ground resistivity is 300 Ω/m.

The electrode on the grounding of the building, you can be with the following elements:

- M. bare Copper conductor 35 mm² 30 m.
- Vertical coated steel Copper Pikes 14 mm 8 pikes of 2m.

With it you will get a ground resistance of 20 ohms.

The protective conductors were calculated properly and according to ITC-BT-18, in the section of circuit calculation.

Also worth noting that the main ground line is not less than 16 mm ² Cu, and liaison with land line, not less than 25 mm ² Cu.

5.5. PHOTOVOLTAIC INSTALLATION

5.5.1. Dimensioning

For the dimensioning of the PV we used a spreadsheet, which from the introduction of some previous data performs the relevant calculations and offers the results with significant data facility designed with regard to production in each one of the months of the year.

The spreadsheet has been done following all recommendations of the Technical Specification for installations connected to the grid published by the Institute for Diversification and Saving of Energy (AIDAE) and mandatory regulation of energy saving Document for HE Technical Code.

The first check to make would be if our installation must comply with the provisions of the HE-5 Contribution Minimum PV Electrical Technical Building Code (CTE), which requires minimum requirements regarding electrical installation and power electrical inverter.

Our being a detached building is not within the scope of the standard. With which do not have to meet minimum requirements.

Below we will explain the process of data entry required by the application and the results obtained.

5.5.2. Integration Into the Building

It was originally planned placement of solar modules arranged in parallel rows on the deck, however it may occur shaded rows between them depending on the sun's position and the position and distance between them.

For this reason it is necessary to check the calculations of minimum distances between rows, depending on the inclination and orientation of the modules.

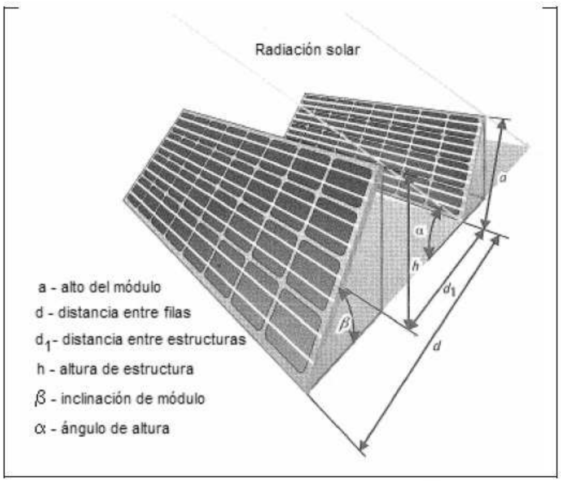


Figure 34. Minimum distances between modules.

6. JUSTIFICATORY CALCULATION

6.1. LOCATION AND CLIMATOLOGIC DETAILS

The building is located in Alcañiz, province Teruel, locality with the following geographic and climatological data:

- Height: 323 m
- Latitude: 41 º 1'46" N
- Long: 0 ° 8'37" W
- Historical minimum temperature: -11 ° C
- Annual average temperature during sunlight hours: 16.8 ° C
- Average relative humidity: 40%
- Average number of days of fog: 28 days
- Average number of clear days: 80 days
- Average number of sunshine hours: 2614 hours

For the design of the system it has been taken into account other weather data such as data of ambient temperature and also data of solar radiation, typical of the climatic zone of the Alcañiz city.

These data have been obtained from various sources: CENSOLAR (Center for Solar Energy Studies), AEMET (Meteorological Agency) and JRC (Joint Research Center).

The weather data can be found in TECHNICAL SHEET.

