Geothermal energy is not a new type of energy. It is the third most important renewable energy source after hydroelectric and biomass, and has been used industrially in some parts of the world for more than a century. It has attracted increased interest in recent years, and has become a serious rival of solar energy.

**Photo of the Earth’s interior:**

- **Low temperature (1 to 60°C):** This temperature is suitable for low-temperature heat pumps, which are used for water heating or space heating. Examples of such areas include Iceland and Iceland.

- **Medium temperature (60 to 150°C):** This temperature is suitable for mid-temperature heat pumps and direct use of hot water. Examples include Iceland and Iceland.

- **High temperature (150 to 350°C):** This temperature is suitable for geothermal power plants. Examples include Iceland and Iceland.

- **Very high temperature (350°C and above):** This temperature is suitable for direct use of hot water or steam. Examples include Iceland and Iceland.

**Geothermal energy is not a new type of energy. It is the third most important renewable energy source after hydroelectric and biomass, and has been used industrially in some parts of the world for more than a century. It has attracted increased interest in recent years, and has become a serious rival of solar energy.**

The purpose of a geothermal facility is to extract this energy stored in the heart of the earth, and to use it for heating or to produce electricity from the steam generated. However, this heat can only be extracted if underground geological formations are permeable or cracked, so that hot water can rise to the surface. In some cases, rock discontinuities enable hot water to surge through cracks at tens of thousands of liters per hour in a thermal spring. There are many sites of this type in France, particularly in Chaudes-Aigues, Southern Auvergne (in the Cantal Department), where water surges out at 82°C. It is the hottest spring in Europe. Clearly, the difficulties in harnessing geothermal heat vary depending on the geological context and depth. Some regions are more favorable than others, and it is no exaggeration to say that there are deposits of geothermal energy in the same way as there are oil deposits. Hot water can be found almost everywhere, provided that we drill far enough. But it is obviously better to search for the best sites, where hot water is sufficient for use.
Prospecting and drilling

The difficulties

It is not enough to drill a well anywhere and hope to find a layer of hot sediment. Sedimentary basins are the best areas, but precise prospecting is necessary even within these areas. Considering the high cost of wells, it is important not to get it wrong, or at least to make the fewest possible mistakes.

**GEOTHERMAL COUPLE**

A system composed of a “rising” main well (through which ground water is pumped up) and a “descending” well at a distance from the main well through which water is reinjected. These couple are necessary when the geothermal hot water is not pure, to transfer heat from geothermal hot water to a secondary heating circuit without any mixing between the two circuits. Another advantage of the couple technique is that it maintains the pressure in the deposit, thus avoiding settlement of geological layers.

**HEAT PUMP**

Technique used when the temperature is too low for direct use in heating. Principle: heat is transferred to a fluid with a low boiling point (example ammonia) that acts as an intermediary. It warms up, and transfers its heat to a water circuit.

**GEOTHERMAL GRADIENT**

Recorded temperature increase for an increase in depth of 1 km. The average value of this gradient is about 32°C, which is about 1°C increase in temperature every 30m. This temperature increase can easily be observed when going down into mines. In volcanic areas, the gradient can exceed 100°C/km.

**GEOTHERMY**

Epithetically: from ancient *therme* (Heat) and “therm” (Heat). Geothermy is heat from deep in the earth.

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**Main geothermal sources in the world**

![Map of geothermal sources in the world](image)

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**GEOTHERMAL HEATING IN FRANCE**

Geothermy is used in France for heating and cooling. But all the projects are pilot projects, and France is considered a pioneer in Europe. The only European country that makes greater use of geothermal energy is Iceland, where the capital, Reykjavik, is 82% heated by geothermal.

