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Geothermal Energy in France. A Resource Fairly Accepted for Heating but Controversial for High-Energy Power Plants

Philippe Chavot, Anne Masseran, Cyrille Bodin, Yeny Serrano and Jean Zoungrana

Abstract: In this chapter, we will see that geothermal energy is guided by dynamics of development that are uneven depending on the region and the nature of the projects. Use of geothermal resources for heating had a major boom following the energy crises of the 1970s, particularly in the Parisian region. High-energy geothermal projects were first developed in the volcanic islands of French overseas territories in the 1980s. Its developments in mainland France are then linked to the energy transition policy implemented in the early 2010s. However, in several regions, opponents point out the risks arising from drilling techniques used to facilitate water circulation in rocks. But criticism is also focused on economic and political aspects. The first part of this chapter reports on the first developments of geothermal energy in France and its links with energy policies. The second part deals with social aspects, evoking the controversies that arose in France from 2014 onwards and the role of consultation mechanisms in these controversial situations.

Keywords: France; Citizen participation, Energy transition, Public controversy

P. Chavot (&) □ C. Bodin □ Y. Serrano
LISEC, University of Strasbourg, 7 rue de l'Université, 67100 Strasbourg, France
e-mail: philippe.chavot@unistra.fr

A. Masseran
CREM, University of Lorraine, île du Saulcy, BP 60228, 57045 Metz Cedex 01, France

J. Zoungrana
SAGE, University of Strasbourg, 5 allée du Général Rouvillois, CS 50008, 67083 Strasbourg, Cedex, France

1 Geothermal Framework

Located at the western end of Europe, the mainland part of France benefits from a temperate climate with strong oceanic influence. It has some ancient massifs (including the Massif Central, which is volcanic) and recent mountain ranges created by several tectonic episodes. These massifs are bordered by very fertile sedimentary basins that have enabled France to become the 8th largest agricultural power in the world. As witnesses of an important colonial past, overseas territories remain attached to the country: the islands of Guadeloupe, Martinique and St. Martin in the French West Indies, Reunion Island in the Indian Ocean, Guyana in South America. The first power plants based on geothermal drilling have been tested in the volcanic island of Guadeloupe.

Since the COP21 climate agreements of 2015, France wants a leading role in the energy transition, a role it confirmed in 2017 by organizing the One Planet Summit. In this chapter, focusing on the developments of geothermal energy in France, we will first present the framework in which this new energy resource was explored by proposing a brief review of France's energy policy. What role are renewable energies playing in this policy, and what about geothermal energy? Secondly, we will address the pioneering work carried out in France on deep geothermal energy and then discuss its contemporary developments. What societal and political evolutions have enabled geothermal energy to establish itself in France? How are its developments managed? And finally, how are the risks associated with drilling and the running of geothermal plants assessed by the public?

1.1 A Late Commitment in the Development of Renewable Energies in France

During its recent history, France has benefited from several energy resources. Important coal deposits were the spearhead of its industrial revolution in the 19th century. However, the First World War raised awareness of the dangers of dependency on a single energy source. This is when the first major hydroelectric dams were built. Similar projects followed one another until the 1970s. Despite the exploitation of a few deposits, France depends on imports for almost all of its oil and gas consumption. The two oil crises of the 1970s led to the major development of the nuclear industry. France then became one of the world leaders in this sector, as much for fuel extraction (carried out in France for a time, then in Niger) as for the manufacture of power plants, and more recently for nuclear waste management (Hecht 1998; Topçu 2013). France is currently the world's second largest nuclear power producer. In 2016,

72.3% of the electricity produced in France came from nuclear power, making it one of the few countries that can export electricity.

This all-nuclear policy has led France to neglect renewable energy sources (RES) for a long time, the hydroelectric sector being the only one to have had a steady development since 1914 and until the 1970s. It currently produces around 11% of the electricity consumed in mainland France.

Other RES sectors were more recently developed due to the policies implemented in France since the early 2000s. Initial measures included the development of national climate plans (2000 and 2004): lined up with the Kyoto Protocol (1997), they aim to reduce greenhouse gas emissions. However, they do not directly encourage the use of RES. The Grenelle Environment Forum¹ (2007) and the subsequent two laws (2009, 2010²) propose more concrete targets for the development of RES: they are expected to account for 23% of the final energy consumption by 2020. An incentive policy towards regional districts have led these to define their own territorial climate plans and promote green energy (heat and electricity). Finally, the Energy transition law adopted on August 15, 2015 includes the Grenelle targets and sets a 32% share of RES in final energy consumption by 2030. The main innovation of this law concerns nuclear power, whose share of electricity production will have to decrease from 78 to 50% by 2025.³ Emphasis is again placed on local territorial actions.

These recent policies are giving results. Between 2005 and 2015, a downward trend in the import of energy resources, electricity consumption and CO₂ emissions was recorded. Demand for primary energy decreased by 9.3% and final consumption by 13%.⁴ Since 2004, the decline in consumption has been most notable in the residential heating and cooling (-15.4%) and trade (-11.7%) sectors.

