# EFFICIENT RENEWABLE SYSTEMS IN BUILDINGS

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Architectural Research for Exchange Students EG

FALL 2018

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## RESEARCH PROBLEM

The Research problem that I pose is the energy consumption from fossil fuel. It is an exhaustible and unsustainable source of energy, so I propose a research about the different kind of renewable energy and how to applicate it in the building systems.

So the aim of my research will be to prove that the renewable energies are better than still using fossil fuel energies.

## INTRODUCTION

Environmental protection is the number one global problem, in consecuence we have no choice but to reduce our energy consumption. One way to accomplish this is to resort to passive and low-energy systems to maintain thermal comfort in buildings.

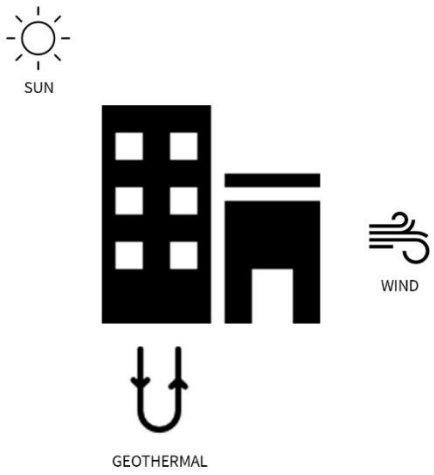
We call greenhouse gases (GHG) those whose presence in the atmosphere contribute to the greenhouse effect (a phenomenon whereby certain planetary atmosphere component gases retain part of the energy that the ground emits heated by solar radiation). Its atmospheric concentration is low, but they are crucial in raising the air temperature next to the ground, making it stay in a range of values suitable for the life existence on the planet.
The most important greenhouse gases are: carbon dioxide (CO2), methane (CH4), nitrous oxide (N2O), CFCs (CFC) and ozone (O3).
So we must take it on count when we stablish certains system services in buildings.

Renewable energies are clean, inexhaustible and increasingly competitive sources of energy. They differ from fossil fuels mainly in their diversity, abundance and potential for use in any part of the planet, but especially in that they do not produce greenhouse gases -causing climate change- nor polluting emissions. In addition, its costs are steadily declining, while the general trend of fossil fuel costs is the opposite, regardless of its conjunctural volatility.

The development of clean energies is essential to combat climate change and limit its most devastating effects. 2014 was the warmest year since records exist. The Earth has undergone a warming of 0.85 ° C on average since the late nineteenth century, says National Geographic in its special issue of Climate Change of November 2015.

In parallel, some 1,100 million inhabitants, 17% of the world population, do not have access to electricity. Similarly, 2.7 billion people - 38% of the global population - use traditional biomass to cook, heat or light their homes with serious risk to their health. Therefore, one of the objectives set by the United Nations is to achieve universal access to electricity in 2030, an ambitious goal if one considers that, according to the IEA estimates, there will still be 800 million people without access to supply at that time. electrical, to follow the current trend.

For this research we are going to consider the enviromental oportunities and how we can use them as renewable systems in buildings. We are going to work with three important elements that exist in the nature: *sun radiation*, the *wind* and the *geothermal energy*.



## RENEWABLE ENERGIES

### 1.GEOTHERMIA

It is a type of renewable energy that is stored under the earth's surface in the form of heat at a constant temperature throughout the year. It is a clean energy that uses the heat of the subsoil to climatize in an ecological way, allowing a saving in the energy bill and a reduction of CO2 emissions.

It has important advantages over other renewable HVAC systems, since it is one of the few that allow to obtain refrigeration, heating and sanitary hot water with the same installation.

Depending on the enthalpy and the temperature in the subsoil, we can make the following classification of the geotermia. (T1.1)

T 1.1 Types of geothermia and uses

| | | Range of temperatures in terrain | Utility |
|---|---|---|---|
| Very low Enthalpy | Subsoil | 5ºC < T < 25ºC | Heating, ACS, Air conditioning ... |
| | Groundwater | 10ºC < 22ºC | |
| Low Enthalpy | Hot Springs | 22ºC < T < 50ºC | Spas, Aquaculture |
| | volcanic zones | T<100ºC | District Heating |
| | Deep sedimentary warehouses | | |
| Medium Enthalpy | | 100ºC < T < 150ºC | Electricity generation |
| High Enthalpy | | T>150ºC | Electricity generation |

As we can see, geothermal energy can be used, depending on its enthalpy and temperatures, for two main applications: heat (air conditioning, sanitary hot water, geothermal heating) and electric power generation.

