

## NEW TECHNOLOGIES IN THE GEOTHERMAL WELL OF MEAUX

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## ABSTRACT

Meaux geothermal plant is the biggest in Europe. The district heating ensure the heating requirement of 15000 housing units, flats, public facilities, hospitals, offices, swimming pools, ... Annual energy saving are about 17000 TOE/year for the four geothermal doublets in exploitation since 1983. A prototype of a special turbopump was installed in May 1984 and was removed in summer 1993 to install corrosion devices in the production well. This pump has provided a 9 years working period without failure. Economics of the system even with an additional electricity consumption of 35-41 % of the turbopump give net saving of 1 to 1,3 M FF for the nine years of exploitation.

## INTRODUCTION

As consequence of the two oil crises, the French government developed a specific policy in order to save energy. General use of geothermal energy in France has been part of this new policy. Therefore, in April 1981, the town of Meaux Hospitals and the municipal Housing Office of Meaux formed a joint syndicate to create and run a big geothermal plant. The President of the Syndicate is the Mayor of Meaux.

In 1981 we already knew a lot about the Paris basin structure because many oil wells had been previously drilled. It is composed of a regular succession of sedimentary formations, which reduces the risk of unsuccessful drilling.

Five aquifers with a temperature higher than 30°C have been identified (Fig. 1). These are :

- 1. The Albien sands,
- 2. The Neocomian sands
- 3. The Lusitanian limestones
- 4. The Dogger limestones,
- 5. The Triassic argillaceous sandstones

Fig. 1 : GEOTHERMAL AQUIFERS IN PARIS BASIN

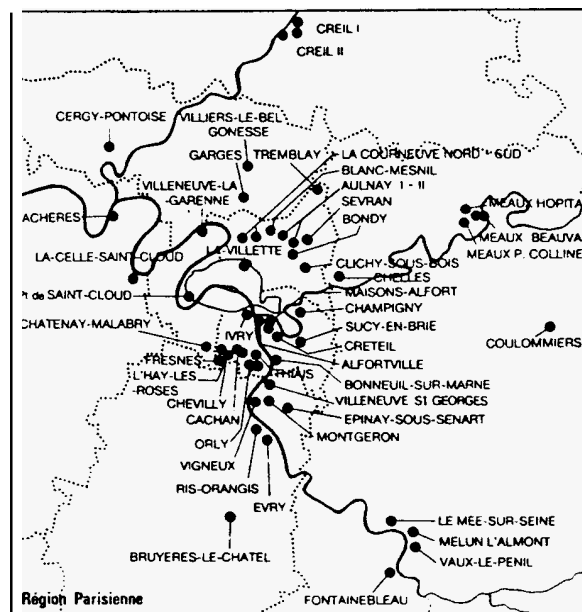
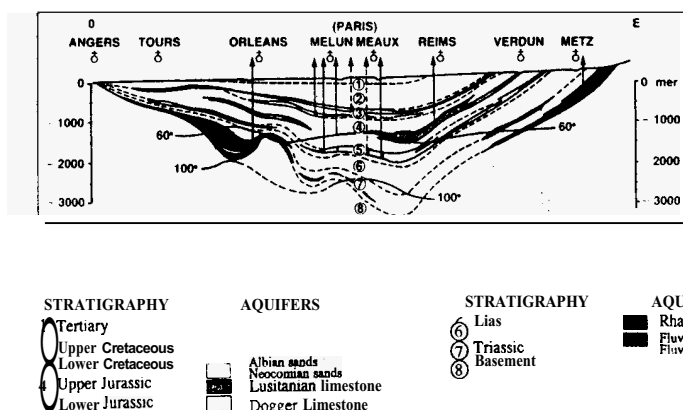


Figure 2 : OPERATING DOUBLET  
IN ILE DE FRANCE

## DESCRIPTION OF THE UNDERGROUND INSTALLATIONS

The town of Meaux is 50 km east of Paris and 50 000 people live there. It is located above the deepest part of the Dogger, which explains the well head temperature of 78°C. Considering the heating requirements at Meaux, four doublets were built. The wells were drilled from August 1981 to October 1982 (See Fig. 3 : Production well and its pumping chamber).

The main feature of these wells are :

- Seven inclined wells, deviated to 30-48 degrees and one vertical well were **sunk** and fitted with single casing of K55 carbon steel, with a final diameter of 7". The 8 mm casing is cemented into the full length of the well.
- Depth at the top of the Dogger : approximately 1760 m
- Vertical total depth : approximately 1900 m
- Total length : 1963-2400 m
- Well head temperature : 76-78°C
- Cumulative artesian flow rate of the four production wells is 822 m<sup>3</sup>/h
- Maximum flow rate with four extraction pumps in operation : 1100 m<sup>3</sup>/h.

