

GEO THERMAL ENERGY

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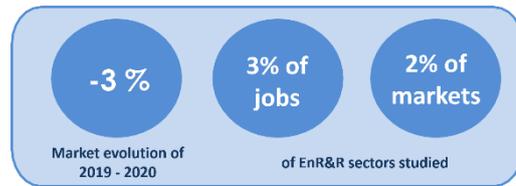
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1. Key points



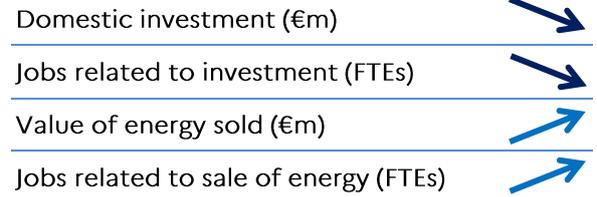
1.1. A declining market: -6% in two years

The market for geothermal energy decreased between 2018 (€595m) and 2020 (€561m). This decrease mainly concerned the market for geothermal heat pumps installed in residential buildings and buildings in the collective and tertiary sectors (surface geothermal). However, the market experienced an upsurge in both low- and high-energy deep geothermal.

Increasingly geared towards renovation, sales of geothermal heat pumps in the residential sector increased by 13% in 2019, but subsequently decreased by 14% in 2020 (3,005 units; Observ'ER).

Between 2009 and 2020, more than 720 geothermal projects were supported by the ADEME Heat Fund (FC), for an investment of €975.9m. These projects ultimately resulted in 302.1 GWh of additional renewable heating in 2020. In the same year, the Heat Fund supported 73 projects totalling €102.4m.

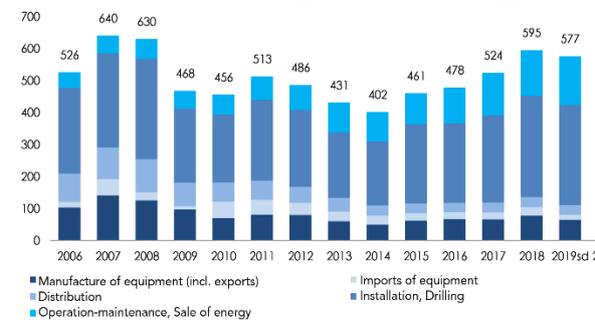
Trends observed 2018-2020



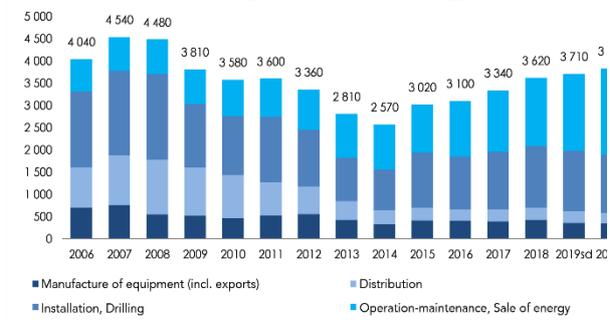
In 2020, the 2.5 TWh produced by low-yield deep geothermal energy mainly supplied the heating networks of the Paris and Aquitaine basins (87%). Other uses are in industry (8%), agriculture/pisciculture (3%) and pools/thermal baths (2%; AFIG).

In contrast to investments and markets, jobs are growing at an average annual rate of 3%, from 3,620 FTEs in 2018 to 3,830 FTEs in 2020. The decline in investment jobs is offset by higher employment in plant operation, equipment maintenance and sale of energy.

Total market related to geothermal energy (€m)



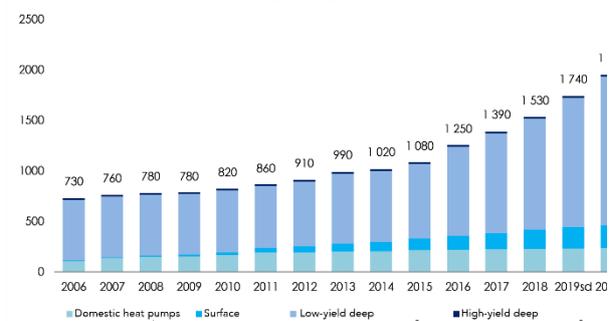
Jobs related to geothermal energy (FTEs)



Operation-maintenance market and energy sold (€m)



Operating-maintenance and energy sale jobs (FTEs)



Which markets and jobs are we talking about?

Jobs are limited to direct jobs: manufacture, sale and installation of equipment, drilling, preliminary studies, operation-maintenance and sale of energy. Indirect jobs (manufacturers' suppliers, heat exchanger manufacturers) are not included. Jobs for the distribution of heating from geothermal energy are presented in the fact sheet on heating networks. In 2019, these are semi-final estimates and, in 2020, provisional estimates.

Manufacturing	Manufacture of geothermal equipment (including geothermal heat pumps)
Distribution	Wholesalers, distributors
Drilling, Installation, Studies	Installation of equipment, networks of installers
Sale of energy	Operation of production units, maintenance of equipment, sale of energy

2. Regulatory context

2.1. A fully structured and supported sector

From 2009 to 2020, 44 deep aquifer geothermal projects were supported by the ADEME Heat Fund with a total investment of €578.8m. These projects resulted in the production of 1.8 TWh of renewable heating.

In 2010, the profession, with the support of ADEME, made a major capacity-building effort with the creation of the French Association of Geothermal Professionals (AFPG). This effort was accompanied by a simplification of regulations, an increase in the skills of the actors (via RGE or Recognised Environmental Guarantor qualifications in surface geothermal) and the implementation of new insurance mechanisms (GEODEEP fund).

Created in 2015, the GEODEEP cluster (made up of fifteen companies) is designed to promote French know-how abroad. This cluster also contributed to the establishment of two funds covering geothermal risks. Dedicated to the EGS (Enhanced Geothermal System) sector in mainland France, the first fund aims to reduce the risks associated with geological hazards (compensation in case of failure). The second is for volcanic geothermal energy and international action. From 2015 to 2019, the operations undertaken by GEODEEP represented a budget of €43m.

Created in 2015, the Géodénergies Scientific Interest Group (GIS) in particular aims to structure a centre of expertise specialised in underground knowledge and technologies.

2.2. Regulatory developments and innovations

2007

- Implementation of the QualiPAC label for installers and of the NF PAC certification for manufactured models

2009

- Creation of the ADEME Heat Fund

2010

- Tax credit eligibility for drilling and installing underground heat exchangers for geothermal heat pumps

2011

- Launch of an ADEME Call for Expressions of Interest (AMI) dedicated to geothermal energy

2013

- New energy label with three very high performance classes: A+, A++ and A+++
- Implementation of the Qualiforage label
- Application of RT 2012 to individual houses

2014

- EU regulation on fluorinated greenhouse gases (F-gases) and road map for reducing emissions by 2050

2015

- Creation of the GEODEEP cluster with 2 guarantee funds over 4 years for EGS/volcanic projects
- Creation of the Géodénergies Scientific Interest Group
- Creation of the simplified Low-Importance Geothermal (GMI) regime
- European Parliament and Council directives on Eco-design and Eco-labelling requirements:
- Obligation for an RGE-certified company to carry out heat pump installation work in order to receive public aid
- Publication of Title V "Geo-cooling" Recognition by RT 2012 of cooling production by geothermal heat pump

2016

- Order fixing the conditions for the remuneration of electricity generated by geothermal energy (opened top-up funding)
- Integration into the French State budget of financing support for renewable energy via the "Energy Transition" Special Assignment Account (Compte d'Affectation Spéciale).