The contribution of geothermy to French energy production is far greater than solar and wind generated energy, and production is now at 200,000 tons of oil equivalent per year. Geothermy accounts for 10% of the energy supplied through urban heat generation networks and 0.4% of the global energy consumption. Geothermy in France increased dramatically between 1980 and 1985, after the first project that was built in 1989. It supplied heating for 3,000 dwellings in a district of Melun (large town in the Seine-et-Marne department) from a water table at 30°C.

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**GEOGRAPHY**

Epidemiologically: from ancient *therme* (Heat) and “therm” (Heat). Geothermy is heat from deep in the earth.

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**ZOOM**

**BRGM**

Bureau de Recherches Géologiques et Minières (Geological Mining Research Bureau)

This BRGM is represented in more than 40 different countries, and works on behalf of governments, government-owned companies, industries and international finance organizations. It is involved in all aspects of earth sciences and its activities include studies, institutional support, engineering assistance, training and technology transfer programs.

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**If we drill far enough, we will find either oil or hot water.**

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**EXPERT OPINION**

How do you fight corrosion? Corrosion was a very serious problem with early projects, but the problem is now perfectly controlled by injecting a chemical that prevents the development of bacteria that create corrosive sulfites. It is an in-depth treatment that needs to be carried out continuously. Provided that the treatment is not interrupted, tubes will not be corroded from the inside and can be used for at least 30 years. All that is necessary is to clean them, like a chimney needs cleaning regularly.
Other large geothermal facilities then flourished in the Paris region, with ground water at a higher temperature (between 70 and 85°C). No fewer than 74 drillings were made in 1986, including 54 in the Paris Basin, 15 in the Aquitaine Basin and 5 in other regions. At the moment, 34 couples (see “Word for word”) are still in operation in the Paris region, supplying an energy equivalent to more than 90,000 TOE (tons of oil equivalent), or 10% of the energy distributed in heating networks in the Paris region, sufficient to heat 150,000 homes. One large French project is the Maison de la Radio in Paris. This building comprises 100,000m² of offices and studios that have partially been heated by water at 27°C, drawn from a depth of slightly less than 600 meters, ever since 1963. This water is then disposed off in the city sewers, after being cooled to 7°C. It is estimated that there are 6 MTOE per year of usable “geothermal reserves” in France, but the energy drawn from existing facilities in the year 2000 was no more than 0.117 MTOE, which is only 2% of the country’s potential. In other words, there is room for a great deal of expansion in this sector. However so far, geothermal heat has only been used in locations in which hot water was found, which is a severe limitation. If we want to develop geothermal energy in the future, we need to find ways to increase the number of attractive areas.

The hot dry rocks technique

Specialists are expecting a great deal from the new “hot dry rocks technique”. Its advantage is that it can use heat from rocks without the presence of a hot aquifer. The method consists of fracturing rocks between two boreholes and pumping in cold water from the surface, to heat it as it comes into contact with deep rocks. The largest full-scale experiment carried out in the world so far is at Soultz-sous-Forêts in Northern Alsace, which was built in 1987 (there is one equivalent Swiss project under way close to Basel, and another in El Salvador). Water is pumped through an injection well into the network of granite fractures at a depth of 3,600m, and recovered through a second well 450m from the first well with zero losses after being heated at 142°C. The results of the Soultz experiment are so good that an industrial consortium has been created composed of EDF (Electricité de France), Edis (Electricité de Strasbourg), the electricity generating companies Pfalzwerke (Germany) and Enel Green Power (Italy), and Shell International (Netherlands). The German company Bostec is responsible for management. The research stage is now complete. The French and German authorities that financed the project have begun the industrial electricity production phase by giving the green light to drill the wells for a first power station with a power of 6 MW, sufficient for the consumption of a town with 25,000 inhabitants. This industrial prototype should be commissioned by 2006 at an estimated cost of 44 million euros. Eighty percent of this amount will be provided by French, German and European public financing for the first phase. In France, other sites with a caloric potential of more than 180°C at a depth of 5,000m have been identified in the Languedoc-Roussillon region and in the Massif Central. Similar energy reserves have also been identified in the Balkans and in Turkey.

