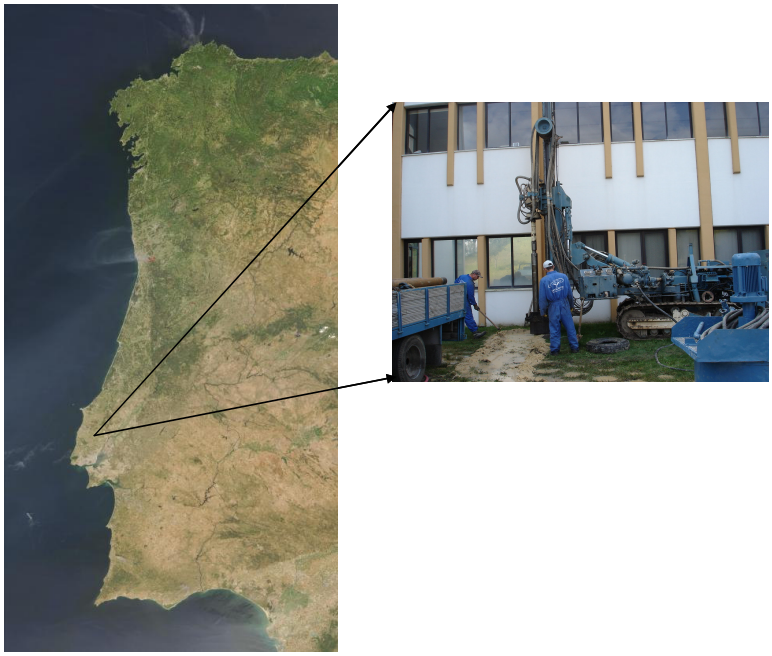
IGEIA
Integration of Geothermal Energy into Industrial Applications



MARKET REPORT ON THE GEOTHERMAL APPLICATIONS POTENTIAL IN THE PORTUGUESE INDUSTRY

With the support of :

Intelligent Energy Europe

June 2007

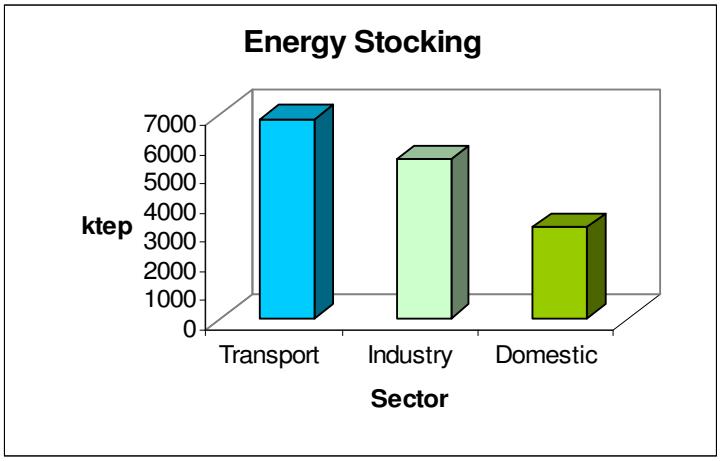
Escola Superior de Tecnologia de Setúbal
Campus do IPS, Estefanilha
2910-761 Setúbal - Portugal
Tel. 351 265 790 000 – Fax. 351 265 721 869
www.estsetubal.ips.pt

Escola Superior Tecnologia SETÚBAL

Table of contents

1) Definition, concept

In Portugal there are three main sectors which consume a lot of the energy: The transportation sector, the industry sector and the domestic sector.



Source: DGEG, 2004

Figure 1 – Energy Stocking

In the industry sector, the two main groups to consume more energy are, according with the International Standard Industrial Classification, the Mining and Quarrying group and the Manufacturing group.

In deed, these two groups are the main goals for the geothermal applications. Some examples of industries that belong to these groups are the Chemical and Plastics Products industries as well the Manufacture of food products.

2) Legal and technical conditions for geothermal applications

Since 1990 that the Portuguese law has define the geothermal resources as a great energy potential for the country: laws 87/90 and 90/90.

