Proceedings World Geothermal Congress 2015
Melbourne, Australia, 19-25 April 2015

France Country Update

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Keywords: Geothermal energy, national policy, market, research

ABSTRACT

Because of its diverse and significant geothermal resources, France has defined ambitious objectives for geothermal development a few years ago. Progress varies considerably among the various geothermal uses:

- Electricity: many projects are emerging on the mainland (combined heat and power); but fewer are planned for the overseas regions, due to a less favourable framework (notably, the feed-in tariff), whereas the issues in terms of energy policy are very high for these isolated territories (La Reunion, in Indian Ocean, Martinique and Guadeloupe, in Caribbean Sea).

- Direct use: new operations are made each year in the Paris basin, which is encouraging but not sufficient. To reach the objective, the number of installations made in the Paris basin must increase and other projects must be launched in a variety of aquifers and geological contexts.

- Ground source heat pumps: the installed capacity is growing very slowly, so the pace must increase to reach the target. Some actions are launched, notably in terms of regulation, but the public financial support is decreasing for individual housing.

1. INTRODUCTION

Geothermal energy has been used in France for a variety of applications for a long time, especially since the two 1970s oil crises. Many geothermal direct use operations have been commissioned since 1961; and most of the wells were drilled in the early 1980s, in the Paris sedimentary basin and also in Aquitaine. There has been renewed interest for this type of geothermal energy since 2007 in the Paris basin.

France currently has two geothermal power plants: the Bouillante power plant in Guadeloupe (French West Indies) and the EGS pilot plant in Soultz-sous-Forêts (Alsace Region, France) which is managed by the GEIE 'Exploitation minière de la chaleur (Bas-Rhin)'. The GEIE is composed of six French and German companies. Geothermal energy provides about 6% of Guadeloupe's electricity demand.

The development of ground-source heat pumps is more recent and still too weak, though the market for heating office buildings and collective public housing is flourishing.

2. NATIONAL POLICY

Due to its large diversity of geothermal resources, France has set up ambitious objectives for the development of each type of geothermal energy. Indeed, a new strategy has been implemented since 2005, mainly due to the 'Grenelle de l'environnement' process which aimed to redefine French policy for sustainable development and included input from industry, environmental associations, local authorities, state services, unions and experts. In 2009, France set a target of 23% of renewable energies in its energy mix by 2020. This requires an additional annual 20 million toe of renewable energies to be produced by 2020, with 50% of the additional production expected from renewable heat and 50% from renewable electricity.

The use of geothermal heat is expected to be increased six-fold between 2006 and 2020, thanks to the use of ground-source heat pumps as well as geothermal district heating. This development has been supported by efficient risk mitigation schemes. An insurance fund covers geothermal exploitation of deep aquifers, whereas Aquapac scheme (an assurances system which cover the geological risk for shallow aquifers) is dedicated to shallow ones. Both of these schemes combine a short-term (initial temperature and flow rate) and a long-term guarantee (exploitability of the resource over 20 years). The two funds are supported jointly by public authorities and by the project owners. They are separate because they insure very different amounts of money: € 4.2 M for the deep projects and € 115 k for the shallow ones.

More recently, the development of geothermal heat has been boosted by the implementation of a renewable heat fund. This new fund, created in 2009, aims at increasing the number of projects using renewable energy for industry, collective housing and commercial building. About € 1.2 billion was allocated to cover all renewable energies for the 2009-2013 periods. It subsidizes the preliminary studies as well as the initial investment. The aim is to fund the difference between a renewable heat project and a reference solution, generally using gas. Funding of geothermal projects, including development of heating networks, is now well established.

Besides, geothermal power capacity must increase from 17 MWe to 80 MWe during the same period 2006-2020, and reach 200 MWe in the long term. There are two purposes linked with these objectives:

- Provide French West Indies and La Réunion with de-carbonized energy by replacing the thermal electricity production at a reasonable cost; the 2020 objective for these islands being 50% renewables instead of 23% at a national level, because the current production is mainly from fossil fuel,

- In the mainland, to improve the French know-how in Engineered Geothermal Systems, building on the experience of Soultz-sous-Forêts, in order to develop this energy in a larger way by 2050.