6.2. CALCULATION OF RADIATION EXPECTED

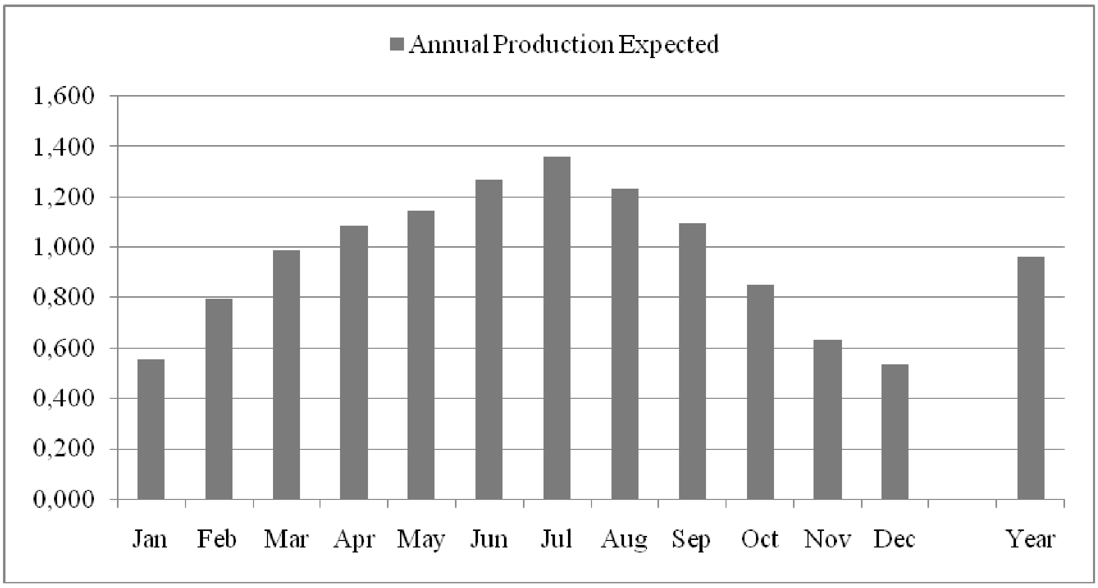
In our case we choose the general case we limit both the orientation and tilt losses as losses by 10% shade, and the combination between them is not greater than 15%.

Our installation will place the direction of the principal axes housing. The inclination of the modules will be 38 °, a value very close to that which we recommend applying calculation.

The azimuth angle of our system is 0 °. Thus the orientation and tilt losses are within the limits that indicates the CTE (10%).

	Annual Production Expected						
MONTH	G_{dm}	*N*	G_{CEM}	G_{dm} *(a=0º, B=38º)*	*PR*	P_{mp}	E_p
	(kWh/m2 day)		*(kW/m2)*	*(kWh/m2 day)*		*(kW)*	*(kWh/ day)*
Jan	3,54	31	1	4,14	0,764	0,176	0,557
Feb	4,8	28	1	5,93	0,764	0,176	0,797
Mar	5,68	31	1	7,35	0,764	0,176	0,988
Apr	6	30	1	8,09	0,764	0,176	1,088
May	6,17	31	1	8,54	0,764	0,176	1,148
Jun	6,63	30	1	9,45	0,764	0,176	1,271
Jul	7,04	31	1	10,1	0,764	0,176	1,358
Aug	6,69	31	1	9,17	0,764	0,176	1,233
Sep	6,19	30	1	8,13	0,764	0,176	1,093
Oct	5,09	31	1	6,34	0,764	0,176	0,853
Nov	3,94	30	1	4,69	0,764	0,176	0,631
Dec	3,44	31	1	3,99	0,764	0,176	0,537
Year	5,44	365	1	7,16	0,764	0,176	0,963

Table XX. Annual Production Expected



Picture XX. Annual Production Expected

6.3. DATA RELATING TO THE SYSTEM

In this section we will select the solar module.

Select one that is established, model C 175M CONERGY brand, and we are all its technical characteristics.

Solar Panel	CONERGY C 175M		
Nominal power	PMax	Wp	176
Tolerance	Tol	%	5
Nominal voltage at the maximum power point	VMPP	V	35,4
Maximum open circuit voltage	VOC	V	44,4
Nominal current at the maximum power point	IMPP	A	5,4
Short circuit current	ISC	A	5,4
Tonc	TONC	ºC	45

Table 13. Technical characteristics of the solar module.

The next item to be selected, it would be the current inverter., and as we have done with the modules, select an already predetermined.

Inversor	SUNWAYS NT 3000		
Nominal power	P_{NOM}	W	3000
Maximun CC power in solar field	P_{ccMAX}	W	3150
Minimun CC power in solar field	P_{ccMIN}	W	2300
Maximun CC voltage in operation in solar field	V_{ccMAX}	V	900
Minimun CC voltage in operation in solar field	V_{ccMIN}	V	340
Connexion CC voltage in solar field	V_{CONCC}	V	410
Disconnexion CC voltage in solar field	$V_{DESCONCC}$	V	340
Maximum CC open circuit voltage	V_{ocMAX}	V	750
Maximun CC current in operation	I_{ccMAX}	A	9.3
Maximun Performance	U_{MAX}	%	97.8

Table 14. Specifications of electric inverter.