In Azores Island, there has been a geothermal power plant since 1980 - Pico Vermelho Power plant - with an initial capacity of 3 MW. This geothermal power plant has been working with boreholes from 800 to 2000 meters deep and with temperatures above 200 Celsius degrees. And in 1994 a second geothermal power plant in S. Miguel Island (Azores) – Ribeira Grande Power plant - started to work with a capacity of 13MW.

In 2006 this two power plant were improve and the first power plant have now more than 8 MW of capacity.

Since 2000 to 2007, in another island of Azores – Terceira Island - was built another geothermal power plant with a capacity of 12 MW. This power plant has two boreholes. The first one has 400 meters deep and a temperature of 180 Celsius degrees. And a second one with a depth of 600 meters and it can achieve temperature of 220 Celsius degrees.

Once these geothermal power plants can achieve temperatures above the 150 Celsius Degrees, they can produce electricity and there for are called High Enthalpy systems. In this case Portugal has been using his geothermal potential for a long time.

However, despite this fact, the low enthalpy systems are now taking the first steps, with the objective to increase the renewable energies use and to decrease the energetic bill.

Until a few years back, the geothermal resources were only used for bathing therapies, but now we have observed a grow interest in projects and studies which have the objective of using the geothermal energy to heat all kinds of buildings.

Between 2005 and 2015 we expect a significant growth in geothermal resources use.

The Geothermal Source Heat Pumps (GSHP) is an example for the use geothermal energy.

A heat pump is a machine which causes the heat to flow in a direction opposite to its natural tendency or “uphill” in terms of temperature.

One of the most important characteristics of heat pumps, particularly in the context of home heating/cooling, is the efficiency of the unit and the energy required to operate it, which is directly related to the temperatures between which it operates.

When the difference between the temperature from the source and the temperature from the sink enlarge, the power input required by the heat pump increases.

The Ground Source Heat Pump retrieves heat from relatively warm soil in the winter and delivers heat to the same relatively cool soil in the summer.

As a result, GSHP regardless of the season, is always pumping the heat over a shorter temperature distance, which leads to higher efficiency and lower energy use.

The GSHP use the moderate and constant value of the ground temperature along the year, to supply heating in an efficient way, cooling and hot water for the buildings, in a friendly environmental process.

Some of its characteristics are:

- Is a secure and approved technology;
- Reduce the heating and cooling cost in 25-75%;
- Reduce the CO2 emissions;
- Increased the life cycle of the building;
- Supply high quality interior comfort;
- Protect the environmental;
- Promote the energetic sustain development.

The ground heat exchanger (GHE) is use for extraction or injection of heat from/into the ground.

These systems consist of a sealed loop of pipes, bury in the ground and connected to a heat pump through which water/antifreeze is circulated.

The GSHP systems require a certain plot of ground for installing the GHEs, which often becomes a significant restriction against their applications in densely populated cities and towns. However it can be implementing in the ground under the building, for new constructions.

The vertical GHE is the most popular design of GSHP systems currently install, since it requires less ground area than the horizontal trench systems.

For vertical boreholes, there are two possible basic concepts for it: U-pipes and Coaxial pipes.

For the borehole drilling it is necessary to have in mind the following considerations:

- Available Area on Site
- Geological Conditions
- Site Utilities

- Installation Noise
- Proximity to building
- Future building expansions

Also, these boreholes should be separated by certain distances to ensure long term operation of the system.

As it was said before, the low enthalpy systems are beginning, there for, it doesn't exist any specific Portuguese legislation for vertical closed loops, including drilling and ground heat exchangers installation.

3) Potential by Country / Climatic Region

Portugal is a country located in the South-West of Europe, with the following coordinates: 39º30 North, 8º West. Is territory is divided by the Tejo river. At North the view is mountainous and as we follow to the South the view became plain with a few mountain ranges.

