France Country Update

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ABSTRACT

There is a large diversity of geothermal resources in France, especially low-energy resources, mainly exploited for direct uses or with geothermal heat pumps; France also exploits high-energy resources for power generation in its Overseas Departments and experiments EGS in Soultz-sous-Forêts.

The exploitation of geothermal resources in France has seen several phases: After a major development phase based on low enthalpy resources from sedimentary basins at the beginning of the 1980's, there was a period of withdrawal during the 1990's marked by very little new activity. Since the end of the 90's a revival in activity is observed for all kinds of geothermal energy, fostered by the decision taken in France to resume an active policy for energy management and the development of renewable energies having. Geothermal energy is expected to contribute largely to the French renewable energy and greenhouse gas reduction targets.

1. INTRODUCTION

Following the implementation of the French Energy Law in 2005 and the large consulting process "Grenelle de l'environnement" launched in 2007, a strong focus has been put in France on the development of renewable energy sources. These two elements, which establish the structure for the French energy policy, assign renewable energy sources – including geothermal energy - an important role and, a priori, the necessary financial resources to allow their real development.

Geothermal energy benefits from an old development in France, for all kinds of geothermal energy, which gives a strong base for a renewed and rapid growth :

- Geothermal heat pumps experienced a first development in the 80's, and, notably through the presence of French SME, the market has developed again since 2003.

- Geothermal district heating already supplies heat for more than 150 000 dwellings, and new operations are launched since 2007.

- Electricity production is especially suitable in overseas departments, that are not connected to the European grid. Bouillante plant on Guadeloupe Island has an installed capacity of 15 MW and considers new development, whereas exploration works shall begin in Martinique and la Réunion.

- Concerning enhanced geothermal systems, after more than 20 years of R&D works, the Soultz project is now operational and provides a worldwide reference for this technology.

2. NATIONAL POLICY

2.1 Strategy

The French national policy towards renewable energy sources took a major bend with the "Grenelle de l'environnement", France's Environment Round Table. The initiative was taken by Nicolas Sarkozy when he was elected president in 2007. For the first time, the consulting process brought together the main society's bodies: unions, local authorities, industry, NGO and administration. For three months, working groups met to propose concrete action to be implemented at national, European and international level. In October 2007, these proposals were opened up to debate by a range of public groups. Thus began a stage looking at the technical, legal and administrative aspects, which will serve to assess how best to implement all the measures decided upon. Around thirty operational committees met to define guidelines and objectives for operational programs.

Following this process, a law project was presented in the Parliament in November 2008 in order to write down the objectives and to give the framework for an ambitious action plan allowing reaching these objectives. The law project was voted with quasi-unanimity in Parliament and Senat.

Among the objectives, the climate change mitigation is the main one, with the following targets, in line with the European Directive on renewable energy sources : To decrease by 38% the building energy consumption, to increase by 20 Mtoe/year the consumption of Renewable Energy (which is in line with the target of 23% of renewable energy sources in energy consumption), and to decrease by 20% GES emissions in transports.

Within this framework, powerful tools were set up, or reinforced, in favour of renewable energies. On the 17th of November 2008, a declaration was made by the Minister for Ecology, Energy, Sustainable Development and Town and Country Planning for 50 measures for the development of high environmental quality renewable energies. Geothermal energy is concerned by several of them:

- A "Renewable heating and cooling fund" is set up by the finance law 2009-2011 voted in November 2008. This law creates a fund for supporting renewable heating and cooling in tertiary, collective buildings or agricultural/industrial process. This fund is dedicated to the funding of operational projects, under the following principle: to reach a renewable energy sources heat price at least 5 % lower than conventional heat. For that, an economic analysis is conducted for each project in order to determine the level of subsidy. This fund is granted 1 billion € for the 2009-2011 period, and is designed to reach gradually 800 millions € per year, magnifying by an important factor the public money dedicated to renewable energy sources heating and

cooling before. Among the renewable energy sources, it is foreseen that geothermal energy projects (geothermal heat pumps and direct use) will represent around 130 M€ for 2009-2011 period.

