CRACOW UNIVERSITY OF TECHNOLOGY

FACULTY OF MECHANICAL ENGINEERING

Final Project Degree (Bachelor Thesis)
Specialty Renewable Energies

PROJECT OF SOLAR INSTALLATION FOR DOMESTIC HOT WATER PREPARATION

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Cracow, June 2019

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Nomenclature

Symbol	Description	Unit
$Q_{d,Hw}$	Daily hot water heat demand	KWh/day
$V_{HW,day}$	Average daily hot water demand	m^3/day
ρ	Water density	998kg/m^3
c	Specific heat of water	4187J/(kg·K)
t_{CW}	Cold water temperature	15ºC
t_{HW}	Hot water temperature	60ºC
z	Heat loss factor	Adimensional
$Q_{k,u}$	Usable heat gain of solar collectors in given period	KWh/day
η	Efficiency of solar collector for given conditions	Adimensional
$H_{T,day}$	Solar irradiation of given plane of solar collector	KWh/m^2
p	Reduction factor	Adimensional
$t_{k,m}$	Mean fluid temperature in collector during the day	ºC
$t_{e,s}$	Mean ambient temperature in time of sunshine	ºC
$G_{T,m}$	Mean daily solar irradiance	W/m^2
a_1	1st order heat loss coefficient	W/(K·m^2)
a_2	2nd order heat loss coefficient	W/(K^2·m^2)

1. Introduction

First of all we will make an introduction about renewable energies, its situation in Spain and we will focus on low temperature solar thermal energy because of it is the main theme of this work

1.1Renewable energies

Renewable energies are those that are constantly being produced naturally and are a never-ending source because they are continuously renewed, unlike fossil fuels, which exist in a very determined quantity or reserve, and are only useful in a longer or shorter term of time but eventually they will disappear.

The main types of renewable energies that exist nowadays are biomass, hydraulic, wind, geothermal, solar and the energy from the sea waves.

1.1.1 Which is the current situation about renewable energies?

Currently, the worldwide contribution of the renewable energies (in relation to the total consume of energy) is around 8% and in Europe is 6%; these percentages belong exclusively to hydraulic and biomass energy.[2]

It is well-known that there is a consciousness-raising about global warning and energy production because of the high consume of fossil fuels, the consequent increment in their price and also the more than probable the impact of these kind of energies in the environment.

Europe represents the 15% of the worldwide energy consumption and because of that some political decisions should be made in order to reduce the petrol and other fossil fuels dependency in the future.[2]

1.2 Current situation inSpain

The global energy crisis caused by all the factors related to fossil fuels (spectacular rise in oil prices, market instability and huge consumption by emerging markets), have a special impact on Europe which it does not have its own energy resources to survive, necessarily depending on third countries to meet its energy demand. In the case of Spain, the problem acquires greater relevance.

Precisely one of the elements that has limited the economic development of Spain has been the poverty of energy resources, in particular the lack of liquid and gaseous hydrocarbons and the poor quality and little amount of existing coal. The scarcity of resources has traditionally condemned the national energy system to a situation of deficit and external dependence. The degree of external self-sufficiency is between 20 and 25% in the last two decades, as we can see in the table below[1]

YEAR	DEGREE OF ENERGY SELF-SUFFICIENCY
1975	22.6
1985	38.9
1995	28
1998	25.6
2003	22.1
2008	21.6
2009	22.9
2010	26.1
2011	24.6
2012	26.2
2013	29.2

Table 1.1: Degree of energy self-sufficiency in Spain 1975 to 2013

The primary energy consumed is mainly of fossil origin: oil (almost half), natural gas (25%) and nuclear and renewable around 10% each. Regarding the energy produced in the country, renewable energy is the main source of useful energy, which exceeds 12% of the total useful energy consumed. As for the renewable energies, without any doubt the wind energy is the most important in Spain. With 23,092 MW of accumulated power, wind power was the second source of electricity generation in Spain in 2017 with a production of 47.896 GWh and electricity demand coverage of 18.2%. Spain is the fifth country in the world by installed wind power, after China, the United States, Germany andIndia

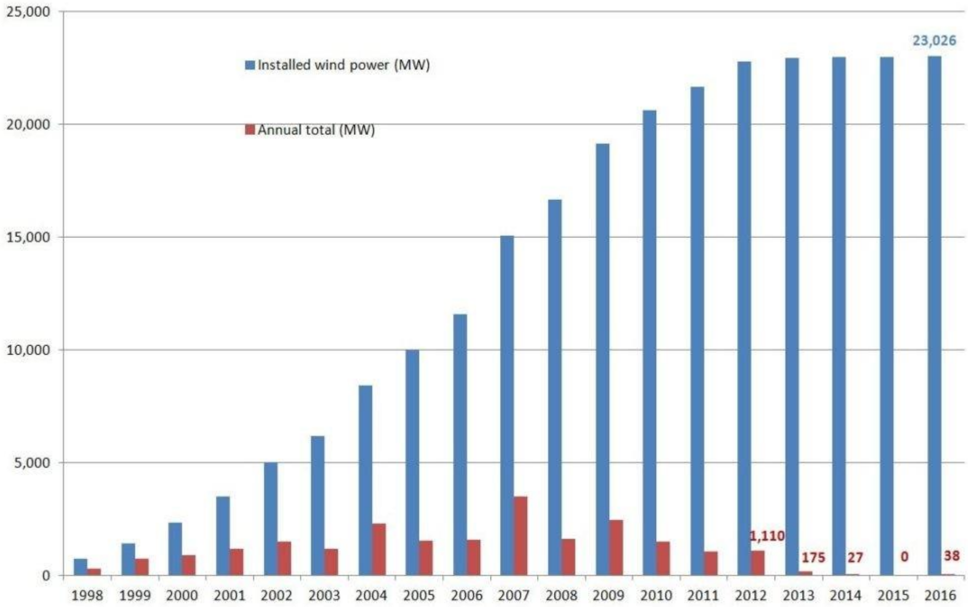

Figure 1.2: Annual evolution and total installed wind capacity in Spain (in MW)

1.2.1 Average energy expenditure inSpain

In Spain, houses consume a fifth of all the energy consumed and a quarter of electricity. A Spanish house consumes 9.9 kilowatt-hours (kWh) per year, equivalent to 0.85 tons ofoil.