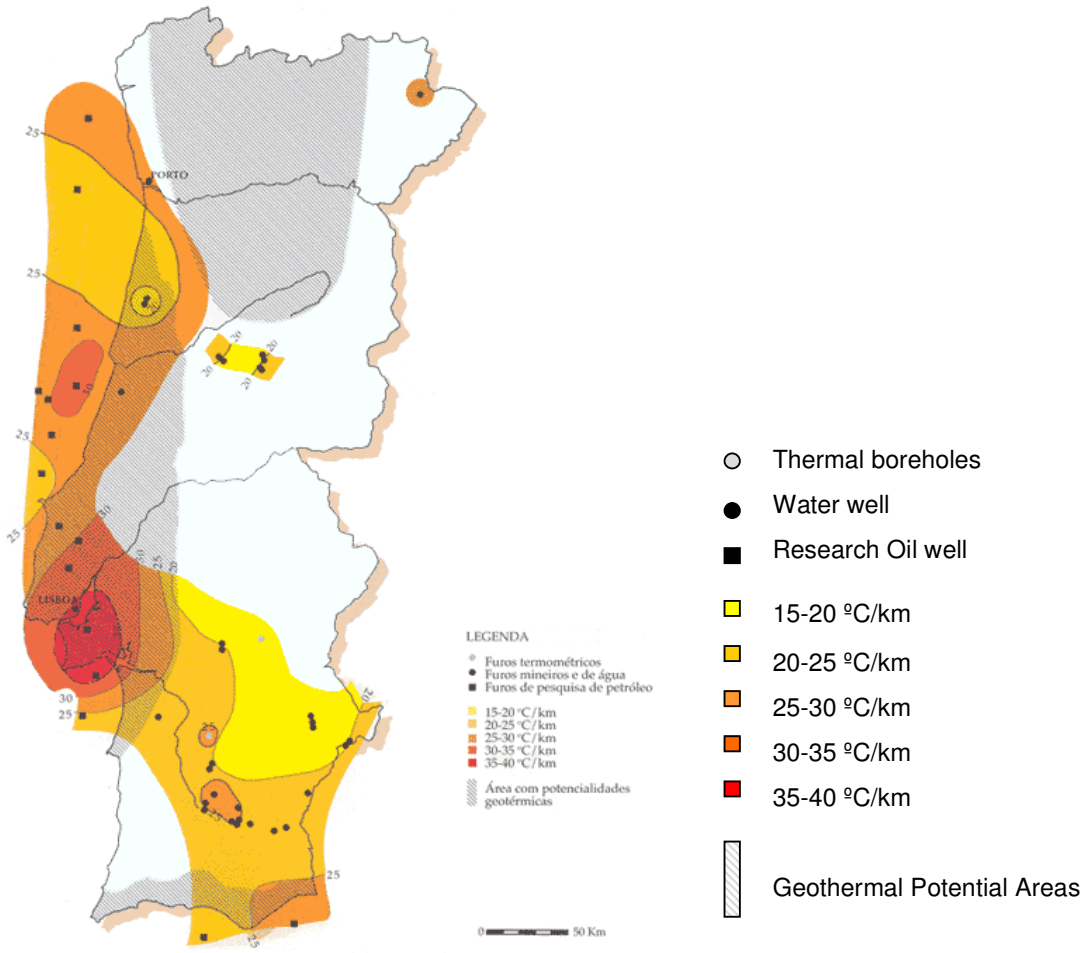
Portugal makes frontier only with Spain and it is limited by the Atlantic Ocean. The Azores and Madeira Island belong to Portugal territory.

Regarding to the geothermal issue, Portugal has a complex and diversified geology which allows taking advantages of the energy that come from the soil. This can be use in two ways:

- The development of thermal polo's with temperature between 20 and 76ºC, such as the Chaves bathhouse which use the underground water to heat the water for the swimming pool using a heat exchanger.

- Or, the use of aquifers such as the one that is being use by Air Force hospital, in Lisbon for building heat, with a well of 1500m deep.

