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SET-UP OF LOW ENTHALPY GEOTHERMAL ENERGY OPERATIONS IN FRANCE ANALYSIS OF OWNERS AND UTILITIES PARTNERSHIP

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ABSTRACT

France posses major low enthalpy geothermal energy resources mainly located in the Paris and Bordeaux areas.

Rapid development of these resources, mainly those in the Paris area, from 1982 to 1986 was possible thanks to a particular type of organizational structure associating for each project, the French state, local authorities as overall managers, engineering bureaus and private companies along with measures to induce and encourage development from both the technical point of view, (knowledge of the resource), and financial point of view (subsidies, insurance cover of the geological risk).

The abrupt cessation of further development from 1988 on as a result of the fall in oil prices revealed the weaknesses in the organizational structures linked on one hand to the large number of owners which limited the effects of scale and the capitalisation of know-how, and on the other, the financial set-up of the operations leaning almost solely on loans, the cover of which was linked to the price of competing energies.

In the future it will be necessary to review the organizational structure if durable development of geothermal energy is desired.

INTRODUCTION

66 low enthalpy geothermal energy operations have been established in France in a little over 20 years since 1970.

56 operations were established in the 4 years from 1982 to 1986, a rate exceeding 14 operations per year.

Today development has ceased (about 200,000 tons of oil equivalent per year are saved by géothermal energy) even though France's low enthalpy geothermal potential is a long way from being fully exploited, and whilst France's energy dependence remains significant and in the long term, it is inevitable that energy prices will once again increase.

To understand this situation, it is important to analyse the administrative, legal and financial factors involved in setting-up geothermal operations in France which, to a significant extent, depends upon the mobilisation of local government.

This particular set-up has in the past, authorised rapid mobilisation of the principal participants but has also led to perverse effects which must be analysed in order to establish an organisational framework for the future.

FRENCH GEOTHERMAL ENERGY RESOURCES AND THEIR EXPLOITATION WITHIN THE OVERALL ENERGY POLICY

French energy policy has changed considerably since the first oil crisis of 1973. This is demonstrated in the figure 1 below; from 1973 to 1991 oil derived energy consumption diminished from 60% to 41% whilst nuclear energy increased from 5% to 33%.

	1973		1991	
	Mtep	%	Mtep	%
Coal	17.7	12	9.6	5
Oil	90.5	60	73.0	41
Gas	8.7	6	24.5	14
Electricity	33.5	22	70.6	40
Hydro.	(25.6)	(17)	(11.1)	(6)
Nuclear	(7.9)	(5)	(59.5)	(33)
Total	150.4	100	177.7	100

Mtep = million of tons of oil equivalent

Fig.1: Structural evolution of energy consumption in France

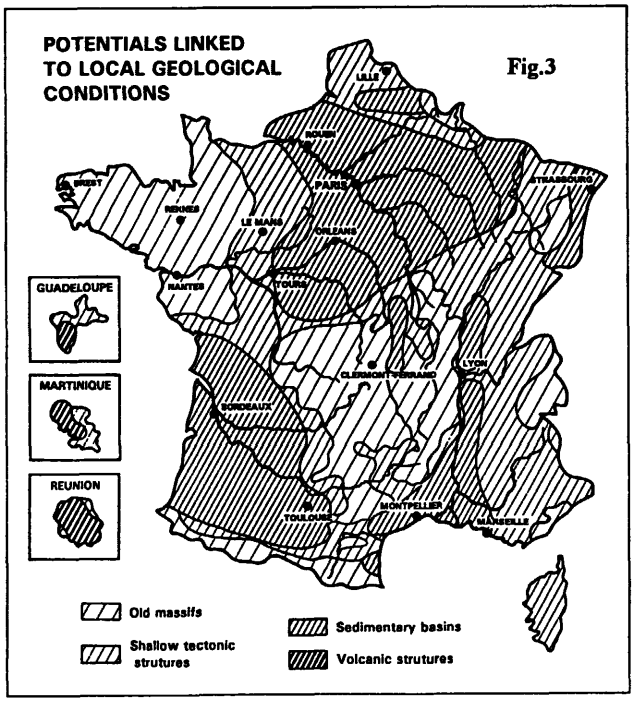
Nevertheless globally speaking, energy dependence on imported hydrocarbon products remains very significant (figure 2). A major part of energy consumption derives from the residential and tertiary sectors (45 %) for heating. Therefore this sector is an excellent target for alternative energies produced in France, this is indeed the case for all new and renewable energies in general and for geothermal energy in particular.