At the same time, the share of renewable energy has increased from 9 to 14.9% of the energy consumed. However, this increase is, for the time being, insufficient to reach the 23% target by 2020. Among RES, the wood sector (74.9%) is preferred for heat production, far ahead of heat pumps (16.1%). For green electricity production, hydropower accounts for the largest share (61.1%), followed by wind power (23.8%) and photovoltaics (8.1%).⁵ Deep geothermal energy occupies a rather modest position in this panorama, less than 1% of the renewable energy production, but projects are still in the process of being implemented.

1.2 Pilot Projects for High-Temperature Geothermal Energy (Power Generation)

¹ The term “Grenelle” refers to the multi-party debates that took place on Rue de Grenelle in Paris in May 1968, at the end of one of the largest workers and students revolts that France has seen in the 20th century. It now refers, by analogy, to any structured, multi-party debate which includes government representatives, representatives of different political sensitivities, various associations and NGOs.

² Act no 2009-967 of 3 August 2009 programming the implementation of the Grenelle for the Environment, and Act no 2010-788 of 12 July 2010 establishing a National Commitment regarding the Environment.

³ However, the current Minister of the Environment has repeatedly pointed out in 2017 that this objective is not sustainable.

⁴ The Total primary energy supply (TPES) amounted to 245.7 MTOE in 2015 and Total Energy Consumption (TFC) was 147.7 MTOE in 2014.

⁵ Ministère de l’environnement, Chiffres clés des énergies renouvelables Édition 2016, <http://reseaux-chaleur.cerema.fr/wp-content/uploads/CC-des-energies-renouvelables-edition-2016.pdf> (accessed on 02/26/2018).

Despite its small footprint, geothermal energy in France already has a long history. In the 1960s, at the instigation of Jean Goguel, sometimes referred to as the “father of French geothermal energy”, the French geological survey organization (the Bureau de recherches géologiques et minières, BRGM), started several exploratory works on volcanic geothermal energy in Guadeloupe on behalf of the Electricity production and distribution company of Guadeloupe. Several wells, from 450 to 2000 m deep, were drilled between 1967 and 1971 by the French oil drilling company Eurafrep (Guillou-Frottier 2003). Exploitation of the resource, whose temperature exceeds 200 °C, began in 1984 with the installation of the first electricity production unit, the Bouillante 1 plant, commissioned in 1985 by the National French electricity company (Electricité de France, EDF) and BRGM. New drillings in the early 2000s led up to the commissioning of Bouillante 2 in 2005.⁶ Bouillante 1 (which was refurbished in 2013) and 2, with a total production capacity of 15.5 MWe, cover 6% of the electricity demand of Guadeloupe (Demarcq et al. 2014).⁷

Over the same period, a more ambitious project for the West Indies aimed to exploit the geothermal resources of the Dominica island. The aim was to develop a large geothermal power plant capable of supplying electricity to the island of Dominica but also to the two neighbouring French islands of Guadeloupe and Martinique via a network of submarine cables. Exploratory studies were carried out as early as 1977 and the project, entitled Géothermie Caraïbes, took concrete form in 2003, involving several partners.⁸ The production capacity is estimated at 150 Mw. Géothermie Caraïbes together with a third power plant in Martinique should allow the three islands to benefit from less expensive energy and be a step closer to energy self-sufficiency (Laplaige et al. 2013). The implementation of this project was, however, slowed down in 2013 by EDF’s withdrawal from Géothermie Caraïbes and from the Bouillante power plant. While the American operator Ormat took over the activities of the Guadeloupe power plants in February 2016 (by purchasing 80% of the shares), the Géothermie Caraïbes project is still pending.

Exploratory work was also carried out in the Indian Ocean during the 1970s and 1980s, on the volcanic island of Réunion to produce electricity. The project was considered economically unviable in 1986 but became relevant again in the 2000s. A first project was aborted in 2008 due to a strong mobilization of the population against drilling, which was to be carried out within a protected natural area. A new project led by Volcanergie (a subsidiary of the Electerre group) is being implemented.

1.3 The Development of Geothermal Energy in Mainland France

In the 1980s, following the oil crisis, low-temperature geothermal energy emerged as one of the lower-cost solutions promising to supply heat to homes and industries. In Mainland France, the “heat” potential of geothermal energy was therefore the primary driving force towards its development. Between 1980 and 1985, some thirty low-energy geothermal plants were built in the Paris Basin and in Aquitaine. In the Paris Basin, the plants exploited the Dogger aquifer, which has a temperature between 55 and 80 °C and is located in fractured limestone at 1600–1800 m depth. These installations did not prove very cost-effective and

⁶ <http://www.geothermie-perspectives.fr/article/historique-lexploitation-champs-bouillante> (accessed on 02/26/2018).

⁷ <http://www.guadeloupe-energie.gp/geothermie/2180-2> (accessed on 02/26/2018).

⁸ The project involves the government of Dominica, the French regions of Guadeloupe and Martinique, the French Development Agency (AFD), the French Environment and Energy Management Agency (ADEME) and the BRGM.

maintenance was complicated due to corrosion. The more favourable political conjecture of the 2000s made it possible to rehabilitate old wells and build new ones. With 44 installations in operation, the Paris Basin has become an area in the world where the density of geothermal plants is among the highest, supplying nearly 200,000 homes (Boissavy et al. 2016). The objective is to keep these plants in operation for about 50 years, which will only be possible if they are able to manage the cooling associated with the re-injection into groundwater of water after heat extraction.