Once we have chosen the photovoltaic module and inverter need to be determined:

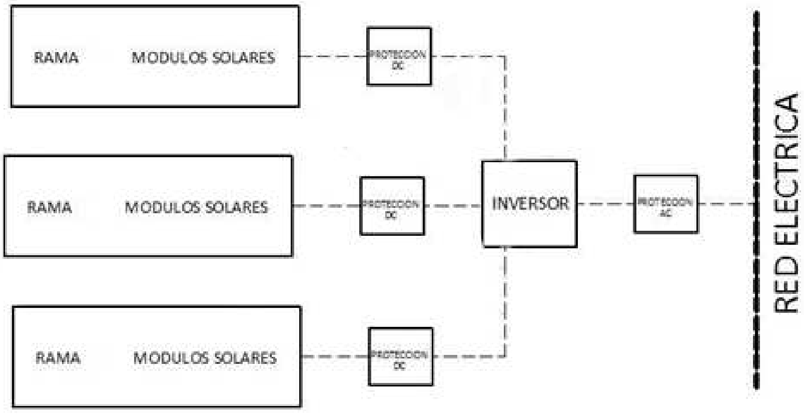
- The number of modules to form each branch photovoltaics.
- The number of parallel branches that can be connected to each investor.

We can make a short summary of how it has been made our PV system.

– 3 branches consist of 6 photovoltaic modules model of CONERGY 175M, with a nominal power of 175 W per module.

– An investor model NT3000 SUNWAYS brand, you can receive a maximum power of 3150 W.

– The total installed power of 3150 Wp.



-

Figure 33. Diagram of the PV system.

To calculate the required values of distance between the rows of modules will use the following formulas:

$$h= a.\ sen\ (\beta) \qquad h= 0.826.\ sen\ (38°) = 0.508\ m$$

The According to the specifications and technical conditions Connected to Network Facilities "distance d, the horizontal average, between rows of modules obstacle height h, which can produce shadows on the installation must ensure a minimum of 4 hours of sunshine around at noon on the winter solstice "

This distance d will be higher than the value obtained by the expression:

$$d_1 = \frac{h}{\tan(61° - \text{Latitude})} \qquad d_1 = \frac{0.508}{\tan(61° - 41°)} = 1.395$$

Thus the arrangement in rows serious modules as follows:

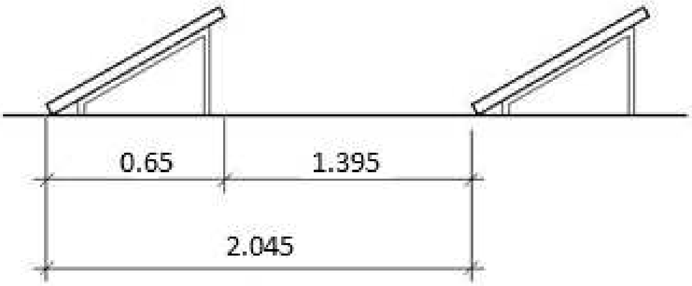


Figure 35. Installation diagram modules in rows.

6.4. CUADRO GENERAL DE MANDO Y PROTECCION

6.4.1. Demanda de Potencias

A continuación vamos a exponer y detallar la demanda de potencias de fuerza motriz y de alumbrado.

POWER DEMAND	
C1	1160 W
C2	2850 W
C3	5400 W
C4	3500 W
C5	3200 W
C6	900 W
C7	2100 W
C12	1380 W
C9	2500 W
C8	2400 W
C11	2300 W
C13	160 W
C14	660 W
C15	690 W
C16	345 W
TOTAL....	29545 W

1.1. Cálculo de la ACOMETIDA

- Potencia a instalar: 29545 W. (Según ITC-BT-44): 35911 W. (Coef. de Simult.: 1)
- Tensión de servicio: 400 V.
- Longitud: 5 m; Cos j: 0.8; Xu(mW/m): 0;
- Canalización: Enterrados Bajo Tubo (R.Subt)

I = 29545 / 1,732 x 400 x 0.8 = 53.3 A.
Se eligen conductores Unipolares **4x25mm²Al XLPE, 0.6/1 kV**
I.ad. a 25°C (Fc=0.8) 84 A. según ITC-BT-07
D. tubo: 63mm.

Caída de tensión: Temperatura cable (ºC): 70.32

e (parcial) = 5 x 29545 / 28.67 x 400 x 25 = 0.515 V. = 0.12 %
e (total) = 0.12% ADMIS (2% MAX.)

1.2. Cálculo de la LINEA GENERAL DE ALIMENTACION

- Potencia a instalar: 29545 W. (Según ITC-BT-44): 35911 W. (Coef. de Simult.: 1)
- Tensión de servicio: 400 V.
- Longitud: 5 m; Cos j: 0.8; Xu(mW/m): 0;
- Canalización: B-Unip.Tubos Superf.o Emp.Obra

I = 29545 / 1,732 x 400 x 0.8 = 53.3 A.
Se eligen conductores Unipolares **4x25+TTx16mm²Cu RZ1-K(AS)**
I.ad. a 40°C (Fc=1) 84 A. según ITC-BT-19
D. tubo: 110mm.
Prot. Térmica: **Fusibles Int. 63 A.**

Caída de tensión: Temperatura cable (ºC): 58.68

e (parcial)= 5 x 29545 / 48.24 x 400 x 25 = 0.306 V. = 0.07 %
e (total) = 0.07% ADMIS (4.5% MAX.)