These data provided refer to the average, but it is evident that not all types of households consume the same. Single-family homes double energy expenditure (15.513 kWh as an annual average) of flats and blocks of flats (7.544 kWh). And of course the consumption increases in the cold continental areas (12.636 kWh) and decreases in the Atlantic (9.293 kWh) and Mediterranean (8.363kWH).

A Spanish house spends on average 990 € a year in energy. The main expenseisheating,whichusuallyaccountsforhalfofallconsumptionandinan isolatedhouselocatedinacoldareacanreach71%.

Below is a list of how the average annual energy expenditure is distributed among the different sources of energy consumption:

- Heating: annual average of 5.172kWh.
- Home appliances: 1.924kWh.
- Hot water: 1.877kWh.
- Kitchen: 737kWh.
- Lighting: 410kWh.
- Air conditioning: 170kWh.

As we can see, the heating and cooling of the home, together with the supply of hot water are a large part of the energy consumption that a home has throughout the year. For this reason, it is an aspect that is worth investing because the energy saving, and therefore economic, can be important.

1.3 Energy from the Sun

The Sun, directly or indirectly, is the origin of all renewable energies, except for tidal and geothermal energy. The energy of the Sun moves to through space in the form of electromagnetic radiation, a part of this energy reaching the atmosphere. From this energy that reaches the atmosphere, a part is absorbed by the atmosphere and the ground, and another part is reflected directly into space from the ground. This is why less than half of the solar radiation effectively reaches the earth's surface, this part being what we can use withenergetic ends in our planet. In the next picture (Fig. 1.2) it is shown the distribution of the solar radiation.

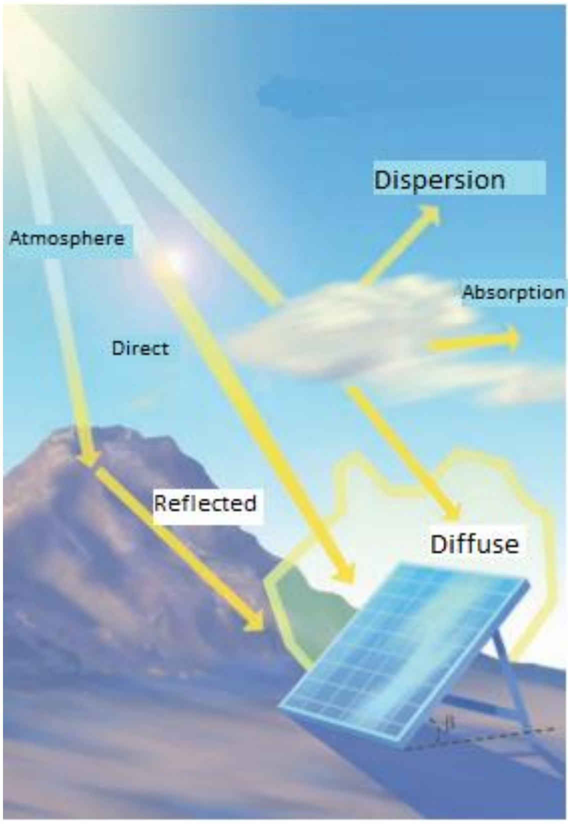

Figure 1.3: Distribution of solar radiation

Solar radiation reaches our planet in three different ways:

• **Direct radiation**: is the radiation that comes directly from the Sun; without having affected anything bythe road and, therefore, without having deviated or changed direction. This radiation is what producesthe shadows. It is the predominant type of radiationon a sunny day.

• **Diffuse radiation**: it is the radiation that reaches us after having affected with any element ofthe atmosphere (dust, clouds, pollutants, etc.), bywhat has changed direction. It is the predominant type of radiation on a cloudy day.

• **Reflected radiation** or albedo: is the radiation reflected by the earth's surface; Becomes importantin areas with snow, with water (as near thesea or a dam) or any other area where thereflection is important.

• **Global radiation**: is the sum of direct radiation and diffuse radiation.

1.4 Solar energy

Solar energy is a renewable energy, obtained from the use of electromagnetic radiation from the Sun. The solar radiation that reaches the Earth has been exploited by humans since ancient times, through different technologies that have been evolving. Today, the heat and sunlight can be exploited by means of various sensors such as photoelectric cells, heliostats or solar collectors, which can be transformed into electrical or thermal energy. It is one of the so-called renewable energies or clean energies, which could help solve some of the most urgent problems facing humanity.

The different solar technologies can be classified as passive or active according to how they capture, convert and distribute solar energy. Active technologies include the use of photovoltaic panels and solar thermal collectors to collect energy. Among the passive techniques, there are different techniques framed in the bioclimatic architecture: the orientation of the buildings to the Sun, the selection of materials with a favorable thermal mass or that have properties for the dispersion of light, as well as the design of spaces by ventilation natural.

1.4.1 Technology and uses of solar energy

Classification by technologies and their corresponding more general use:

-Solar thermal energy: It is used to produce low temperature hot water for sanitary use and heating.

-Photovoltaic solar energy: It is used to produce electricity through semiconductor plates that are altered by solar radiation.

-Concentrating thermosolar energy: It is used to produce electricity with a conventional thermodynamic cycle from a fluid heated at high temperature (thermal oil).

-Hybrid solar energy: Combine solar energy with other energy. According to the energy with which it is combined is a hybridization:

-Renewable: biomass, wind energy.

-Non-renewable: fossil fuel.

1.4.2 Thermal solar energy

Solar thermal energy (or solar thermal energy) consists of harnessing the Sun's energy to produce heat that can be used to cook food or to produce hot water for domestic water consumption, whether hot water, heating, or for the production of mechanical energy and, from that, on electrical energy. Additionally it can be used to power an absorption refrigeration machine, which uses heat instead of electricity to produce cold with which the air in the rooms can be conditioned.

Solar thermal energy is mainly used for heat fluids, usually water. Depending onthe final temperature reached by the fluid at the outlet, The facilities are divided into:

Low temperature

They are the most widespread and are intended for those applications that do not demand water temperaturas above 90 ° C, such as, for example, the production of domestic hot water (DHW) for homes and sports centers, support for heating housing, water heating for swimming pools, etc.

Mean temperature

Intended for those applications that require tempe -water ratios between 80 ºC and 250 ºC,as, for example, the heating of fluids forindustrial processes and the desalination of water from sea.

High temperature

Intended for those applications that require water temperatures above 250 ° C, as is the case of steam generation for the electricity production.