The distance between the position of production and injection wells at the top of the reservoir were calculated in order that the cold water bubble formed around the injection does not reach the production well before thirty years of operation.

Three of the production wells are equipped with electropumps (2 BWIP+ 1 Centrilift), placed between 147 m and 245 m below the surface.

The fourth production well is driven by a Guinard turbopump. This special equipment has been supported by the Demonstration programme of DGXVII (GE 456/86/FR).

This aim was achieved by testing a turbopump consisting of a submersible pump driven by a turbine fed by water supplied from the surface by a high-pressure pumping set. The novelty of the project lies in its dispensing with down-well electrical components. This gives the following advantages : high reliability ; easy, low-cost maintenance ; reduced bulk ; no electric cable ; easier removal and handling ; and less risk of corrosion. The major disadvantage is that more electricity is consumed. The point of this project was to check the new system's reliability and whether the lower maintenance cost can offset the additional electricity consumed by the pump.

### THE TURBOPUMP : TECHNICAL DESCRIPTION

The pumping set comprises (Fig. 3) :

#### a) Down hole

##### A "Turbopress" turbine-driven pump assembly :

- \* a packer sealing off the suction and delivery sides of the submersible pump ;
- \* a submersible pump (Pi) at a depth of 261 m.

Characteristics : flow : 300 m<sup>3</sup>/h (Qp)  
head : 212 metres  
speed : 6750 rev/min ;

- \* and, on the same shaft, a five-stage turbine (T) providing all the power needed by the pump.

Characteristics flow : 130 m<sup>3</sup>/h (Qt)  
head required : 879.3 metres WG

The "Turbopress" pump-turbine unit runs in two hydrostatic bearing, with a balance disc to take up part of the end thrust and a thrust bearing to take up the remainder. The hydrostatic bearings and the thrust bearing are lubricated by geothermal fluid supplied by pressure differential.

#### b) On the surface

- \* The high-pressure centrifugal supply pump (Pa), type DVMX, which supplies the turbine.

Characteristics 13 overpressure stages  
speed : 2920 rev/min  
flow : 130 m<sup>3</sup>/h (QT)  
head : 831.5 metres WG ;

- \* one single-stage centrifugal booster pump (type NDO 20 x 12 x 25 L)

Rated characteristics : speed 2920 rev/min  
flow : 430 m<sup>3</sup>/h  
total manometric head : 47.8 metres WG

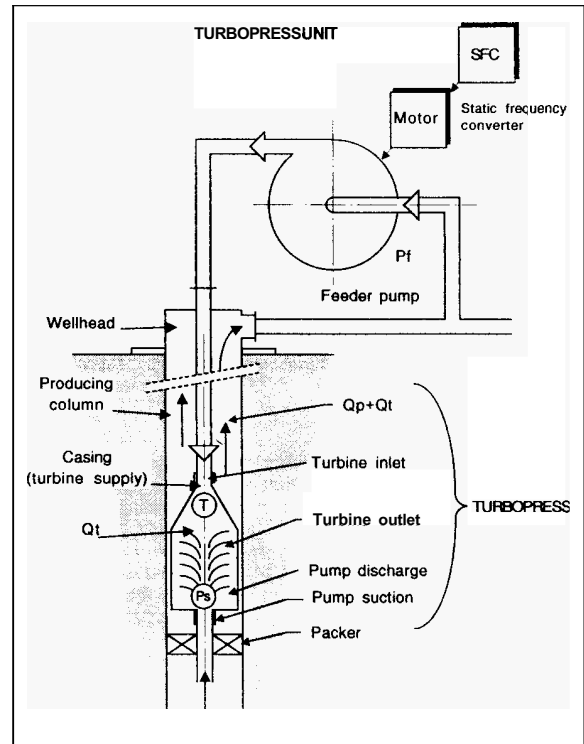


Figure 3 : TECHNICAL DESCRIPTION OF THE TURBOPUMP

\* a Jeumont-Schneider 380 V 500 kW motor, which drives both surface pumps.

Overall characteristics of the pumping set are as follows :

- effective flow : 300 m<sup>3</sup>/h
- effective operating power : 450 KW
- manufacturer's claimed overall efficiency : 45.5 %
- The flow is varied by means of a frequency converter acting on the power supply.
- To reduce the noise level of the surface pumping set as much as possible its speed has been deliberately restricted to 2970 rev/min, although the technology would easily permit it to operate at much higher speeds (5000 rev/min). (The speed cannot be reduced further because of the flow/head characteristics required of this pump).