For electricity, the main support is the new feed-in tariff initiated in July 2010. Geothermal electricity is now bought at an increased price of 130 €/MWh in the overseas departments (instead of 100 €/MWh) and 200 €/MWh on the mainland. A bonus is given if the co-produced heat is also used. This has resulted in many companies emerging to manage deep geothermal projects, above all on the mainland. The support scheme for overseas department should therefore be re-examined. In addition, there are currently no risk mitigation schemes for geothermal power projects, which is another barrier to its development.

Another issue after having determined these national objectives was to raise awareness and mobilise the stakeholders at a local level. That has been done on 12th July 2010 with a law ('Loi portant engagement national pour l'environnement') defining two tools: the regional schemes for climate, air and energy ('Schémas régionaux climat air énergie') and the territorial schemes for climate and energy ('Plans climat énergie territoriaux'). In terms of renewable energy, the regional schemes aims at identifying the installed capacity, evaluating the potential for each type of energy, defining different scenarios and at the end setting regional objectives. The territorial schemes complement them as they are an action plan of local authorities to contribute to these regional objectives.

In addition, a national committee for geothermal energy ('Comité national de la géothermie') has been put in place in October 2010 by the French Ministry for sustainable development. Gathering various stakeholders, its objective is to make recommendations, especially on three topics: administrative simplification and quality; information; training and education.

More recently, the government launched in 2013 a huge debate on energy transition to update the environmental policy that was determined in 2007 through the "Grenelle Environnement" process. The conclusions are not fully known for the time being.

3. DEVELOPMENT OF GROUND SOURCE HEAT PUMPS

The potential of ground source heat pumps are the most significant potential of the various types of geothermal energy that can be developed in France, both in terms of open-loop systems with good shallow aquifers in many regions in France, and of closed-loop systems (vertical borehole heat exchangers, horizontal heat exchangers, geothermal piles, etc.).

The market for ground sources heat pumps covers two aspects which have a very different pattern: the heat pumps for individual housing and heat pumps for 'residential collective' sector and 'tertiary' sector.

The first market is highly rated by the AFPAC; the second is much more difficult to assess. Two assessment tools exist: The AFPG and the Heat Funds. It has very precise statistics, but these account for only geothermal operations supported by the Funds and in the case of Ground Source Heat Pumps including the tertiary sector, it does not represent most operations.

Nevertheless, the statistics of the Heat Funds allow seeing the evolution of the market trend heat pumps, other than for individual houses.

Very ambitious objectives have been defined with an increase of around ten-fold between 2006 and 2020. Several years after the definition of these objectives, the situation for ground-source heat pumps remains unsatisfactory: the market is very difficult for individual housing, with a significant decrease since 2008 that cancels a large part of the increase that has happened since 2000. The economic crisis has had an effect on the construction sector: the reduction of the number of new buildings and the decreased budget to build them had a cruel effect on geothermal solutions. The relatively low cost of gas does not help either. However, this situation affects above all individual heat pumps.

Moreover, public support is decreasing for individual housing. A 36% tax reduction existed in 2011 for individual housing, covering the heat pump and the geothermal heat exchanger. It decreased to 26% in 2012 and is now 15% or must be combined with additional works on energy efficiency. In addition, there is also zero-interest loans and an energy saving certificate scheme.

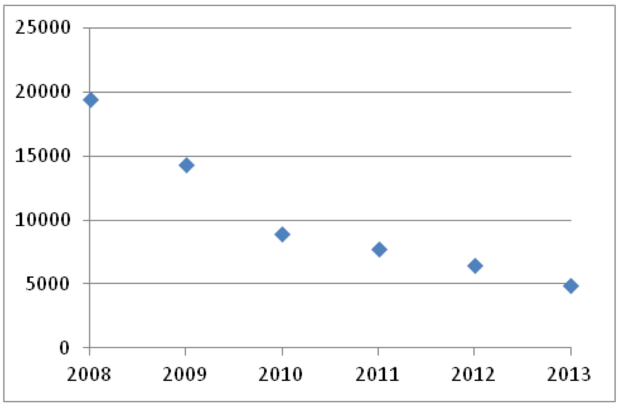

Figure 1: Evolution market of ground source heat pump for individual housing (statistics from AFPAC, French Heat pump association)

Collective heat pumps are less concerned, mainly because of the advantage of the combined heat and cold production, with high energy efficiency (including free cooling).