High temperature geothermal energy is emerging in France thanks to the creation of the pilot project of Soultz-Sous-Forêts in 1985 and of the EEIG (European Economic Interest Grouping), which manages the project since the late 1990s.⁹ A truly genuine laboratory for deep geothermal energy, it was intended to exploit the thermal anomaly of the Rhine basin by first developing a Hot Dry Rock type geothermal project. After several exploratory phases, and two boreholes more than 5000 m deep, the group discovered a very saline aquifer located 3500 m deep, in a naturally fractured granitic bedrock and a temperature of 200 °C. The EEIG's activity provided the basis for the Enhanced Geothermal System (EGS) technique. The aim has been to experiment the different types of stimulation (hydraulic or chemical) that allow better water circulation in micro-cracks. The EEIG was converted into an industrial site in June 2016 following the acquisition by Electricité de Strasbourg (a subsidiary of EDF), which invested 8 million euros in the site. With a capacity of 1.7 MW, the site can now produce 12,000 MWh of electricity per year, supplying electricity to the equivalent of 2400 homes.

Inspired by the Soultz-Sous-Forêts model, many projects have been launched since the 2000s in the German, Swiss and French regions of the Rhine basin. Thus, on the French side, in Alsace, the 24 MW Rittershoffen geothermal power plant was inaugurated in 2016. It supplies heat to the Roquette starch factory located about 30 km away. In Alsace, three cogeneration power plant projects are currently being carried out within the Eurometropolis of Strasbourg and three projects are being defined in Northern Alsace and in the near outskirts of Strasbourg. The Rhine basin is not the only area where deep geothermal energy is being developed. The Ministry of Mines has issued a dozen or so research permits regarding high-temperature geothermal energy, to be carried out in Alsace and in areas of the Massif Central and of south-western France (Fig. 1). Thus, 23 projects could be completed by 2030, which would generate 211.5 MWe and 245 MWth for an investment of 1500 million euros.

⁹ This project is supported by the European Commission, the French Ministry of Research through the AFME (now ADEME), and the German Ministry of Environment.

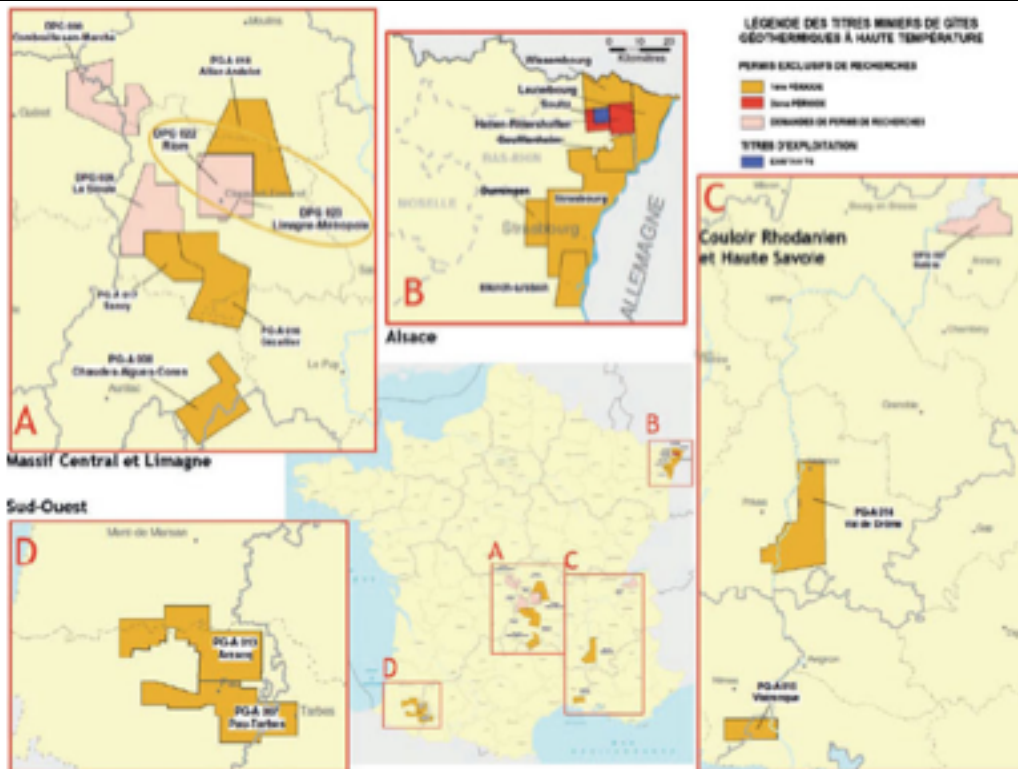


Fig. 1 Map related to permit areas for high temperature resources. Rose color: pending applications. Brown and red colors: permits issued. Blue color: concessions. Modified from: Ministry of Environment, January 2016, presented in AFGP 2016