Production		Final consumption	%	Sectors	%	Mtep
7.5	Coal	9.6	5	Iron & steel	4	8
3.4	Oil	73	39	Industry	24	45
2.9	Gas	25	13	Residential-Tertiary (*)	45	85.3
87.4	Electricity	71	38	Agriculture	2	3.3
(13.8)	(Hydro.)			Transport	25	46.2
(73.6)	(Nuclear)					
10.2	Renewable *	10	5			
111.4	Total	188	100		100	188

Mtep = million of tons of oil equivalent
* including 6 Mtep of non commercial firewood

Fig.2: Energy in France (1991 in Mtep)

France posses major and significant geothermal energy resources, mainly of the low enthalpy type, occurring in sedimentary basins on the European mainland of France (figure 3). These resources were discovered during oil exploration operations.



With regard to overseas territories potential resources exist on the island of the Réunion and in the West Indies (Martinique and Guadeloupe). They are high enthalpy resources and occur in the context of volcanic islands (Piton de la Fournaise, Soufrière, Mont Pelée). To date only one source is exploited on the island of Guadeloupe at Bouillante by a power plant of 4 MW. With regard to mainland France, although resources are widespread the regions the best doted are in Aquitaine, principally the Bordeaux area and in the Paris Basin in the region known as "Ile de France" the centre of which is Paris itself.

The Aquitaine Basin encloses sweet water aquifers which can be exploited from wells which, once thermal capacity is exhausted, can be drained into the surface water system. Whilst vast quantities of hot water are available, the very complex nature of the geology introduces a significant degree of incertitude with regard to prospecting for geothermal waters.

In contrast the Paris Basin (i.e. the city of Paris and its surrounding areas), is characterized by a far more simple geological structure Different aquifer horizons separated by impermeable layers constitute particularly interesting geothermal resources with regard to urban heating. These include the Albian (30 - 40°C), Lusitanian (50 - 60°C), Dogger (60 - 80°C), and Trias (70 - 90°C) and occur at depths form about 500 m to 2500 m.

The combination of a major resource and a demand for heating has brought about significant growth in this sector for the "Ile de France" region.

The carbonate Dogger horizon has been the almost exclusive horizon exploited using doublet drilling techniques. The waters of the Dogger could be strongly saline (total disolved salt from 10 to 30g/l) and have to be re injected in to the aquifer once their thermal energy has been exhausted. This is to avoid pollution of surface waters but also this maintains pressures in the aquifer (Figure 4).