Figure 2: Evolution market of ground source heat pump for collective and tertiary buildings (statistics from 'renewable heat fund' that cover probably 50% of the real market)

Geographical information systems have been developed in many regions in order to give at each point of the map, values of the geothermal resource (flow rate, temperature, deepness and chemical characteristics) of shallow aquifers which can be used for pre-feasibility studies, when each type of energy is studied for a given building.

A significant amount of work has been done in terms of standards and certification. A standard for borehole heat exchangers has been published in August 2010 and revised in 2011: this NF-X 10-970 standard describes the technical requirements but also the division of responsibilities between the heat pump installer, the driller and the contracting authority. A standard has also been published on the pipes used in these exchangers and another one is being written for grouting. NF-X 10-999 standard, on water drillings, has been revised in 2014 to enhance the way geothermal drillings were taken into account. The certification of both installers and drillers is also being promoted, as well as the related training sessions.

A major need is clarification of the regulation for ground source heat pumps. Procedures for shallow geothermal projects are currently unclear, and may be either very onerous, or non-existent. In addition, the environmental requirements are not defined. Consequently, a significant work has been done on regulatory procedures and the new regulation is expected in 2014-2015. In particular, technical requirements will be defined, the certification of the driller will be mandatory and online declaration will be available. The vulnerability of the underground in terms of geology and hydrogeology will be assessed, so that these geothermal operations will be forbidden in the most environmentally sensitive places and the validation of an expert will be compulsory in some others.

Besides, the French thermal regulation for buildings, focusing only on primary energy (1 electrical kWh requires 2.58 thermal kWh to produce) and neglecting greenhouse gas emissions or the consequences on the national trade balance, does not help geothermal energy compared to biomass and even natural gas. A more balanced approach should be included in the future standard.

Some R&D projects are also launched to adapt the geothermal solutions to the evolution of buildings in terms of energy efficiency.

4. GEOTHERMAL DISTRICT HEATINGS

France has very favorable deep aquifers, notably in the Paris and Aquitaine sedimentary basins, and a remarkable experience in geothermal district heating. The installed thermal power is estimated at 345 MWt and comprises about 50 plants, most used for district heating; a few of them are feeding greenhouses and fish farms.

37 doublets or triplets are operating in the Dogger aquifer of the Paris basin, which is a unique concentration in the world in terms of low enthalpy. Many of them have been realized in the late 1970s and the beginning of the 1980s and are still running. The water is pumped from the Dogger Aquifer (1,600-1,900 m depths) at temperatures of 60-80°C, goes through a heat exchanger and is injected in the same aquifer.

There are also 10 single wells in Aquitaine (South-West of France), without reinjection. These operations have been realised in the beginning of the 1980s and this technical situation was chosen as the pumped water is not saline and can be discharged to the surface. The regional geology is moreover quite complicated, so that the drilling of reinjection wells is not easy. In addition, the temperature of the geothermal resources is lower than the one of the Paris Basin, which makes the profitability of the geothermal operation in Aquitaine Basin harder to justify.

New geothermal direct use operations have been realised since 2007 in the Paris basin. There are rehabilitation of existing operations and brand new ones. For instance, a fully new doublet has been realised by ADP to convert the district heating of the Orly Parisian airport to renewable energy. The operation has been successful and will produce 36 GWh of heat per year.

In terms of rehabilitation, several strategies exist:

- some doublets are transformed into a triplet as in Champigny-sur-Marne: a new production well was drilled and both existing wells are used as injection wells after a casing relining that decreases the well diameter and the flow rate,

- some doublets are closed and a new doublet was drilled in the vicinity (in Coulommiers for instance): this solution is compulsory if the existing wells are too damaged and are chosen in some other cases as the conversion to a triplet decreases the investment but has a more limited lifetime,

- sometimes like in Maisons-Alfort, the casing of the two wells is relined and the flow rate is reduced, notably if the district heating is not big enough and/or if there are other competing base load sources of heat connected to the district heating.