- Tax credit are maintained until 2012 for the purchasing of heat pumps.

- R&D works on geothermal heat pumps are supported with two priorities : assessment of the potential of the superficial underground and aquifers for geothermal heat pumps, and the installation of an experimental platform devoted to R&D for geothermal heat pumps in BRGM.

- A R&D program will be launched to accompany Soultz-sous-Forêts pilot plant exploitation.

- The feed-in tariff for geothermal electricity will be raised.

2.2 National targets

Following the "Grenelle de l'environnement", an operational committee devoted to renewable energy sources proposed in 2008 a burden sharing among renewable energy sources in order to reach the +20 Mtoe/year of renewable energy sources in 2020. For geothermal energy, the following targets were set up, updating the targets set in the law on energy in 2005:

	2006	2012	2020
geothermal district heating	130	195	500
large geothermal HP	50	100	250
individual geothermal HP	40	240	550
Total geothermal heating	220	535	1300

Table 1: "Grenelle de l'environnement" targets for geothermal heating (in ktoe/year)

	2006	2020
Guadeloupe	15	90
Martinique	0	40
La Réunion	0	60

Table 2: "Grenelle de l'environnement" targets for geothermal electricity production in French overseas departments (MW installed capacity) (including importation from Dominica)

3. FRENCH GEOTHERMAL RESOURCES

France disposes of several types of geothermal resources.

Low-energy resources, developed for thermal applications, are primarily located in the two major existing sedimentary basins: the Paris Basin (for which Paris is the geographical centre) and the Aquitaine Basin in southwest France. The resources are found at depths between 600 and 2,000 m.

Other French regions also have high potential for low-energy resources, but the geological structures are more complex and the fields much more localized (Alsace, Hainault, Bresse, Limagne, etc.).

France also possesses high-energy resources that are potentially exploitable for electricity production. These are located essentially in its Overseas Departments (the volcanic islands of the Antilles - Guadeloupe and Martinique – and the Indian Ocean – La Réunion).

Finally, the entire French territory has a good supply of superficial water-bearing strata that can be exploited using heat pumps.

Several works have been conducted in the last years by BRGM (French Geological Survey), with the cooperation of ADEME (French Energy Agency) to update the assessment of French geothermal resources. A specific focus is now put on the potential of clayed sandstone aquifers in various French sedimentary basins, which are not exploited yet.

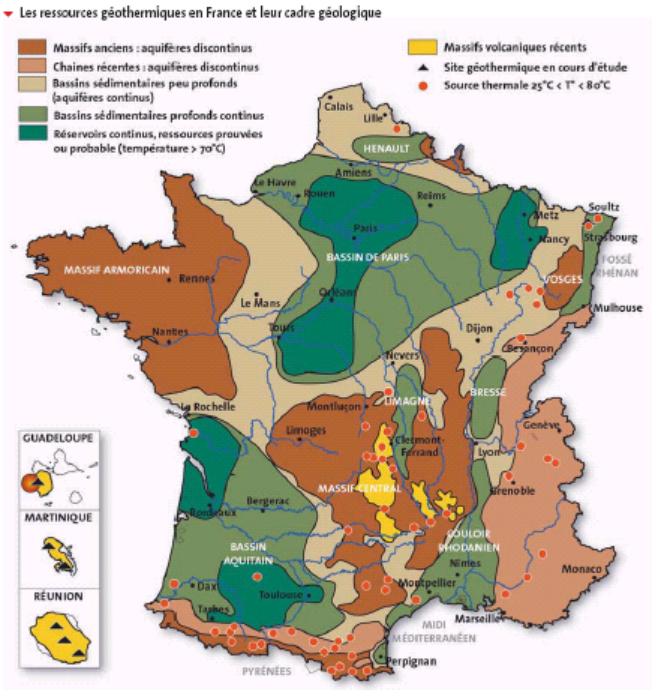

Figure 1: French geothermal resources

4. THE DEVELOPMENT OF GEOTHERMAL HEAT PUMPS

4.1 Heat pumps for individual houses:

After a fast increase until 2007, the market of geothermal heat pumps for individual houses is stagnant, at around 20 000 units per year. In parallel, we observe a boom in the selling of air-source heat pumps. The main reason for this is that the system of tax credit is largely in favour of air source heat pumps (see figure 2).