2017

- Order of 16 August: Inclusion of "Geo-cooling" in Title V of RT 2012 (Thermal Regulation)

2019

- Decree on the ESSOC Act amending the principles of mining exploration and exploitation titles
- Entry into force of the Tertiary Decree

2020

- Order on obligations to reduce final energy consumption in buildings for tertiary use
- Abolition of geothermal top-up funding
- Progressive transformation of the CITE into MaPrimeRénov'
- "France Relance" Plan: €6.7bn budget for energy renovation, including €2bn for the MaPrimeRénov' scheme (CITE level in 2017) as of 2021

2021

- Permanent abolition of the CITE (Energy Transition Tax Credit)
- MaPrimeRénov' extended to all domestic households

2022

- Restriction of MaPrimeRénov' to housing more than 15 years old only (instead of 2 years)
- Ban on installing a fossil fuel boiler with emissions exceeding 300 gCO₂/kWh in existing buildings on 1 July
- Application of RE 2020 (Environmental Regulation) on 1 January

The decree concerning Low-Importance Geothermal (GMI¹) deposits means that most geothermal infrastructure less than 10 metres deep can be excluded from the Mining Code. It also led to the creation of a simplified and computerised reporting regime for GMI activities. The aim of these provisions was to ensure better supervision of the sector and to secure, simplify and reduce the time needed to implement geothermal heat pump projects.

With regard to high-yield deep geothermal (generating electricity), the French Association of Geothermal Professionals (AFPG) helped to negotiate the new system, namely top-up funding. This bonus came into effect in December 2016 at €246/MWh for EGS geothermal electricity, which was more remunerative than the old one (€130 in overseas France and €200 on the mainland). This technology for the exploitation of high-yield deep geothermal (electrical, combined heat and power) was first applied in the same year. After thirty years of research and development, the Soultz-sous-Forêts and Rittershoffen power plants were commissioned and entered the industrial operation phase.

The new Multiannual Energy Programme (PPE) revised the feed-in tariff in such a way that new projects could no longer benefit from it after 2020. Nevertheless, a quota of around 60 MWe has been negotiated and will benefit from the old feed-in tariff (AFPG).

Since 2017², “geo-cooling” has been included in the 2012 Thermal Regulation (RT 2012). Geo-cooling is the direct use of underground resources to cool buildings without the use of an intermediate cooling unit.

Similarly, the 2019 decree³ on the ESSOC Act⁴ amended the principles of mining exploration and exploitation titles by removing the concept of temperature, and thus allowing co-extraction of minerals through solution mining.

2.3. Financial aid for geothermal heat pumps in the residential sector

Available since 1 April 2018, the “Heating Boost” (Coup de Pouce Chauffage) scheme aims to encourage households to replace their coal, oil or gas heating installation (excluding condensing boilers) with, among other things, an air/water-type heat pump. Depending on the household’s income, this bonus varies between €2,500 and €4,000.

Pursuant to Article 15 of the Finance Law for 2020, the CITE (the Energy Transition Tax Credit) is gradually being transformed into “MaPrimeRénov’”, a more energy performance-focused subsidy that takes income levels into account. This bonus is paid by the French National Housing Agency (ANAH). Initially reserved for owner-occupiers, this bonus has been available to all owners and co-owners' unions since 11 July 2021.

¹ Decree No. 2015-15 of 8 January 2015 amending Decree No. 78-498 of 28 March 1987, as amended, relating to research and exploitation certificates for geothermal energy, Decree No. 2006-649 of 2 June 2006, as amended, relating to mining, underground storage and the mining and underground storage inspectorate

² Order of 16 August 2017 on the approval process for the inclusion of geo-cooling in the 2012 thermal regulation

³ Decree No. 2019-1518 of 30 December 2019 on exploration and exploitation titles for geothermal deposits

⁴ Government Reform Act No. 2018-727 of 10 August 2018 for a Trust-Based Society (ESSOC)

The amount of this bonus has been increased for the installation of geothermal heat pumps: €4,000 for middle-income earners, €8,000 for low-income earners, and €10,000 for lowest-income earners.

The scheme also provides for a “Total Renovation” package for households implementing a work package that achieves a minimum energy saving of 55%. The amount of the bonus can vary from €3,500 to €7,000. This bonus can be coupled with the “Energy Efficient Building Bonus” and the “Energy sieve exit bonus”. Households not eligible for this premium are eligible for the “MaPrimeRénov’ Sérénité” scheme.

The MaPrimeRénov’ subsidy can be combined not only with the “Heating Boost” subsidy, but also with the Zero-Interest Eco-Loan (éco-PTZ) and the reduced VAT rate of 5.5% (instead of 20%).

France, leading EU geothermal heating consumer in 2020

France was the EU’s largest consumer of geothermal heat (2,341.9 GWh), ahead of the Netherlands (1,717.5 GWh), Italy (1,634.9 GWh) and Hungary (1,494.2 GWh).

In terms of gross geothermal electricity generation, France (including the French overseas departments) was the 4th EU producer country (17.1 MW installed and 133.2 GWhe produced), well behind Italy (915.5 MW and 6.0 TWhe), Portugal (34.0 MW and 217.2 GWhe) and Germany (47.0 MW and 231.0 GWhe).

As regards sales of geothermal heat pumps, the gap between France and other European countries remained large. In 2020, only 3,005 geothermal heat pumps were sold in France, far behind Sweden (23,760 units), Germany (22,200 units) and the Netherlands (19,350 units).

Source: *EurObserv’ER (2021), State of renewable energy in Europe, 20th review*

3. Actors in the geothermal sector

Investments made in geothermal energy require many industrial skills: integrators and developers, design offices, equipment manufacturers, drilling companies and construction companies (installers).

3.1. Integrators and developers

The main integrators and developers of geothermal projects are CFG Services (subsidiary of the Bureau of Geological and Mining Research - BRGM; €4.2m revenue for 17 employees in 2020), Fonroche (with a dozen ongoing projects representing €400m in investment by 2025), Teranov, Électerre de France and ÉS-Géothermie.

3.2. Design offices

In the field of geothermal energy, specialised offices carry out geoscience and thermal studies.

Surface geothermal energy: ARTELIA, EGEE Développement, Geosophy, GEOTHER, GPC Instrumentation Process, HYDRO INVEST, HydroGéologues Conseil, HYGÉO, S2T, STRATEGEO Conseil, ACCENTA, Amstein+Walthert, BatiMgie, I THERM CONSEIL\

Deep geothermal energy: Compagnie Française de Géothermie (CFG; BRGM subsidiary), TLS Geothermics

Several structures have activities in both surface and deep geothermal: BURGEAP, Antea Group, ECOME Ingénierie, ERG, G²H Conseils, BYGéo, CEBI 45 (Climatique Énergie – Bâtiment et Industrie) and SERMET.

The term “RGE Études” refers to study or project management services carried out for large buildings or renewable energy installations. As regards geothermal energy, qualifications are issued by the engineering qualification body OPQIBI (62 qualified in geothermal production facility engineering and 36 qualified in geothermal resource studies as of 31 December 2021) and I.Cert.

3.3. Manufacture of appliances

Heat-pump-assisted surface geothermal in the residential sector: Manufacturers of geothermal heat pumps below 30 kW include:

- In 2008, Sofath joined the De Dietrich Remeha group. The latter merged with the Baxi group in 2009 and became BDR Thermea. Today, BDR Thermea is the 3rd manufacturer of heating appliances in Europe and is present in a hundred countries (revenue of €404.2m in France in 2020 for 1,100 employees).
- Since 2010, the German Vaillant Group (2nd European heating group and represented by the Vaillant brand in France for geothermal heat pumps) has maintained a production line in its Nantes plant.
- Atlantic designs and manufactures the majority of its products in France (revenue of €2.2bn; 10,000 employees). The group has 10 factories in France, manufacturing 5m appliances per year (heat pumps, thermodynamic water heaters, boilers, solar water heaters), and 2,500 employees.
- The Swedish group Nibe Industries has taken over the business activities of Technibel (revenue of €2bn for 18,000 employees worldwide).

Aware of the potential for more energy-efficient heating systems, generalist companies⁵ have entered the heat pump market as manufacturers or importers: Viessmann, Muller, Weishaupt, Carrier, Climaveneta of the Mitsubishi Electric Group, as well as French companies Lemasson (revenue of €4.9m for 40 employees in 2020) and SDEEC (revenue of €4.4m for 30 employees). The main European manufacturers of geothermal heat pumps are Swedish (Nibe Heating) and German (Stiebel Eltron and Bosch through many subsidiaries).