1.4 Geothermal Policy and Stakeholders

The development of low and high-temperature geothermal energy is backed by various provisions taken within the framework of the national climate plan (2004) and the Grenelle 1 and 2 laws (2009/10). First, the Renewable Heat Fund was created in 2009, which includes a total allocation of 1.12 billion euros and target renewable energy and energy recovery (EnRR) heat projects. It allows operators to produce heat at a competitive price compared to the use of fossil fuels. The revival of low-temperature geothermal energy in the Paris Basin has been partly achieved thanks to this Fund. It has also encouraged provincial cities to integrate the development of geothermal energy into their territorial climate plan.¹⁰ This is the case, for example, with the climate plan of the Eurometropolis of Strasbourg, which sets a target of 20–30% of renewable energy usage for private and public needs.¹¹ Secondly, EDF's electricity purchase tariffs were revalued in 2010, setting the price of kWh from geothermal energy at 20 cents, which also benefited from an 8 cents premium. This measure made it possible to ensure the economic viability of cogeneration projects and led several companies to favour this option rather than heat production alone, despite the low efficiency of converting heat into electricity. Finally, the establishment of a guarantee fund set up by companies with the

¹⁰ <http://www.energivie.info/PCET> (accessed on 02/26/2018).

¹¹ <http://blog.bio-ressources.com/non-classe/alsace-geothermie-profonde> (accessed on 02/26/2018).

support of the Ministry of Ecology allowed companies to obtain financial compensation in the event of unsuccessful drillings.

The development of geothermal energy depends on the mining code, since it is linked to the exploitation of underground resources. Likewise, the granting of research and concession licenses is controlled by the state and by local prefectures. For low-temperature geothermal energy (<150 °C), all procedures are managed locally. The exclusive licence to prospect (Permis exclusive de recherche, PER) is granted by the prefecture for a period of three years. For high-temperature resource projects (>150 °C) with or without electricity generation, applications for the PER are processed by the Ministry of Mines. In this case, the state or prefecture solicits several evaluations or consultations:

- The analysis of licence applications, their compliance with the legal framework and the monitoring of drilling operations is carried out by the Regional Directorate for Environment, Development and Housing (DREAL) linked to each prefectures.
- Additional expertise can be provided by the French national institute for industrial environment and risks (Ineris), with regard to subjects relating to risk management. The Departmental Council of Environment and Sanitary and Technological Risks (CODERST) can also be sought regarding environmental and sanitary issues.
- In addition, the public and the local residents are consulted at various stages of the procedure. We will come back to that later.

Outside this regulatory framework, multiple actors are involved in the definition and implementation of projects. The French Geological Survey, BRGM, which, as we have seen, has played a decisive role in the implementation of overseas projects, also intervenes more or less directly in mainland France. It provides its expertise, makes available and coordinates information intended for professionals, whether it concerns subsoils geology or the preparation of applications.¹² It can also become financially involved in projects.

Low temperature projects generally depend on local dynamics, involving cities or service providers in charge of water management or heat networks. Therefore, in the Paris Basin, projects are set up by local authorities, which are already involved in the management of heat networks. Only a few projects in the outskirts of Paris are carried out by new operators in the RES sector. For example, Engie, the historical operator of natural gas distribution in France, recently became involved in the creation of several heat networks powered by geothermal energy through its subsidiary, Engie Réseau.

High-temperature geothermal energy projects don't have as many local connections, their main objective being the production of electricity. New players have emerged and competition is conducted under the Ministry of Mines' arbitration. 18 high temperature PER have been issued during the last five years, including two overseas. The project leaders are subsidiaries of large groups specialized in the energy sector (Electricité de Strasbourg Géothermie, 5 licences), newly formed groups in the field of renewable energies (Fonroche, 7 licences) or in the geothermal energy sector (TLS, 1 licence), and local companies created to exploit geothermal resources (Electerre, Volcanergie, Géothermie de la Guadeloupe).¹³

¹² The main BRGM reports are available at <http://infoterre.brgm.fr> (accessed on 02/26/2018).

¹³ These companies generally request a low-temperature permit in conjunction with a high-temperature permit, in order to be able to exploit the resource even if the temperature is less than 150 °C. A draft decree aims to lower the low-high temperature threshold to 110 °C.

These companies work closely with the research sectors, national agencies and offices as well as professional drilling businesses. Electricité de Strasbourg Géothermie (ESG) draws on the experience gained during its involvement in the Soultz-sous-Forêts EEIG consortium (see above). The Rittershoffen power station is the result of a collaboration between ESG, BRGM, the French Environment and Energy Management Agency (ADEME) and the Caisse des dépôts et consignations. Finally, ESG is involved, together with the CNRS and the Ecole et Observatoire des Sciences de la Terre (EOST) in the creation of the Laboratoire d'excellence (Labex¹⁴) G-EAU-THERMIE profonde located in Strasbourg, Alsace. This Labex is itself involved in collaborations with the Karlsruhe Institute of Technology (KIT) in Karlsruhe with whom it organises an annual European Geothermal Workshops (EGW) since 2012.¹⁵ These collaborations aim to better understand and exploit the geothermal resources of the Rhine basin.