2. Components of the installation

In this work we will focus on domestic water heating using low temperature solar thermal energy

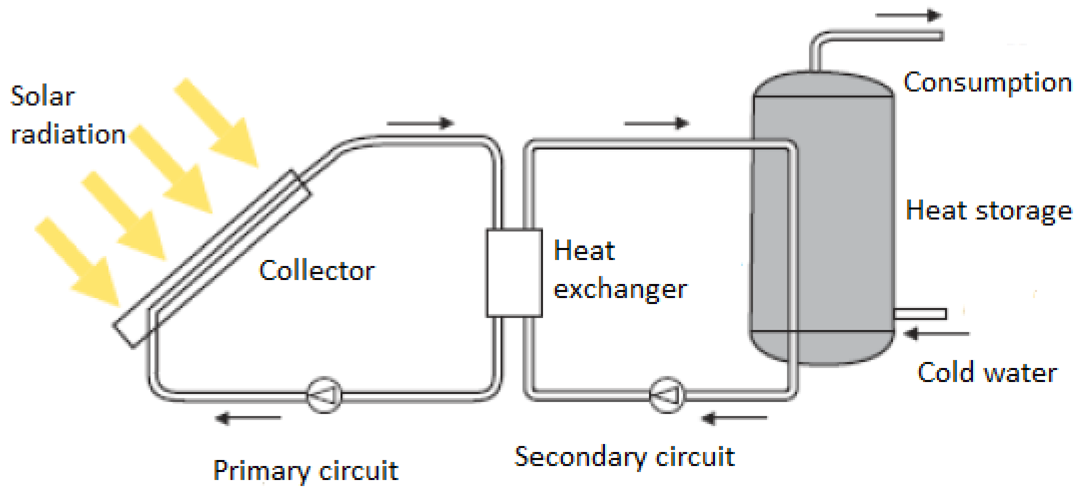

Figure 2.1: Basic scheme of a low temperature solar installation with hot water application

A solar thermal installation consists of solar collectors, a primary and secondary circuit, heat exchanger, heat storage, expansion vessel and pipes. If the system works by thermosyphon it will be the density difference by temperature change that will move the liquid. If the system is forced then we will also need: pumps and a main control panel.

2.1 Solar thermal collector

The sunlight can be used energetically in two conceptually different ways:

-As a heat source: low or medium solar thermal energy. The low temperature method is the most extended and it is destined to those applications that doesn't require temperatures of the water higher than 90ºC, like hot water production. The medium temperature method comprises temperatures between 80ºC and 250ºC, like the heating of fluids of certain industrial processes and sea water desalination.

-As an electricity source: solar photovoltaic and high temperature solar thermal energy. It consists on generating water vapor in order to produce electricity.

A solar collector is a device that uses solar energy to heat a heat transfer fluid (HTF) such as water, air, thermo-oil or molten salt. The collector absorbs a large portion of incident solar radiation and converts it to useful heat. A certain part of incident solar radiation is lost due to convection and heat transfer to the ambient environment.

The glass that covers the collector not only protects the installation but also allows to conserve the heat producing a greenhouse effect that improves the performance of the collector.

For most solar collectors there are characteristic dimensions. In general terms, the basic unit consists of a flat collector of 1.8 to 2.1 m² in area, connected to a storage hot water tank of 150 to 200 liters capacity; To this system frequently some thermostatic control devices are added in order to avoid freezing and loss of heat during the night. The domestic units work by means of the thermosyphon mechanism, that is, by the circulation that is established in the system due to the temperature difference of the layers of liquid stratified in the storage tank.

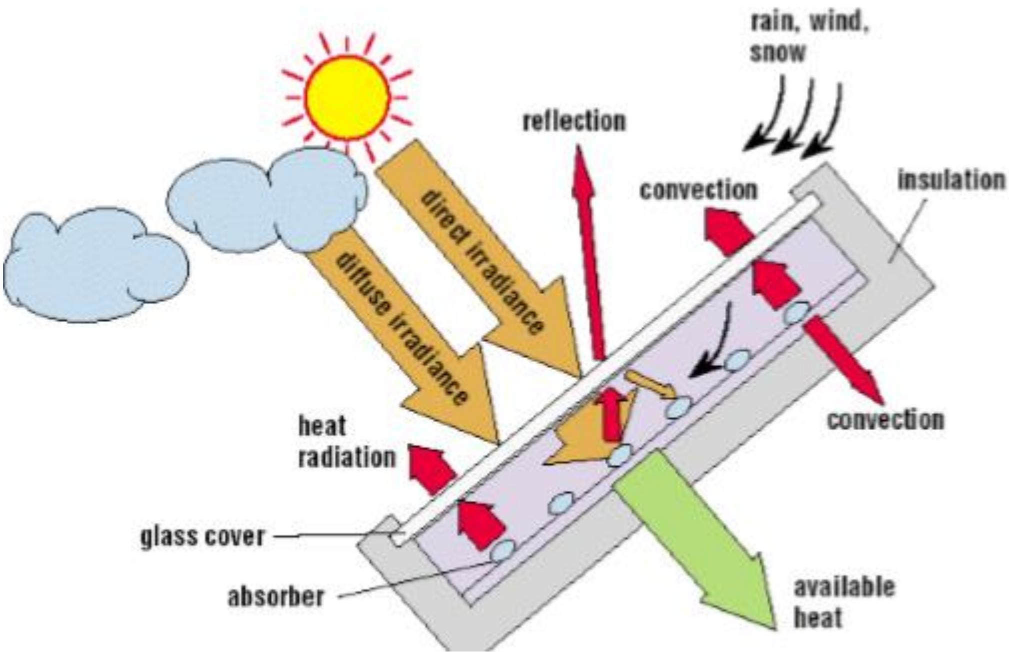

Figure 2.1: Distribution of solar radiation in a flat plate solar collector

The solar collectors are composed of the following elements:

• **Cover**: It is transparent, it may be present or not. It is usually made of glass although they are also used in plastic since it is less expensive and manageable, but it must be a special plastic. Its function is to minimize the losses by convection and radiation and therefore it must have a solar transmittance as high as possible.

• **Air channel**: It is a space (empty or not) that separates the cover of the absorbent plate. Its thickness will be calculated taking into account to balance the losses by convection and the high temperatures that can be produced if it is too narrow.