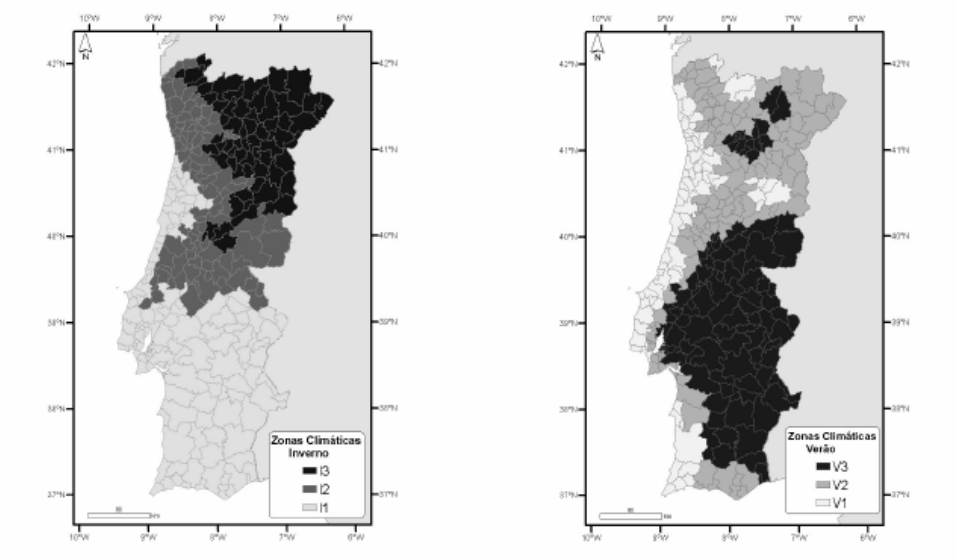
In the following image you can observe the areas with geothermal potential in Portugal (except the Azores and Madeira Islands).



Source : INETI, 2006

Figure 2 – Geothermal Potential Areas in Portugal

Portugal clime is influence by the relief, latitude and proximity to the sea, which can provide soft winters, especially in the South of the country. At North the winter are colder and it snows at the highest point of the Portugal. The summers are hot and dry at North, and moderate at South. The average temperature is 13ºC in North and 18ºC in South. However, The Portuguese climate is dividing by regions which have special features. Both Summer and Winter have three zones. However in the Summer this zones are divided North zones and South zones, so in total we have 6 zones for Summer.



Source: RCCTE (Portugal Legislation – 80/06)

Figure 3 – Climate zones of Portugal

The first Portuguese map represents the winter zones. They have I1 which is the softer winter to I3 which is the hardest winter. The same happens with the second map, which represents the summer zones. V1 is the softer summer and V3 is the hardest summer.

The next few tables, represent some maximum limits for cooling (Summer) and heating (Winter) for residences and small buildings.

Table 1 – Maximum limits for cooling (Summer Zones)

Zone	**KWh/m2.year**
V1 (North)	16
V1 (South)	22
V2 (North)	18
V2 (South)	32
V3 (North)	26
V3 (South)	32

Source: RCCTE (Portugal Legislation – 80/06)

For the heating values it is necessary do consider a building geometry form factor (FF) equal to 1 and some characteristic for locals in different winter zones (day degrees). Once these characteristics are established, the maximum values for heating are calculated trough the following expression:

$$Ni = 4{,}5 + (0{,}021 + 0{,}037 \times 1) \times DD$$

Table 2 – Maximum limits for Heating (Winter Zones)

Zone	**Heating-day Degrees (DD)**	**KWh/m2.year**
I1	1490	90,92
I2	1630	99,04
I3	2430	145,44

Source: RCCTE (Portugal Legislation – 80/06)