A high potential for development

The worldwide geothermal potential available using this “hot dry rocks technique” is large and is estimated at 15 million TOE per km², to a depth of 10 km. The Soultz experiment suggests that this new type of geothermal energy could be developed starting from 2030, beginning with areas with a high geothermal gradient. Pascal Vix, Engineer at Electricité de Strasbourg and co-manager of the European Joint Venture that supervised and coordinated the Soultz project, is firmly optimistic. “According to expert estimates, the Earth’s temperature at a depth of 40km is 1,000°C. Therefore we live on an almost limitless stock of energy. All we need to do is to discover how to harness it”. Another expanding application is called “surface geothermy”, and uses heat pumps. This makes use of the least visible fraction of geothermal energy, and can be used to heat or air condition small buildings. These heat pumps open up new opportunities, and are feasible almost anywhere. The technique consists of drilling a pair of wells to a depth of about 100m, so that a heat exchanger composed of polyethylene tubes can be inserted. The fluid that circulates in these tubes collects heat from the rock to supply a heat pump on the surface. This system has been widely developed in Switzerland, where there are not less than 60,000 installations that now generate 440GWh. There are 40,000 in Germany and Austria, 100,000 in Sweden and the United States is planning to build 400,000. The next objective is to evaluate the political intentions of other countries in this respect, at a time when the trend is toward an “energy mix”, and to increase the percentage of renewable energies in the world energy bank. The Franco-German experiment carried out in Alsace is opening up new prospects for geothermal energy, which had been expected to remain restricted to very local areas considering the geographical conditions necessary for the production of electricity (use at high temperatures). However, we will have to wait until the pilot plant is commissioned before we can make a good evaluation of the possibilities of worldwide construction of this new technology, and particularly the economic conditions for this type of use.

**ADVANTAGES OF GEOTHERMAL ENERGY**

1. It is a reliable energy and viable with time since it does not depend on atmospheric or climatic conditions.
2. It respects the environment, and has little or no effect on it. It generates almost no polluting substances, only this carbon dioxide and only a small quantity of hydrogen sulphide (H₂S). Most of these substances are re-injected into the geothermy system, and do not re-enter the environment.
3. Geothermal wells have a very limited visual impact. Once a well has been drilled it is completely invisible, since the wellhead is buried. One was even built in a schoolyard.
4. Geothermal water is often saline, with a very high content of mineral salts – up to 100g/l, which is three times more than seawater. It can only be used through a heat exchanger, in other words a device through which it transfers its heat to a parallel heating circuit containing fresh water. The two liquids never come into contact resulting in a loss of efficiency.
5. Geothermal water is almost always corrosive. This corrosion is to salt, but sometimes also bacteria, which increase maintenance costs.
6. There is a risk of pollution when the extracted water contains heavy metals. This water has to be re-injected into the geothermy system.
7. Although the extracted energy is free, investment and maintenance costs are very high.
8. Depletion of the resource is possible. Underground hot water stores are considered renewable since they are continuously heated by the internal heat in the earth, but the rate of use must not exceed the rate of renewal.
9. The use of geothermal energy remains limited to very specific regions, particularly close to volcanic areas.

**THE SOULTZ-SOUS-FORÊTS PILOT SITE (ALSACE, FRANCE)**

[Image of Soultz-sous-Forêts geothermal site with diagrams and descriptions of different components like a water circulation system and production wells.]

**DISADVANTAGES OF GEOTHERMAL ENERGY**

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- Geothermal water is almost always corrosive. This corrosion is due to salt, but sometimes also bacteria, which increase maintenance costs.
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- The use of geothermal energy remains limited to very specific regions, particularly close to volcanic areas.

**WE ARE SITTING ON TOP OF AN ALMOST LIMITLESS STOCK OF ENERGY. ALL WE HAVE TO DO IS TO FIND A WAY TO USE IT.”**