1.3. Cálculo de la DERIVACION INDIVIDUAL

- Potencia a instalar: 29545 W. (Según ITC-BT-44): 35911 W. (Coef. de Simult.: 1)
- Tensión de servicio: 400 V.
- Longitud: 15 m; Cos j: 0.8; Xu(mW/m): 0;
- Canalización: B-Unip.Tubos Superf.o Emp.Obra

I = 29545 / 1,732 x 400 x 0.8 = 53.3 A.

Se eligen conductores Unipolares **4x25+TTx16mm²Cu RZ1-K(AS)**
I.ad. a 40°C (Fc=1) 84 A. según ITC-BT-19
D. tubo: 63mm.

Caída de tensión: Temperatura cable (ºC): 58.68

e (parcial) = 15 x 29545 / 48.24 x 400 x 25 = 0.918 V. = 0.229 %
e (total) = 0.229% ADMIS (4.5% MAX.)

1.4. Cálculo de la Línea:

- Potencia a instalar: 16110 W. (Según ITC-BT-44): 16878 W. (Coef. de Simult.: 1)
- Tensión de servicio: 400 V.
- Longitud: 0.3 m; Cos j: 0.8; Xu(mW/m): 0;
- Canalización: C-Unip.o Mult.sobre Pared

I = 16878 / 1,732 x 400 x 0.8 = 30.45 A.

Se eligen conductores Unipolares **4x6mm²Cu PVC, 450/750 V**
I.ad. a 40°C (Fc=1) 46 A. según ITC-BT-19
Prot. Térmica: I. Mag. Tetrapolar Int. **32 A.**
Protección diferencial: Inter. Dif. Tetrapolar Int.: **40 A.** Sens. Int.: **30 mA.**

Caída de tensión: Temperatura cable (ºC): 61.47

e (parcial) = 0.3 x 16878 / 47.79 x 400 x 6 = 0.04 V. =0.01 %
e (total) = 0.38% ADMIS (4.5% MAX.)

a. Cálculo de la Línea: C1

- Datos por tramo

Tramo	1	2	3	4	5	6
Longitud(m)	6.5	12	15	7	7.5	16
P.des.nu.(W)	240	180	180	120	240	0
P.inc.nu.(W)	0	0	40	0	0	160

- Potencia a instalar: 1160 W. (Según ITC-BT-44): 960x1.8+200=1928 W.
- Tensión de servicio: 230 V.

- Longitud: 64 m; Cos j: 1; Xu(mW/m): 0;
- Canalización: B-Unip.Tubos Superf.o Emp.Obra

I = 1928 / 230 x 1 = 8.38 A.

Se eligen conductores Unipolares **2x1.5+TTx1.5mm²Cu PVC, 450/750 V**
I.ad. a 40°C (Fc=1) 20 A. según ITC-BT-19
D. tubo: 16mm.
Prot. Térmica: I. Mag. Bipolar Int. **10 A.**

Caída de tensión: Temperatura cable (ºC): 44.78

e (parcial) = 2 x 31.49 x 1928 / 50.64 x 230 x 1.5 = 6.95 V. = 3.02 %
e (total) = 3.2% ADMIS (4.5% MAX.)

b. Cálculo de la Línea: C2

- Datos por tramo

Tramo	1	2	3
Longitud(m)	12	15	2.5
Pot.nudo(W)	850	1000	1000

- Potencia a instalar: 2850 W. Potencia de cálculo: 2850 W.
- Tensión de servicio: 230 V.
- Longitud: 29.5 m; Cos j: 0.8; Xu(mW/m): 0;
- Canalización: B-Unip.Tubos Superf.o Emp.Obra

I = 2850 / 230 x 0.8 = 15.49 A.

Se eligen conductores Unipolares **2x2.5+TTx2.5mm²Cu PVC, 450/750 V**
I.ad. a 40°C (Fc=1) 26.5 A. según ITC-BT-19
D. tubo: 20mm.
Prot. Térmica:I. Mag. Bipolar Int. **16 A.**

– Caída de tensión: Temperatura cable (ºC): 56.32

e (parcial) = 2 x 23.4 x 2850 / 48.63 x 230 x 2.5 = 4.77 V. = 2.07 %
e (total) = 2.46% ADMIS (6.5% MAX.)

c. Cálculo de la Línea: C3

- Potencia a instalar: 5400 W. Potencia de cálculo: 5400 W.
- Tensión de servicio: 230 V.
- Longitud: 11 m; Cos j: 0.8; Xu(mW/m): 0;
- Canalización: B-Unip.Tubos Superf.o Emp.Obra

I = 5400 / 230 x 0.8 = 29.35 A.