Heat-pump-assisted surface geothermal in the collective and tertiary sectors: In the field of surface geothermal energy, the main European suppliers of geothermal heat pumps (water/water heat pumps) with a power of more than 50 kW are the Swedish company Nibe Heating, as well as the German companies Buderus, Bosch, Viessmann, Alpha Innotec, Waterkotte, Stiebel Eltron and Weishaupt.

⁵ Manufacturers of boilers, electric heating and domestic hot water tanks, air-conditioning technicians

In France, the CIAT (Compagnie Industrielle d'Applications Thermiques⁶) is the main manufacturer of high-power heat pumps (revenue of €114.5m in 2020 and 810 employees). Other manufacturers exist on this market: Carrier, Daikin, Enertime, Friotherm and Lemasson.

Deep geothermal energy: Several other suppliers of various goods and services are also involved in low- and high-yield deep geothermal energy: turbines for ORC (Organic Rankine Cycle), heat exchangers, tubes, equipment and systems in electrical and mechanical engineering, and chemicals among others.

3.4. Drilling and boring

In 2019, 365 companies were specialised in drilling and boring⁷, with a revenue of €525.3m and 1,950 salaried employees. The reduction in activity is mainly due to the low level of oil exploration.

Among the main companies were S.M.P (Société de Maintenance Petroleum; revenue of €50.2m in 2020) and Foragelec (revenue of €9.4m for around twenty employees). In February 2020, Entrepose Group sold all the shares of Entrepose Drilling (Compagnie de Forage Cofor) to Averno Group.

One of the objectives of the GMI deposit decree (which entered into force in 2015) is to provide administrative simplification, enabling an improvement in the quality of the boreholes. This is because remote reporting procedures are only possible if the drilling work is carried out by an RGE QualiForage driller. As of 4 January 2021, the Qualit'EnR association counts only 65 certified companies (27 in surface drilling and 36 in boring), figures identical to the previous year.

3.5. The "Qualit'EnR heat pump" label and "Qualibat" certification for installers

For the 8th consecutive year, the number of RGE (Recognised Environmental Guarantor) qualifications awarded by the association Qualit'EnR in the field of renewable energy has grown. As of 4 January 2021, the association includes 8,280 companies qualified to install heat pumps (including both aerothermal and geothermal heat pumps).

There is also the Qualibat certification. Today, nearly 65,000 companies have this certification, including 45,190 RGE-certified professionals (compared with 20,860 RGE-certified companies in 2021⁸).

3.6. Geothermal heating network operators and managers

Apart from local authorities and mixed economy companies, the main operators of heating networks based on low-yield deep geothermal energy are Dalkia (EDF subsidiary), ENGIE Solutions and Storengy (Engie subsidiaries).

Dalkia France is a major player in geothermal energy in Île-de-France, with about thirty geothermal doublets in operation supplying more than 100,000 housing equivalents. To date, Dalkia operates 18 low-yield deep geothermal facilities in Île-de-France and 36 surface geothermal facilities in France.

ENGIE Solutions supplies 35% of the renewable heating of geothermal origin in Île-de-France through 10 networks supplying the equivalent of 60,000 homes. In January 2017, Engie's two subsidiaries – Engie Solutions and Storengy – won the public service delegation for the new low-yield deep geothermal heating network of the Plaine Rive Droite (Bordeaux Métropole), which will eventually meet 82% of heating needs. ENGIE is particularly present internationally for electricity generation projects (Indonesia, Mexico).

In addition to these two main groups, there are other operators whose heating and cooling networks mobilise geothermal resources: Idex manages 50 heating and cooling networks (€890m of revenue for 3,600 people) and Coriance manages 37 heating and cooling networks and has 28 geothermal sinks (€172m of revenue). Mention may also be made of Électricité de Strasbourg (Soultz-Sous-Forêts) and ECOGI (Roquette-Frères; Rittershoffen) in electricity and heating, as well as Fonroche (Vendenheim-Reichstett, leading electricity-steam combined heat and power plant in France, with commissioning postponed to late 2022 following seismic episodes).

⁶ Bought by the US industrial conglomerate United Technologies (UTC) in 2015

⁷ INSEE, ESANE Base, NAF 43.13Z Test drilling and boring

⁸ <https://data.ademe.fr/reuses/nombre-d'entreprises-rge>

4. Market and employment situation

In this section, distinctions are made between:

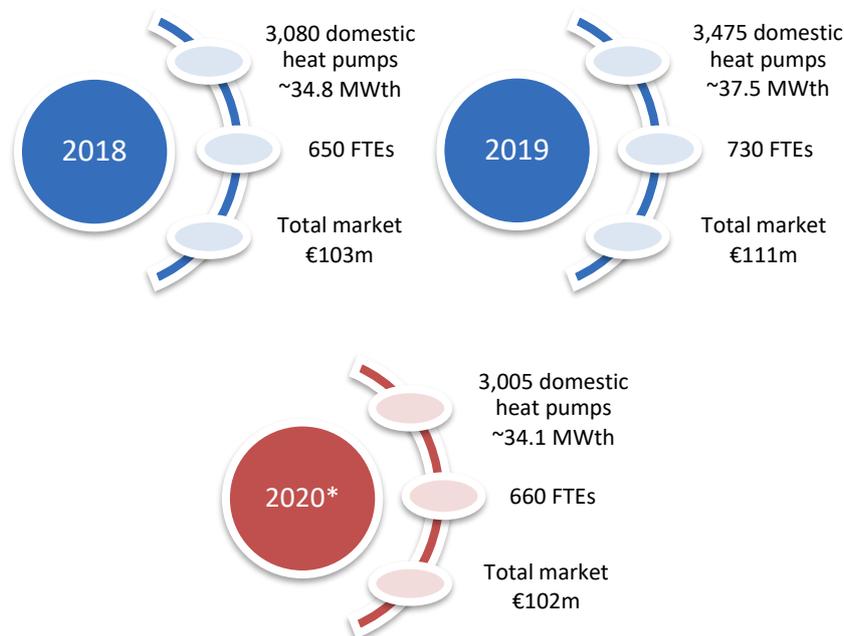
- Heat-pump-assisted surface geothermal energy in the residential sector
- Heat-pump-assisted surface geothermal energy in the collective-tertiary sector
- “Low-yield” deep geothermal energy (direct heat recovery)
- “High-yield” deep geothermal energy (electric and combined heat and power)

4.1. Heat-pump-assisted surface geothermal energy in the residential sector

Sales of geothermal heat pumps to private individuals, increasingly destined for renovation, have been declining over the past decade. Nearly 22,000 heat pumps were sold in the residential sector in 2008. After recovering sales by 13% in 2019 (3,475 units), sales were down again to 3,005 units in 2020, equivalent to 34.1 MWth⁹. This decrease applied to all types of geothermal heat pump, with -11% for ground/ground and ground/water heat pumps and -14% for water/water heat pumps.

Despite a 4% increase in average prices over two years, investments (including exports) kept pace with sales and went from €76m in 2018 to €84m in 2019 and €74m in 2020. The same applies to associated jobs: 430 FTEs in 2018, 500 FTEs in 2019 and 430 FTEs in 2020. In 2020, the manufacture of equipment for export required a dozen or so jobs. Distribution, installation and drilling jobs accounted for 88% of investment jobs.

The installed base of geothermal heat pumps in the residential sector was estimated to be in excess of 187,000 units in 2020. The market for the servicing and maintenance of this base was €28m (up 2% compared to 2019), involving 230 jobs.



* IN NUMERI estimates. FTEs: full-time equivalents.