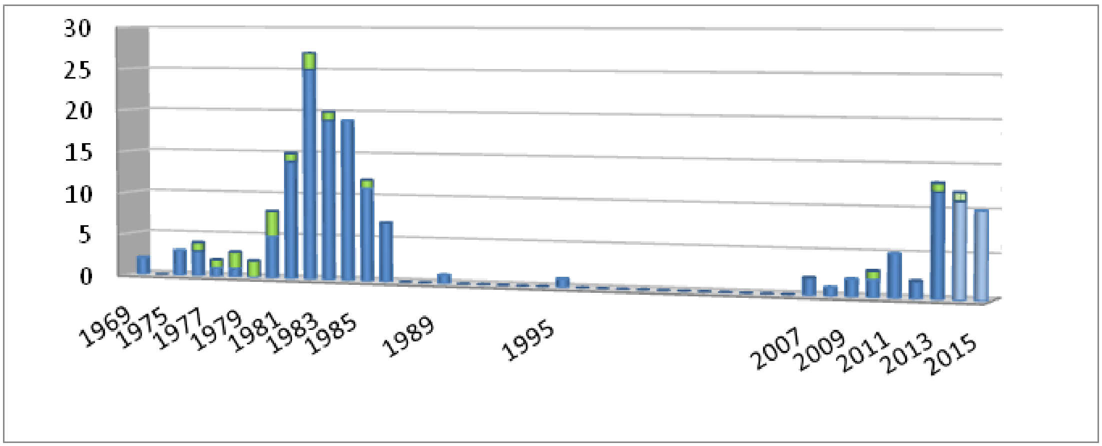

Figure 3: Evolution of geothermal district heating in France: from 1969 to 2015 (realistic expectation) : blue = Paris Basin, green = Aquitaine Basin

A significant number of rehabilitations are still expected in the following years. A specific management of the Dogger aquifer has been put in place to prevent use conflicts. The data of the various running operations is collected by BRGM and thermo-hydraulic modelling of the aquifer is performed, in order to be able to decide whether new drillings can be performed or will disturb the existing operations.

In addition, some operations are also carried out in the intermediate aquifers of the Paris basin: one doublet has been realized in the Albian aquifer (650 m depth), for district heating in Issy-les-Moulineaux. With a 28°C temperature and a 200 m3/h flow rate, this operation has a thermal capacity of 5.4 MWt for heating and 1.3 MWt for hot sanitary water, thanks to the use of heat pumps. Another doublet has been realized on the same principle in the Neocomian aquifer (900 m depth, 34°C temperature) for a district heating linked with 3,500 social households in Plessis-Robinson, near Paris.

Some operations are also expected in the Aquitaine basin in the next years. An exploratory well has also been drilled in 2010 in Gardanne, in the South-East of France, but was a failure due to its low temperature.

A significant R&D project has been Geostocal, funded by ANR and ended in 2012. It studied the feasibility of an inter-seasonal storage of excess heat (from a waste incinerator) in a deep aquifer in terms of financial sustainability, well design and geochemical behaviour. The conclusions were positive and an industrial demonstration operation will hopefully be implemented in the following years.

In addition to the renewable heat fund described earlier, a tax reduction for heating networks using more than 50% of renewable energy (the tax paid by the customer for the consumed heat is 5.5% instead of 19.6%) has been put in place since 2010 and is a strong driver for the conversion of the district heating to renewables.

However, the development of geothermal district heating remains too low to achieve the 2020 targets that have been defined. It would be necessary to explore new aquifers and support demonstration projects exploiting them, both in the Paris basin (Lusitanian or Trias) and in other French regions.

5. GEOTHERMAL POWER PRODUCTION

5.1 Overseas departments

In the overseas department, geothermal energy is cheaper than power generated by fossil fuels and must be developed to enhance the energy independence of these territories. The single existing power plant, located in Bouillante in Guadeloupe, encountered technical and social issues from 2009 to 2012 but is now running again properly. It comprises two units, one double-flash 4 MWe unit running since 1986 and a single-flash 11 MWe unit inaugurated in 2004. In 2010-2011, a partial reinjection has been put in place and improvement works on wells and pipes have been performed. The first power unit has been rebuilt in 2013-2014.

The plant is run by Geothermie Bouillande, a subsidiary between BRGM and EDF. Even if this electricity production is negligible compared to the national demand, it is important to notice that the installed capacity in Guadeloupe represents more than 6% of the need for electricity of the island. The drilling of additional exploration is also envisaged.