• **Absorbent plate**: The absorbent plate is the element that absorbs solar energy and transmits it to the liquid that circulates through the pipes. The main characteristic of the plate is that it has to have a great solar absorption and a reduced thermal emission. As common materials do not meet this requirement, combined materials are used to obtain the best absorption / emission ratio.

• **Pipes or ducts**: The tubes are touching (sometimes welded) the absorber plate so that the energy exchange is as large as possible. The liquid circulates through the tubes, which will heat up and go towards the accumulation tank.

• **Insulating layer**: The purpose of the insulating layer is to cover the system to avoid and minimize losses. In order for the insulation to be the best possible, the insulating material must have a low thermal conductivity.

2.1.1 Types of solar thermal collectors

2.1.1.1 Flat plate solar collector (FPSC)

Flat-plate solar collectors can absorb both beam and diffuse solar radiation. There are typically used for low-temperature applications such as water heating as well as space heating and cooling.

A flat-plate solar collector has an absorber plate made of a material with high thermal conductivity, for instance copper or aluminium, a transparent cover made of solar glass, and tubes for collector HTF flow. The whole structure is assembled in a sealed housing with thermal insulation at the sides and bottom.

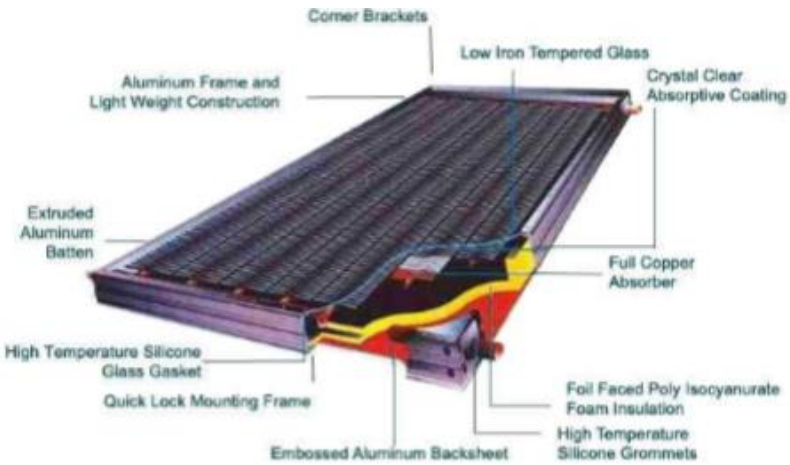

Figure 2.2: Components of flat plate solar collector

The absorber can absorb up to 95% of incident solar radiation. The absorbed energy is partially (50-70%) used for heating of the collector fluid HTF; the rest is lost into environment.

A transparent cover reduces the collector energy losses caused by reflection, radiation and convection, while thermal insulation reduces the heat losses by conduction. An FPC has a simple design and is suitable for heating water (or other liquids) or air up to 100ºC.

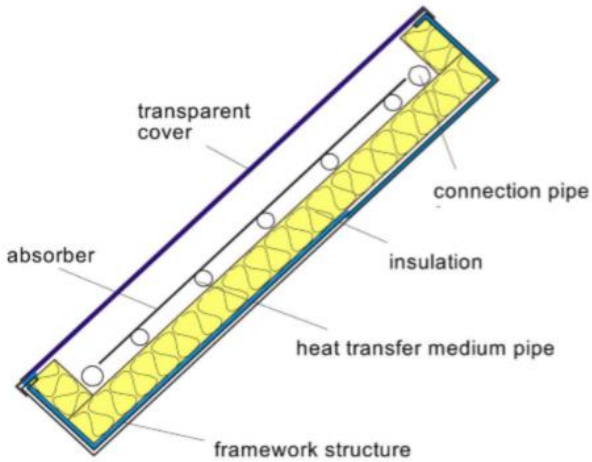

Figure 2.3: Components of the transparent cover

Differences in the material of the coating

Selective Coatings	Absorptance α	Emittance ε	α/ε
Black Chrome	0.93	0.10	9.3
Black Nickel on polished nickel	0.92	0.11	8.4
Black Nickel on galvanized iron	0.89	0.12	7.4
Cu on nickel	0.81	0.17	4.7
Co3O4 on silver	0.90	0.27	3.3
Cu on aluminium	0.93	0.11	8.5
Cu on anodized aluminu	0.85	0.11	7.7
TiNOX	0.95	0.04	23.75