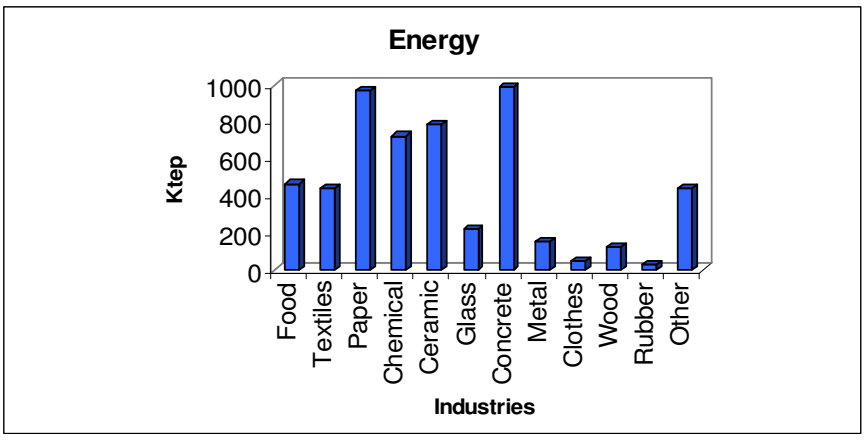
In Portugal, every study about the energetic consumption has in mind every sector that spends energy and all the types of energy that exist to guaranty all economic activities. In the industry sector the main industries which are considered in those studies are the following:

- Food Manufacturing
- Textiles Manufacturing
- Paper Manufacturing
- Chemical and Plastic Manufacturing
- Glass
- Concrete
- Metal Manufacturing
- Clothes Manufacturing
- Wood Manufacturing
- Rubber
- Others

However, despite the fact that some sectors may not be considered as industry sector, they are big consumers of energy. Such sectors are:

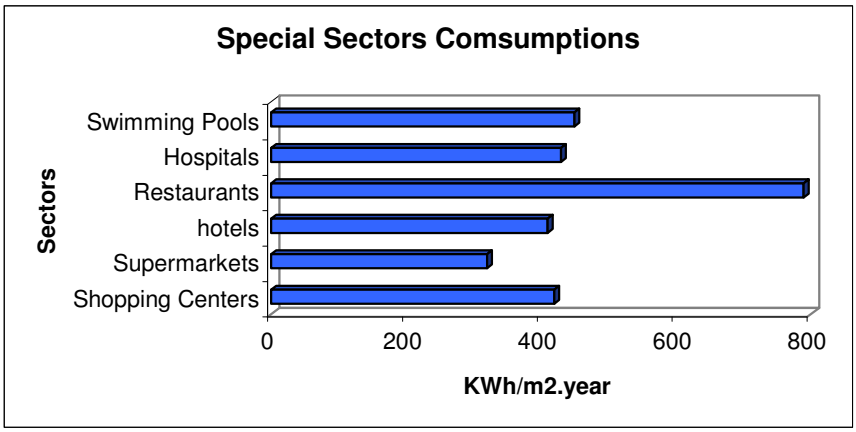
- Hotels
- Restaurants
- Shopping Centers
- Supermarkets
- Swimming Pools
- Hospitals

In the following image we can see the total energy consumption for each industry describe above, regarding to the year 2004.



Source: DGEG, 2004

Figure 4 – Energy Consumption by Industrial Sector



Source: DGE, 1994

Figure 5 – Energy Consumption by special sector

Despite de fact that this information has more than ten years, few things have been done to change these values. In this case we can take these sectors to work as industries and introduce the geothermal energy to reduce the energy consumption.

4) Sectors Selection

To decide which of the industries can be the main target to apply the geothermal energy, we need to consider the energy consumption as well to define which one's are consuming a lot of non-renewable energy.