The turbopump has been running since April 1984, without the submersible portion of the system being brought to the surface.

The only technical problems experienced with the surface equipment have been due to leaks and failures of mechanical packings of the motor. During the first two heating seasons these snags necessitated remedial action and repeated shut-downs, which penalized the exploitation of the doublet.

The system has functioned perfectly, i.e. without any technical problems since the end of 1986.

Since there are two doublets nearby (Beauval 1 and 2) the turbopump can be compared with a conventional submersible electric pump. During the period 1986-1989 the turbopump used 35-41 % more electricity on average. The turbopump has needed no maintenance, while a variety of maintenance problems have caused the electric pump at Beauval 1 to be brought to the surface 1.5 times a year.

The turbopump unit was removed from the well during the summer 1993 not because of breakdown or technical problems but to install in the production well a corrosion inhibitor piping system.

At that time the remaining fear was linked to the removal of the packer, since its point of attachment to the 13" 3/8 casing may cause corrosion and thus perforation as recently been observed in other sites (Creteil, Chevilly Larue) but finally no anomaly has been detected.

The unit has been tested and showed a capacity corresponding to 90 % of the nominal efficiency at the beginning of production period 9 years before.

## DESCRIPTION OF THE SURFACE INSTALLATION

The extracted geothermal water is discharged from the submersible pumps and then flows into a decanter. It then passes through plate heat exchangers of 0.7 mm titanium steel, where it releases its heat, before being pumped back into the Dogger.

The occurring deposits are mainly concentrated in the decanter and usually not present in the plate heat exchanger. No trace of corrosion has been observed on the 400 plates of each heat exchanger since the beginning of the exploitation.

Now in order to distribute the heat produced in the geothermal loop, 3 heating networks have been created. They have been operating since October 1983. They serve the three principal districts of Meaux (Fig. 4).

- 1) Beauval district (2 doublets)
- 2) Collinet district (1 doublet)
- 3) Hospital district (1 doublet).

The geothermal heat supplies 10 500 housing units, 2 hospitals, 2 large schools, 2 swimming pools, small schools, offices, public buildings, etc., giving a total of 15 000 dwelling equivalents.

These three networks total 21 km long and supply 130 heating sub-stations. Some of these are also provided with sanitary hot water.

Total connected power is 127 MW.

When the outside temperatures fall below +6°C, the geothermal power is insufficient, and back-up energy is supplied by two heating stations fed with oil or natural gas.

Average energy delivered annually is 200 000 MWh. 76 % of which comes from geothermal.

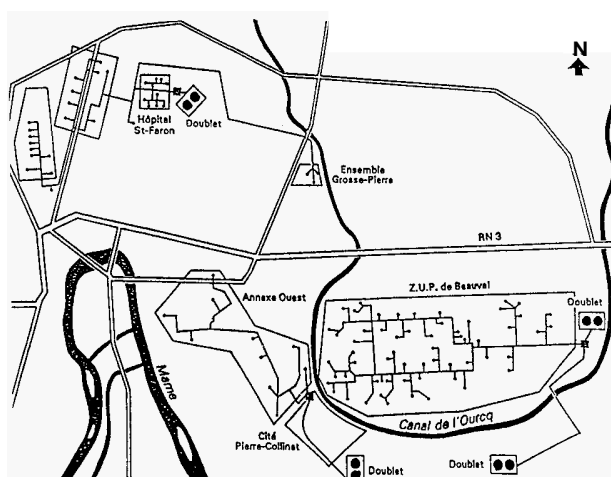


Figure 4 : LOCATION OF GEOTHERMAL DOUBLETS IN THE TOWN

## CORROSION AND SCALING PROBLEMS IN THE WELLS

We just have to look at the composition of the Dogger's water to understand why corrosion of the casing made of carbon steel is very likely to happen in water at 78°C.

Indeed there is a Sodium chloride content of about 35 g/l but the water contains also dissolved gases such as carbon dioxide and hydrogen sulphide.

This natural corrosivity is increased by any change in velocity, temperature or pressure of the water running through the piping system and during its flow through the pumps and exchangers. In 1986, after three years of operation, the following troubles were observed

Piercing of the K55 steel pipes in the heating station equipment  
Four perforations in the casing of the pumping chamber were detected, beside the electropump. These perforations come from galvanic corrosion, due to the fact that the outer body of the

pump is made of stainless steel. The casing was repaired using a metal casing patch, put into place by expansion and then glued. Uniform corrosion of casing, causing reduction in thickness, especially in the pumping chamber, occurred where the thickness of the casing has been halved in some places. Partial clogging of the injection levels due to the accumulation of Iron Sulphide around the injection point.