Table 2.1: Differences in the material of the coating

Solar collector energy balance

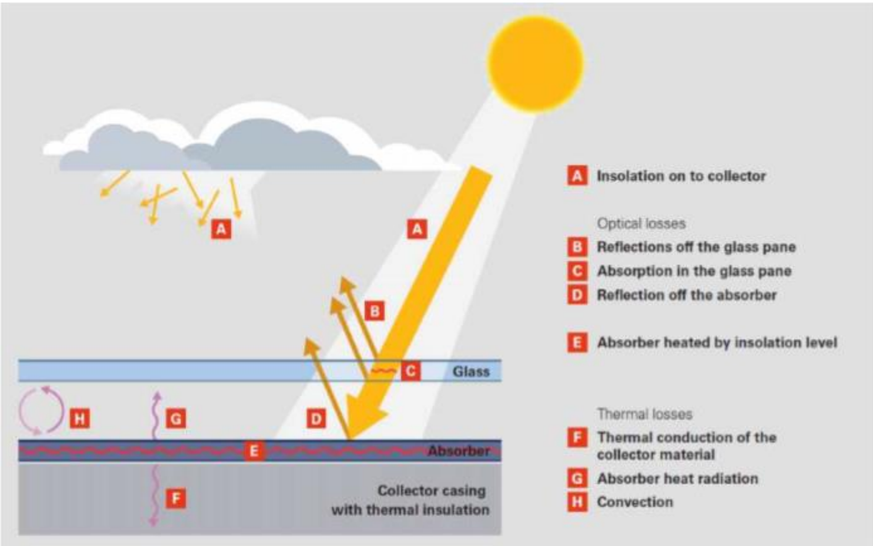

Figure 2.4: Solar collector energy balance

Configuration of the solar collector

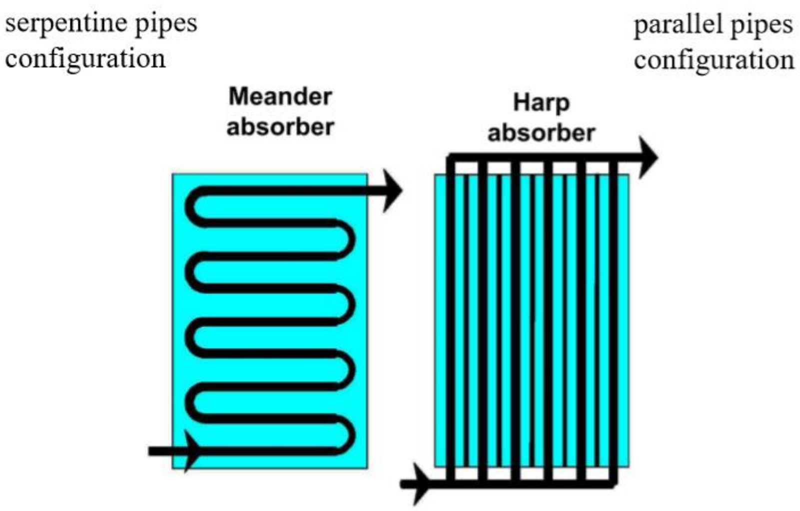

Figure 2.5: Types of solar collector pipes configuration

2.1.1.2 Evacuated Tube Collectors (ETC)

An evacuated-tube collector contains several rows of glass tubes connected to a header pipe. Each tuve has the air removed from it (evacuated) to eliminate heat los through convection and conduction. Inside the glass tuve, a flat or curved aluminum or copper fin is attached to a metal pipe. The fin is coverd with a selective coating that transfers heat to the fluid that is circulating through the pipe. There are two main types of evacuated tube collectors:

-Direct-flow evatuated-tube collectors.

-Heat pipe evacuated-tube collectors.

Figure 2.6: Evacuated Tube Collectors (ETC)

Direct-flow evatuated-tube collectors.

A direct-flow evacuated tube collector has two pipes that run down and back, inside the tube. One pipe is for inlet fluid and the other for outlet fluid. Since the fluid flows into and out of each tube, the tubes are not easily replaced. Also, should a tube break, it's posible that al lof the fluid could be pumped out of the system – if a closed loop is used, or your water will Flow out as in a broken pipe, if an open loop is used.

Figure 2.7: Direct-flow evatuated-tube collectors.

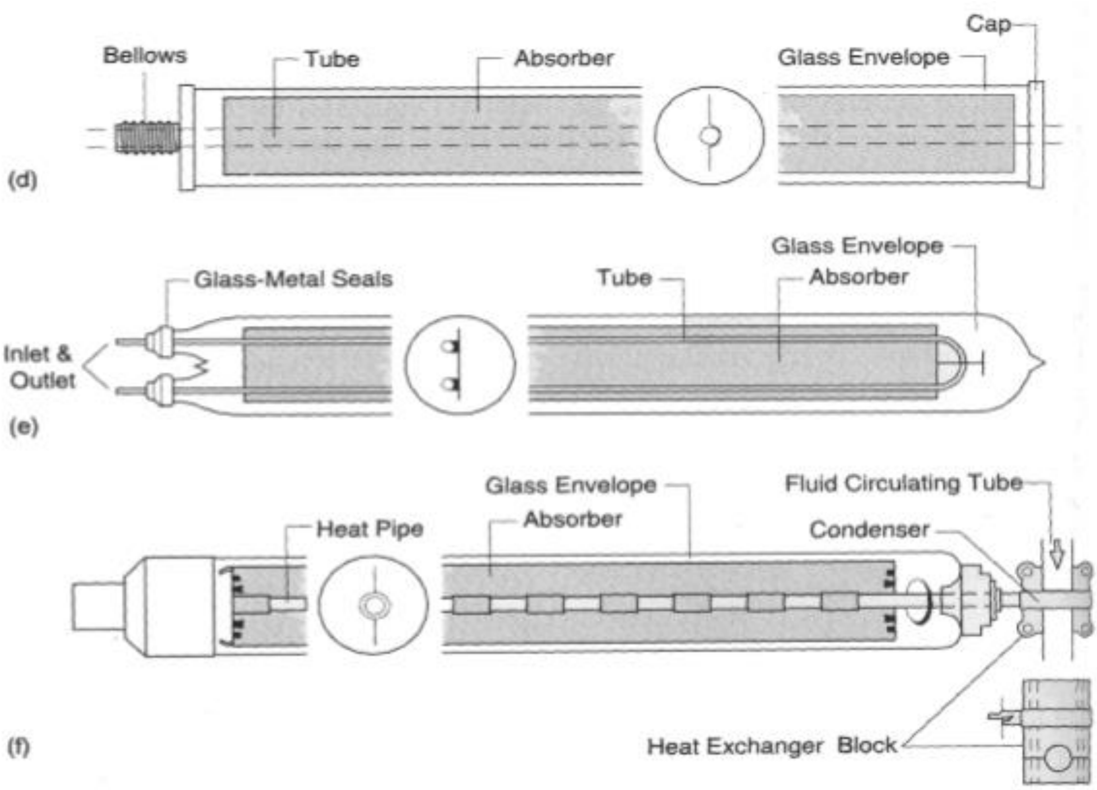

Figure 2.8:Direct-flow evatuated-tube collectors components

2.1.1.3 Heat pipe evacuated-tube collectors

Heat pipe evacuated tube collectors contain a copper heat pipe, which is attached to an absorber plate, inside a vacuum sealed solar tube. The heat pipe is hollow and the space is also evacuated. Inside the heat pipe is a small quantity of liquid to boil at lower temperatures than it would at normal atmospheric pressure. When sunlight falls the Surface of the absorber, the liquid in the heat tube quickly turns to hot vapor and rises to the top of the pipe. Water or glycol, flows through a manifold and picks up the heat. The fluid in the heat pipe condenses and flows back down the tube. This process continues, as long as the sun shines.

Since there is a “dry” connection between the absorber and the header, installation is much easier than with direct Flow collectors. Individual tubes can also be exchanged without emptying the entire system of it’s fluid and should one tube break, there is a Little impact on the complete system.

Heat pipe collectors must be mounted with a minimum tilt angle of around 25º in order for the internal fluid of the heat pipe to return to the hot absorber

Figure 2.9: Heat pipe evacuated-tube collectors

2.2 Primary circuit

The primary circuit, is a closed circuit, transports the heat from the collector to the heat storage (system that stores heat). The heated liquid (water or a mixture of substances that can transport the heat) carries the heat to the heat exchanger. Once cooled, it returns to the collector to reheat, and so on.