In the following graph, the different applicable technologies for each use are indicated. (T 1.2)

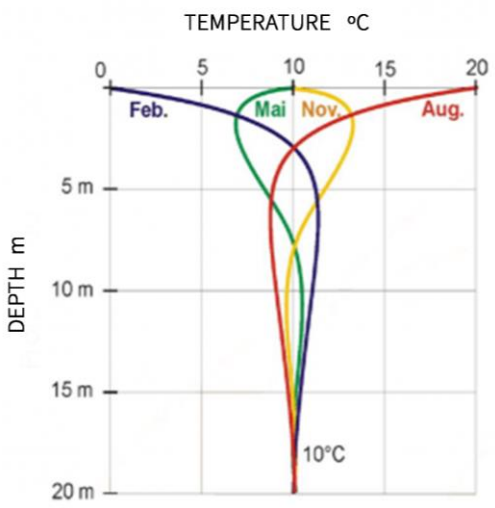
The application of geothermal energy of very low enthalpy for heat production to geothermal heating and air conditioning for single family homes, residential buildings, office buildings, schools, is the most commonly used system in building.

T 1.2 Types of geothermia and applications

| | Geothermic Resources | Range of temperatures in terrain | Technology |
|---|---|---|---|
| Very low Enthalpy | | 5ºC < T < 25ºC | Heat pump |
| Conventional | Low Enthalpy | 22ºC < T < 50ºC | Might need Heat pump |
| | | 50ºC < T<100ºC | District Heating |
| | Medium Enthalpy | 100ºC < T < 150ºC | Electricity generation |
| | High Enthalpy | T>150ºC | Electricity |
| No Conventional | EGS-HDR | T>150ºC | Electricity generation |
| | Supercritical | T>300ºC | Electricity Hydrogen |

HOW DO WE TAKE ADVANTAGE OF GEOTHERMAL ENERGY WITH VERY LOW ENTHALPY?

If you look at the graph, for different times of the year, the ground temperature tends to be constant (10ºC) at 10 meters depth.




The blue color corresponds to winter (0ºC outside), and as we deepen the temperature increases, until reaching a value of 10ºC.

The color Red corresponds to the summer time (20ºC outside), where the opposite occurs. As we go deeper, the temperature drops to a value of 10ºC.

At a depth of 15 to 20 meters, it is considered that the land begins to be at a constant temperature all year round, regardless of the outside temperature, with a value slightly higher than the annual average of the surface.

Below 20 meters, the temperature increases at a rate of about 3ºC per 100 meters of depth, due to the geothermal gradient. That is to say, as it deepens, greater importance acquires the energy coming from the interior of the earth and less the one coming from the sun. However, in the first few tens of meters, the sun is a real source of energy, which not only heats the earth's crust, but also heats the entire atmosphere, and consequently the rainwater that becomes an extra supply of energy to the terrain.

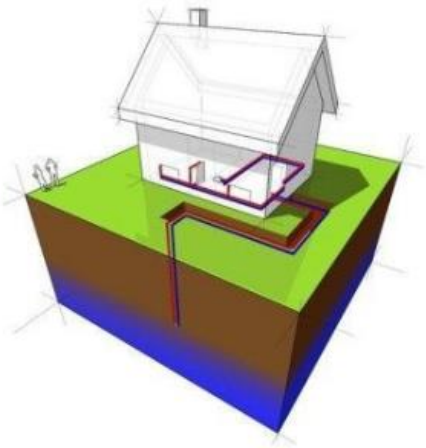
HOW DO WE CAPTURE GEOTHERMAL ENERGY?

We have an inexhaustible source of energy during all seasons. To take advantage of this energy, we need systems that allow us to capture or transfer it as a consequence of the thermal jump between the terrain and the heat transfer fluid. Also, it is possible to extract the groundwater and take advantage of its temperature. Let's see the systems for capturing geothermal energy.

VERTICAL GEOTHERMAL UPTAKE WITH GEOTHERMAL PROBES

In the event that the available surface is not sufficient to run the previous system, if there are channels in the subsoil, or if the energy demand is high, the system of geothermal probes (heat collectors) is used upright in the interior of one or several perforations, with depths that can range between 25 to 150 meters, and drilling diameters of only 10 or 15 cm.

It has the advantage that it occupies little space and provides great stability of temperatures.



VERTICAL GEOTHERMAL CAPTURE WITH PILOT PROBES

When for reasons of foundation and low resistance of the terrain, it is necessary to have piles, these elements are used for the capture of geothermal energy by integrating the probes in the reinforcements. They are called energy piles.

It has the advantage that we take advantage of necessary elements in the construction of the building, with which, it is not necessary to carry out exclusive surveys for its installation.

GEOTHERMAL UPTAKE OF LAKES OR RIVERS

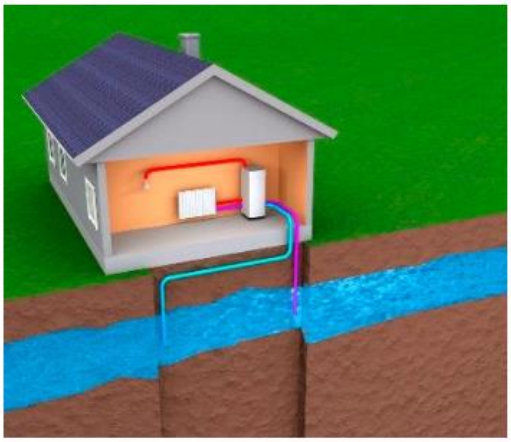
It is the most economical system, since no wells or excavations are needed. It consists of taking advantage of rivers or lakes that have hot springs at an adequate temperature, introducing directly the collectors, making the thermal exchange with the water and not with the land.