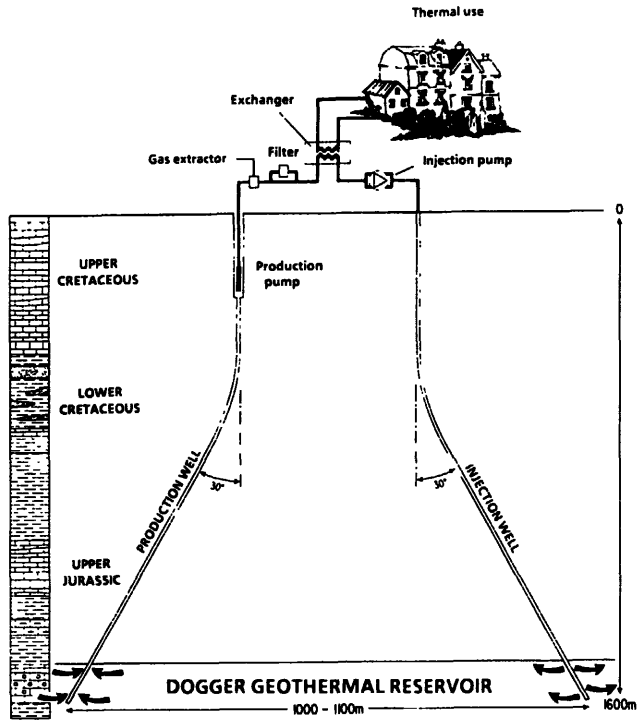


Fig.4: Geothermal doublet

This reservoir presents hydraulic and chemical characteristics which are particularly well adapted to exploitation by doublet drilling techniques. Output of the exploitation is between 150 to 300 m3/h and the Injectivity Index of the reservoir, which is exploitable through holes without casing improves by dissolution.

Other reservoirs occurring in Alsace, Bresse, in the Rhodanian corridor and in Limagne show far more significant levels of uncertainty and to date have not undergone any development.

In two major locations, Aquitaine and "Ile de France", geothermal energy is mainly used for heating purposes (Figure 5).

This has been made possible by connecting the geothermal installations to a specially adapted urban heating network. It is considered that a geothermal drilling doublet should be connected to about 4,000 dwellings or equivalent in order to be economically viable.

The necessity to connect many dwellings explain why most case geothermal energy operations are connected to urban heating networks development. In addition, because the modest amount of thermal energy characterizing this resource, it is necessary to optimize heat supply in enhancing low temperature thermal transmitters (floor panels, radiating panels) and in seeking a maximum number of thermal down steps.

Overall, a geothermal energy operation requires a considerable amount of effort in terms of rationalizing energy use.

When an operation is set up the system composed of the geothermal system, the energy supply, the traditional network and thermal heat.emitters, it requires more sophisticated management than in pre-existing more standard systems. This is notably the case in intermediate climatic conditions of spring and fall (returns at low temperatures onto the heating network).