2.3 Heat exchanger

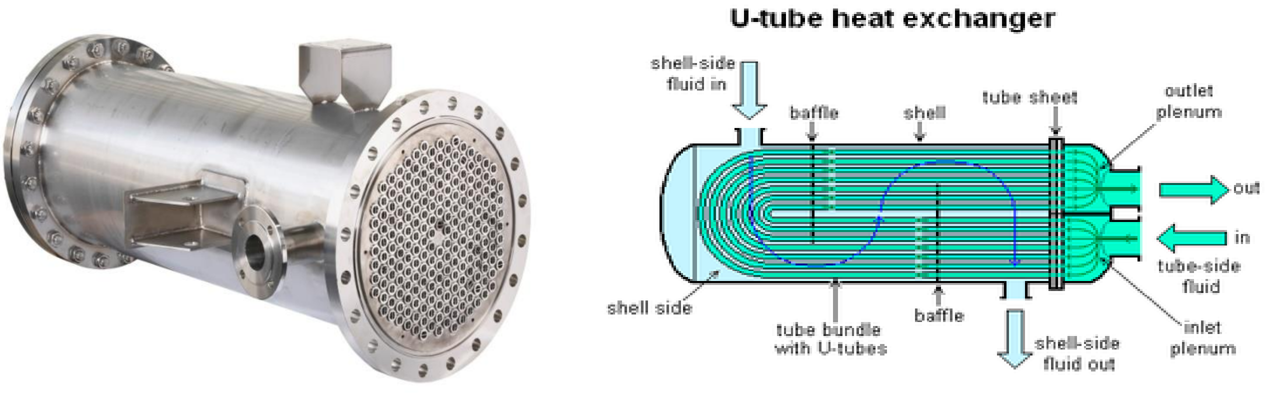

Figure 2.10: Heat exchanger

The heat exchanger heats the drinking water through the heat captured from the solar radiation. It is located in the primary circuit, at its end. It has a serpentine form, since this way it is possible to increase the contact surface and, therefore, the efficiency.

The water that enters the heat exchange, as long as it is cooler than the coil, will heat up. This water, heated in sunny hours, will be available for later consumption.

2.4 Heat storage

Figure 2.11: Heat storage

The heat storage is a tank where heated water accumulates useful for consumption. It has an entrance for cold water and an outlet for hot water. The cold enters underneath the accumulator where it is with the exchanger, as it is heated it moves upwards, which is where the hot water will come from for consumption.

Internally it has a system to avoid the corrosive effect of the hot water stored on the materials. On the outside it has a layer of insulating material that prevents heat losses and is covered by a material that protects the insulation from possible dampness and shock.

2.5 Secondary circuit

The secondary or consumption circuit, (open circuit), enters cold supply water and at the other end of the heated water is consumed (shower, washbasin, ...). The cold water goes through the heat storage first, where it heats the water until it reaches a certain temperature. The hot water pipes from the outside must be covered by insulators.

If the consumption includes heating, the heat-emitting system (radiators (60 ° C), fan-coil (45 ° C), underfloor heating (30 ° C), radiant base, radiant wall, ...) which is more convenient to use is the low temperature (<= 50 ° C), in this way the solar heating system has higher performance.

However, you can install systems that are not low temperature, to use conventional radiators.

2.6 Pumps

Figure 2.12: Pump

The pumps, if the installation is forced circulation, are of recirculation type (there are usually two per circuit), working one half of the day, and the couple, half of the time remaining. The installation consists of the clocks that lead the operation of the system, make the exchange of the pumps, so that one works the first 12 hours and the other the remaining 12 hours. If there are two pumps in operation, there is the advantage that if one stops working, there is the substitute, so that the process can not be stopped when one of these fails. The other reason to consider, is that thanks to this exchange the pump does not suffer so much, but it is left to rest, to cool down, and when it returns to be in good condition (after 12 hours) it is put back on track. This causes the pumps to be able to lengthen the operating time without having to do any kind of previous maintenance.

In total and as defined above, there are usually four pumps, two in each circuit. Two in the primary circuit that pump the water from the collectors and the other two in the secondary circuit that pump the water from the accumulators, in the case of a forced circulation type installation.

2.7 Expansion vessel

Figure 2.13: Expansion vessel

The expansion vessel absorbs volume variations of the heat transfer fluid, which circulates through the collector ducts, maintaining the adequate pressure and avoiding losses of the mass of the fluid. It is a container with a gas chamber separated from the liquid one and with an initial pressure depending on the height of the installation.

The most used is with a closed expansion vessel with a membrane, without mass transfer on the outside of the circuit.

2.8 Pipes

The pipes of the installation are covered with a thermal insulation to avoid heat loss with the environment. In the past, copper pipes were used. Then, PEX-AL-PEX tubes were used, consisting of three plastic-aluminum-plastic layers, much cheaper and with a longer life than traditional copper pipes. After the years of use of the equipment and the accumulation of solar radiation, it was found that the PEX crystallized destroying itself by pressure. Currently, it is used for closed circuit piping of stainless steel BPDN insulated with elastomeric foam and surrounded by a mica of EPDM that gives thermal insulation and provides durability when protecting against radiation, and faults by breakage of joints and welds.

2.9 Control Panel

There is also a main control panel in the installation, where temperatures are shown at every moment (a thermal regulator), so that the operation of the system can be controlled at any time. The clocks responsible for the exchange of bombs also appear.

3. Project

The main objective of this project is the solar hot water installation in a family home of 4 people in the province of Valencia.

We will first calculate the total heat demand, then the average daily solar collector efficiency with the parameters of the solar collector we are going to use, and finally the required solar collector area to produce the total heat demand.

We will make the calculations in April and September, and we will select the biggest area obtained.