The above systems correspond

to closed circuits, in which the heat transfer fluid circulating in the pipes is not in contact with the ground, nor with the water, making a thermal exchange between them. There must be a hydraulic pump on the surface that has to overcome the pressure drop in the circuit.

Groundwater collection for geothermal energy There is an open system, which consists of the collection of groundwater. To do this, water is extracted to the heat pump and returned to another point of the subsoil in a different perforation. The hydraulic pump must have a high power to ensure a sufficient flow.

The disadvantage is that the efficiency of the system may be lower than the systems described above, due to the high electrical consumption of the pump.



WHAT APPLICATIONS DOES GEOTHERMAL ENERGY HAVE?

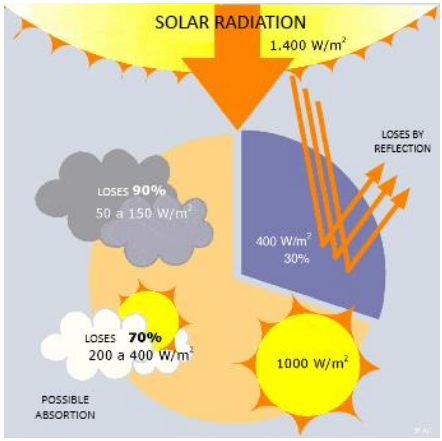
Geothermal energy with wells The applications of geothermal energy are the following:

- Small and medium power geothermal heating
- Sanitary hot water by geothermal
- Swimming pools
- Refreshing soil (In summer, reversing the cycle, we would absorb heat from the interior of the building and transfer it to the subsoil or to a swimming pool.)
- With this, the radiant floor system will act as a cooling system for the house or premises.

## 2.SUN

Almost all the available energy comes from the Sun. It is the cause of the winds, of the evaporation of surface waters, of the formation of clouds, of rains and, consequently, of waterfalls. Its heat and light are the basis of numerous chemical reactions essential for the development of plants and animals that over the centuries have produced fossil fuels such as coal or oil. The solar radiation intercepted by the Earth constitutes the main source of renewable energy within our reach. The amount of solar energy captured by the Earth annually is approximately 5.4 x 1024 J, a figure that represents 4,500 times the energy consumed.

Despite its abundance, the use of solar energy is mainly conditioned by three aspects: the intensity of the solar radiation received by the Earth, the daily and annual cycles to which it is subjected and the climatological conditions of each place. The profitable use of solar radiation as an energy source is directly linked to the geographical location of the chosen place to take advantage of it and the temporal variations. In general, the term of solar radiation refers to solar irradiation values, that is, the amount of energy received per unit area in a given time. These values usually express the energy that comes from the direct radiation of the solar disk and the diffuse radiation that, scattered by the atmosphere, comes from the rest of the sky. The proportion between direct and diffuse radiation varies according to the climatic conditions, and, on cloudy days, the diffuse radiation can be annulled.




The earth receives up to 10,000 times more solar energy than is needed for human consumption. This, in addition to showing the potential of this resource, responds to how much solar energy can be used. The reason why it is, in general, known: to generate electricity or for other uses, such as heating.

IN WHAT IS SOLAR ENERGY USED?

**Solar lighting** through solar panels for homes and businesses. This allows to improve the efficiency in the consumption of energy and reduce the costs in electricity, what in the alternative energy. Architectural trends increasingly adopt this type of lighting as the basis of sustainable design.

**Heating**. Solar heaters take advantage of the sun's energy and transform it into thermal energy by using water or air. Heating systems can be passive, use natural circulation, or active, use pumps to circulate water and generate heat.

**Transports powered by solar energy**. They are powered by photovoltaic energy. These include electric vehicles by solar panels, buses and railways. There are also roads with sunlight.

In **technology**, as solar chargers, useful for charging cell phones, tablets, computers, flashlights or other appliances that work with solar technology such as dryers, radios, lamps, among others.

## 3.AIR and WIND

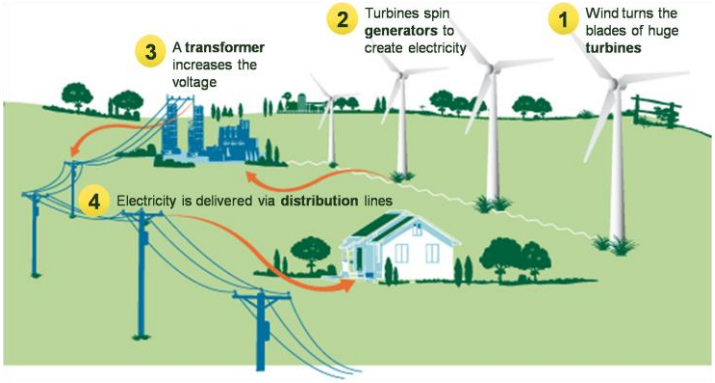
The air is a means through which it allows us to circulate the wind, ventilation, evaporation, etc. Which is crucial for certain cooling and heating systems.