Other forms of collaboration exist in the field of geothermal energy. A co-investment partnership in the drilling rig was initiated by Fonroche together with two more experienced German companies¹⁶: Herrenknecht Vertical GmbH and Angers&Soehne GmbH. These groups notably co-founded Foragelec. Lastly, international connections are also being set up as part of shareholdings. Hence, the Bouillante plant, which was partially acquired by the American company Ormat Technology with 59.3% of the capital, has these other shareholders: BRGM (for 20.36% of the capital) and the Caisse des Dépôts et Consignations (19.91%).¹⁷

The companies and agencies involved in the development of geothermal energy find themselves within the Association française des professionnels de la géothermie (AFPG), created in 2010. In addition, a group of companies from the French energy industry gathered around the GEODEEP Cluster in relation with a consulting agency, the AFPG, and various service companies. The cluster's objective is to propose turn-key solutions for all low and high energy projects. It created a guarantee fund to compensate the company in the event of an unsuccessful drilling (see above).

2 Studying Social Aspects of Geothermal Energy Development in France

The French energy transition policy, implemented since the early 2000s, has led to a major reconfiguration of the energy field. The former centralized and state managed power production (typical of nuclear policy) has given way to decentralized management involving a multitude of actors. Local and regional authorities are becoming increasingly responsible and, as we have seen, the evaluation and control of projects is carried out by a plurality of actors. Finally, a consultation of citizens is required by the environmental legislation alongside the mining code because such geothermal projects are considered to have a possible impact on the environment or on the quality of life of local residents.

This reconfiguration is a privileged field of study for the humanities and social sciences (HSS). Energy sociology tends to become an area of research in itself, which the Ministry of

¹⁴ Labex are high quality research laboratories created in the early 2000. They are part of a €45 billion investment program aiming at favoring French innovation.

¹⁵ The last EGW workshops was held in Karlsruhe on 12–13 October 2017: <https://indico.scc.kit.edu/indico/event/343/> (accessed on 02/26/2018).

¹⁶ According to the document below, these German companies have achieved 8 deep boreholes in Germany and have 150 years of existence in the field of geothermal energy. http://www.fonroche.fr/sites/default/files/GEO_STRAS_Brochure_A6_FAQ_32pages%20WEB.pdf (accessed on 02/26/2018).

¹⁷ <http://www.brgm.fr/brgm/le-groupe-brgm/geothermie-bouillante> (accessed on 02/26/2018).

Research coordinates through the National Thematic Alliance of Humanities and Social Sciences (Athena) (Labussière and Nadaï 2015).¹⁸ The involvement of HSS in the energy field is also facilitated by the fact that social analyses are increasingly required within the calls for scientific projects launched by the European Community or the French National Research Agency (ANR). It is within this framework that initial work has been carried out on the social aspects of geothermal developments.

2.1 Legal Public Consultations

Geothermal projects over 200 m deep are subject to a variety of assessments and controls, and approval procedures can take a very long time. For example, the procedures that opened up geothermal drillings within the Eurometropolis of Strasbourg in 2017 began in 2010. In this context, the public is consulted several times (see Table 1). First, when considering applications for exclusive licence to prospect,¹⁹ two different procedures are put in place depending on the nature of the licence: for low temperature licence administrated by local prefecture, citizens' opinions are collected through a local public enquiry; for high temperature licence controlled by the State, the Ministry of Environment has set up a web platform to collect citizens' comments.²⁰ Once the licence has been granted, a second consultation is carried out for the exploration authorization request administered by the prefecture, which takes the form of a public inquiry. Finally, the public is consulted again before the plant is put into operation and during the application for a concession.

	Low temperature project	High temperature project
	Drilling from 200m upwards < 150°C	> 150°C
Application for an Exclusive licence to prospect (PER)	Administered by the prefecture. Organisation of a public inquiry.	Administered by the Ministry of Mines. European competition. Public consultation via a web platform
Permit is issued	Prefectural decree, valid for 3 years	Ministerial decree, valid for 5 years
Authorization of Exploration Work	Administered by the prefecture. Organization of a public inquiry	
Commissioning of the plant	Administered by the prefecture Registry of public consultation.	
Concession application	Administered by the prefecture. Organization of a public inquiry (valid for 50 years, renewable for a period of 25 years)	

Table 1 Mandatory public consultations for low and high temperature geothermal projects

¹⁸ The Athena Alliance presents itself as a forum for strategic cooperation and consultation between universities and research organizations. It takes a reflective look at HSS research orientations and contributes to the construction of a research policy: <http://www.allianceathena.fr/> (accessed on 01/ 10/2018).

¹⁹ The exclusive research license gives the company an exclusive right to carry out exploration work on geothermal deposits within a defined perimeter and to apply for a concession if the resource is proven.

²⁰ This collection of citizens' points of view is done via the online system "Consultations publiques": <http://www.consultations-publiques.developpement-durable.gouv.fr/> (accessed on 01/10/ 2018).

In addition to these consultations, monitoring committees or acceptability surveys may be set up from time to time by prefectures or companies when drilling is carried out or during the first years of the power plant' operations.