3.1 Installation location

Valencia province (Spain)

Longitude: 0°22'38.6" O

Latitude: 39°28'11.1" N

Altitude: 22 meters above sea level

3.2 Total solar radiation in Spain

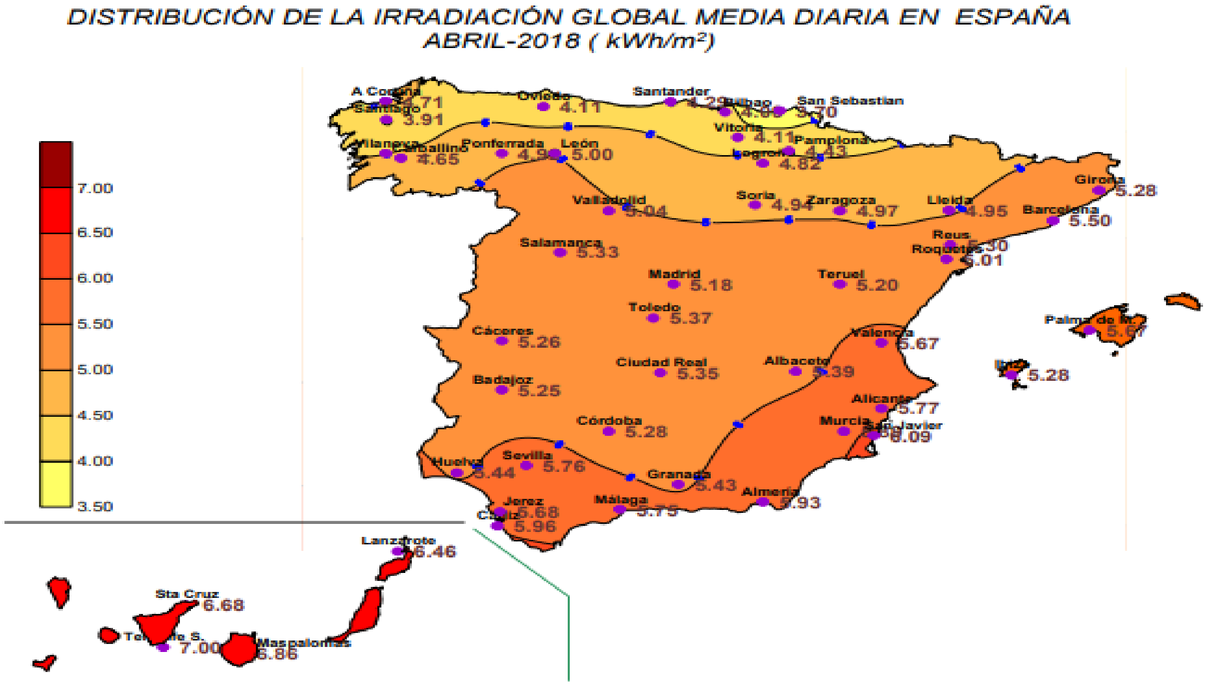

Figure 3.1: Solar radiation in Spain (April)

We can see that the irradiance of Valencia in April is 5.67 kWh/m^2

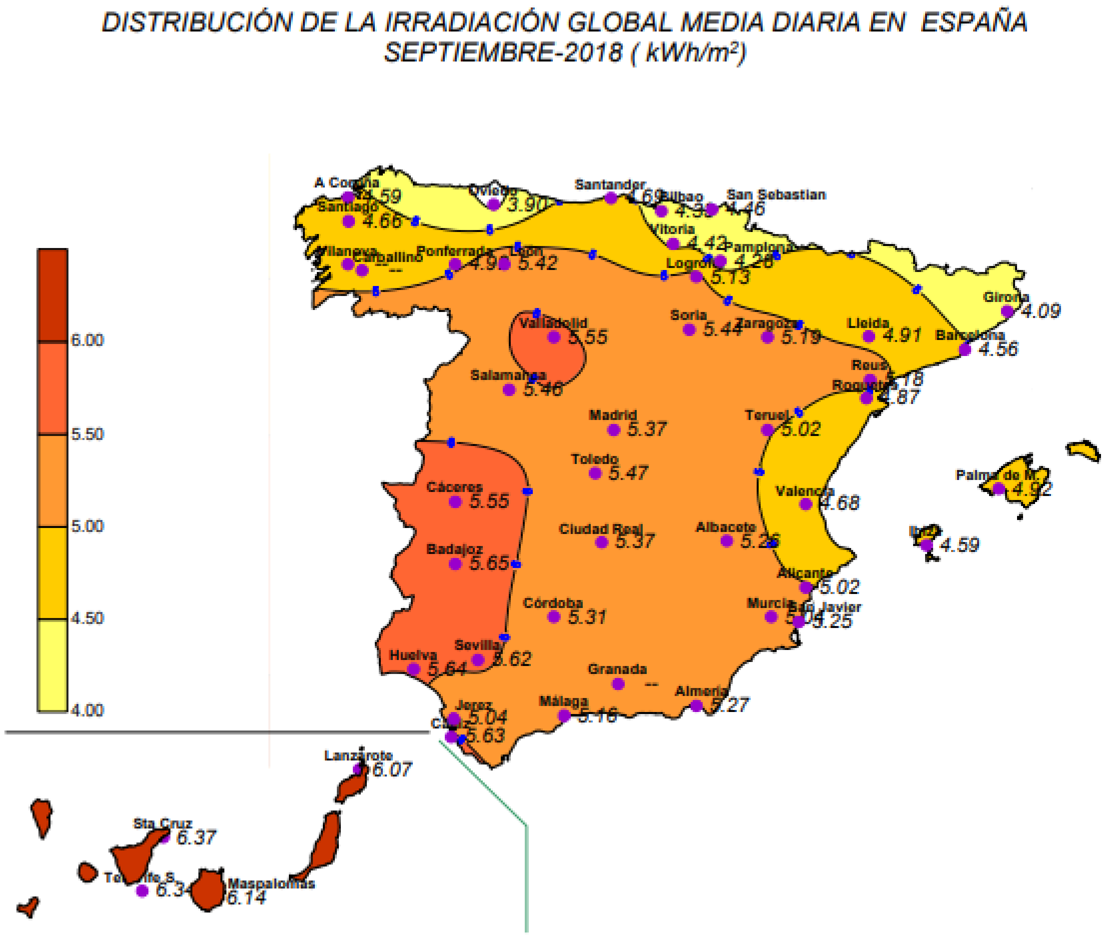

Figure 3.1: Solar radiation in Spain (September)

We can see that the irradiance of Valencia in September is 4.68 kWh/m^2

3.3Total heat demand

The hot water preparation factor and reduction factor are shown, respectively, in tables 3.1 and 3.2. The factors are neded for equations (3.1) and (3.3).

