USING GEOTHERMAL ENERGY FOR URBAN HEATING IN BORDEAUX MERIADECK AND PESSAC

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ABSTRACT

We have known for a long time that under Bordeaux there is a medium-temperature water reservoir which could be used as a major thermal source for space heating.

The existence of fresh water at some depth under Bordeaux meant that it might be possible to design geothermal projects on the basis of a single well and postpone reinjection for several years.

Meriadeck is the fust geothermal operation (GE 17/80/FR) to have been completed under the conurbation. The well came into operation in October 1982 and is still running in 1994 without problems. Geothermal station of Pessac (GE 46/81/FR) has been exploited since the first half of 1983.

Total energy savings of this two plants are estimated at 1600 TOE/year.

INTRODUCTION

The geothermal resources

The Bordeaux conurbation is immediately above a deep faulted geological anticlinal fold. Some deep lying strata form an overlap running from the south to the north of this structure.

The potential reservoirs are :

- Shallow aquifers for the exclusive use of the city's drinking water in the first 500 metres.
- Limestone of the Cretaceous at about 600 metres.
- Cenomanian-Turoniandolomites and sands between 850 and 1000 metres which are the drilling objective (Fig. 1). This aquifer which covers the entire Aquitaine basin is hydrodynamically active with feeder and outflow zones. The flow rate of fresh water through this single reservoir under the Bordeaux area is currently estimated at 4000 m^3/h.
- There may be reservoirs below 1500 metres in the Jurassic, but the water will be saline.

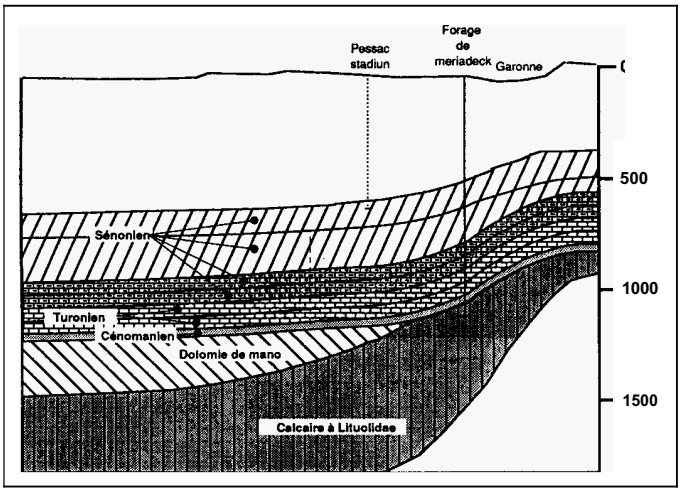

Figure 1 : Geological cross section under Bordeaux

Potential consumers

The Mériadeck quarter in the town centre, where renovation began in 1966 and is due for completion in 1985, comprises 170000 m^2 of offices and shops and 120000 m^2 of housing in most of which the installations are all-elecmc.

In Pessac the main consumers are the SA **HLM** "La Gironde" which built 1526 flats between 1970 and 1973. They were heated by an oil fired central heating plant and low temperature heating panels and floors.

TECHNICAL DESCRIPTION OF MERIADECK GEOTHERMAL PLANT

The geothermal well

The drilling of a single vertical well was completed on January 15,1981. The site was an area comprising some 400 m^2 surrounded by a new building and anti-noise measures were necessary. A baffle wall was designed and installed around the machinery and motors used during drilling.

The reservoir comprises two strata : dolomitic limestone at the top and sands at the bottom lying between 920 and 1125 metres (Fig. 2).

The dolomitic reservoir of the type known as the Mano dolomite (Jurassic) is not present under the Turonian at Médiadeck. Exploration and coring between 1125 and 1148 metres showed that it has been eroded.

Calculations on the effects of exploiting the reservoir proved that 20 years of exploitation on the reservoir will lower the water table by 10 metres within a 1.15km radius of the well.