Se eligen conductores Unipolares **2x6+TTx6mm²Cu PVC, 450/750 V**
I.ad. a 40°C (Fc=1) 46 A. según ITC-BT-19
D. tubo: 25mm.
Prot. Térmica: I. Mag. Bipolar Int**. 25 A.**

Caída de tensión: Temperatura cable (ºC): 59.94

e (parcial) = 2 x 11 x 5400 / 48.04 x 230 x 6 = 1.79 V. = 0.78 %
e (total) = 1.16% ADMIS (6.5% MAX.)

d. Cálculo de la Línea: C4

- Datos por tramo

Tramo	1	2
Longitud(m)	7.5	8
Pot.nudo(W)	1800	1700

- Potencia a instalar: 3500 W. - Potencia de cálculo: 3500 W.
- Tensión de servicio: 230 V.
- Longitud: 15.5 m; Cos j: 0.8; Xu(mW/m): 0;
- Canalización: B-Unip.Tubos Superf.o Emp.Obra

I = 3500 / 230 x 0.8 = 19.02 A.

Se eligen conductores Unipolares **2x4+TTx4mm²Cu PVC, 450/750 V**
I.ad. a 40°C (Fc=1) 36 A. según ITC-BT-19
D. tubo: 20mm.
Prot. Térmica: I. Mag. Bipolar Int. **20 A.**

Caída de tensión: Temperatura cable (ºC): 54.89

e (parcial) = 2 x 11.39 x 3500 / 48.87 x 230 x 4 = 1.77 V. = 0.77 %
e (total) = 1.15% ADMIS (6.5% MAX.)

e. Cálculo de la Línea: C5

- Potencia a instalar: 3200 W. - Potencia de cálculo: 3200 W.
- Tensión de servicio: 230 V.
- Longitud: 20 m; Cos j: 0.8; Xu(mW/m): 0;
- Canalización: B-Unip.Tubos Superf.o Emp.Obra

I = 3200 / 230 x 0.8 = 17.39 A.

Se eligen conductores Unipolares **2x2.5+TTx2.5mm²Cu PVC, 450/750 V**
I.ad. a 40°C (Fc=1) 26.5 A. según ITC-BT-19
D. tubo: 20mm.
Prot. Térmica: I. Mag. Bipolar Int. **16 A.**

Caída de tensión: Temperatura cable (ºC): 60.58

e (parcial) = 2 x 20 x 3200 / 47.93 x 230 x 2.5 = 4.64 V. = 2.02 %
e (total) = 2.4% ADMIS (6.5% MAX.)

1.5. Cálculo de la Línea:

- Potencia a instalar: 4380 W. (Según ITC-BT-44): 5100 W. (Coef. de Simult.: 1)
- Tensión de servicio: 400 V.
- Longitud: 0.3 m; Cos j: 0.8; Xu(mW/m): 0;
- Canalización: C-Unip.o Mult.sobre Pared

I = 5100 / 1,732 x 400 x 0.8 = 9.2 A.

Se eligen conductores Unipolares **4x2.5mm²Cu PVC, 450/750 V**
I.ad. a 40°C (Fc=1) 26.5 A. según ITC-BT-19
Prot. Térmica: I. Mag. Tetrapolar Int. **16 A.**
Protección diferencial: Inter. Dif. Tetrapolar Int.: **25 A**. Sens. Int.: **30 mA**.

Caída de tensión: Temperatura cable (ºC): 45.76

e (parcial) = 0.3 x 5100 / 50.46 x 400 x 2.5 = 0.03 V. = 0.01 %
e (total) = 0.38% ADMIS (4.5% MAX.)

a. Cálculo de la Línea: C6

- Datos por tramo

Tramo	1	2	3	4
Longitud(m)	18	20	15.5	20
P.des.nu.(W)	300	300	180	120

- Potencia a instalar: 900 W. (Según ITC-BT-44): 900x1.8=1620 W.
- Tensión de servicio: 230 V.
- Longitud: 73.5 m; Cos j: 1; Xu(mW/m): 0;
- Canalización: B-Unip.Tubos Superf.o Emp.Obra

I = 1620 / 230 x 1 = 7.04 A.