Besides, surface exploration has been carried out in Martinique Island, including geophysics and in Vieux-Habitants, which is located south of Bouillante in Guadeloupe island; exploration is also envisaged in La Réunion. Exploration drillings on Dominica island, funded by the French Agency for Development, have been performed and the results are promising. The expected potential exceeds the local demand of this independent island located between Guadeloupe and Martinique islands, so an electric interconnection with one or both of these surrounding islands is being considered.

Moreover, the Interreg project “Caribbean Geothermal” has officially started. This 8.5 M€ project, coordinated by the Guadeloupe region, will accelerate geothermal development in the entire Caribbean region.

5.2 Engineered Geothermal Systems in the mainland

In the mainland, the Soultz EGS pilot plant, which is known worldwide, has been connected to the grid at the beginning of 2011. This pilot plant is run by the European Economic Interest Grouping "Exploitation Minière de la Chaleur", which is a gathering of six French and German companies (EDF, ES, PFALTZWERKE, ENBW, EVONIK, BESTEC). As the single EGS plant in the world, it is an important laboratory for European research, which gathers many research institutes from France, Germany, Switzerland and Norway.

It also inspired the Ecogi project: the first well has been drilled between September to December 2012 and stimulated in 2013; the second one is done in 2014. This EGS project aims at producing 24 MWt of industrial heat thanks to two deep wells (2,500 m depth) located in Rittershoffen (Alsace region, France). The produced heat will be transferred to Beinheim through a 15 km-long pipe and used in a starch factory.

Thanks to the new feed-in tariff put in place in 2010, many CHP projects are emerging and will allow France to develop its expertise in EGS: 8 permits have been delivered and 10 others are under examination. The targeted regions are Alsace, but also Massif Central and Aquitaine.

6. INDUSTRY AND RESEARCH

French industry covers all aspects of geothermal: turbine and heat pump manufacturers, surface and subsurface engineering companies, drillers, etc. In 2010, most of them gathered into a national geothermal association called AFPG. Among other actions, AFPG organizes the French Geothermal Days, a two-day conference and exhibition, and publishes also a yearly market study. A directory of the French geothermal players has been published in 2012 by the French renewable energy association (SER), which represents all renewable energies.

In 2011, a strategic geothermal roadmap was published by ADEME (the French Agency for Environment and Energy) in close link with industry and experts. It describes the challenges and issues of the geothermal sector, gives a 2020 vision, and identifies the technical and scientific barriers to define the R&D priorities and the need for demonstration operations.

French research covers the entire range of geothermal topics, especially EGS, using the pilot plant at Soultz-sous-Forêts. The 3rd phase of the Soultz R&D programme is on-going, focusing on exploitation, monitoring, and determination of the lifetime of such geothermal projects. The 4th phase is being discussed.

To boost innovation, the French government has put in place the “Investment for the Future” program that funds several RD&D actions: we can mention first two demonstration projects in high enthalpy, Fongeosec in the south-west of France, led by Fonroche, and Geotref in the French West Indies, led by Teranov.

After two calls for projects on all research domains in France, 171 Laboratories of excellences have been awarded. The “G-Eau-Thermie Profonde” Laboratory received its official quality label in March 2012. Based in Alsace, it will focus on deep geothermal energy and receive a €33 million funding for an 8-year period.

An Institute of Excellence for Carbon-Free Energies called GeodEnergies has been awarded. Based in Orléans, it is still under construction and will work on three industrial sectors associated with subsurface levels: CO_2 storage, energy storage and geothermal energy (heat and electricity).

In addition, several national technological clusters have been established to develop collaborative industry and research institute R&D projects, and include:

- Avenia, based in Aquitaine, deals notably with deep geothermal applications,
- Synergile aims at developing renewable energies in the overseas department,
- S2E2 (Orléans) deals with shallow geothermal and smart buildings,
- EnergiVie in Alsace.