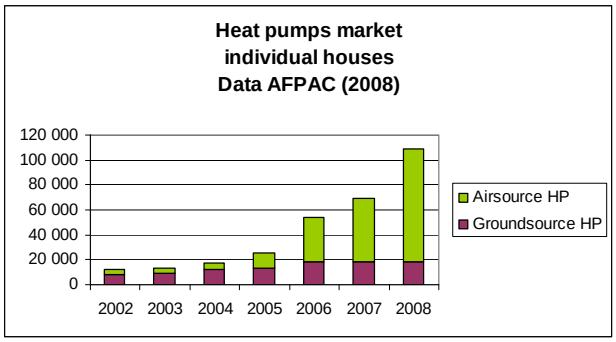

Figure 2: Evolution of heat pumps market for individual houses (data AFPAC (association française des pompes à chaleur) 2008)

There is a slight evolution in the employed technologies: France was previously characterized by a strong market for the horizontal closed-loop ground-source type, and especially Direct Expansion Heat Pumps, with several very active SME. But for the last years, borehole heat exchangers have grown, and the direct expansion system are now in reduction. Another important evolution is the rapid rise of the geothermal heat pumps in refurbished houses. The table 3 below shows clearly these evolutions.

4.1 Heat pumps for tertiary and collective buildings :

In the tertiary and collective buildings, the market for geothermal heat pumps is booming:

Groundwater heat pump projects, benefiting of a good profitability, represent the quasi totality of the market. No statistics are available for this market, but it is estimated at more than 100 operations per year. The growth of this market can be illustrated by the data from the AQUAPAC guarantee (see below). This guarantee is used only in areas where the hydrological knowledge is poor, and represents therefore a small part of the market. The evolution of the number of projects that applied to this guarantee is shown below.

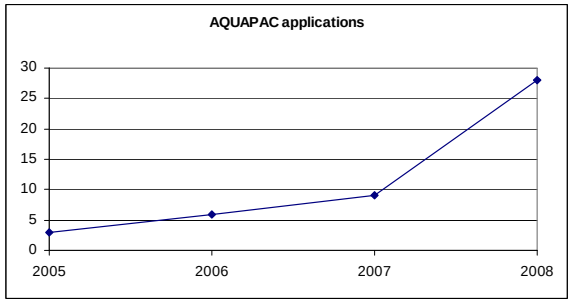

Figure 3: Evolution of the number of projects submitted to AQUAPAC guarantee

The first large operations on borehole heat exchangers are emerging, but until 2008 they weren't bankable with the subsidies allocated to such projects, and were therefore limited to demonstration projects. From 2009 on, with the Renewable heating and cooling fund, the situation will change, and one expects to see this market boom as well.

4.2 Energy and environmental assessment

Together, in 2008 the geothermal heat pumps installed in France represent an average annual saving of approximately 180 000 toe of fossil fuel: The number of geothermal heat pumps installed in individual houses is evaluated at 122 000 units, contributing to a saving of approximately 110 000 toe of fossil fuels. The geothermal heat pumps in collective and tertiary buildings contributing for the others 70 000 toe of fossil fuel.

4.3 Public programs in favor of the development of geothermal heat pumps:

Several actions are conducted by the heat pump industry and by public bodies to accompany this development. Among others, can be quoted the following:

- initiatives to push the quality of installations : AFPAC, the French association for heat pumps, manages a label for heat pumps installers since 2007 named QUALIPAC ; BRGM, EDF and ADEME support a quality label for borehole heat exchangers drillers named QUALIFORAGE, which counts around 70 drilling companies. French standards have been established for the heat pumps (NF PAC) as for the wells.

- A geological risk guarantee, AQUAPAC, covers geological risk for large groundwater heat pumps projects. This guarantee is partially funded by ADEME, allowing a low cost for the contracting body.