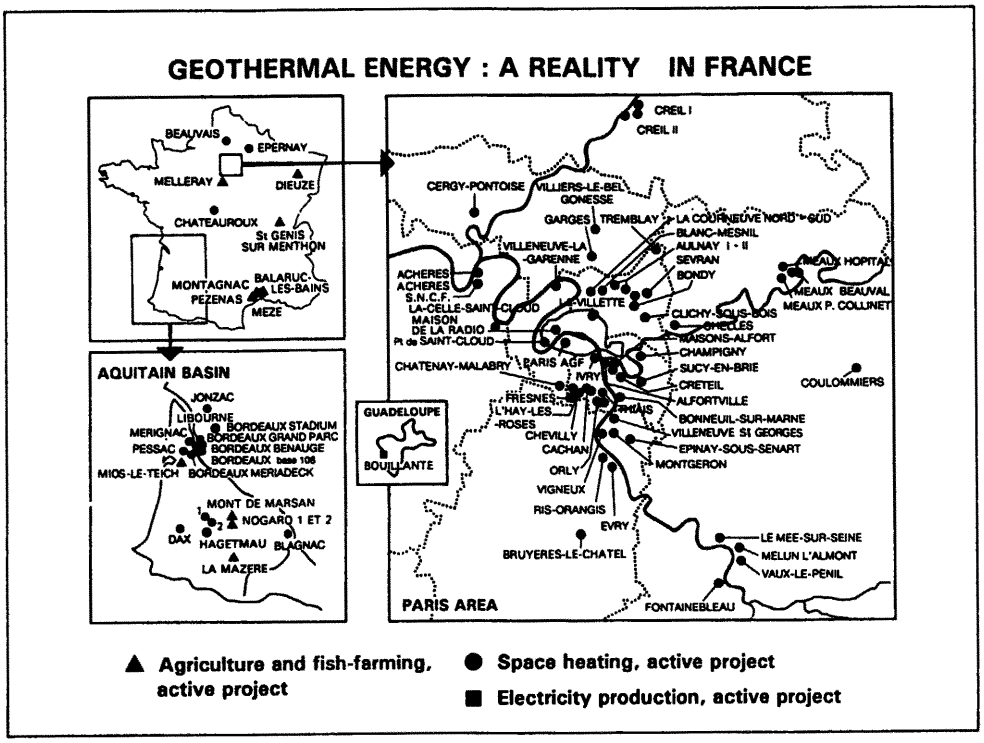


Fig.5: Geothermal operations in France

THE OF PUBLIC AUTHORITIES IN THE DEVELOPMENT OF GEOTHERMAL ENERGY

Following the first oil crisis of 1973, funding for research aimed at attaining energy independence for France grew considerably. The priority programme was nuclear energy development with a second nuclear option, supergenerators and a third option, nuclear fusion. Backing was also allocated to new and renewable energy sectors (ENR) in a general way and to geothermal energy in particular.

Public authorities intervened centrally by acting on the legal aspects, financing, and at a local level, by bringing about an increase of commitment and participation.

Research and exploitation conditions regarding geothermal "deposits" of high (more than 150 °C) and low enthalpy types (less than 150 °C) are now defined in the Mining Law.

The state delivers exclusive exploration then exploitation licences with regard to geothermal "deposits", and this through a public enquiry system. Such licences are only issued to organizations able to demonstrate their ability to conduct research and/or exploitation of such resources. The state also fixes technical conditions for the operations (geological horizon, location and description of the wells, hydraulic and thermal output for the exploitation, etc..) in addition to the protection zones around the wells.

These rules concerning the sub-surface are accompanied by certain dispositions which concern the heating network which is destined to ease connection with users, notably a classification procedure.

Dispositions taken involve information on the resource, the investment and covering geological risk.

As a first step studies were financed through the Geothermal Energy Committee to made french geothermal energy resource inventories based on oil exploration data (notably studies by the BRGM and ELF).

Secondly, financial assistance for preliminary studies was established to encourage local authorities to evaluate the technical feasibility and the economics of such operations, i.e. the balance between resource and requirement.

Finally, financial assistance was made available to facilitate the putting into operation of projects either in the form of subsidies of 10 to 15% throught the Committee for Geothermal Energy or the French Agency for Energy Management (AFME), within the framework of a special fund for major works (FSGT), or on the basis of loans at below-market interest rates provided by state owned financial institutions (Banks, Credit National, Caisse des depôts et consignation (CDC), Caisse d'equipement des collectivites locales (CAECL)).

Parallel to this an insurance system against geological risk linked to the geothermal resource was created comprising two attributes linked to the short and long term.

The first, short term attribute guaranteed reimbursement of 90% of the cost of the first borehole in the event of failure in terms of energy quality of the evaluated resource by computing output against temperature .

The second attribute, this one long term, guaranteed either incidents relating to the well linked to the geothermal resource, through the refunding with a franchise of FF600,000 (about USD 100,000), of repairable damage. Or a partial reduction or total disappearance of the resource through payment up to the end of the

contract (15 years on average), of fixed degressive compensation related to the age of the installations.

Management of the system was given over to a specially created company SAF-Geothermie, the shareholders of which constituted by mainly public owned financial establishments (CDC, Credit National, Credit Foncier de France, Union des HLM, Compagnie BTP) and involved in geothermal energy.

Finance for the system is ensured by an initial dotation from national authorities (Agency for the Environment and Energy Management (Ademe) which replaced the AFME, and the Ministry of Industry) in addition to subscriptions of the owners fixed respectively at 1.5% and 3% of the sum guaranteed for in the short and long term. As far as the long term fund is concerned the guarantee is assured along a first line up to the sum of FF4.7 million by the fund and beyond this up to FF36 million (about USD 6million) by two successive consortium of insurance companies.

GEOTHERMAL ENERGY OPERATIONS AND THEIR EXPLOITATION

The operational aspects of geothermal energy exploitations was characterized by considerable involvement of local authorities which used loans on a massive scale for the set-up of operations and with the assistance of engineering bureaus and companies .