Wind energy is the energy obtained from the wind. It is one of the oldest energy resources exploited by the human being and is today the most mature and efficient energy of all renewable energies. The term "aeolian" comes from the Latin "aeolicus", pertaining to or relative to Eolo, God of the winds in Greek mythology. Wind energy consists of converting the energy produced by the movement of the blades of a wind turbine driven by the wind into electrical energy.

It is important to note that wind energy does not emit toxic substances or air pollutants, which can be very harmful to the environment and human beings. Toxic substances can acidify terrestrial and aquatic ecosystems, and corrode buildings. Air pollutants can trigger heart disease, cancer and respiratory diseases such as asthma. Wind energy does not generate waste or water pollution, a very important factor considering the shortage of water. Unlike fossil fuels and nuclear power plants, wind energy has one of the lowest water consumption footprints, which makes it a key to the preservation of water resources.

### ENERGY ENVELOPE

A system of individual solar galleries is proposed for each dwelling and covered with a practicable latticework of aluminum slats; and the North facade, formed by a network of courtyards flanked by circulation corridors, protected, in turn, by the polycarbonate panels. Depending on the time of year, these thermal mattresses are activated or deactivated, generating an internal air flow. During sunny winter days, the heated air in the galleries is driven to the cold areas of the house. During the summer nights, on the contrary, the flow runs in the opposite direction, capturing and destroying fresh air from the mountains through the yards.

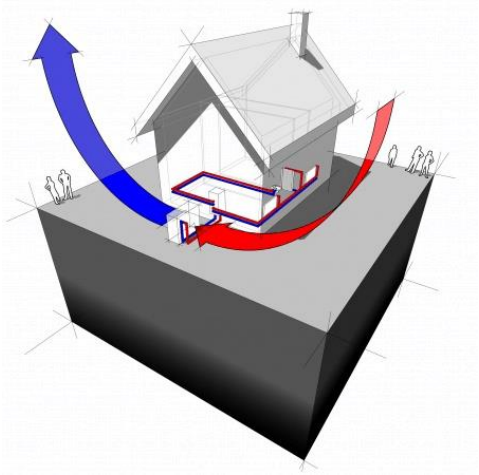



Another way of obteining energy from the wind is the Aerothermy.

### AEROTHERMY

Aerotermia is based on extracting free energy from outside air by means of a high efficiency inverter heat pump. A heat pump extracts energy from one place to transfer it to another. And for this, you need an outdoor unit, and one or more indoor units. In air conditioning or conventional air conditioning, the heat pump is used to heat or cool the air of the rooms to be air-conditioned, being generally air-air systems or direct expansion of a refrigerant.

In aerotermia systems, heat pumps are of the air-water type. The heat is extracted, or rather, the energy existing in the outside air, and is transferred to the water supplied to the heating system and / or domestic hot water. These pumps are designed and built to obtain maximum performance in severe weather conditions, both in winter and in summer.



The aerotermia systems are initially designed to be used in single-family homes, as well as small-medium buildings. It can be installed, both for existing buildings and for new buildings, which have a location for the outdoor unit (s).

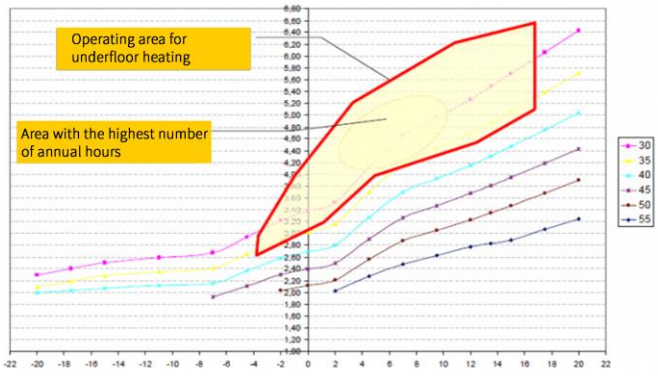
The perfect combination would be with a low temperature heating system, such as underfloor heating or efficient radiators with thermal solar panel system.

HOW IS IT POSSIBLE THAT WE GET HEAT FROM THE AIR WITH AEROTERMIA?

The answer is based on the operation of the heat pumps. The air, even at low temperatures (in winter), contains energy that is absorbed by the refrigerant circulating in the circuit between the outdoor and indoor unit.

The outdoor unit acts as an evaporator (gives cold to the environment) in winter; the indoor unit acts as a condenser, transferring the heat to the water in the heating circuit and / or domestic hot water.

Regarding the aerotherm yields, in the following graph, it is observed how the equipment performances vary according to the outside temperature and the water flow temperature setpoint.