- Geographical information systems are progressively developed in each French region, to assess the potential of superficial aquifers for geothermal energy.

	2005	2006	2007	%		2008	%	
				new	Retrofit		New	retrofit
Direct expansion systems	7 800	9 600	9 600	98	2	7 900	95	5
Water or groundwater	5 400	8 850	9 000	75	25	11 530	60	40
TOTAL Geothermie	**13 200**	**18 500**	**18 600**	**87**	**13**	**19 430**	**74**	**26**

Table 3: Breakdown of the market for geothermal heat pumps for individual houses (data AFPAC 2008)

To date, the GIS for Ile de France, Centre, Lorraine, Midi-Pyrénées regions are available online (www.geothermie-perspectives.fr).

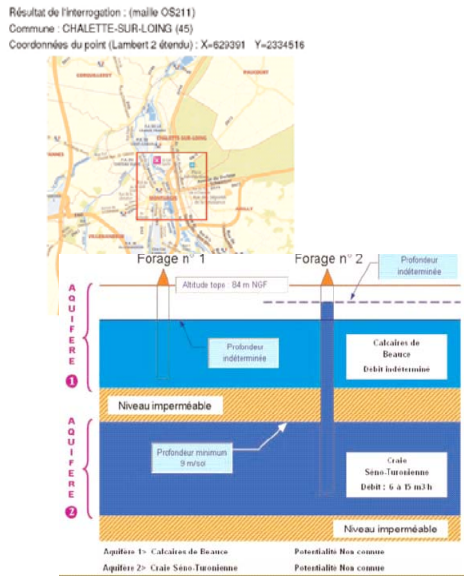

Figure 4: view from the GIS "potential of superficial aquifers for geothermal exploitation in Region Centre.

- An experimental platform for geothermal heat pumps and their underground heat exchangers has been created by BRGM in Orléans, in partnership with the Région Centre.ces. This platform is aimed at a global assessment of the performances of heating systems functioning with geothermal heat pumps. Horizontal and vertical heat exchangers are driven in a controlled manner, allowing simulating the heat demand of any heat pump or building.

5. THE DEVELOPMENT OF LOW ENERGY RESOURCES AND DIRECT USES

5.1 current situation and development:

The nature of the existing resources has led France to favour thermal applications of geothermal resources.

To this end, until the year 2000, 112 deep exploration wells (drilled wells or rehabilitated existing wells) have been created since 1961, 97 of which were finally brought into operation, mainly between 1980 and 1987. At present, **65 geothermal production plants** (installations with single, double and triple wells) are in operation. These correspond to **60 geothermal operations** *sensu stricto*.

Approximately a third of operations have been discontinued, due to technical, economic or financial problems.

Most of the plants are located in the Paris Basin, followed by the Aquitaine Basin.

Almost half of operations concern district heat networks, which are essentially in the Paris region where they serve on average 4,000 to 5,000 LUEs (Living Unit Equivalents). Other installations serve heating systems for fish-breeding installations, horticultural greenhouses, swimming pools or aquatic leisure complexes. Table 4 below gives the repartition of operations for direct use in France.

Since 2007, a renewed interest is observed regarding geothermal district heating, especially in Paris Region: after the drilling of a doublet replacing an old one in Orly city in 2007, 2008 was marked by:

- The drilling of one well in Sucy-en-Brie, in order to transform an old doublet in a triplet (the new well being used as production well, and the two old wells as reinjection wells).

- The preparation of a new operation for Paris city district heating, the drilling operation having successfully been performed in spring 2009.

- The preparation of a new operation in Aix en Provence, the drilling operation having successfully been performed in spring 2009.

- Several feasibility studies are engaged for operations in Paris Basin, Alsace and other regions.

5.2 Energy and environmental assessment

Together, all these operations represent an average annual saving of approximately 130,000 toe of fossil fuel serving about 166,000 LUEs. The annual tonnage of CO_2 emissions avoided is estimated at 400,000 tons.

5.3 Public programs in favor of the development of low energy resources:

Besides the Renewable heating and cooling fund, that makes geothermal projects bankable, public authorities implement actions to foster the revival of low energy geothermal energy in France.