⁹ Observ'ER (2021), Monitoring the 2020 market and prices for individual heat pumps

4.2. Heat-pump-assisted surface geothermal energy in the collective and tertiary sectors

In 2020, surface geothermal in the collective-tertiary sectors represented 32% of the installed thermal power of the sector. It concerns installations up to 200 metres deep where the temperature is generally below 20°C. With good energy and environmental performances, this system is made up of 3 devices:

- A capture device for exploiting the resource via a variety of sensors (horizontal sensor, ground-water doublet, vertical geothermal sensor, probe field, compact heat exchangers, geothermal baskets and wall, thermo-active foundations, waste-water and sea-water energy recovery systems¹⁰);
- Device for adjusting (increasing or decreasing depending on the device) the temperature of the heat-transfer fluid (geothermal heat pump);
- Control device (instrumentation, control) to ensure the desired production and correct operation between devices.

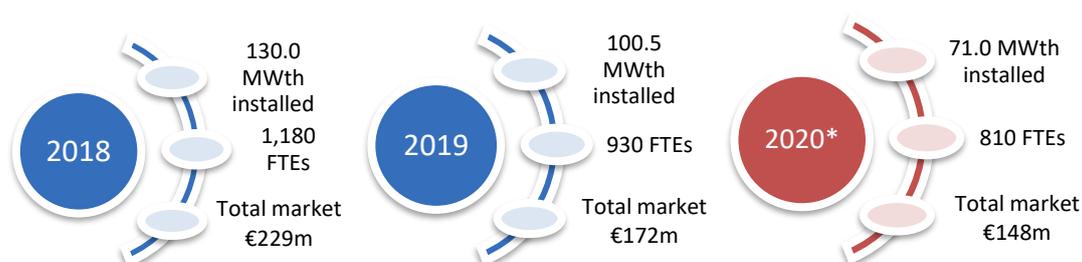
This system covers the heating, domestic hot water (DHW), air conditioning and cooling needs of new or renovated buildings.

As for geo-cooling, it allows highly efficient direct cooling of a building (40 kWh of cooling for 1 kWhe used) without making the heat pump operate. At a depth of 10 to 200 metres, the subsoil temperature is stable and below 20°C. The "Thermo-refrigerating Pump; TFP" heat pump system is capable, with the same equipment, of simultaneously producing heating and air conditioning. The efficiency of the TFP mode is very high, with 8 to 12 kWh of heating and cooling for 1 kWhe used. Heat recovery from waste waters or sea water is also under development, even for cooling applications.

This heading is limited to equipment installed in collective housing, services and other productive activities.

According to the AFPG's sector studies, commissioning decreased as of 2018, going from 130 MWth to 100.5 MWth in 2019 and 71 MWth in 2020. The required investment (exports included) decreased by 23% on average per year between 2018 (€206m) and 2020 (€121m). Associated jobs followed the same trend (manufacturing, distribution and installation of equipment, drilling work) and fell from 990 FTEs in 2018 to 580 FTEs in 2020, a decrease of 23% on average per year.

Heat production from surface geothermal energy, which is essentially self-consumed, has not been included in this sheet. Only equipment servicing and maintenance services have been included. In 2020, this market totalled €27m for a base of more than 13,660 installations and 230 jobs.



* IN NUMERI estimates. FTEs: full-time equivalents.

4.3. "Low-yield" deep geothermal energy

This technology directly uses heat from deep aquifers (800 to 2,000 metres) to heat a building complex or neighbourhood via a heating network or to provide heating for agricultural and industrial uses. Some cooling networks also draw their renewable energy source from aquifers.

In France, the main geothermal operations for district heating were carried out between 1982 and 1986 after the second oil crisis. In its early stages, the sector faced technical difficulties due, in particular, to the aggressiveness of the geothermal fluid exploited, which caused corrosion of the combined casing of the boreholes, as well as problems of profitability¹¹. The fall in oil prices and the gradual decline in inflation

¹⁰ The techniques developed (except for capture) are the same as those of surface geothermal. These projects are therefore included in the ADEME Renewable Heat Fund under the heading "Geothermal".

¹¹ Financed by loans at the high interest rates of the time, these installations had their revenue indexed on fossil-fuel energy prices.

from the mid-1980s onwards are the main causes of this decline in profitability, leading to the closure of some installations. From 1987 to 2007, only three deep geothermal installations were established in the Aquitaine region.

Despite these difficulties, 2/3 of the facilities built at that time are still in operation today. France has very favourable geothermal resources located mainly in the Paris basin, in Aquitaine and in Alsace. Low-yield deep geothermal energy is thus the leading renewable energy developed in the Île-de-France region. This region is home to the world's highest density of such installations exploiting the same deep aquifer. In 2006, there were 60 units operating deep aquifers, including 34 district heating networks and 26 various operations (greenhouse heating, swimming pools).

As of 2009, the sector has experienced a revival of activity with the construction and operation of almost 40 new or refurbished installations between 2010 and 2020 (European Geothermal Energy Council - EGEC, AFPG). The decisive tool for the development of low-yield deep geothermal is the existence of the geological and hydrogeological risk coverage system, in place since the early 1980s. Managed by SAF Environnement (a subsidiary of the CDC - Caisse des Dépôts et Consignations) at the request of ADEME (owner of the Guarantee Funds), this scheme consists of two parts:

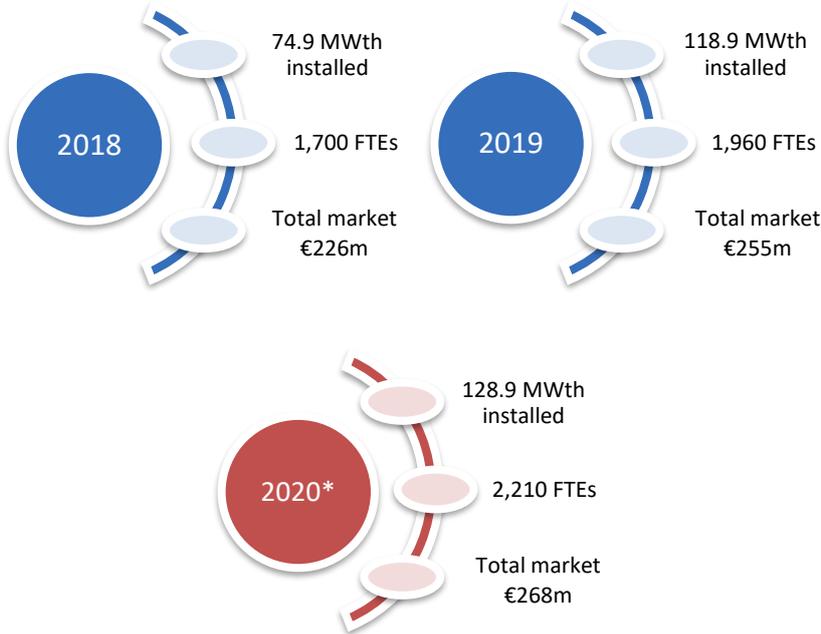
- A "short-term" component, ensuring the commissioning of a deep reservoir with a projected flow/temperature combination allowing up to 90% reimbursement of a geothermal borehole in the event of a total failure (maximum 65% compensation and possible additional 25% by the region);
- A "long-term" component, ensuring operations in service against the risk of depletion of the geothermal resource in terms of flow and/or temperature for 20 years.

Furthermore, low-yield deep geothermal could not have been deployed so strongly without the establishment of the ADEME Heat Fund. This fund subsidises low-yield deep geothermal operations at a level of about 20-25% of the investment costs.

According to the AFPG's sector studies, commissioning increased as of 2018, going from 74.9 MWth to 118.9 MWth in 2019 and 128.9 MWth in 2020. The required investments increased by 12% on average per year between 2018 (€150m) and 2020 (€188m). Associated jobs kept pace with investments (manufacturing, drilling, preliminary studies) and increased from 600 FTEs in 2018 to 740 FTEs in 2020, an average increase of 11% per year.

At around 1,140 GWh in 2010, low-yield deep geothermal heating output exceeded 1,440 GWh in 2013 as a result of new developments (French Data and Statistical Studies Department or SDES, Follow-up to the European Renewable Energy Directive). In 2020, 2,267.3 GWh of heating was produced, with a market value of €80.5m. Jobs in plant operation and sale of heating totalled 1,470 FTEs.