On the vertical axis, the values of the outside temperature are represented, and on the ordinate axis the value of the COP (Coefficient Of Performance). As the water flow temperature and more outside temperature decrease, the COP increases.

We can indicate that you can achieve savings of up to 50-55% with underfloor heating installations, and up to 15-20% in heating radiators, with respect to a conventional boiler system with diesel and in the most favorable cases.

Some advantages of this energy are:

- High efficiency and lower operating costs.
- Simple installation.
- Maximum savings with low temperature heating systems (underfloor heating, low temperature radiators).
- Adaptable to existing installations.
- You can get cold (refreshing) in Summer, with the inversion of the cycle.
- Clean energy. Low CO2 emissions.

And some disadvantages to take on count:

- Higher initial investment compared to a conventional system.
- Location of outdoor unit (aesthetics, noise ..).

## APPLICATION IN BUILDINGS OF RENEWAL ENERGIES

After talking about the renewal energies, we are going to pose how to applicate them in the system of the buildings and some examples in real life os this application.

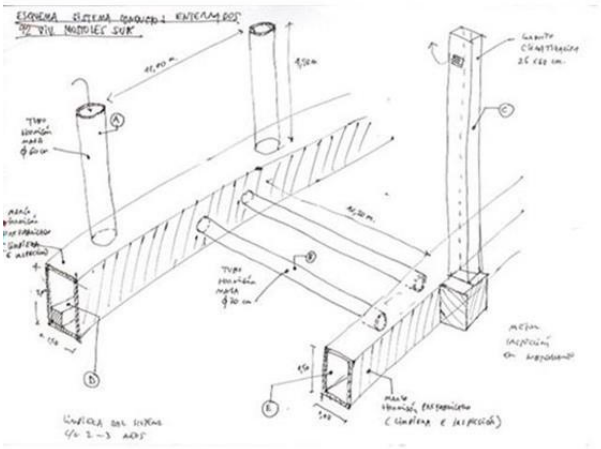
## GEOTHERMIA

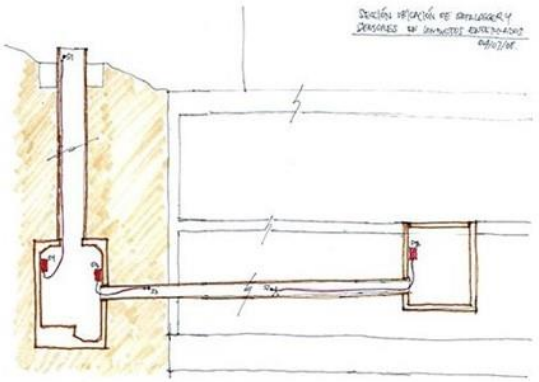
### 3.1.1 AIR / GROUND EXCHANGER

These systems take advantage of the thermal stability of the ground (whose temperature approaches the annual average temperature) to pre-treat (cooling or heating) the outside air and introduce it into the building by means of natural draft or mechanical support. The potential for use consists of the damping of the marked sinusoid of summer and winter temperatures by incorporating a renewal temperature at a substantially constant temperature throughout the year, resulting in substantial energy savings.

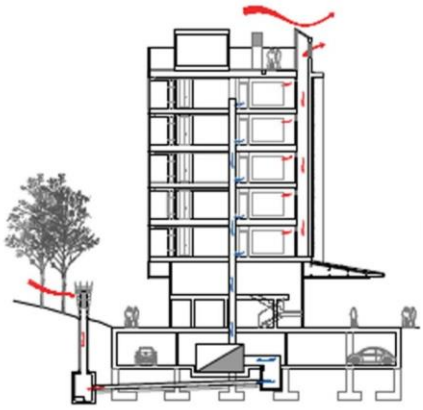
A heat pump is used, which is a thermal machine that allows energy to be transferred in the form of heat from one environment to another as required. Its operation is very similar to a traditional air conditioner that works for cold or heating. The subsoil is usually at a neutral temperature throughout the year (cooler in summer than air and more temperate in winter), so that the Heat pump performance is very high as it needs less work to perform the energy transfer.

An architecture studio called Ruíz Larrea put into practice this system ina building so here are their schemes and images of the construction of it.

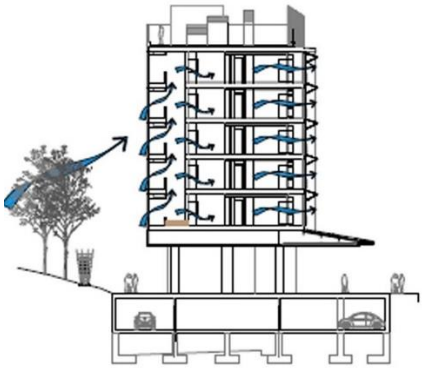




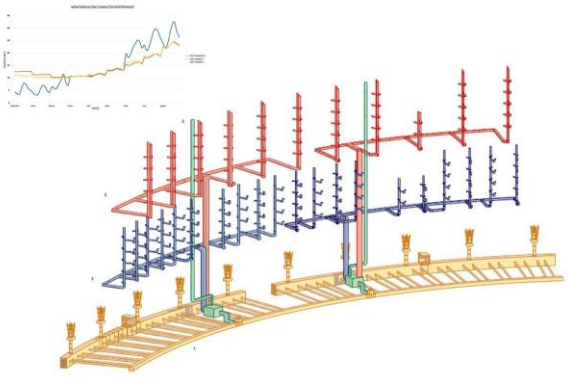
How the warm air enter in the building and go out.