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ADEME (French Agency for Energy and Environment) and BRGM (France's leading public institution in Earth Science field) have created a general geothermal website for France: www.geothermie-perspectives.fr

The list of valid high temperature geothermal permits is published on the following website: http://www.developpement-durable.gouv.fr/Les-titres-miniers-en-cours-de.html

The website of Interreg project "Caribbean Geothermal" gathers information about the whole region: http://geothermie-caraibes.org

APPENDIX : STANDARD TABLES

Table 2. UTILIZATION OF GEOTHERMAL ENERGY FOR ELECTRIC POWER GENERATION AS OF 31 DECEMBER 2013

Locality	Power Plant Name	Year Commissioned	No. of Units	Status[1)]	Type of Unit[2)]	Total Installed Capacity MWe*	Total Running Capacity MWe*	Annual Energy Produced 2012[3)] GWh/yr	Total under Constr. or Planned MWe
Guadeloupe	Bouillante	1° 1986 2nd 2004	2		2F	15,5	15,5	105,4	
Alsace	Soultz-sous-Forets	2010	1		B-ORC	1,5	1,5	10,2	
Total						17	17	115,6	

* Installed capacity is maximum gross output of the plant; running capacity is the actual gross being produced.

TABLE 3.1 UTILIZATION OF GEOTHERMAL ENERGY FOR DIRECT HEAT AS OF 31 DECEMBER 2013 (other than heat pumps)

Locality	Type[1)]	Maximum Utilization Flow Rate (kg/s)	Temperature (°C) Inlet	Temperature (°C) Outlet	Enthalpy[2)] (kJ/kg) Inlet	Enthalpy[2)] (kJ/kg) Outlet	Capacity[3)] (MWt)	Annual Utilization Ave. Flow (kg/s)	Energy[4)] (TJ/yr)	Capacity Factor[5)]
PARIS BASIN										
Alfortville	D	76	73	44			9,5	44	168	
Aubervilliers (2)	D						8,5		150	
Bonneuil s/marne	D	78	79,3				6,0	14	56	
Cachan 1 & 2	D	100	70				11,5	36	113	
Champigny 2	D	78	78	~ 45			11,0	48	210,8	62%
Chelles 2	D	78	69	~ 40			9,5	16	60,9	20%
Chevilly Larue & L'Haÿ les	D	155	72,6	~ 43			19,2	67	253	42%
Clichy S/Bois	D	50	71	44			5,6	16	73	41%
Coulommiers 2	D	64	85	61			6,4	36	114	56%
Créteil	D	84	78,9	50			10,1	67	256	80%
Epinay-sous-Sénart	D	70	72	49			6,7	67	203	96%
Fresnes	D	70	73	46			7,9	37	132	53%
La Courneuve	D		58				7,4	54	122,9	50%
Le Blanc Mesnil Nord	D	49	66	~ 40			7,0	27	91,7	55%
Le-Mée-sur-Seine 2	D	38	72	52			3,2	29	76,2	76%
Maisons Alfort 1	D	84	73	50			8,1	58	175	69%
Maisons Alfort 2	D	72	74	54			6,0	36	95	50%
Meaux Beauval & Collinet	D	113	75	46			13,7	37	90	32%
Meaux Hopital	D	36	76	51			7,3	45	148	67%
Melun l'Almont	D	72	72	42			9,0	45	178	62%
Montgeron	D	61	72,5	45			7,0	27,5	100	45%
Neuilly-sur-Marne 2 (2)	D						13,4		150	
Orly II Nouvelet	D	98	75	49			10,7	35,5	121	0,36
Orly Aéroport (2)	O						8		120	
Ris Orangis	D	52	72	53			4,1	35,3	88,5	0,68
Sucy en Brie	D	55	78	~ 50			6,2	35	125,1	0,64
Thiais	D	70	76	~46			8,8	40	156,7	0,57
Thorcy - Val Maubuée (2)	D						10,0		160	
Tremblay-en-France	D	76	73	46			8,6	52,5	186	0,69
Vigneux-sur-Seine	D	67	73,2	~44			8,2	31	120,9	0,47
Villeneuve-St-Georges	D	97	76	45			12,6	34	139	0,35
Villers-le-Bel Gonesse	D	64	67	~40			7,2	22	78,1	0,34
TOTAL 3.1							**278,5**		**4 311,8**	

TABLE 3.2 UTILIZATION OF GEOTHERMAL ENERGY FOR DIRECT HEAT AS OF 31 DECEMBER 2014 (other than heat pumps)