Se eligen conductores Unipolares **2x1.5+TTx1.5mm²Cu PVC, 450/750 V**
I.ad. a 40°C (Fc=1) 20 A. según ITC-BT-19
D. tubo: 20mm.
Prot. Térmica: I. Mag. Bipolar Int. **10 A.**

Caída de tensión: Temperatura cable (ºC): 43.37

e (parcial) = 2 x 39.17 x 1620 / 50.89 x 230 x 1.5 = 7.22 V. = 3.14 %
e (total) = 3.27% ADMIS (4.5% MAX.)

b. Cálculo de la Línea: C7

- Datos por tramo

Tramo	1	2	3
Longitud(m)	15	10	25
Pot.nudo(W)	800	300	1000

- Potencia a instalar: 2100 W. - Potencia de cálculo: 2100 W.
- Tensión de servicio: 230 V.
- Longitud: 50 m; Cos j: 0.8; Xu(mW/m): 0;
- Canalización: B-Unip.Tubos Superf.o Emp.Obra

I = 2100 / 230 x 0.8 = 11.41 A.

Se eligen conductores Unipolares **2x2.5+TTx2.5mm²Cu PVC, 450/750 V**
I.ad. a 40°C (Fc=1) 26.5 A. según ITC-BT-19
D. tubo: 20mm.
Prot. Térmica: I. Mag. Bipolar Int. **16 A.**

Caída de tensión: Temperatura cable (ºC): 48.86

e (parcial) = 2 x 33.1 x 2100 / 49.91 x 230 x 2.5 = 4.84 V. = 2.11 %
e (total) = 2.49% ADMIS (6.5% MAX.)

c. Cálculo de la Línea: C12

- Potencia a instalar: 1380 W. - Potencia de cálculo: 1380 W.
- Tensión de servicio: 230 V.
- Longitud: 18 m; Cos j: 0.8; Xu(mW/m): 0;
- Canalización: B-Unip.Tubos Superf.o Emp.Obra

I = 1380 / 230 x 0.8 = 7.5 A.

Se eligen conductores Unipolares **2x2.5+TTx2.5mm²Cu PVC, 450/750 V**
I.ad. a 40°C (Fc=1) 26.5 A. según ITC-BT-19
D. tubo: 20mm.
Prot. Térmica: I. Mag. Bipolar Int. **16 A.**

Caída de tensión: Temperatura cable (ºC): 43.83

e (parcial) = 2 x 18 x 1380 / 50.81 x 230 x 2.5 = 1.7 V. = 0.74 %
e (total) = 1.12% ADMIS (6.5% MAX.)

1.6. Cálculo de la Línea:

- Potencia a instalar: 7200 W. - Potencia de cálculo: 7200 W. (Coef. de Simult.: 1)
- Tensión de servicio: 400 V.
- Longitud: 0.3 m; Cos j: 0.8; Xu(mW/m): 0;
- Canalización: C-Unip.o Mult.sobre Pared

I = 7200 / 1,732 x 400 x 0.8 = 12.99 A.

Se eligen conductores Unipolares **4x2.5mm²Cu PVC, 450/750 V**
I.ad. a 40°C (Fc=1) 26.5 A. según ITC-BT-19
Prot. Térmica: I. Mag. Tetrapolar Int. **25 A.**
Protección diferencial: Inter. Dif. Tetrapolar Int.: **25 A**. Sens. Int.: **30 mA**.

Caída de tensión: Temperatura cable (ºC): 50.05

e (parcial) = 0.3 x 7200 / 49.7 x 400 x 2.5 = 0.043 V. = 0.01 %

e (total) = 0.38% ADMIS (4.5% MAX.)

a. Cálculo de la Línea: C9

- Potencia a instalar: 2500 W. - Potencia de cálculo: 3500 W.
- Tensión de servicio: 230 V.
- Longitud: 15 m; Cos j: 0.8; Xu(mW/m): 0;
- Canalización: B-Unip.Tubos Superf.o Emp.Obra

I = 2500 / 230 x 0.8 = 13.58 A.

Se eligen conductores Unipolares **2x2.5+TTx2.5mm²Cu PVC, 450/750 V**

I.ad. a 40°C (Fc=1) 26.5 A. según ITC-BT-19

D. tubo: 20mm.

Prot. Térmica: I. Mag. Bipolar Int. **16 A.**

Caída de tensión: Temperatura cable (ºC): 64.61

e (parcial) = 2 x 15 x 2500 / 47.29 x 230 x 2.5 = 2.75 V. = 1.19 %

e (total) = 1.36% ADMIS (6.5% MAX.)

b. Cálculo de la Línea: C8

- Potencia a instalar: 2400 W. - Potencia de cálculo: 5750 W.
- Tensión de servicio: 230 V.
- Longitud: 16 m; Cos j: 0.8; Xu(mW/m): 0;
- Canalización: B-Unip.Tubos Superf.o Emp.Obra

I = 2400 / 230 x 0.8 = 13.04 A.