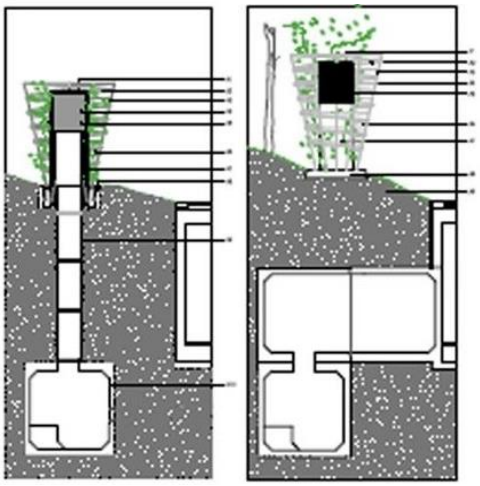
And then, the cold air circuit.



This is the axonometry scheme of the system installation of this geothermal method.



Detail of the conduit that extracts heat from the earth and conducts it.



## SUN

### 3.2.1 PHOTOVOLTAIC PANEL

A photovoltaic panel is a type of solar panel designed for the use of photovoltaic solar energy. Its function is to transform solar energy into electricity. The photovoltaic modules are formed by a set of photovoltaic cells interconnected between them. The photovoltaic cells that make up a photovoltaic panel are embedded and protected. The photovoltaic panel is in charge of directly transforming the energy of solar radiation into electricity, in the form of direct current.

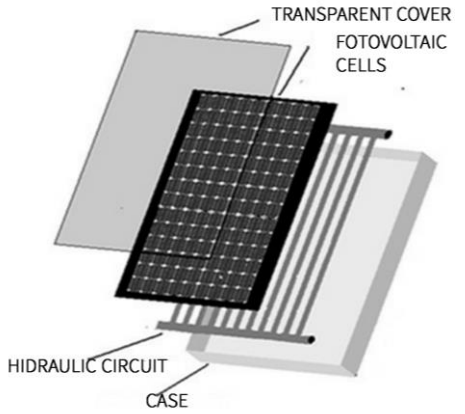
Photovoltaic panels produce electricity in the form of direct current and usually have between 20 and 40 solar cells. In any case, it is usual for the modules to consist of 36 cells to reach the volts needed to charge the batteries (12 V).

Photovoltaic solar panels can be joined together in two ways:

Connection in parallel. This type of connection is made with a union of the positive poles and, on the other hand, of the negative poles. The parallel connection between the solar panels provides a voltage equal to that of the module (12-18 V)

Connection in series. The way to connect in series two or more photovoltaic panels is connecting positive pole of the first with negative of the second and successively. The series connection gives a voltage equal to the sum of each module (for example 12 V, 24 V, 36 V, etc.), depending on the number of interconnected plates.

It is advisable to use materials that have good mechanical properties, as well as great durability, taking into account the long service life of the facilities. Normally, the support elements are: Anodized aluminum (light weight and high strength), galvanized iron (suitable for heavy loads) or stainless steel (for very corrosive environments, it is the highest quality and highest price).




### 3.2.2 SOLAR CHIMNEY

The chimney effect is the tendency of a fluid to rise when heated, due to the decrease in its density. This natural thermal phenomenon is used to evacuate the overheating inside a construction, facilitating the exit of hot air through the openings located in the upper part. This thermal impulse can induce a depression capable of sucking cooler air through the lower part.

#### PERFORMANCE

The operation of a solar chimney consists of creating air currents by the different densities of the air according to its temperature. These are the ones that create the natural ventilation of our homes since they renew the air inside and refresh it.

During the daylight hours, the solar energy heats the chimney and causes the masses of hot air to move upwards. This process occurs because the hot air is less dense than the cold, so it tends to rise.

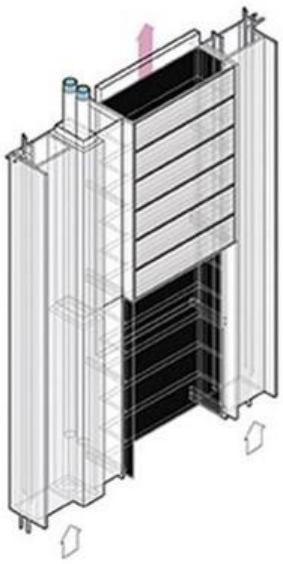
When this air comes out, its space is occupied by the air below, which will begin to warm up. Also, there is a series of renovation slits through which air from outside will enter.