As we can see from the figure 4, the main industries that consume a large quantity of energy are the Paper Industries, Chemical and Plastic Industries, Ceramic and Concrete Manufacturing. However the Paper sector is consuming more of renewable energy, so our main targets are:

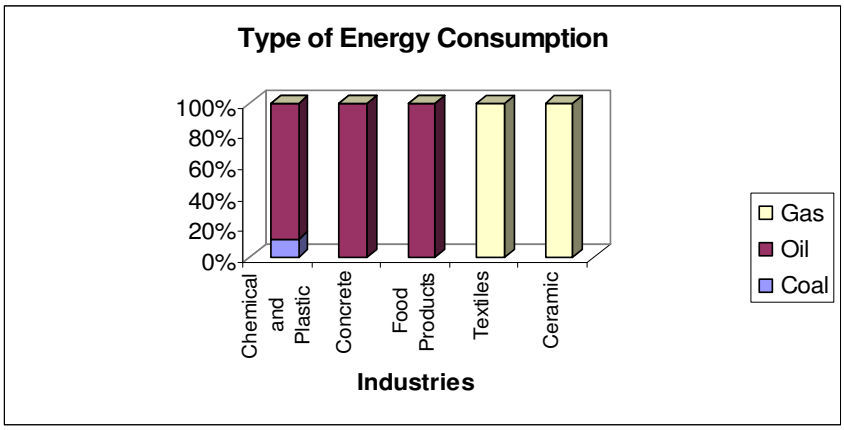
- Chemical and Plastic manufacture

- Manufacture of Food Products

- Textiles Manufacture

- Ceramic Manufacture

- Concrete



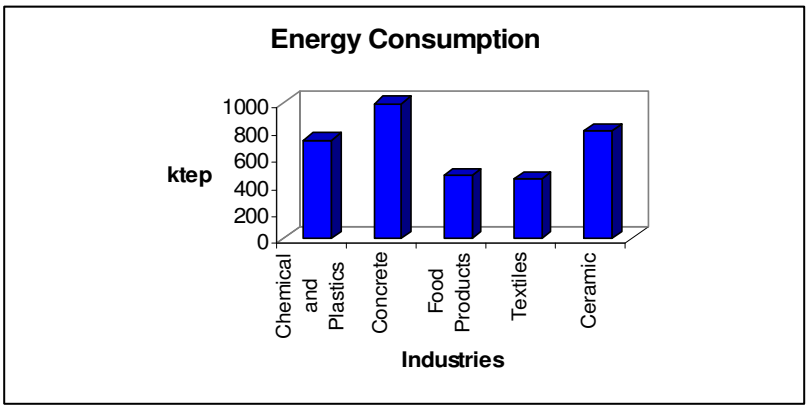
Source: DGEG, 2004

Figure 6 – Energy consumption by fuel type

Regarding to the sector of Food Products we can associate the restaurants, since they are a special sector that presents a large consume of energy.

5) Study sector by sector

As we can see in the following figure, the major industries that need a large supply of energy are the concrete and ceramic industries. Their consumption can achieve the 800 ktep per year.



Source: DGEG, 2004

Figure 7 – Energy Consumption by Industrial Sector

Although the Food Products Sector is not the one consuming more energy (of the five selected), it is important to analyse this sector since restaurants and supermarkets may be incorporated in this industry sector.