The Geological Risk Guarantee organized in the 80's has been reactivated: it offers a low cost insurance against geological risk for driling projects.

ADEME, ARENE (Ile de France regional environmental association) and BRGM joined to organize meetings with stakeholders in 2007. Following these exchanges it was decided to elaborate a program for boosting geothermal energy for the Paris Basin. It covers technical and economic aspects.

A Technical Center has been created inside BRGM to support geothermal stakeholders, for design, realization, exploitation….This technical center develops a pragmatic approach, based on the stakeholders' needs:

	Paris Basin	Aquitaine Basin	Other regions	Total
District heating	29	5	-	34
fishfarming, greenhouses, …	-	4	6	10
Bathing, …	-	9	3	12
Space heating without urban network	2	-	2	4
				60

Table 4: geographical breakdown of geothermal resource direct use in France in 2008

- Centralize all information, studies, data and organize public access to it in order to enhance information diffusion and access to organized data,

- Conduct specific studies on issues that the development of geothermal district heating could raise. Its role will be to coordinate the best specialists, and manage the results diffusion.

3 tasks have already been launched :

- State of the art of geothermal operations (Analysis of all existing options, technical (drilling, equipment), call for tender process, insurances…)

- Dogger aquifer management

- Scientific works around drillings

6. ELECTRICITY PRODUCTION IN OVERSEAS DEPARTMENTS

Due to their volcanic environment, the French Overseas Departments - Guadeloupe, Martinique and La Réunion – represent, for France, prime candidates for geothermal electricity production. Moreover, they are isolated islands, where electricity production by classical plants is costly and polluting.

France benefits of a successful experience in Guadeloupe, with the geothermal plant of Geothermie Bouillante. With two units, the first one, Bouillante 1, commissioned in 1984, and the second one, Bouillante 2, commissioned in 2004, the installed capacity is 15 MWe. A good rate of avaibility is achieved, greater than 90%. 95 GWh were delivered to the grid in 2007.

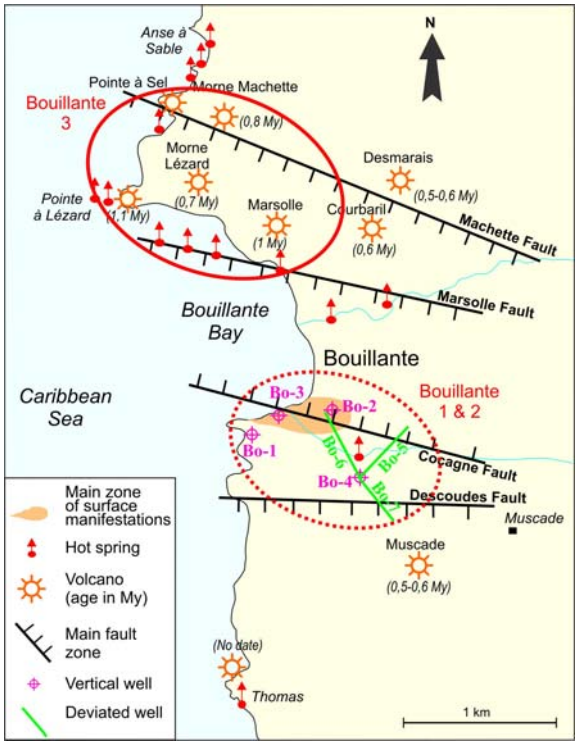

Figure 5: Bouillante geothermal field .

In the other islands, no field developments have taken place to date. Nevertheless, exploration program are planned :

From July 2008 on, due to a drawdown of the pressure in the field, and to avoid surface manifestations around the plant which is in an urban area, the operating capacity was decreased to 11 MWe. The operating capacity will stay at this level until partial reinjection of the brine is implemented. The installation of the reinjection facilities will take place before the end of 2009.

Moreover, Geothermie Bouillante plans to drill exploratory wells for the extension of Bouillante plant (project "Bouillante 3"), in the northern part of Bouillante Bay (see figure 5). An additional capacity of 20 to 30 MW is expected. Drillings were authorized in December 2008 and could take place by the end of 2009.