The dimensions of the solar chimney, that is to say, the width of the vertical axis or the height are important since they are directly related to the amount of air that is heated and therefore the volume of air that renews. Other design elements in which we have to fix are the location and orientation of the solar chimney, the thermal characteristics of the house, among others.

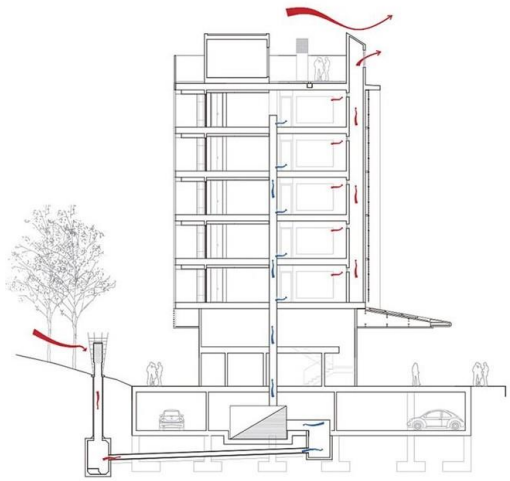
Also, currently, there is the possibility of incorporating a solar panel to the fireplace. This helps to increase the temperature in the highest part of the chimney and therefore to make the air renewal easier. In addition, this method can heat our homes in winter naturally if we close the opening on the outside of the chimney.

The solar chimney consists of a first skin of polycarbonate enclosure and a second skin of black slate able to store the accumulated heat and give it to the houses when there is no radiation but a demand for heating.

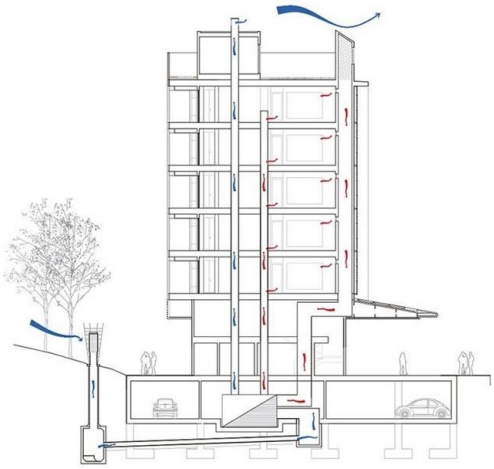
Here is the axonometry of this concept:



The scheme of a solar chimney in a building, first the warm air:

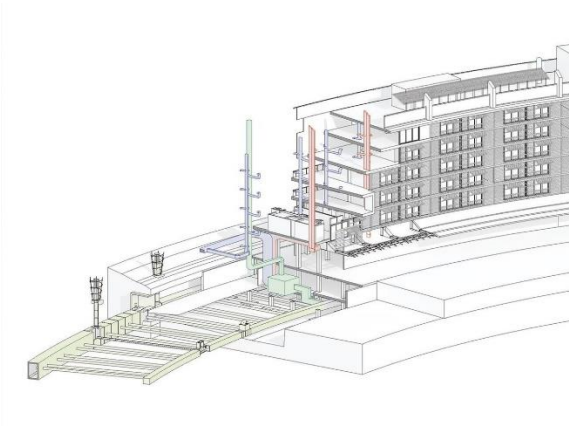


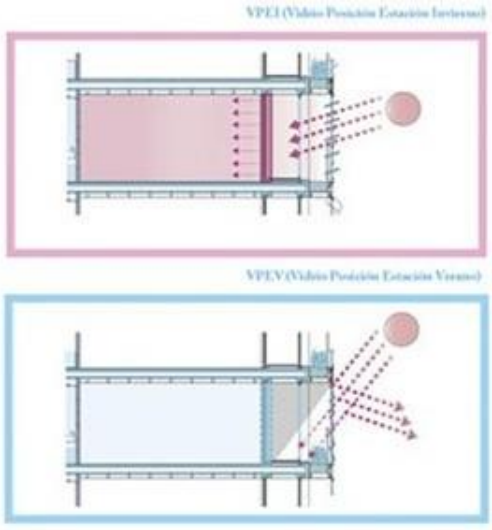
A second scheme of cold air circuit:



The real exterior apparience of one solar chimneys are like this photo below:

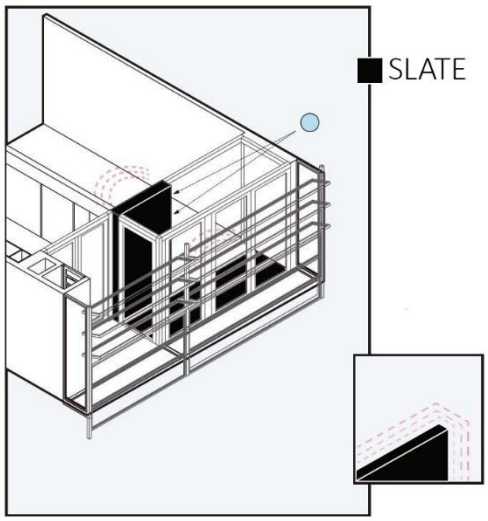
How it is integrated in a real Project in the interior system, how it will work and the apparience of it in a schematic drawing.