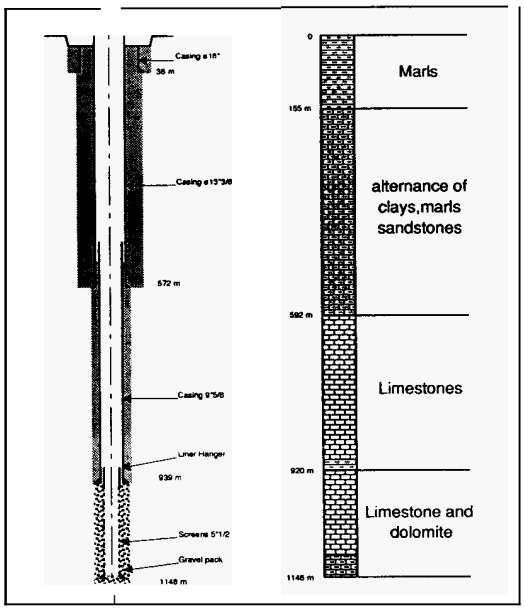

Figure 2 : Well design and geology

Characteristics of the well are :
- Final depth : 1148 metres
- 13" 3/8 casing : 0 to 526.6 m
- 9" 5/8 casing : 435 to 930 m
- 5" 1/2 production casing : 908.5 to 1146 m

After passing through a heat exchanger, the water will be chlorinated and fed into the drinking water supply of the town.

The results were better than expected : fresh water (with a salinity of 0,4 g/l) and a well-head temperature of 53.4°C. Advisable flow rates was 150 m^3/h.

Supplies to the reservoir are guaranteed, mainly because of the inflows from other very broad reservoirs.

The geothermal energy at the surface

The district heating network was built step by step and all consumers connected in 1985.

The artesian flow of the well is 41 m^3/h and the average pumping rate is 138 m^3/h at 53°C.

The main heat exchanger at the well-head extracts 47°C from the geothermal water which is then ueated and channelled into the sewage system and into the city's drinking water supply in the future. From the heat exchanger a closed loop distribution network involving 2000 m of piping buried under the streets, carries the geothermal water to substations to which customers are connected in parallel. A supply temperature of 50°C (± 2 °C) is guaranted. Monitoring and invoicing is done on a pro rata basis of the amount drawn off (proportional prices per m^3) and the flow rate contracted for (fixed rate per m^3/h). This encourages customers to make the maximum use of the heat obtainable per unit volume of the fluid distributed. This arrangement also makes it possible to limit the volume of extracted geothermal water. (Fig. 3).

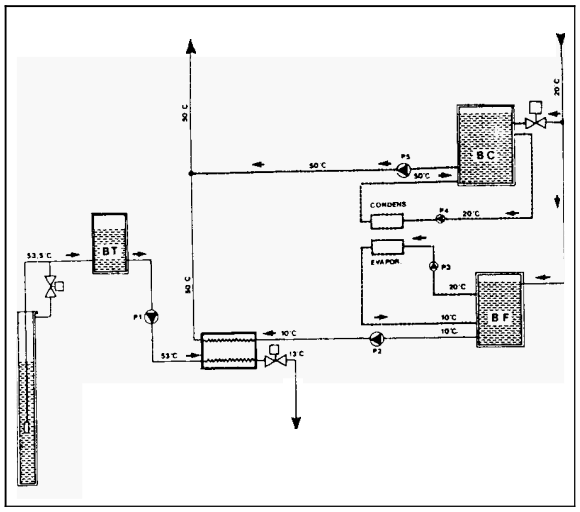

Figure 3 : Principle diagram of the station

DETAIL OF INSTALLATIONS

1. The heating centre

A large room measuring 40 x 12 x 5 m, built entirely underground, and containing :
- the well head with the pump ;
- six buffer storage tanks, each with a capacity of 90 m^3, made of stainless steel and lagged with polyurethane.

The large capacity of the tanks means that :
- the number of times the pump with its fixed flow rate has to start up can be limited ;
- the pump can be stopped completely during EDF peak periods as the installation can run continuously for two hours on the combined artesian flow and the water stored in the tanks ;
- a battery of three identical pumps (P1) which pump water from the buffer tanks into the primary heat exchanger circuit ;
- two identical heat exchangers connected in parallel and designed for the following maximum operating conditions ; 75 m^3/h per heat exchanger, in both the primary and the secondary circuits ; water temperature increased from 10 to 50°C in the secondary circuit ;
- a battery of three identical pumps (P2) pumping water from the two cold water tanks (with capacities of 90 m^3 and 60 m^3 respectively) into the secondary heat exchanger circuit and then into the distribution network.