Note: The heating output from low-yield deep geothermal installations (SDES) also takes into account heating from high-yield deep geothermal units (combined heat and power).



* IN NUMERI estimates. FTEs: full-time equivalents.

4.4. “High-yield” deep geothermal energy

High-yield deep geothermal energy (generating electricity) is used to generate electricity from deep water vapour sources. If the natural characteristics are sufficient (active volcanic zone), high-yield deep geothermal not only makes it possible to recover energy in the form of heat, but also to produce combined heat and power by generating electricity at the same time. Without these characteristics, the use of a discontinuous technology of the EGS (Enhanced Geothermal System) type is necessary.

In France, high-yield deep geothermal energy concerns 4 plants: one using volcanic geothermal (Bouillante) and three using EGS technology (Soultz-sous-Forêts and Rittershoffen, launched in 2016; Vendenheim-Reichstett with possible commissioning in 2022).

Volcanic geothermal energy

Conventional high-yield deep geothermal in volcanic areas allows electricity to be generated from steam using a turbine.

After a reinforcement of Unit 2 in 2005, the capacity of the Bouillante plant (Guadeloupe) was 15 MWe. After a period of high production (86.5 GWh on average between 2006 and 2009), its production dropped sharply to only 16.2 GWh in 2010, a drop linked to technical difficulties and cyclical phenomena among other things. Renovation of Unit 1 began in 2013, with commissioning in 2014. The investment of €4.4m allowed production of 83.1 GWh in 2014. In 2016, BRGM sold its shares in the plant to the American company Ormat. In 2020, the unit returned to a high production level with 109.5 GWh (Guadeloupe Regional Energy and Climate Observatory).

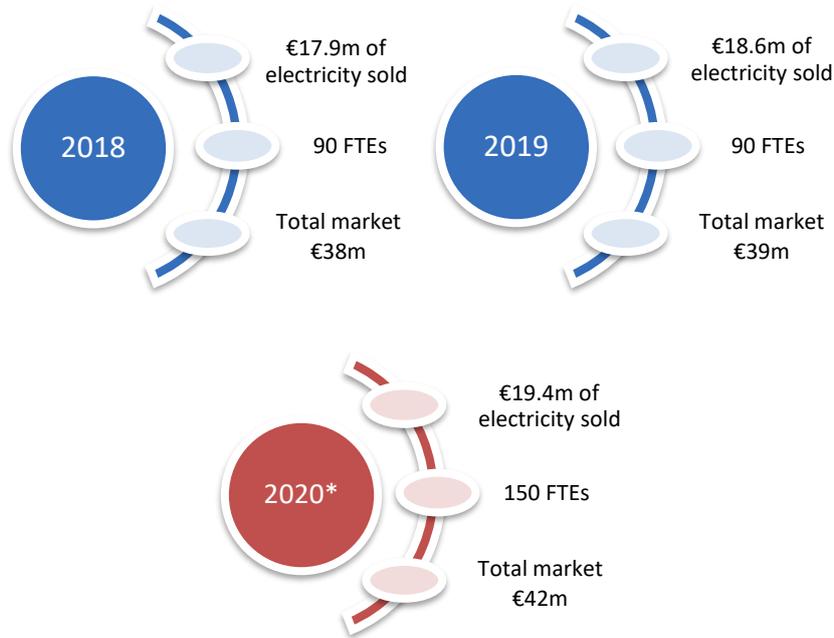
Enhanced Geothermal System

The period from 2000 to 2006 saw the finalisation of the deep geothermal trial programme of Soultz-sous-Forêts in Alsace. A first well injected water at a depth of 5,000 m. As it circulated through naturally fractured rocks, this heated water was recovered by two boreholes and gave its heat, at the surface, to a secondary fluid that actuated a turbine generating electricity. Cooled by the first borehole, the water was then re-injected. A pilot plant of 1.5 MW was commissioned in early 2008 and allowed the industrial validation of this new technology, which considerably widened the areas of potential generation of electricity and high-temperature heating from geothermal resources. The plant was revamped in 2015 and inaugurated in 2016 (thermal power of 11.4 MWth and electrical power of 1.7 MWe). The cost of this renewal was €11m.

The project's achievements subsequently enabled the validation of EGS technology, which has been used at the Rittershoffen¹² plant in particular. Inaugurated in 2016 for an investment of €55m, this 24 MWth power plant supplies heat to the starch processing plant Roquette-Frères.

Led by industrialist Fonroche, the 1st geothermal power plant in combined heat and power at Vendenheim-Reichstett represents a total investment of more than €100m (€10m dedicated to exploration, €40m to the drilling of two sinks, and €50m for the construction and connection of the plant). The results from the first borehole in 2017/18 were conclusive. A second borehole was drilled in 2019. According to feedback from the TERRE (Energy Transition, Renewable Energy, Energy Networks) mission directorate of Strasbourg Eurométropole, a request for the definitive closure of the site (which was 95% completed in 2021) was filed by the local prefecture. This situation has thus triggered a dispute between the operator and the French State. It is very difficult to predict the future of the facility. With a total power of 40 MWth and 9 MWe, its possible commissioning has been postponed until the end of 2022.

¹² Bringing together Électricité de Strasbourg (ÉS), Exploitation de la Chaleur d'Origine Géothermale pour l'Industrie (ECOGI, known as Roquette-Frères) and the Caisse des Dépôts et Consignations, this project is supported by ADEME and the Grand-Est region.

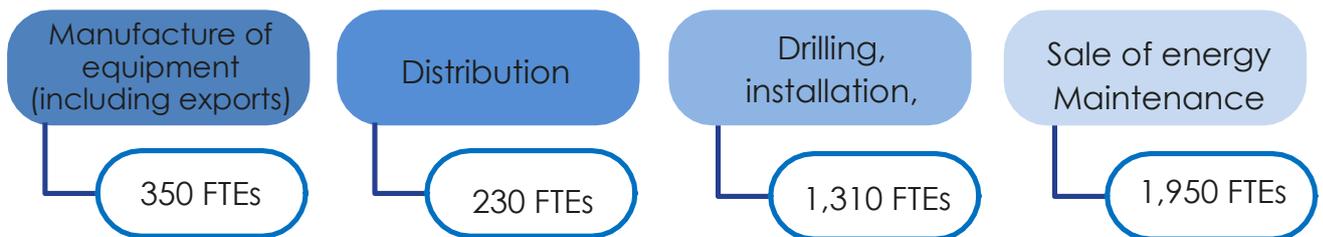


* IN NUMERI estimates. FTEs: full-time equivalents.

4.5. A sector worth €560m in 2020, employing 3,830 direct jobs

In 2020, the total market for the four geothermal sectors was €560m, including €403m for domestic investment, €155m for the value of the energy sold and the operation-maintenance services of the facilities, and €2m for the export of equipment.

Employment totalled 3,830 FTEs, including 1,870 FTEs associated with domestic investment, 1,950 FTEs for commercial energy generation and facility operation-maintenance services, and 20 FTEs for manufacture of equipment for export.



Note: These markets and jobs do not include the staff of R&D organisations (BRGM, universities, companies), nor studies, engineering and export work, nor exploration work related to research permits for which no data could be collected.