Of the 66 geothermal energy operations set up in France, almost 90% were undertaken by public organizations and 75 % by local authorities within the framework of low-cost housing programs. Local authorities were involved to different degrees, directly in terms of municipal programs or indirectly through local syndicates or companies in partial public ownership. In the latter structure the local authorities were associated with both other public and private bodies.

The role of the local authorities can be explained on one hand through a political desire to participate in the goal of energy independence, improvement of the environment, and on the other through the very "local" character low enthalpy geothermal energy.

Substitution of oil by geothermal energy improves the environment both from the chemical point of view by the reduction in emissions of COx, NOx, SOx, and dust as well the acoustic and urban aspects with the disappearance of noise pollution from trucks delivering fuel.

It can be noted that whilst local authorities manage extensive numbers of buildings and are therefore major potential clients for this type of energy, the local authorities also fulfil a fundamental role in the definition and the development of urban infrastructure by the creation (in France) of Priority Urbanization Zones (ZUP in French) or Zones of Concerted Development (ZAC in French). The local authorities are thus major players and inevitably, have to be involved in this kind of development.

The role played by the low-cost housing organisations (HLM) is obvious given their mandate to provide social housing at low cost. This type of housing also presents the particularity of being well adapted to geothermal energy utilisation with extensive closely packed buildings which can be provided with low temperature heat emitters in the form of floor panels. The local authorities are represented on the administrative boards of these organisations

In terms of the efficient use of energy, it is necessary to link up numerous users of divers origins over a local authority area. This necessarily implies either the agreement or at least a common desire on the part of municipal authorities to push forward with this type of installation.

Financially, in terms of size of investment required, geothermal energy is characterized by long term amortissement, this in the order of 15 to 20 years. Local authorities from the financial establishments' point of view, represent a partner with a guaranteed long terms solvability and credibility.

With regard to management of the operations, local authorities often delegated responsibility for the development phase to a subsidiary of CDC Geochaleur and to the exploitation phase to the part-public part-private companies responsible for the follow through of operations and collection of payments made for heating .

Whereas the majority of operations were conceived within the public domain, the main development work was undertaken according to public tendering procedures.

Those set-ups (Figure 6) selected associated under the responsibility of an overall delegated management organisation, Geochaleur, a sub-surface specialist engineering firm (CFG, Geotherma, SPEG...), for design and control of the geothermal circuit, and another engineering firm to build the surface infrastructures (civil engineering, heating network, supplementary boilers, distribution sub-stations etc.).

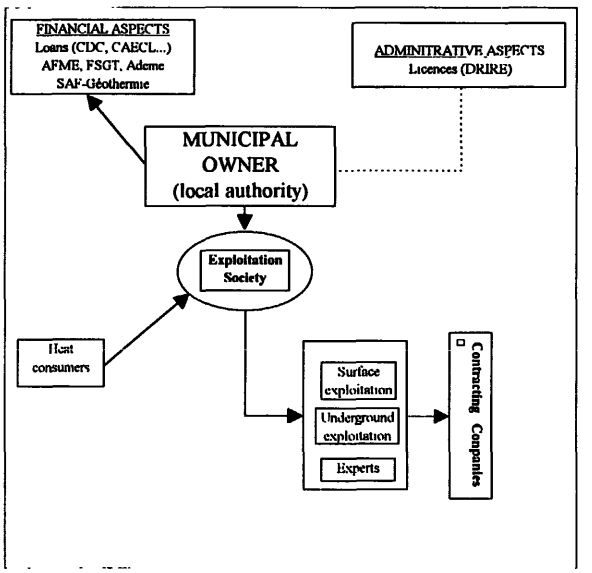


Fig.6: Exemple of organisation breakdown of a geothermal operation in France

With regard to these engineering firms, whilst surface work is fairly standard in its nature, in contrast a new "savoir faire" was developed with regard to sub-surface work:

- production by open hole throught large diameter casing ;
- new production pumps with high output operating in an aggressive environment and equipped with frequency variators ;
- generalisation of titanium plated heat exchangers.