On its return from the distribution network, the water is split between two circuits :
- one to supply the cold water tanks,
- the other to supply the three polyurethane-lagged hot water tanks with their total capacity of 180 m^2.

The water from the cold water tanks is pumped out by a battery of pumps connected in series. The water then returns to the cold water tanks at a temperature of about 10°C and is then pumped out by the P2 pumps as described above.

Water from the hot water tank is pumped out by the battery of pumps P4, fed to the condensers of the heat pumps connected in series and returned to the hot water tanks at a remperature of about 50°C. Then the water is pumped out by another series of three pumps (P5) and returned to the distribution network together with the water from the heat exchangers. The total volume of water stored in the cold and hot water tanks allows the heat pumps to be stopped during EDF peak periods whilst the 50°C water from the hot water tanks continues to be used.

2. Regulating the temperature and water flow

The temperature and flow rate are regulated as follows :
- Water temperature in the distribution network : it is absolutely essential to ensure that users receive water at a constant temperature (within 2°C) from the network. Since water is delivered to each individual user, the flow rate in the network varies with demand. The water temperature at the heat exchanger outlet is regulated by modifying the flow in the primary circuit which is itself regulated by a motor-driven valve installed at the exchanger outlet. The remperature of the back-up hot water stored in the hot water tanks is regulated by heat pumps - functioning successively in cascade - which maintain the water temperature at a constant 50°C at the outlet from the last condenser.
- The flow rate : P1, P2 and P5 pumps are so designed that two pumps on their own can regulate the maximum flow in their circuit : the third is an emergency pump.

When the flow in the circuits decreases as a result of a drop in demande or because of regulation, the pressure supplied by the pumps increases and one of them shuts down for as long as the one that is left can cope with the flow on its own.

The second starts up when the pressure falls due to increased flow.

3. Remote control and signalling

The Bordeaux Municipal Gas Board operates the installation from its Bordeaux control centre. The heating centre is not permanently manned. A telemetry centre has therefore been installed to feed information to the control centre on the installation's main operating functions such as starting temperature, faults, electric switching operations, etc. In the event of a serious fault, the duty staff at the control centre will be able to use a remote control system to stop the installation operating whilst the drainage pumps used for evacuating any water from seepage or leaks or, in the event of serious damage, the artesian water, remain in operation.

DESCRIPTION OF PESSAC PLANT

The geothermal well

The drilling proceeded without incident and reached the Cenomanian Turonian at a depth of 825 and 1035 m as planned.Although drilling continued to 1084 m, older strata rather than the Mano dolomite were encountered (Fig. 4).Since drilling was close to a residential area, this had to be protected by an eigh-metre high, 480 m^2 baffle screen consisting of a tubular frame with prefabricated double-skin acoustic panels. This proved conpletely satisfactory.

Pumping mals were more successful than expected, the flow-rate obtained being 193 m^3/h for drawdown of 100 m and a wellhead temperature of 48.4°C. The water has good physico-chemical qualities byt contained hydrogen sulphide.

A submerged variable-speed pump operating at 150 m^3/h was installed and the geothermal fluid is carried from the production well to the heating centre 200 m away by epoxy resin-coated, polyurethane-foam-insulated pipes.

Using the geothermal energy on the surface

Existing installations

Existing installations consisted of a central heating plant fired by low-sulfur fuel oil with an installed capacity of 19,720 KW. Heat was distributed by the primary network at a constant temperature of 110°C to 13 sub-stations.

In the existing system domestic hot water was produced by exchangers and heating was provided by mixing sub-stations. The inlet temperature **of** the underfloor heating panel network was 50°C and the return temperature 38°C for the lowest external temperatures. The output required for an external base temperature of -5°C and production of domestic hot water at 48°C is 7,177 **KW.** Average consumption is 18,815MWh per year.