2.2 The Public Inquiry, a Platform for Protest

The public inquiry mechanism is an old system (1810) whose scope was extended to environmental issues in 1983. Organized by the prefecture, these public consultations only involve municipalities or groups of municipalities likely to be impacted by development projects. The publicity surrounding the consultation is rather limited and the documents made available to the public are generally difficult to understand by citizens unfamiliar with science and technology: "Their function seems to be more to satisfy legal requirements [...] than to encourage participation" (Blatrix 1996, p. 302). However, these consultations are often seen as an indication of whether or not a project is accepted by inhabitants. Thus, according to prefectures and operators, low participation in EPs is equivalent to unconditional acceptance of the project. In practice most EPs for low temperature permits or projects have received few, if any, citizen input. As a consequence, all these projects have been validated by the relevant prefectures. However, the EPs can also become a platform for expressing protest, as was the case during the consultations on cogeneration projects in Alsace, Haute-Savoie and Reunion Island.

An examination of these protests reveals at least five types of criticism.

1. The inhabitants criticize deep geothermal energy because of the various consequences that drilling can have on their environment, such as induced seismicity, groundwater pollution, radioactive upwelling, and even the risk of explosion (related to the use of isobutene during the transformation of heat into electricity). It is in urban areas that the issue of risk is most sensitive and sometimes takes precedence over any other consideration. In Strasbourg in particular, a drilling project located within an industrial zone classified as high risk area, according to the Seveso European directive, where a large quantity of hydrocarbons and chemicals are stored, caused a wave of hostility. A consensus was quickly reached against the project leading the operator to back down.
2. The imprint of a project on its natural environment was at the heart of the criticisms of the project on Reunion Island in 2005. Drilling on dry rock (Hot Dry Rock) was to be carried out in La plaine des sables, a tourist zone classified as a natural park and for which the inhabitants hoped for UNESCO recognition as a world heritage site. Several local NGOs mobilized until the project was abandoned in 2010. The debate resurfaced in 2016, when a new exclusive licence to prospect was requested from the Ministry for the Salazie-Cilaos area outside the enclave of the natural park.
3. The lack of hindsight on the EGS type of deep geothermal energy is pointed out. Indeed, the cogeneration projects that were to see the light of day in Alsace and Haute-Savoie are the first of their kind in Mainland France. Hence, numerous opponents to these projects refer to uncertainties in regards to seismic risk and call for the application of the precautionary principle. This argument has taken on a particular dimension in Alsace, where local scientists have stressed that further research is needed to better understand the behaviour of naturally cracked rocks when by opponents exploiting deep aquifers. Referring to these statements, geothermal energy has often been qualified as a non-mature technology during public enquiries and the promoters as sorcerer's apprentices.

4. Several activist groups criticize the very idea of producing electricity from geothermal heat. Alsace Nature, which federates the main Alsatian environmental associations, points out the low expected returns (the rate of 10% is often brought up). Opponents and elected officials in Haute-Savoie, on the other hand, point out that their department already produces enough electricity via hydro-electric power stations, which have much better yields. Finally, and more generally, the economic model underlying cogeneration is usually criticized. Opponents argue that electricity generation is about enriching businesses rather than contributing to the evolution of local energy mixes towards more renewable energy.
5. Finally, many arguments attempt to discredit the companies involved: their youth and lack of experience, their inability to present clear files at the time of public enquiries, their quest for profits, etc. Many opponents argue that it would be dangerous to leave risky projects in the hands of unknown companies. In this context, locally based companies seem to be more protected from criticism, as is visible in Alsace in the competition established between the local operator Electricité de Strasbourg and the Aquitaine based Fonroche. In Haute-Savoie, groups of elected officials argue that the geothermal energy projects (considered as experimental) should be equally backed by the company, scientific laboratories and local authorities. Similar calls were made in Guadeloupe when the Bouillante plant was handed over to the American group Ormat.

These arguments are made by organized collectives. Leadership sometimes comes from residents' associations, sometimes from elected officials or environmental protection associations, who manage to mobilize citizens by various means: organization of public meetings, publication of the municipal council's or neighbourhood councils' deliberations, use of media platforms (blogs, local press or associative press). Citizens who are alerted and involved in this way are likely to make a significant contribution to public enquiries. What's more, their arguments demonstrate a form of technical, economic and political expertise towards the projects (Chavot et al. 2016). In these circumstances, the opposition thus formed may seem legitimate and credible in the eyes of the investigating commissioners in charge of the public inquiries: indeed, they come to a negative conclusion regarding the project in three out of four consultations conducted in spring 2015 within the Eurometropolis of Strasbourg,

These controversies have real implications for a project's dynamic. In Alsace, two projects that should have taken place in the Eurometropolis of Strasbourg (EMS) have been abandoned by the operators. In Haute-Savoie, no action is taken on applications for low and high temperature licences, which equates to a refusal by local prefecture and supposedly the ministry of mining. However, the public inquiry only has a consultative value. Thus, in Alsace, the prefecture invalidated the investigator's conclusions by deciding to publish a decree authorizing exploration works on one of the contested projects. The arguments put forward to justify this decision underline the project's value to the community and towards energy transition. In this case, the prefecture has taken little account of the criticisms expressed. It has considered them as expressions of individual interests or fears that could be addressed through appropriate communication. Thus, monitoring committees have been set up for this project as well as for two others who benefited from a favourable prefectural decree in 2017.