These developments were followed up by hydraulics and hydraulico-mechanical systems innovations, the cleaning out of wells and anti corrosion treatment by injection of organic corrosion inhibitors at the bottom of the production well in order to protect the circuits.

In terms of the exploitation of the geothermal energy operations the responsibilities are generally shared between heat distribution network operator and the geothermal circuit operator (the wells, the outlet pump , the anti-corrosion treatment operation).

It should be noted that this set-up, whilst operational, has no beneficial effects of scale, nor a centralized capitalisation of the know-how.

The financial set-ups were characterized in general by a high level of debt for the owners, in the order of 90 % of operational costs and this for periods of 15 to 20 years, with sales contracts comprising a "safeguard" clause guaranteeing a reduction (able to reach 20%) with respect to the sale price compared to other types of energy, most commonly fuel oil.

This type of set-up was undertaken in the economic context of high energy costs, high interest rates (11 to 15 %) and a high level of inflation. In addition some of the management costs were underestimated.

The equilibrium of this system was based on constant growth in energy prices, i.e., about 2 to 5% per year, with an initial level that of the period 1980 to 1984 when energy prices were high.

With the collapse of oil prices (Figure 7) between 1986 to 1988 competing energies became attractive again and were able to compete with the development of the heating networks of certain areas.

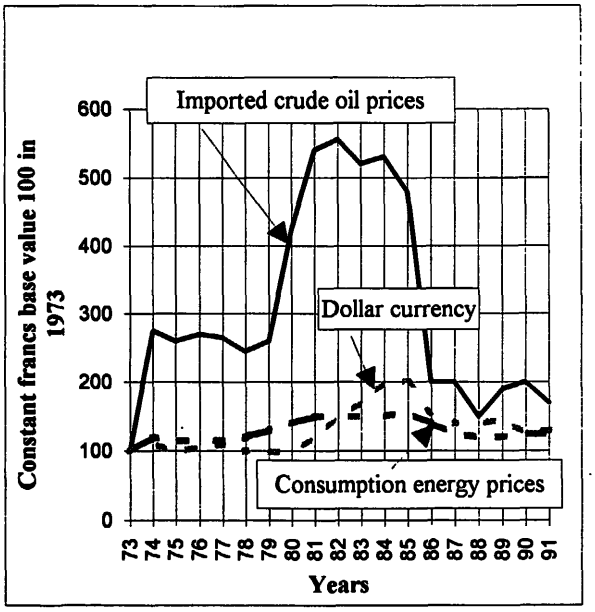


Fig.7: Directing prices evolutions

In addition the application of the "safeguard" clause reduced income from the sale of the geothermal heat. Since this period most geothermal energy operations have been in financial difficulty.

To resolve the financial difficulties in which the local authorities have found themselves, the central government has proposed renegociation of loans, with regard to the rates, the payback period and has encouraged the management organisation to rationalize operation (Mission Brosse).

In some cases doublet were closed because exploitation costs were not covered, and it was necessary for some local authorities to increase local taxes to be able to reimburse loans.

CONCLUSIONS AND PROSPECTS

The system put into place was well adapted to an energy context of high prices and strong inflation.

On the other hand it is ill adapted for durable development where energy prices fluctuate.

In addition experience has shown that dividing up the overall management does not enable the effects of scale to come into play on the costs of operations by the various enterprises any more than the capitalisation of the acquired know-how.

All took place in the end as if, in order to make economies for a state appointed organisation required to develop a new, technically complex and financially risky line, the responsibility was assumed by local authorities who were overwhelmed by the technical aspects, amounting in the end to using local taxpayers as guarantors and now the hostages of the system for many years to come.

In future it will be necessary to envisage a more centralized organisation with a far greater auto financing capacity whilst maintaining a system which guarantees the resource.