### 3.2.3 RADIATOR INERTIA WALL

A wall of radiating inertia is proposed, capable of accumulating the received solar radiation and yielding it in the form of heat. Covered with slate, a dark material and collector, this element is in the summer self-shaded by the gallery's own configuration. In addition, this wall becomes a thermal emitter when connected to the air-water heat pump, and can function if needed as an active heating element.




This idea is implemented in the Madrid 0,0 project of the mentioned above architects, Ruíz Larrea. Which it is a proyect with almost zero consumption.

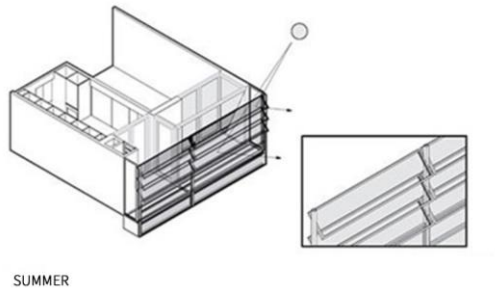
The exterior facade as a resut of this integrated Wall:

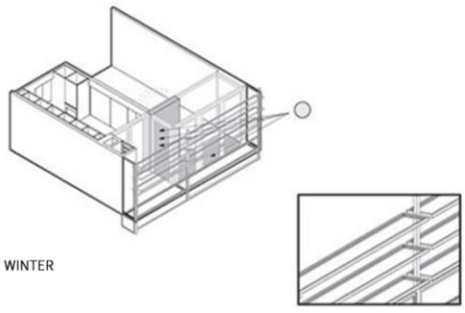
## AIR/WIND

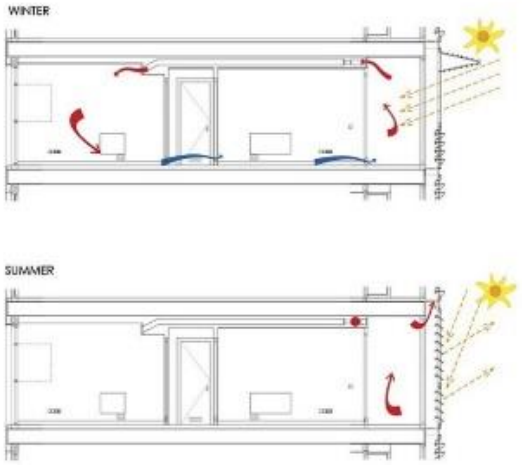
### 3.3.1CLIMATIC GALLERY

The gallery is a natural complement to conventional heating systems. During the winter, the incident radiation raises the interior temperature of the air by greenhouse effect. This volume of air can be taken through a top grid and be driven by a small fan connected to a thermostat to the colder parts of the house or operate passively. The arrangement of the grilles and the aerators integrated in the walls and the carpentry favors the convective movement of the air inside the house. During the summer, the fan shuts off, the grille closes and the gallery can be externally ventilated.

This is the operation of the climatic gallery in the two seasons: summer and winter.



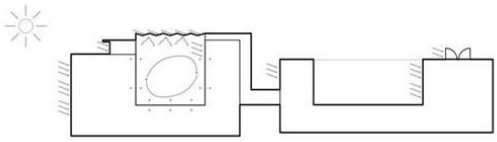

And the real apparience of it in a proyect:

### 3.3.2 COOLING COURTYARD

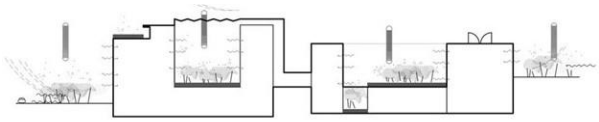
The Cooling Courtyard allow the capture, cooling and distribution of favorable prevailing winds within the building. They are constituted by lattices, garden areas, sheets of water and active systems of evaporative cooling.

Extracted from the bioclimatic functioning of the Andalusian courtyards as evaporative organs, sanctioned by the architectural tradition, they overlap in height as a sectional projection of any historical fabric of the Andalusian capital in its urban plan.

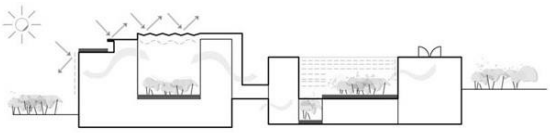
Solar capture, use of the greenhouse effect.



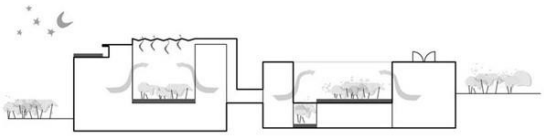
Evaporative envelope by vegetation.



Natural ventilation.



Night ventilation



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