The heating plant was kept in order to provide back up heat at temperatures below 5°C (which are fairly rare in Bordeaux) and emergency heat if necessary. The pumps in the primary circuit were replaced by two variable-speed pumps.

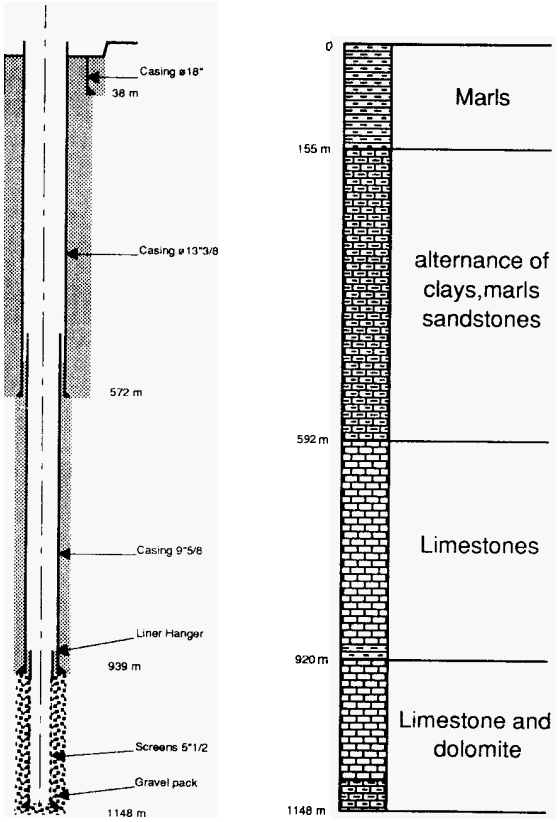

Fig. 4 - Cross section of the well

Work on the sub-stations

Work was carried out in the summer **of** 1982, outside the heating period. **A** prefabricated module was designed and constructed in view of the necessary lead times and in order to ensure as few interruptions as possible. This consisted of :

- the exchange between the primary circuit and the loading circuit for the hot water tanks ;
- the heating exchanger ;
- pumps, valves ;
- regulation, protection and control unit.

The hot water storage tanks installed have a capacity of 65 litres per flat.

Geothermal-heating centre

The equipment was so bulky that it has been housed in a 120m2 building adjacent to the existing heating plant.

The main items of equipment are :

- **two** stainless steel plate exchangers with a total output **of** 2,697 K W ;
- two heat pumps with a total output of 475 KW for a calorific value of 1,960 KW ; each pump consists of six groups workmg in cascade ;
- distribution pumps ;
- regulator, protection and control panel.

The geothermal fluid passes through the exchangers and then through the pump condensers before being discharged at a temperature of 28°C.

The return heating circuit follows the same principle : exchanger then heat pump condenser.

Regulation ensures optimum operation ; it controls :

- the flow-rate of the geothermal fluid by regulating the speed of the submersible pump :
- the flow-rate of the primary network by varying the speed of its pumps ;
- operation of the heat pumps with twelfth-by-tweflth cascade adjustment of their output ;
- operation of the oil-fired boilers.

The geothermal network works on variable flow and the primary heating network works on variable flow and temperature (Fig. 5).

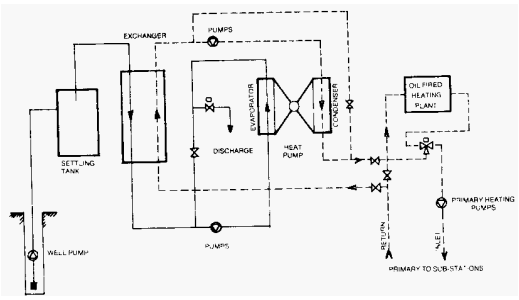

Fig. 5 - Diagram of the network

EXPLOITATION OF THE TWO PLANTS

The following tables (1993) summarize the characteristics of the two plants comparing the theoritical figure planned in the feasibility study and the real exploitation data

Bordeaux Méria.	Flow rate m^3/h	Prod. temp °C	Disch. temp °C	Durat. h	Therm prod. MWh	Energy sav. TOE/Y
Theoritical potential	102	54	20	8760	35240	3031
Average production	90	53	47	8700	**5450**	469
Pessac						
Theoritical potential	193	48	20	8760	54913	4723
Average production	130	48	30	4500	12215	1050

In the Meriadeck plants, it appears that the difference of temperature between production and discharge **is** very small (6°C) and thermal production more than 6 times less than expected. In Pessac the figure is better and heat production lower because exploitation flowrate at 130 m^3/h instead of 193 m^3/h expected.