- In La Réunion Island (Indian Ocean), the Regional Council plans exploratory drillings near the volcano Piton de la Fournaise. These wells could be drilled in 2010.

- In La Martinique (French West Indies), an exploration plan shall be set up in 2009 by the local authorities.

Geothermal energy shall contribute largely to the objective set in the Grenelle I law, to reach 50% of renewable energy in energy consumption in French Overseas Departments.

7. ENHANCED GEOTHERMAL SYSTEMS

Since 1987, France has been committed, beside Germany and the European Union, to deep and fractured rock geothermal resources. Highly encouraging results were obtained from research conducted at Soultz-sous-Forêts (Alsace) in the east of France. This resulted, in 1999, in the decision to implement a scientific pilot plant designed to demonstrate the feasibility of the concept of deep geothermal resources.

The design of this pilot required the drilling of three wells 5,000 m deep, (2 production wells and 1 injection well), and the development of an enhanced reservoir by hydraulical and chemical stimulation of the deep fracture network. During the period 2001-2007, successful stimulation and long-term circulation testing between the wells in the deep reservoir heat exchanger have been performed.

Following this phase, the construction phase of the newly-created geothermal power plant at Soultz started in autumn 2007 with the building of an ORC (Organic Rankine Cycle) plant having a net power capacity of 1.5 MWe. During the construction phase, a lot of effort has been dedicated for taking into account industrial risks such as fire due to the organic working fluid and environment issues such as noise, vibration, and visual impact. Surface equipments (turbine, air cooling system, heat exchanger) as well as two different types of down-hole pumps were installed respectively on surface and in the production wells. The different components of the power plant have been testing from April 2008. Many improvements were done during the first months of operating. For example, a new lubrication system of the line shaft pump axis has been set up after the damage of the shaft axis. A specific filtering system of the geothermal brine has also been improved because the first filter generation was not designed enough for corrosive fluid. During the circulation tests done in 2008, hydraulics, induced microseismicity and corrosion were monitored continuously. In December 2008, the thermal output ranged around 12 MW thermal for a cumulative flow-rate ranging around 28 l/s. In 2008, the first kWh has been produced mid

June when the power plant was officially inaugurated by the French Prime Minister.

Currently, a scientific program is set up to accompany the first years of exploitation, associating French, German and Swiss research centres. The main objective will be to acquire data on the system during its exploitation, and will be to work on its long-term management.

5. CONCLUSION

Geothermal activities in France have increased significantly over recent years. The ambitious targets set during the “Grenelle de l’environnement” process put all kinds of geothermal energy, as other renewable energy sources, in the spotlight. The overall public awarenessis getting better and better, as it could be shown through a poll made by ADEME in 2004 and 2008 : In 2004, only 7% of the people knew about geothermal energy, whereas this figure rose to 28% in 2008. Nowadays, financial incentives give strong opportunities to develop new projects. France shall thus be in a position to reach the targets for geothermal energy, provided this favourable context leads to a strong development of the supply side.

APPENDIX : STANDARD TABLES

TABLE 1. PRESENT AND PLANNED PRODUCTION OF ELECTRICITY

	Geothermal		Fossil Fuels		Hydro		Nuclear		Other Renewables (specify)		Total	
	Capac-ity MWe	Gross Prod. GWh/yr	Capac-ity MWe	Gross Prod. GWh/yr	Capac-ity MWe	Gross Prod. GWh/yr	Capac-ity MWe	Gross Prod. GWh/yr	Capac-ity MWe	Gross Prod. GWh/yr	Capac-ity MWe	Gross Prod. GWh/yr
In operation in December 2008	17	100	18300	51400	25400	68100	63100	418300	3200 800 80	5700 (win 5500 (biomass and waste) (solar)	110897	549100
Under construction in December 2008	0		4500		0		1600		1000 250			
Funds committed, but not yet under construction in December 2008	0											
Total projected use by 2015	50		24400		27400		64700		20200 3400 1580	(wind) (biomass and waste) (solar)		