Se eligen conductores Unipolares **2x2.5+TTx2.5mm²Cu PVC, 450/750 V**

I.ad. a 40°C (Fc=1) 26.5 A. según ITC-BT-19

D. tubo: 25mm.

Prot. Térmica: I. Mag. Bipolar Int. **16 A.**

Caída de tensión: Temperatura cable (ºC): 62.61

e (parcial) = 2 x 16 x 2400 / 47.6 x 230 x 2.5 = 2.8 V. = 1.22 %

e (total) = 1.6% ADMIS (6.5% MAX.)

c. Cálculo de la Línea: C11

- Tensión de servicio: 230 V.
- Canalización: B-Unip.Tubos Superf.o Emp.Obra
- Longitud: 2 m; Cos j: 0.8; Xu(mW/m): 0;
- Potencia a instalar: 2300 W. - Potencia de cálculo: 2300 W.

I = 2300 / 230 x 0.8 = 12.5 A.

Se eligen conductores Unipolares **2x2.5+TTx2.5mm²Cu PVC, 450/750 V**
I.ad. a 40°C (Fc=1) 26.5 A. según ITC-BT-19
D. tubo: 20mm.
Prot. Térmica: I. Mag. Bipolar Int. **16 A.**

Caída de tensión: Temperatura cable (ºC): 50.63

e (parcial) = 2 x 2 x 2300 / 49.6 x 230 x 2.5 = 0.32 V. = 0.14 %
e (total) = 0.52% ADMIS (6.5% MAX.)

1.7. Cálculo de la Línea:

- Tensión de servicio: 400 V.
- Canalización: C-Unip.o Mult.sobre Pared
- Longitud: 0.3 m; Cos j: 0.8; Xu(mW/m): 0;
- Potencia a instalar: 1855 W. (Según ITC-BT-44): 2383 W. (Coef. de Simult.: 1)

I = 2383 / 1,732 x 400 x 0.8 = 4.3 A.

Se eligen conductores Unipolares **4x2.5mm²Cu PVC, 450/750 V**
I.ad. a 40°C (Fc=1) 26.5 A. según ITC-BT-19
Prot. Térmica: I. Mag. Tetrapolar Int. **16 A.**
Protección diferencial: Inter. Dif. Tetrapolar Int.: **25 A**. Sens. Int.: **30 mA.**

Caída de tensión: Temperatura cable (ºC): 41.26

e (parcial) = 0.3 x 2383 / 51.28 x 400 x 2.5 = 0.01 V. = 0 %
e (total) = 0.38% ADMIS (4.5% MAX.)

a. Cálculo de la Línea: C13

- Potencia a instalar: 160 W. (Según ITC-BT-44): 160 W.
- Tensión de servicio: 230 V.
- Longitud: 19.5 m; Cos j: 1; Xu(mW/m): 0;
- Canalización: B-Unip.Tubos Superf.o Emp.Obra

I = 160 / 230 x 1 = 0.7 A.

Se eligen conductores Unipolares **2x1.5+TTx1.5mm²Cu PVC, 450/750 V**
I.ad. a 40°C (Fc=1) 20 A. según ITC-BT-19
D. tubo: 16mm.
Prot. Térmica: I. Mag. Bipolar Int. **10 A.**

Caída de tensión: Temperatura cable (ºC): 40.06

e (parcial) = 2 x 19.5 x 160 / 51.5 x 230 x 1.5 = 0.35 V. = 0.15 %
e (total) = 0.53% ADMIS (4.5% MAX.)

b. Cálculo de la Línea: C14

- Datos por tramo

Tramo	1	2
Longitud(m)	20	10
P.des.nu.(W)	540	120

- Potencia a instalar: 660 W. (Según ITC-BT-44): 660x1.8=1188 W.
- Tensión de servicio: 230 V.
- Longitud: 30 m; Cos j: 1; Xu(mW/m): 0;
- Canalización: B-Unip.Tubos Superf.o Emp.Obra

I = 1188 / 230 x 1 = 5.17 A.

Se eligen conductores Unipolares **2x1.5+TTx1.5mm²Cu PVC, 450/750 V**
I.ad. a 40°C (Fc=1) 20 A. según ITC-BT-19
D. tubo: 16mm.
Prot. Térmica: I. Mag. Bipolar Int. **10 A.**

Caída de tensión: Temperatura cable (ºC): 43.56

e (parcial)=2 x 21.82 x 1188 / 50.86 x 230 x 1.5 = 2.95 V. = 1.28 %
e (total) = 1.66% ADMIS (4.5% MAX.)

c. Cálculo de la Línea: C15

- Potencia a instalar: 690 W. - Potencia de cálculo: 690 W.
- Tensión de servicio: 230 V.
- Canalización: B-Unip.Tubos Superf.o Emp.Obra
- Longitud: 15 m; Cos j: 0.8; Xu(mW/m): 0;

I = 690 / 230 x 0.8 = 3.75 A.