2.3 Acceptability Surveys and Sociological Work on the Public

Several types of studies have been carried out to have a better knowledge of the inhabitants, mainly in Alsace. They involve either the companies or social science researchers. The 2012

study on the “acceptability of risks related to deep geothermal energy” around the Soultz-sous-Forêts power plant is one of the first of its kind in France (Lagache 2012). The aim was for the ESG operator to understand how the inhabitants perceive the nuisances or risks associated with the operation of the plant. Indeed, until the hydraulic stimulation phase stopped in 2005, several micro-seismic events of up to 2.9 amplitude on the Richter scale were felt by the population. A quantitative survey was therefore carried out among the inhabitants of the two villages surrounding the power plant. This survey was also thought of as a moment of exchange and communication with the inhabitants. The latter obtained information about the power plant through investigators or various didactic materials.

On analysis, this survey gives the impression that the inhabitants are not bothered by the presence of the power plant. Noise (56.7%) and seismicity (55.7%) are the two most frequently cited “known nuisances”.²¹ But only 25.6% of the population mention that the site’s activity could become troublesome, and 17.2% believe they are at risk. However, the installation of a geothermal power plant near one’s home does not seem to be widely accepted, since only a minority (32.2%) would not mind it. In a publication (Lagache et al. 2013), the authors of the study point out that the perception of geothermal energy is rather positive, while stressing that it remains difficult to measure the acceptability of risk, since the latter would remain subjective data. They also conclude from the survey that residents are little or poorly informed. According to the authors, this is evidenced by the fact that the inhabitants are not very sensitive to the site’s benefits (only 39.4% believe that the site has an economic impact on the territory). It is therefore important, according to the authors, to continuously inform the inhabitants so that they also become aware of the benefits of deep geothermal energy. Further acceptability studies will soon be carried out by operators in northern Alsace and near a planned site in the South West of France.

In the spring of 2015, following criticism of geothermal projects in the Eurometropolis of Strasbourg, the labex G-EAU-THERMIE Profonde of the University of Strasbourg set up a working group on social sciences. A first research project entitled «How to deal with a public inquiry? Views from residents and deep geothermal projects stakeholders in Alsace» (ORAGÉO) aims to study the public enquiries and in particular to follow the progress of those organized in spring 2015. Three corpuses are compiled and analysed. The first concerns all opinions and documents produced in the course of the public inquiries and observations made at the investigation sites. The second focuses on media discourses and the communication of the actors (daily regional press, blogs and documents from associations, declarations and public meetings...). Finally, a series of qualitative interviews was conducted with various stakeholders, whether or not they are engaged in the controversy (industrialists, scientists, representatives from the associations, elected officials, experts commissioned by the prefectural authorities, investigating commissioners, etc.).

Three important observations come out of this study. First of all, there is a significant gap between the discourse on geothermal energy from the project promoters and the way in which the inhabitants perceive these projects. The former speaks of geothermal energy in very general terms, highlighting the objectives pursued and its usefulness towards energy transition and building a local energy mix. However, the inhabitants are first and foremost interested in the concrete and local impacts of these projects on their territory, and in particular the risks and benefits for their community.

²¹ Corrected data based on Lagache 2012.

Secondly, the views and arguments of each party are publicized very differently. While the regional daily newspapers tend to follow local authorities and, to a lesser extent, the project promoters in their communications, the associative press and blogs are relays for the opposition. However, the information is not treated the same way in each of these media. On the one hand, the local news media talk about geothermal energy according to classical journalistic standards, claiming “objectivity”. On the other hand, blogs and the associative press claim to be a partisan informant towards internet users or local residents and deliver content that is much more in-depth and argued, and above all closer to the readers’ daily lives.

Thirdly, the organization of public enquiries plays a decisive role in the dynamics of a controversy, but does not allow projects to be renegotiated. The files submitted to the public enquiries by operators reveal well-defined projects. They specify the location of boreholes, the measures taken to control risks, as well as the possible impacts on the natural and human environment. The way in which these files are made can only arouse support or rejection by the local residents. And indeed, only a few citizens’ contributions are aimed at making the projects evolve, with the notable exception of those coming from environmental protection associations. Most are aimed at discrediting the projects. In this context, the part played by the investigating commissioner may be crucial. Its role can be compared to that of a gatekeeper (White 1964): it selects, preserves, and rejects elements and arguments put forward by inhabitants, associations, elected officials and operators to draw up its own subjective opinion. In the case of the contested Strasbourg projects, the Commissioners rely heavily on citizens’ contributions, stressing that the operators have not been able to provide sufficiently convincing and reassuring information. Moreover, their negative conclusions took into account the social and political context, notably the unfavourable social climate and the lack of commitment from the Eurometropolis of Strasbourg towards these projects.

The involvement of the social science working group in a second project, which is supported by the Labex, as well as in the European H2020 DESTRESS project, allows it to address the issue of the perception of geothermal energy more broadly. Researchers are now interested in the construction and circulation of views on deep geothermal energy in urban and rural contexts. This research calls for a variety of tools: exploratory interviews with the various stakeholders (industrialists, elected representatives, associations, journalists); survey by questionnaires of opinions and representations of deep geothermal energy in urban and rural areas; analysis of media discourses (press, television, radio, blogs, communications from local and regional authorities); organization of comprehensive interviews and focus groups with local residents.