5. PPE targets vs 2021 preliminary estimate

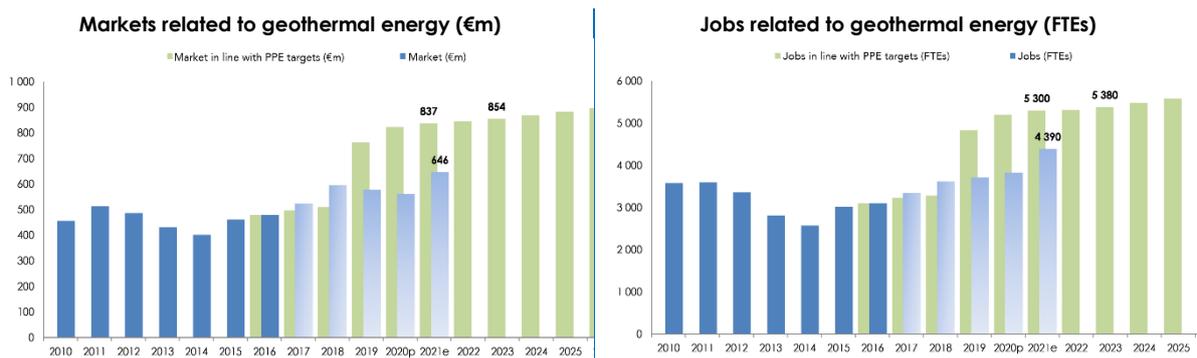
The following table presents the objectives of the Multiannual Energy Programme (PPE) in terms of heat production from geothermal energy by 2023 and 2028.

Thermal production from geothermal energy (TWh)				
	2018	2023	2028 Low scenario	2028 High scenario
Geothermal heat pumps *	3.1	4.6	5	7
Deep geothermal energy	2.0	2.9	4	5.2

(*) Residential and collective-tertiary sectors

Source: Low-yield deep energy Ministry of Ecological Transition, Decree No. 2020-456 of 21 April 2020 on multiannual energy planning

- For individual houses, the “high” scenario in 2028 corresponds to an installed base of 315,000 geothermal heat pumps (regardless of the 2023 interim target). With a base of more than 180,530 heat pumps in 2018, this would represent the installation of an additional 13,450 heat pumps on average each year between 2019 and 2028, the equivalent of 151.9 MWth per year (source: Observ’ER).
- For surface geothermal heat production in the collective-tertiary sector, the “high” scenario in 2028 corresponds to an installed base of 1,000 collective housings per year equipped with a geothermal heat pump. For the tertiary sector, it is estimated that approximately 730 units would have to be installed each year between 2019 and 2028. Thus, an additional 1,730 PACs would have to be installed each year between 2019 and 2030, the equivalent of 121.9 MWth per year (source: AFGP).
- For deep geothermal, it is assumed that no new investments will be made in EGS (high-yield deep geothermal) projects. The PPE revised the EGS geothermal electricity feed-in tariff in such a way that new projects could no longer benefit from it after 2020. As a result, the full 2028 deep geothermal average target of 4.6 TWh is attributed to low-yield deep installations, more than double the 2018 heat output (2.1 TWh; SDES). For this purpose, it is estimated that 38.5 MWth would have to be brought into service each year between 2019 and 2028 (source: AFGP).
- For high-yield deep geothermal, only the possible commissioning of the Vendenheim-Reichstett unit in the Grand-Est region at the end of 2022 has been taken into account. As a reminder, 95% of investments had already been made in 2021.



(*) Assumptions: estimates made at costs, prices and employment ratios current from 2010 to 2020 and at costs, prices and employment ratios constant in 2020 from 2021 onwards; p: provisional; e: estimated

Source: IN NUMERI estimates

The total geothermal market is estimated at €837m in 2021 and €854m in 2023. In 2023, investments are expected to total €627m and operation-maintenance €227m. Jobs are expected to reach 5,380 FTEs by 2023: 3,330 FTEs for the completion of investments and 2,050 FTEs for the operation of production units and maintenance of all installed heat pumps.

Markets and jobs compatible with the PPE’s targets have been compared with the current trend in the sector, represented by the 2021 preliminary estimate. This trend is below the PPE projection: €646m and 4,390 FTEs for the trend, €837m and 5,300 FTEs for the PPE projection.

This comparison reflects the difference between the new capacities to be brought into service annually in each case. This is based on Uniclimate’s 2021 review as regards the evolution of geothermal heat pump

sales in the residential sector. For surface geothermal in the collective and tertiary sectors, as well as low-yield deep geothermal (with investments made over three years before commissioning), the AFGP’s sector studies have been used. The new commissioning ultimately totalled 268.6 MWth. To meet the PPE targets, 312.4 MWth would have had to be brought into service the same year (an additional 16%).



Source: IN NUMERI estimates

6. Industry outlook

6.1. Significant potential and encouraging prospects

Heat-pump-assisted surface geothermal energy in the residential sector

In July 2020, the 5th Environmental Defence Council announced a ban on the installation of oil-fired boilers as of 1 January 2022. They will be banned in new housing and will have to be replaced by more efficient equipment (high-performance gas boilers, pellet boilers, heat pumps) in the case of replacing old appliances. Replacement is not mandatory and it will still be possible to have devices repaired. Nevertheless, this measure should further promote geothermal heat pumps as a sustainable heating solution for households.

Heat-pump-assisted surface geothermal energy in the collective-tertiary sectors

The simplification of procedures (GMI), the increase in projects supported by the ADEME Heat Fund, as well as the increase in the prices of petroleum products are in line with an increase in activity. In 2021, nearly 80 geothermal projects (excluding deep aquifer) were supported by the ADEME Heat Fund for an investment of €71.5m. These projects ultimately resulted in the production of 53.4 GWh of additional renewable heating over the year.

According to professionals¹³, it is important to give further support to informing and training local authorities on the benefits of heat pumps on a shared geothermal wall. The surface area used is minimal as a single borehole is sufficient to meet the heating, domestic hot water and cooling needs of a 200 m² house under current thermal regulations. Since 2022, the ADEME Heat Fund has extended its support to these installations.

The “Tertiary”¹⁴ decree on obligations to take action in reducing final energy consumption in tertiary buildings of more than 1,000 m² has also supported the growth of the sector. The target is to reduce the final energy consumption of the buildings concerned by 40% in 2030 and 60% in 2050 through renovation work, installation of energy-efficient equipment, and modification of building operation procedures or of user behaviour.

Low-yield deep geothermal energy

The momentum from the 2010s is not expected to diminish. Low-yield deep geothermal energy is also expected to play an important role in greening fossil heating networks.

In 2021, 3 deep aquifer geothermal projects were supported by the ADEME Heat Fund, for an investment of €53.2m and a production of 255.1 GWh of additional renewable heating over the year.

High-yield deep geothermal energy

According to the AFPAC sector study (2021), 11 Exclusive Research Permits (PERs) for the exploration phase have currently been issued in mainland France and 3 PERs in the overseas departments and regions. If all these projects are implemented, the total power of the installed base in France would amount to 166 MWe by 2028.

However, there are several uncertainties regarding the success of these projects: the sector’s competitive pricing of electricity generation by reducing construction costs, the geothermal resource and its capacity to develop co-products (such as lithium). Recent seismic activity should also be taken into account, delaying several exploration and drilling projects already in progress, particularly in the Grand-Est region (Fonroche projects: connecting the Hurtigheim and Eckbolsheim units to the Vendenheim-Reichstett unit and the Illkirch project). Additionally, the abolition by the PPE of top-up funding for geothermal sites fixed in 2016 does not support the development of the sector. As mentioned above, the PPE has not set any target for deep geothermal energy in combined heat and power generation.

¹³ Source: Internal communication by AFPAC (French Heat Pump Association), Daikin and Cerise Techniques

¹⁴ Decree No. 2019-771 of 23 July 2019 on obligations to take action in reducing final energy consumption in buildings for tertiary use; Order of 10 April 2020 on obligations to take action in reducing final energy consumption in buildings for tertiary use

PPE support measures

Heat-pump-assisted surface geothermal energy in the residential sector

- Sustain the support available via MaPrimeRénov' for air/water and geothermal heat pumps, aiming for similar out-of-pocket expenses whichever solution is chosen

Heat-pump-assisted surface geothermal energy in the collective-tertiary sector

- Support heat-pump-assisted geothermal, as well as geothermal renewable cooling projects, through the Heat Fund;
- With the support of ADEME, set up local facilitation activities, with at least one facilitator specialised in geothermal energy per region;
- Allow the Heat Fund to contribute to the financing of regional maps for Low-Importance Geothermal (GMI), and, where applicable, to the financing of decision support on the economic profitability of the surface geothermal resource.