Se eligen conductores Unipolares **2x2.5+TTx2.5mm²Cu PVC, 450/750 V**
I.ad. a 40°C (Fc=1) 26.5 A. según ITC-BT-19
D. tubo: 20mm.
Prot. Térmica: I. Mag. Bipolar Int**. 16 A.**

Caída de tensión: Temperatura cable (ºC): 40.96

e (parcial) = 2 x 15 x 690 / 51.34 x 230 x 2.5 = 0.7 V. = 0.3 %
e (total) = 0.68% ADMIS (6.5% MAX.)

d. Cálculo de la Línea: C16

- Potencia a instalar: 345 W. - Potencia de cálculo: 345 W.
- Tensión de servicio: 230 V.
- Canalización: B-Unip.Tubos Superf.o Emp.Obra
- Longitud: 7.5 m; Cos j: 0.8; Xu(mW/m): 0;

I = 345 / 230 x 0.8 = 1.88 A.

Se eligen conductores Unipolares **2x2.5+TTx2.5mm²Cu PVC, 450/750 V**
I.ad. a 40°C (Fc=1) 26.5 A. según ITC-BT-19
D. tubo: 20mm.
Prot. Térmica: I. Mag. Bipolar Int. **16 A.**

Caída de tensión: Temperatura cable (ºC): 40.24

e (parcial) = 2 x 7.5 x 345 / 51.47 x 230 x 2.5 = 0.17 V. = 0.08 %
e (total) = 0.45% ADMIS (6.5% MAX.)

6.4.2. Resultados Obtenidos

Cuadro General de Mando y Protección

Denominación	P.Cálculo (W)	Dist. (m)	Sección (mm²)	I.Cálculo (A)	I.Adm (A)	.C.T.Parc. (%)	C.T.Total (%)
ACOMETIDA	29545	5	4x25Al	53.3	84	0.12	0.12
L.G.A.	29545	5	4x25+TTx16Cu	53.3	84	0.07	0.07
DERIV. IND.	29545	15	4x25+TTx16Cu	53.3	84	0.229	0.229
LINEA 1	16878	0.3	4x6Cu	30.45	46	0.01	0.38
C1	1928	64	2x1.5+TTx1.5Cu	8.38	20	3.02	3.2
C2	2850	29.5	2x2.5+TTx2.5Cu	15.49	26.5	2.07	2.46
C3	5400	11	2x6+TTx6Cu	29.35	46	0.78	1.16
C4	3500	15.5	2x4+TTx4Cu	19.02	36	0.77	1.15
C5	3200	20	2x2.5+TTx2.5Cu	17.39	26.5	2.02	2.4
LINEA 2	5100	0.3	4x2.5Cu	9.2	26.5	0.01	0.38
C6	1620	73.5	2x1.5+TTx1.5Cu	7.04	20	3.14	3.27
C7	2100	50	2x2.5+TTx2.5Cu	11.41	26.5	2.11	2.49
C12	1380	18	2x2.5+TTx2.5Cu	7.5	26.5	0.74	1.12
LINEA 3	7200	0.3	4x2.5Cu	12.99	26.5	0.01	0.38
C9	2500	15	2x2.5+TTx2.5Cu	13.58	26.5	1.19	1.36
C8	2400	16	2x2.5+TTx2.5Cu	13.04	26.5	1.22	1.6
C11	2300	2	2x2.5+TTx2.5Cu	12.5	26.5	0.14	0.52
LINEA 4	2383	0.3	4x2.5Cu	4.3	26.5	0	0.38
C13	160	19.5	2x1.5+TTx1.5Cu	0.7	20	0.15	0.53
C14	1188	30	2x1.5+TTx1.5Cu	5.17	20	1.28	1.66
C15	690	15	2x2.5+TTx2.5Cu	3.75	26.5	0.3	0.68
C16	345	7.5	2x2.5+TTx2.5Cu	1.88	26.5	0.08	0.45

7. DRAWINGS

The documentation of drawings is in the correspondent document, DOC_02 DRAWINGS. In this document can be found the documentation of: geographical location, plants distribution, facades, sections and construction details of the housing.

8. CONCLUSION

Exposed the purpose and usefulness of this project, we hope that it deserves the approval of the Administration, giving us the necessary approvals for processing and commissioning.

Budapest, June 2013
The Student of Electrical Engineering

Signed: Enrique Esteve Martínez
ID code: IF1VX7