Four zones are investigated, three within the EMS and one in northern Alsace, which correspond to locations where deep geothermal projects are being implemented at different stages of development. Two geothermal projects are supported by local operator ES and two others by its competitor Fonroche. This work makes it possible to test different hypotheses in order to better understand changes in attitude of the inhabitants towards geothermal energy:

- H1. The perception of the risks and benefits of geothermal energy varies according to the way people experience and give meanings to their territory of life.

The most contested project is the one that was to be set up in a Seveso area, while the inhabitants have been fighting for a long time to reduce the dangerousness of the area. Conversely, there is very little opposition to geothermal energy in northern Alsace, where pilot sites have been set up and new projects are being defined. This is an area where many oil

wells have been drilled in the past, and residents and elected officials see the exploitation of underground resources as a real source of economic development.

- H2. The way in which local authorities invest in the field of RES, notably through their climate plan, plays an important role in adherence to deep geothermal projects.

Thus, to the south of Strasbourg, a project currently being drilled appears to be well integrated into local politics and there is little controversy, as with projects located in Northern Alsace. This is not the case in Haute-Savoie, where the exclusive licence to prospect application was rejected in part because the project went against the framework of the community climate plan.

- H3. More generally, the local roots of a project influence how it is perceived by the inhabitants.

Labex researchers distinguish between projects “anchored” in the territory, on the one hand, which are the outcome of a long concerted maturation between different actors, and “off-ground” or unrooted projects, on the other hand, elaborated in favour of economic advantages and/or national political programs, often ignoring the specificities of the local territory (Chavot et al. 2017). And it is very often the unrooted projects that prove to be the most contested, as is visible in Alsace and Haute-Savoie. This type of project is often viewed by people in terms of costs and benefits: the local residents consider that the risks incurred are higher than the benefits they could obtain from such projects.

As part of the DESTRESS project, the perception of geothermal energy is studied in connection with two locally anchored projects and two off-ground projects.

3 Conclusions

The national energy policy implemented in France since the beginning of 2010 has undeniably favoured the development of geothermal energy. It has notably enabled a renewal of district heating geothermal projects and assisted the first cogeneration projects. The targets for 2020 set by ADEME and BRGM are as follows²²:

- Individual ground-source heat pumps: 7000 GWh
- Intermediate geothermal energy (probe fields, groundwater heat pumps for collective buildings and for tertiary use, thermoactive foundations, etc.): 2900 GWh
- Deep geothermal energy (heat networks): 5800 GWh
- Electric geothermal energy: 80 MWe.

As we have seen, small and medium-scale projects have developed without controversy. This is not the case for those aimed at cogeneration of heat and electricity. The innovative and therefore potentially risky aspect of these deep geothermal projects is more or less well accepted locally. In addition, these projects involve state policy, local government policy and industrial interests. In this context, local elected officials and citizens feel they have a say.

²² Source: <http://www.geothermie-perspectives.fr/article/production-denergie-geothermique-en-france#chiffres-pac> (accessed on 02/26/2018).

However, deep geothermal energy projects depend on the Mining Code, which gives companies and the state full powers to exploit the wealth of the subsoil. Thus, this type of regulation tends to encourage “off-ground” projects, since it is not necessary, according to the Mining Code, to consult with local authorities ahead of the projects. Nonetheless, citizens are consulted alongside the environmental code since these projects are likely to have an impact on the environment or on the quality of life of local residents. Thus, the implementation of deep geothermal project generates a contradiction between the Mining Code and the Environmental Code in terms of “local democracy”. And this contradiction is not without provoking political dissents at the local level.

But the new energy policy tends also to encourage local and regional authorities to draw up climate plans and develop a local energy mix, especially to supply heat to district heating networks. Within this framework, a number of locally anchored projects, based on cooperation between territorial and industrial authorities, have emerged, as is the case in the south of Strasbourg. Projects in Northern Alsace are also taking this form. Although these projects are not co-constructed with the population, they do reflect local identities and generate little opposition.

The controversies that emerged in the 2010s reveal the tensions between the imposition of off-ground projects and the dynamics already present at the local level. The outcome of the controversy will depend on how the local and regional authorities will be able to accommodate or not the projects initiated by industrialists. Thus, in Haute-Savoie, the projects were postponed due to unmanageable opposition from local authorities and local residents. In Alsace, the Eurometropolis of Strasbourg has opted to integrate off-ground projects into its energy policy. However, the adherence of local residents to this policy is not yet guaranteed, and controversy persists over certain projects.

The preliminary results of the social science studies carried out in Alsace show that local residents want to influence their territory’s future, especially regarding the issue of energy. In what spaces will they be able to express themselves and be heard? An experiment is currently being carried out within the EMS: the public is invited to contribute to the definition of the future 2030 Climate plan through their participation in public meetings and online platform. Is this framework capable of fostering citizen participation? And will local residents most involved in the life or defence of their territory recognize themselves in this type of device?

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