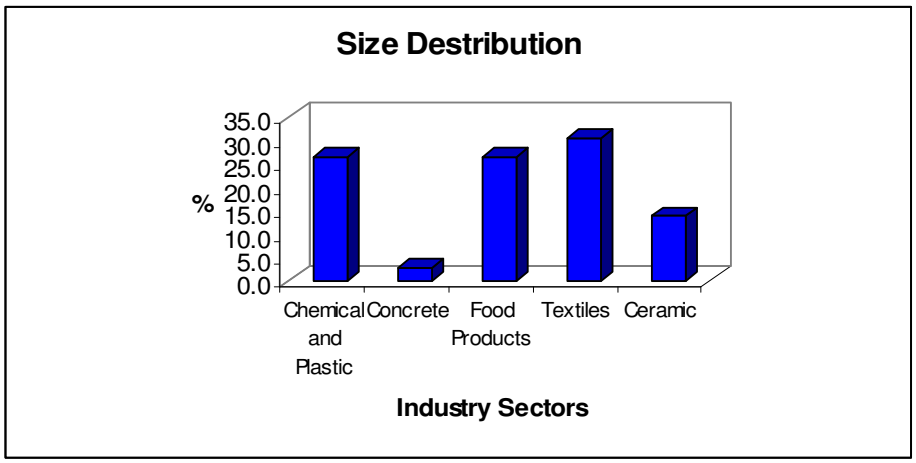


Figure 8 – Number of Entities for Industry

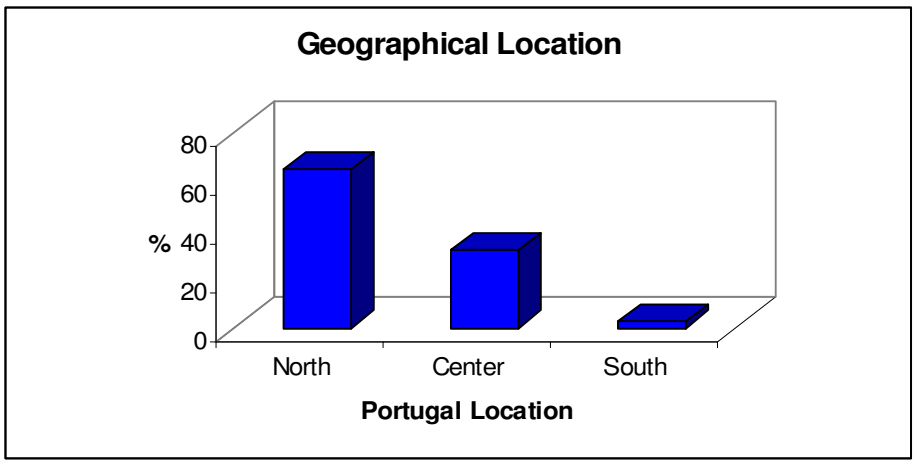


Figure 9 – Industry Geographical Distribution

Unfortunately, it is not easy to determine the right location of all industries from the selected sectors. But it is known that the North of Portugal is a quite industrial zone which is why it presents the large percentage of industries locations.

Regarding to the number of entities, the food sector is one of the three industrial sectors which have more companies.

Each industrial sector, before presented, have specific characteristic that need to be analyse in detail. That kind of study will be present on another report from D15 of IGEIA project. However it is possible to give examples of special sectors where the geothermal energy would satisfy the energetic needs. For example a four star Hotel in Madeira Island which have Swimming pool, 400 rooms and an useful area of 14000 m^2. The swimming Pool consume 180 310 kWh/year of electricity for the HVAC system and 190 000 KWh/year of gas for heating the water. This Hotel has others consumption such as:

- Air Cooling (900 000 kWh/year of electricity)
- Air Heating (32 600 kWh/year of gas, 37 900 kWh/year of electricity)
- Hot Water (320 000 kWh/year of gas)
- Circulation Pumps and fans coil (129 000 kWh/year of electricity)

- Illumination (741 800 kWh/year of electricity)
- Car Park (97 790 kWh/year of electricity)
- Laundry (5 380 kWh/year of electricity)
- Kitchen (13 386 kWh/year of electricity)
- Other equipments (572 800 kWh/year of electricity)

The Geothermal Heat Pumps could satisfy the energetic needs for this Hotel in some sections. For example: the swimming pool water heating; the air heating and cooling and the hot water with high efficiency.

Other example can be a supermarket with a useful area of 10 000 m^2. It has the following electrical consumptions:

- Illumination (1 239 000 KWh/year)
- Industrial Cool (1 239 000 KWh/year)
- Ventilation (206 500 KWh/year)
- Air Heating (413 000 KWh/year)
- Air Cooling (619 500 KWh/year)
- Others (413 000 KWh/year)

Once again the geothermal heat Pump can satisfy the necessities from the air heating and cooling and part of the industrial cooling.

6) Main Conclusions

Portugal is starting in geothermal energy when regarding to low enthalpy systems. However, because it has a strong geothermal potential, it can be a strong point to Ground Source Heat Pumps implementation. We are just starting and there are a large number of industries and special buildings where the geothermal energy can be apply for heating and cooling.