TABLE 2. UTILIZATION OF GEOTHERMAL ENERGY FOR ELECTRIC POWER GENERATION AS OF 31 DECEMBER 2009

Locality	Power Plant Name	Year Com-missioned	No. of Units	Status[1)]	Type of Unit[2)]	Total Installed Capacity MWe	Annual Energy Produced 2008 GWh/yr	Total under Constr. or Planned MWe
Bouillante	Bouillante 1	1984	1		2F	4	10 (2008)	
Bouillante	Bouillante 2	2004	1		1F	11	79 (2008)	
Soultz-sous-Forêts		2008	1		B	2,2	0 (2008)	
Total			3			17,2	89	

TABLE 3. UTILIZATION OF GEOTHERMAL ENERGY FOR DIRECT HEAT AS OF 31 DECEMBER 2007 (other than heat pumps)

Locality	Type[1]	Maximum Utilization					Capacity[3]	Annual Utilization (data :2007)		
		Flow Rate	Temperature (°C)		Enthalpy[2] (kJ/kg)			Ave. Flow	Energy[4]	Capacity
		(kg/s)	Inlet	Outlet	Inlet	Outlet	(MWt)	(kg/s)	(TJ/yr)	Factor[5]
Bassin Parisien :										
Alfortville	D	76	73	44			9,2	41	155,4	0,53
Bonneuil sur Marne	D	78	79,3	49			9,9	23	91,9	0,29
Cachan Nord & Sud	D	100	70	46			10,0	56	176,5	0,56
Champigny sur Marne	D	78	78	45			10,8	48	210,8	0,62
Chelles	D	78	69	40			9,5	16	60,9	0,20
Chevilly Larue + L'Hay	D	155	72,6	43			19,2	67	261,3	0,43
Clichy Sous Bois	D	50	71	44			5,6	16	56,1	0,32
Coulommiers	D	64	85	61			6,4	28	89,1	0,44
Créteil	D	84	78,9	50			10,1	53	203,3	0,64
Epinay sous Sénart	D	70	72	49			6,7	59	179,5	0,85
Fresnes	D	70	73	46			7,9	33	116,4	0,47
La Courneuve Nord	D	55	58	40			4,1	33	78,0	0,60
La Courneuve Sud	D	50	56	40			3,3	21	44,9	0,43
Le Blanc Mesnil Nord	D	49	66	40			5,3	27	91,7	0,55
Le Mée sur Seine	D	38	72	52			3,2	29	76,2	0,76
Maisons Alfort1	D	84	73	50			8,1	44	132,0	0,52
Maisons Alfort2	D	72	74	54			6,0	28	74,7	0,39
Meaux Beauval & Colli	D	113	75	46			13,7	55	210,2	0,49
Meaux Hopital	D	36	76	51			3,8	23	74,4	0,63
Melun l'Almont	D	72	72	42			9,0	41	160,5	0,56
Montgeron	D	61	72,5	45			7,0	17	60,8	0,27
Orly 1 & 2	D	98	76	49			11,1	69	244,8	0,70
Ris Orangis	D	52	72	53			4,1	23	58,5	0,45
Sucy en Brie	D	55	77	50			6,2	35	125,1	0,64
Thiais	D	70	76	46			8,8	40	156,7	0,57
Tremblay en France	D	76	73	46			8,6	46	164,0	0,61
Vigneux sur Seine	D	67	73,2	44			8,2	31	120,9	0,47
Villeneuve Saint Georg	D	97	76	45			12,6	30	123,9	0,31
Villers le Bel	D	64	67	40			7,2	22	78,1	0,34

TABLE 3. (CONTINUED)