Locality	Type[1]	Maximum Utilization					Capacity[3]	Annual Utilization		
		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]
Other Basins										
Bassin Aquitain										
Argelouse/Sore	G	42	48	18			5,3	15	59,4	36%
Bordeaux Benauge	B	55,5	42	30			2,8	1	1,4	2%
Bordeaux Stadium	B	36	34	26			1,2	4	3,9	10%
Merignac - BA 106	H	67	52	40			3,4	37	58,4	55%
Mios le Tech	F	55,5	73	30			10,0	14	77,2	25%
Mont-de-Marsan 1	H	70	60	54			1,8	60	47,4	86%
Mont-de-Marsan 2	H	17	56	44			0,9	6	8,9	33%
Saint Paul les Dax 1	H+B	42	47	22			4,4	15	49,6	36%
Saint Paul les Dax 2	H+B	8,5	60	30			1,1	4	15,5	46%
Blagnac1	B	8,5	55	28			1,0	3	11,5	38%
Nogaro 2	F	50	51	27			5,0	21	66,6	42%
Jonzac 1	H+B	8,5	60	30			1,1	5	19,8	59%
Jonzac 2	B	17	58	26			2,3	10	43,3	60%
Auvergne										
Aigueperse	G	17	43				1,6	14	41,4	80%
Centre										
Chateauroux	D		34				5,8		53,5	
Languedoc										
Lodève 2	G		52	~			1,3	5	22,6	54%
Pézenas	F+B	30	38	~			4,0	18	41,7	33%
Lorraine										
Dieuze	F	31	31	~			1,4	13	18,8	42%
Lunéville	B	41	25	15			1,7	2	3	5%
Nancy1 - Thermes	B	38	45	29			2,5	5	11,3	14%
Total							**58,4**		**655,2**	
Total 3.1 + 3.2							**336,9**		**4 967,0**	

TABLE 4. GEOTHERMAL (GROUND-SOURCE) HEAT PUMPS AS OF 31 DECEMBER 2013

Locality	Ground or Water Temp. (°C)[1]	Typical Heat Pump Rating or Capacity (kW)	Number of Units	Type[2]	COP[3]	Heating Equivalent Full Load Hr/Year[4]	Thermal Energy Used (TJ/yr)	Cooling Energy (TJ/yr)
Total France	15	2 010 000	163 000	W+V+H	4		10 900	Unknown
TOTAL	15	2 010 000	163 000	W+V+H	4		10 900	Unknown

TABLE 5. SUMMARY TABLE OF GEOTHERMAL DIRECT HEAT USES AS OF 31 DECEMBER 2013

Use	Installed Capacity[1] (MWt)	Annual Energy Use[2] (TJ/yr = 10^{12} J/yr)	Capacity Factor[3]
Individual Space Heating[4]	9,5	157,2	
District Heating [4]	284,1	4365,4	49%
Air Conditioning (Cooling)			
Greenhouse Heating	8,2	123,4	48%
Fish Farming	18,4	183,4	32%
Animal Farming			
Agricultural Drying[5]			
Industrial Process Heat[6]			
Snow Melting			
Bathing and Swimming[7]	16,7	137,6	26%
Other Uses (specify)			
Subtotal	**336,9**	**4967,0**	
Geothermal Heat Pumps	2010,0	10900,0	17%
TOTAL	**2346,9**	**15867,0**	

[4] Other than heat pumps

[5] Includes drying or dehydration of grains, fruits and vegetables

[6] Excludes agricultural drying and dehydration

[7] Includes balneology

TABLE 6. WELLS DRILLED FOR ELECTRICAL, DIRECT AND COMBINED USE OF GEOTHERMAL RESOURCES FROM JANUARY 1, 2010 TO DECEMBER 31, 2014 (excluding heat pump wells)

Purpose	Wellhead Temperature	Number of Wells Drilled				Total Depth (km)
		Electric Power	Direct Use	Combined	Other (specify) (1)	
Exploration[1]	(all)					
Production	>150° C				2	6000
	150-100° C					
	<100° C		16			29600
Injection	(all)		10			21600
Total			26			57200
(1) industrial use						

TABLE 8. TOTAL INVESTMENTS IN GEOTHERMAL IN (2013) US$

Period	Research & Development Incl.	Field Development Including Production	Utilization		Funding Type	
			Direct	Electrical	Private	Public
	Million US$	Million US$	Million US$	Million US$	%	%
1995-1999						
2000-2004						
2005-2009	46	43	40	49	70	30
2010-2014	61	47	150	50	70	30