The two plants have a unexploited thermal potential and new consumers could still benefit in 1994.

ECONOMICS OF THE PROJECTS

The investment in Meriadeck amounted 21660 KF (1981 without taxes) and is dismbuted between drilling 32 %, heating station 27 %, water treatment for tap water 10 %, mechanical and electrical equipment 12 % and distribution network 19 %.

In 1993, the exploitant (Gaz de Bordeaux) has analysed the exploitation costs (over 7 years) giving the following results per year :

- Complementary investments : 80 000 FF
- Energy (backup, electricity for pumping equipment) : 57 000 FF
- Maintenance costs : 156000 FF

Average exploitation cost per year is 293 000 FF. Which represent about 0,05 FF/KWh or 8,2 Ecu/MWh.

Real pay back is bad because of underexploitation of the resource. Calculation in 1981 gave around 10 years the result in 1994 taking into account subsidies for the project indicates about 15-16 years.

In Pessac the situation is rather different, the total investment accounted to 18 500 000 FF (including all taxes) in 1982 values.

The following table give dispatchs between loans and subsidies.

LOANS	
Caisse des Dépôts et Consignations	6 473 000
CILG (CIL de Guyenne et Gascogne)	3 308 000
TOTAL	**9 781 000**
SUBSIDIES	
Comité Géothermique	2 292 000
PALULOS	2 200 000
F.S.G.T.	1 849 000
E.E.C.	600 000
A.F.M.E.	1 277 000
TOTAL	**8 218 000**

The Community (EEC) support was in respect of the drillling phase and amounted to FF 1 200 000 of which half was considered as a subsidy (FF 600 000) and half as repayable loan in case of success.

A detailed analysis of the exploitation has been done by the exploitant for the years 1985-1986-1987 (in KF).

Items	1985	1986	1987
P1 Energy costs	1330	976	826
P2 Suivi and electricity for heat pump	1960	2224	2058
P3 Maintenance	421	430	430
P4 Loans repayment	810	850	890
TOTAL	4521	4480	4204
Reference price with	7438	5396	4442

The net saving are decreasing with the lowering of conventional energy price after 1985.

In 1994 and since 1983 the total energy production in Pessac is about 12000 TOE. During this period the total price of conventional energy saved (as saving an average price of 1500 FF/TOE) is 18 000 000 FF to be compared to the 18 500 000 FF of investments. The final pay back is about 12 years and less than 6 years with subsidies.

CONCLUSIONS

These two plants of Bordeaux region give satisfactory results even if the geothermal heat potentical is underexploited (20 % of total power is extracted). This remark can be extended to all the geothermal plants being in Bordeaux which give energy savings of 2800 TOE/y to be compared to a possible 16000 TOE/y.

From the technical point of view, the installations with only one well production, a submerged pump and a single netword proved very efficient. No stops, no breakdown, no over costs to maintain the installation give very low exploitation and production costs between 8,2 Ecu/MWh in Mériadeck and 18,6 Ecu/MWh in Pessac.

The CILG (a company owning many buildings in Bordeaux area with different heating systems) calculated that taking gaz price as reference (100), the cost of 1 MWh (energy and maintenance costs) was 105 for oil, 78 for heavy fuel, 77 for coal and only 51 for geothermal energy.

The acceptable pay back for this type of installation should be twice lower if a full scale exploitation of geothermal heat produced was realised.

The follow up of hydrodynamics of the geothermal reservoir and the productivity of the aquifer still maintained indicates that numerous new plants can be constructed in the Bordeaux area in addition to the existing six.