Deep geothermal energy

- Support the Heat Fund's investment in geothermal energy, geothermal heating and cooling networks, geothermal heat storage solutions;
- Sustain the Guarantee Fund of the Société Auxiliaire de Financement (SAF) and adapt it where necessary in order to develop the potential of new aquifers that are not well known according to the conclusions of the sizing study conducted by ADEME;
- Modify the mining code to explicitly mention geothermal cooling production.

Source: Multiannual Energy Programme 2019-2023 and 2024-2028, January 2020 Project

7. Detailed results

Markets related to geothermal energy

Level of activity generated in the territory (€m)	2006	2008	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019s ^d	2020 ^p
Domestic investment													
Equipment manufactured in France	61	84	52	48	44	39	32	48	49	48	55	61	65
Imports of equipment	17	25	51	47	38	30	28	23	22	22	27	16	18
Distribution of equipment	89	104	60	60	50	43	32	31	29	30	32	30	26
Drilling, installation, preliminary studies	268	315	214	253	240	204	200	248	249	274	316	313	295
Total investment:	435	527	376	408	373	317	293	350	349	375	430	420	403
Operation-maintenance, Sale of energy	49	61	61	73	78	93	92	96	112	133	143	153	155
Sale of energy	38	43	37	45	47	59	55	57	70	87	94	100	100
Maintenance	11	18	24	28	31	34	36	39	42	46	50	53	55
Domestic market *	483	588	437	481	451	410	385	446	461	507	573	573	558
Exports													
Equipment	43	42	19	33	36	21	17	15	18	17	22	4	2
Total market **	526	630	456	513	486	431	402	461	478	524	595	577	561
Production **	509	605	405	466	448	401	374	438	457	502	568	560	543

(*) Domestic market: Total investments + Operation-maintenance and domestic energy sales

(**) Total market = Domestic market + Exports; Production = Total market - Imports

IN NUMERI estimates, sd: semi-final estimates, p: provisional estimates

Total market by type of geothermal

€m	2006	2008	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019s ^d	2020 ^p
Surface – Residential sector	474	533	301	262	220	179	122	117	100	101	103	111	102
Ground/ground heat pumps	214	174	81	39	26	18	18	16	14	15	15	15	14
Ground/water heat pumps	79	59	34	32	37	33	18	17	15	16	15	16	15
Water/water heat pumps	181	301	186	191	157	128	86	84	71	71	73	80	73
Surface – Collective-tertiary sector	12	52	109	184	178	155	163	175	198	213	229	172	148
Low-yield deep energy	29	36	45	62	72	73	95	136	155	181	226	255	268
High-yield deep energy	11	9	1	6	16	23	22	32	25	29	38	39	42
Total market	526	630	456	513	486	431	402	461	478	524	595	577	561

Jobs related to geothermal energy

Jobs (FTEs)	2006	2008	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019s ^d	2020 ^p
Linked to domestic investment													
Manufacture of equipment	410	370	340	310	300	260	210	300	280	270	290	330	330
Distribution of equipment	910	1,220	970	750	620	430	320	290	260	270	280	270	230
Drilling, installation, preliminary studies	1,700	1,930	1,320	1,460	1,270	980	910	1,230	1,190	1,290	1,380	1,360	1,310
Total	3,020	3,530	2,630	2,520	2,190	1,670	1,440	1,820	1,730	1,830	1,950	1,950	1,870
Related to maintenance and sale of energy	730	780	820	860	910	990	1,020	1,080	1,250	1,390	1,530	1,740	1,950
Sale of energy	620	620	630	630	660	710	720	760	900	1,010	1,120	1,300	1,490
Maintenance	110	160	190	240	250	280	290	330	350	380	420	440	460
Related to the domestic market	3,750	4,300	3,450	3,390	3,100	2,650	2,450	2,910	2,980	3,220	3,480	3,690	3,820
Related to exports	290	180	120	220	250	150	120	110	120	120	130	20	20
Total jobs	4,040	4,480	3,580	3,600	3,360	2,810	2,570	3,020	3,100	3,340	3,620	3,710	3,830

IN NUMERI estimates, sd: semi-final estimates, p: provisional estimates

Total jobs by type of geothermal

FTEs	2006	2008	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019sd	2020p
Surface – Residential sector	3,330	3,560	2,320	1,880	1,570	1,120	760	780	670	670	650	730	660
Ground/ground heat pumps	1,570	1,210	620	260	170	120	120	110	100	100	90	100	90
Ground/water heat pumps	550	400	260	200	230	210	110	110	100	100	100	110	100
Water/water heat pumps	1,210	1,960	1,450	1,410	1,160	790	530	560	470	470	460	520	470
Surface – Collective-tertiary sector	80	300	590	990	960	830	840	970	1,060	1,130	1,180	930	810
Low-yield deep energy	600	610	650	720	770	790	910	1,130	1,310	1,450	1,700	1,960	2,210
High-yield deep energy	30	20	20	20	60	70	70	150	70	90	90	90	150
Total jobs	4,040	4,480	3,580	3,600	3,360	2,810	2,570	3,020	3,100	3,340	3,620	3,710	3,830

Installed base of facilities and units; Energy production

Installed base:	2006	2008	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020
Surface – Residential sector MWth	204.8	660.4	962.9	1,078.7	1,170.2	1,244.0	1,295.1	1,343.3	1,382.2	1,420.7	1,455.5	1,493.1	1,527.2
Surface – Collective-tertiary sector MWth	5.1	37.5	116.0	196.1	270.3	339.0	414.5	499.9	600.1	715.2	845.2	945.7	1,016.7
Low-yield deep energy MWth	0.0	0.0	8.0	8.0	28.0	59.8	69.8	93.3	188.2	257.4	332.3	451.3	580.1
High-yield deep energy MWth	-	-	-	-	-	-	-	-	35.4	35.4	35.4	35.4	35.4
High-yield deep energy MWe	15.0	15.0	15.0	15.0	15.0	15.0	15.0	15.0	16.7	16.7	16.7	16.7	16.7
Electricity generation GWh	86.7	99.1	16.2	62.2	56.5	90.2	83.1	91.9	97.6	133.1	127.0	128.5	128.5
Thermal production GWh	1,093.0	1,116.3	1,139.5	1,186.0	1,244.2	1,441.9	1,383.7	1,418.6	1,688.2	1,978.0	2,129.7	2,267.3	2,267.3

(*) MWe = electric power; MWth = thermal power

Sources: In Numeri estimation according to Observ'ER; AFPG (2011, 2013, 2015, 2019, 2021), Geothermal energy in France, Sector study; EGEC, 2016 European Geothermal Congress report; ADEME, Reviews of the Heat Fund; ADEME and BRGM, 2019 Reports (RP-69577-FR and RP-68601-FR); SDES, Renewable energy dashboard (Renewable energies review) and European Renewable Energy Directive dashboard

Note: This year, the former "Domestic heat pumps and water heaters" fact sheet has been divided into two parts:

1. The results for geothermal heat pumps in the residential sector (ground/ground, ground/water and water/water) are now presented in this "Geothermal" fact sheet.
2. The results for air/water and air/air aerothermal heat pumps and thermodynamic water heaters installed by private individuals are presented in a separate sheet (Domestic aerothermal heat pumps and thermodynamic water heaters).

Consequently, this fact sheet presents the results of four types of installation and geothermal unit: Heat-pump-assisted surface geothermal energy in the residential sector; Heat-pump-assisted surface geothermal energy in the collective-tertiary sector; Low-yield deep geothermal energy; High-yield deep geothermal energy. Therefore, it is not possible to compare the results of this edition directly to those of previous years.