Hot water preparation	***z***
Local flow heaters	0.00
Central storage heaters (no hot water circulation)	0.15
Central storage heaters with controlled circulation	0.30
Central storage heaters with circulation (no control)	1.00
District heating, large distribution systems	> 2.00

Table 3.1: Hot water preparation factor

Application	***p***
Hot water preparation, up to 10 m^2	0,20
Hot water preparation, from 10 to 50 m^2	0,10
Hot water preparation, from 50 to 200 m^2	0,05
Hot water preparation, above 200 m^2	0,03
Hot water and space heating, up to 10 m^2	0,30
Hot water and space heating, from 10 to 50 m^2	0,20
Hot water and space heating, from 50 to 200 m^2	0,10
Hot water and space heating, above 200 m^2	0,06

Table 3.2: Reduction factor

Daily energy demand calculation

The calculations will be carried out for the following assumptions:

-4 person x 35L/(person·day)=140L/day=0.14m^3/day

-Hot water 60ºC, cold water 15ºC

-Central storage heater with circulation(no control), z=0.3

-Small system up to 10m^2, p=0.2

Daily energy demand for hot water preparation is calculeted from the equation [3.1]:

$$Q_{d,Hw} = \frac{(1+z)V_{HW,day} \cdot \rho \cdot c \cdot (t_{HW} - t_{CW})}{3.6 \cdot 10^6} \tag{3.1}$$

After substitution:

$$Q_{d,Hw} = \frac{(1+0,3)0.14 \cdot 1000 \cdot 4187 \cdot (60-15)}{3.6 \cdot 10^6} = 9.525 KWh/day$$

3.4 Average daily solar collector efficiency

For the project the KS2100F TLP AC solar collector was chosen [7]. The collector is shown on Fig. 3.1 and its optical parameters are given in Tab[3.3]

Figure 3.1: KS2100F TLP AC solar collector

parameters	Value
Gross area of the collector:	2.06 m²
Optical efficiency (or gross):	75.3%
Coefficient of heat loss a1 (or gross):	3,168 W / (m²K)
Coefficient of heat loss a2 (or gross):	0.012 W / (m²K²)
Length:	2022 mm
Width:	1019 mm

Table 3.3: Optical parameters of : KS2100F TLP AC solar collector

Average daily solar collector efficiency is calculated in the equation 3.2:

$$\eta_k = \eta_0 - a_1 \frac{t_{k,m} - t_{e,s}}{G_{T,m}} - a_2 \frac{(t_{k,m} - t_{e,s})^2}{G_{T,m}} \qquad (3.2)$$

-Fluid temperature $t_{k,m}$= 40ºC

-Ambient temperature in period of sunshine (April)$t_{e,s}$ = 13ºC

-Ambient temperature in period of sunshine (September)$t_{e,s}$ = 22ºC

-Mean daily irradiance *G*T,m (April) = 1901W/m^2

-Mean daily irradiance *G*T,m (September) = 1555W/m^2

Calculation for April:

$$\eta_k = 0.753 - 3.168\frac{40-13}{1901} - 0.012\frac{(40-13)^2}{1901} = 0.703$$

Calculation for September:

$$\eta_k = 0.753 - 3.168\frac{40-22}{1555} - 0.012\frac{(40-22)^2}{1555} = 0.713$$

3.5 Solar collector area required

For the solar collector area calculation the daily balance should be calculated first:

$$Q_{d,Hw} = 0.9\eta_k H_{T,day} A_k (1-p) \tag{3.3}$$

Calculation for April

$$A_k = \frac{Q_{d,Hw}}{0{,}9\eta_k H_{T,day}(1-p)} = \frac{9.525}{0.9 \cdot 0.753 \cdot 5.67(1-0.2)} = 3.0985m^2$$

Calculation for September

$$A_k = \frac{Q_{d,Hw}}{0{,}9\eta_k H_{T,day}(1-p)} = \frac{9.525}{0.9 \cdot 0.713 \cdot 4.68(1-0.2)} = 3.96m^2$$

We will need 3.96 m^2 of solar collector to produce the total heat demand.

We will use 2 units of the mentioned collector of 2.06m^2

4. Economical issue

For the installation of hot water preparation, the Solar set 2 TLPAC-200 (KS2100) was chosen[7]. The set is shown on Fig. 4.1.

Figure 4.1: Solar set HEWALEX 2 TLPAC-200 (KS2100)

Solar set HEWALEX 2 TLPAC-200 (KS2100) is designed for heating utility water for standard needs of 2-4 people with optimal setting of solar collectors. The basic elements of the set include 2 flat plate collectors type KS2100F TLP AC with a total gross area of 4.12 m^2 and a 2-coil hot water heater with a capacity of 200 liters .

No.	Elements of the set	Quantity
1	KS2100F TLP AC solar collector	2 pcs.
2	Collector connection set ZPKS 2	1 set
3	Armaflex HT lagging in 18/13 mm cover	2 m
4	Pumping and control unit ZPS 18e-01 ECO	1 set
5	The heater OKC200NTRR / SOL	1 piece.
6	Diaphragm vessel assembly ZNP 18DS	1 set
7	Connection set for the PC 200-500 preheater	1 set
8	Liquid Termol EKO -25 ° C	20 kg

Table 4.1: Solar set HEWALEX 2 TLPAC-200 (KS2100)

Net price of the set is 1744.19€

5. Summary

The solar installation for hot water for hot water preparation has some disadvantages as its dependence on the climate, and that the times of the year that we have more sun, is when this resource is least needed.

However, the cost of operation during the more than 25 years of life of a solar thermal installation is irrelevant compared to the cost derived from the purchase of fuel or electric power, repairs and maintenance associated with a conventional energy system.

Since we would obtain energy from the sun, we saved the corresponding electric energy or the energy that is usually obtained by burning fuel in a boiler. To this is added the period of amortization of the cost of the installation that can range between 5 and 12 years depending on the size of the installation, of the aids obtained by the lost fund, of the place where it is installed and of the needs of the user.

It is estimated that, on average, hot water for sanitary use represents about 25% of the energy consumption of a house[10] and therefore constitutes an interesting chapter of savings, in addition to coming from a strong free and inexhaustible energy, reduce the emission of gases that cause global warming, independent of the high costs of gas and electricity and that the cost of the set (€ 1744.19) is recoverable in the medium term.

Therefore, the economic advantages and the low cost of maintenance in relation to conventional systems must be added the environmental advantages, since, on average, a m2 of solar thermal collector is able to avoid the emission to the atmosphere of one ton of CO_2.

6. **Bibliography**

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