Locality	Type[1]	Maximum Utilization					Capacity[3]	Annual Utilization (data :2007)		
		Flow Rate	Temperature (°C)		Enthalpy[2] (kJ/kg)			Ave. Flow	Energy[4]	Capacity Factor[5]
		(kg/s)	Inlet	Outlet	Inlet	Outlet	(MWt)	(kg/s)	(TJ/yr)	
Autres bassins:										
région Centre										
Châteauroux	D		34						53,5	
Lorraine										
Dieuze	F	31	31	20			1,4	13	18,8	0,42
Lunéville	B	42	25	15			1,8	2	3,0	0,05
Nancy1 - Thermes	B	39	45	29			2,6	5	11,3	0,14
Nancy 2 -Caserne Kell	D		30						22,6	
Bresse										
Montrevel en Bresse	B	17	32	20,1			0,8	4	6,9	0,26
Languedoc										
Montagnac	F	10	30	20			0,4	21	28,3	2,14
Lodève 1	G	10	30	20			0,4	24	31,6	2,40
Lodève 2	G	10	52	20			1,3	5	22,6	0,54
Pézenas	F+B	53	38	20,1			4,0	18	41,7	0,33
Limagne										
Aigueperse	G	17	43	20			1,6	14	41,4	0,80
Bassin Aquitain										
Argelouse/Sore	G	42	48	18			5,3	15	59,4	0,36
Bordeaux Benauge	B	55,5	42	30			2,8	1	1,4	0,02
Bordeaux Mériadeck	D		52						11,9	
Bordeaux Stadium	B	36	34	26			1,2	4	3,9	0,10
Gujan Mestra	B		25						7,2	
Hagetmau	B		32						10,1	
Merignac - BA 106	D	67	52	40			3,4	37	58,4	0,55
Mios le Tech	F	55,5	73	30			10,0	14	77,2	0,25
Mont-de-Marsan 1	D	70	60	54			1,8	60	47,4	0,86
Mont-de-Marsan 2	D	17	56	44			0,9	6	8,9	0,33
Pessac -Salge Formar	D		48						58,2	
Saint Paul les Dax 1	D+B	42	47	22			4,4	15	49,6	0,36
Saint Paul les Dax 2	H+B	8,5	60	30			1,1	4	15,5	0,46
Blagnac1	B	8,5	55	28			1,0	3	11,5	0,38
Blagnac 2	D		60						22,7	
Nogaro 2	F	50	51	27			5,0	21	66,6	0,42
Jonzac 1	D+B	8,5	60	30			1,1	5	19,8	0,59
Jonzac 2	B	17	58	26			2,3	10	43,3	0,60
TOTAL							290		4531	

TABLE 5. SUMMARY TABLE OF GEOTHERMAL DIRECT HEAT USES AS OF 31 DECEMBER 2008

Use	Installed Capacity[1] (MWt)	Annual Energy Use[2] (TJ/yr = 10^{12} J/yr)	Capacity Factor[3]
Individual Space Heating[4]			
District Heating [4]	300	4900	52%
Air Conditioning (Cooling)			
Greenhouse Heating	9	155	55%
Fish Farming	19	212	35%
Animal Farming			
Agricultural Drying[5]			
Industrial Process Heat[6]			
Snow Melting			
Bathing and Swimming[7]	17	162	30%
Other Uses (specify)			
Subtotal	345	5429	
Geothermal Heat Pumps	1000	7500	24%
TOTAL	1345	12929	

TABLE 6. WELLS DRILLED FOR ELECTRICAL, DIRECT AND COMBINED USE OF GEOTHERMAL RESOURCES FROM JANUARY 1, 2005 TO DECEMBER 31, 2009 (excluding heat pump wells)

Include thermal gradient wells, but not ones less than 100 m deep

Purpose	Wellhead Temperature	Number of Wells Drilled				Total Depth (km)
		Electric Power	Direct Use	Combined	Other (specify)	
Exploration	(all)					
Production	>150° C					
	150-100° C					
	<100° C		4			6,5
Injection	(all)		3			4,5
Total			7			11

TABLE 8. TOTAL INVESTMENTS IN GEOTHERMAL IN (2009) US$

Period	Research & Development Incl. Surface Explor. & Exploration Drilling	Field Development Including Production Drilling & Surface Equipment	Utilization		Funding Type	
			Direct	Electrical	Private	Public
	Million US$	Million US$	Million US$	Million US$	%	%
2005-2009	46	43	40	49	70	30