8. Source data

Data	Calculated from	Sources	Confidence level
Investment €m			
Surface – Heat pumps in the residential sector			
Sales x Price per unit			
Sales; Price per unit (€/heat pump)		Observ'ER	***
Distribution margin		Distribution networks (%): Observ'ER Margin rate on purchases (%): ESANE, NAF 46.74B and 47.52B	***
Drilling cost (€/heat pump)		AFPG; Observ'ER; ADEME, Heat Fund	**
Surface – Heat pumps in the collective-tertiary sector			
Installed capacity x Price per unit			
Power (MW)		AFPG, Geothermal energy in France, Market studies; EGEC, 2016 European Geothermal Congress report	**
Price per unit (€/geothermal heat pump)		ADEME, Heat Fund Reviews; Observ'ER	*
Breakdown of investment (€m)	Equipment, drilling, installation	AFPG (2011), Geothermal energy in France, Market study	*
Low-yield deep energy			
Installed capacity x Price per unit			
Power (MW)		EGEC, 2016 European Geothermal Congress report; AFPG, Geothermal energy in France, Market studies; ADEME-BRGM	**
Price per unit (€/MW)		H. Prévot (2006), Heating networks C. Boissavy (2014), Geothermal energy in France, AFPG Report INSEE, TP04 Index, IdBank 1688280-1710990	*
Breakdown of investment (€m)	Equipment, drilling, studies	In Numeri estimate	*
High-yield deep energy			
Investment and breakdown (€m)	Equipment, drilling, studies	Official websites; Press releases; Communications from the Strasbourg Eurométropole	***
Manufacturing (€m)			
Equipment: Domestic market + Exports - Imports			
Surface – Heat pumps in the residential sector			
Domestic market (€m)	Manufacturers' / Importers' revenue	Observ'ER	***
Manufacturing (€m)		INSEE, EAP; Company accounts	**
Import, Export (€m)		Eurostat, Products 84.15.81.00, 84.15.82.00 and 84.18.61.00	**
Surface – Heat pumps in the collective-tertiary sector			
Domestic market (€m)	Investment in surface equipment excluding commercial margins	Margin rates on wholesale purchases: ESANE, NAF 46.74B	**
Foreign trade (€m)	According to the [Imp/IH] and [Exp/IH] ratios for all geothermal heat pumps		**
Energy value (€m)			
Heating value (€m)			
Thermal production x Price per unit			
Production (ktoe)		SDES, European Renewable Energy Directive dashboard and Renewable energy dashboard	**

Heating price (€/MWh)		ADEME (2019), Cost of renewable energy in France; INSEE, TP04 Index, IdBank 1688280-1710990	**
Value of electricity (€m)		CRE (French Energy Regulatory Commission), CSPE (Electricity Public Service Contribution) Deliberations, Appendices 1	***
Maintenance (€m)			
Surface – Heat pumps in the residential sector	€150/year maintenance per heat pump	In Numeri estimate	*
Surface – Heat pumps in the collective-tertiary sector	€2,000 per year per geothermal heat pump	In Numeri estimate	*
Jobs (FTEs)			
Manufacture of geothermal heat pumps	Manufacturing €m x [Production/Workforce] ratio	Company accounts	**
Manufacture of low- and high-energy equipment	Manufacturing €m x [Output-Subcontracting+Margins/Employment] ratio	2006-08 and 2016-19: CN, Branch A38.CK 2009 to 2015: ESANE, NAF 28	
Distribution	Margins €m x [Margins/Employment] ratio	2006 to 2008: CN 2009 to 2016: ESANE, NAF 46.74B and 47.52B	**
Preliminary studies	Studies €m x [Output/Employment] ratio	2006 to 2019: CN, Branch A88.71	**
Drilling and sensors	Drilling €m x [Production/Employment] ratio	2006-2007; 2017-2019: CN, Branch 43 2011 to 2016: ESANE, NAF 43.13Z	**
Installation – Surface geothermal	Installation €m x [Output-Subcontracting+Margins/Salaried and non-salaried workforce] ratio	2006 to 2008: CN, Branch 45.3F 2009 to 2015: ESANE, NAF 43.22B	**
Installation – High-yield deep energy	Installation €m x [Production-Subcontracting+Margins/Employment] ratio	2006-08 and 2016-19: CN, Branch A88.33 2009 to 2015: ESANE, NAF 33	**
Maintenance	Maintenance €m x ratio [Production-Subcontracting+Margins/Employment]	2006 to 2008: CN, Branch 45.3F 2009 to 2015: ESANE, NAF 43.22B	**
Sale of heating – Low-yield deep energy	Commissioning x [FTE/MW] ratio	Press releases:	**
Sale of electricity – High-yield deep energy	According to the workforce of the Bouillante plant	Press releases:	**

(*) Unestimated series based on published and reliable sources; (**) Series reconstructed by interpolating several sources, extrapolating or according to observed trends; (***) Series estimated on the basis of data not updated due to lack of recent information.

9. General method of assessment

Scope of the fact sheet

- High-yield deep geothermal energy for electricity (Bouillante power plant) and combined heat and power generation (Soulz-sous-Forêts, Rittershoffen and Vendenheim-Reichstett power plants).
- Low-yield deep geothermal energy (direct-use geothermal), which is the production of heating for large district heating networks and a few applications for heating greenhouses and swimming pools.
- Heat-pump-assisted surface geothermal energy on probe fields, surface water, waste water or sea water. The scope is that of intermediate applications (collective housing, tertiary, industrial, agricultural).
- Heat-pump-assisted surface geothermal energy for private individuals (residential sector).

Domestic investment

First, the annual manufacturing for each of the four sectors indicated have been identified and valued. The data come from different sources: Observ'ER, AFPG Sector studies, EGEC Report 2016, ADEME Reviews of the Heat Fund, Reports of ADEME and the Bureau of Geological and Mining Research, Official websites and press releases, Internal communications of the Strasbourg Eurométropole, INSEE, Study on heating networks (H. Prévot, 2006), Study on geothermal energy in France (C. Boissavy, 2014).

Subsequently, investments have been broken down into major components: manufacture and distribution of equipment, installation work (including preliminary studies), drilling work.

Operation-maintenance and energy sale services

The energy produced and sold (electrical and thermal) has also been determined and valued at unit prices. The data on energy production are taken from the SDES reports (Dashboard of and Follow-up to the European Directive). The data on heating sale prices are taken from the 2019 ADEME study "Cost of renewable energy in France". The sums for electricity sold are derived from CRE reports (CSPE Deliberations, Appendices 1). Self-consumed energy has not been included.

The value of heat pump maintenance services in the residential and collective-tertiary sectors (very low-yield geothermal) has also been estimated at a unit cost per heat pump and per year.

Estimated jobs

For each of the investment and maintenance components, associated jobs are estimated on the basis of employment ratios associated with the different activities. These ratios are calculated using data from the French National Accounts (CN), ESANE and company accounts.

For jobs related to the sale of energy, the ratios or workforce data are taken from official project websites or press releases.

ADEME IN BRIEF

At ADEME - the Agency for Ecological Transition - we are firmly committed to combating climate change and degradation of resources.

On all fronts, we mobilise citizens, economic players, and regions, empowering them to move towards a resource-efficient, carbon-free, fairer, and more harmonious society.

In all areas - energy, air, circular economy, food, waste, soils, etc., we advise, facilitate and help finance many projects, from research through to solution-sharing.

At all levels, we put our expertise and prospective capabilities at the service of public policy.

ADEME is a public establishment under the joint oversight of the French Ministry of the Ecological and Solidarity Transition and the French Ministry of Higher Education, Research and Innovation.

THE ADEME COLLECTIONS



FACTS AND FIGURES

ADEME the leader: It provides objective analyses using regularly updated statistical indicators.



KEYS FOR ACTION

ADEME the facilitator: It produces practical guides to assist stakeholders in implementing their projects methodically and/or in accordance with the regulations.



THEY DID IT

ADEME the catalyst: Stakeholders talk about their experiences and share their know-how.



EXPERTISE

ADEME the expert: It reports on the results of research, studies and collective achievements made under its auspices.



HORIZONS

ADEME, focused on the future: It provides a realistic, forward-looking vision of the issues involved in the energy and ecological transition to help everyone build a better future.

GEOHERMAL ENERGY