To solve this problem we first cleared the injection area acidifying the injection levels. Then we tried to stop the formation of Iron Sulphide to avoid another clogging.

On the other hand we happened to know that this product is linked to the presence of bacteria in the well combined with the corrosion of steel samples placed in the flowing geothermal fluid thanks to several geoprobes. These samples are placed and removed through a handling chamber thus avoiding shut-down.

This process enabled us to develop a treatment, by injection of a corrosion inhibitor from surface, which reduces corrosion speed to a tenth of its original rate. This treatment has been in general used on all injection wells since the end of 1988, after cleaning of the wells using special drilling jetting bits.

But it was not so easy to use on the production wells because the inhibitor had to be injected at the very bottom of the well. Besides we noticed a regular increase in water H<sub>2</sub>S content which may help the formation of Iron Sulphide.

That is why, in September 1990, we introduced a new process on three of the production wells, consisting of injection of the corrosion inhibitor at the bottom of the well, using a special tubing made of epoxy resin reinforced by fiber glass, known as a Well Bottom Treatment Tubing (WBTT).

The WBTT has an external diameter of nearly 40 mm due to their small length (3 m) which impose a screwing annexion.

In the production well of Beauval 2, the doublet where the turbo pump was installed a special tubing made of Incoloy coated with Santoprene has been installed in August 1993 with a reduced external diameter of 19 mm giving less pressure losses in the production well.

## ECONOMIC ASPECT

The financing of the whole plant (4 doublets + district heating networks) came down to a little bit more than 123 million Francs (Geothermal wells = 35, geothermal loop including heat exchanger and pumps = 18, geothermal and district heating networks = 60, project management and miscellaneous = 10).

The Meaux turbo pump unit was a prototype which has been the forerunner for a second generation of pumps. Incremental capital cost compared with a conventional submersible pumping set was about 800.000 FF.

This sum was mostly raised through loans, with an average interest rate of 14 % FF 23,5 million came from subsidies and the EEC gave FF 1,5 million for testing the turbopump.

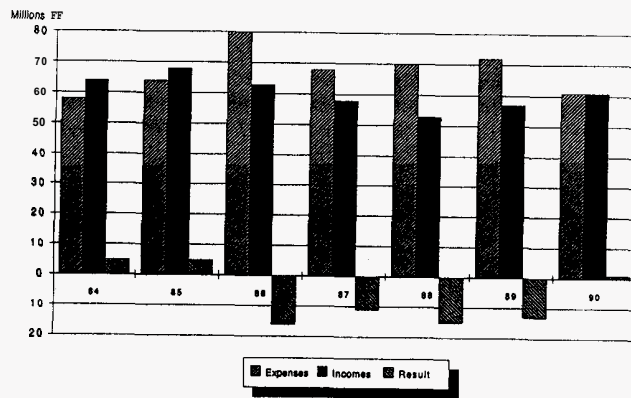
The Syndicate first experienced economic difficulties in early 1986 with the fall in fuel prices. Indeed the incomes are proportional to the cost of classic fuels such as oil and gas while the expenses, essentially loan repayments, are fixed.

Thus, whereas one has initially forecasted a continuous rise in fuel prices of 8-10 % per year, the Syndicate lost 20 % of its income between 1985 and 1988 while loan payments increased of 33 % during the same period because progressive.

It should be noticed that all geothermal projects experienced the same financial problems.

Long discussions with public administration resulted in the interest rate on loans being renegotiated at 7 % repayable over a new 20 year period beginning in 1990.

This management of the Syndicate restored the budget balance in 1990 (Fig. 5). The average selling price of each MWh distributed to the district heating consumers is FF 318 (45,5 Ecu).



**Figure 5 : FINANCIAL RESULTS**

The turbopumps produces about **45000 MWh** (effective thermal production) and uses **30 KWh** of electricity per **MWh** extracted. The excess cost due to the higher electricity consumption of the turbopump compared with a conventional one is about **220 000 FF/year**.

The saving on maintenance and improved reliability (non stop in geothermal production to remove and change the equipment) are assessed at **320-350 000 FF/year**.

Finally the turbopump gives annual savings of **100 000 to 130 000 FF** which ensure a satisfactory pay back of between **6 and 8 years** which fulfills the original aim of the project and the expected rentability.

A standardized turbopumps has been developed in 1986 and **GUINARD**, the manufacturer, set up a Division specializing in turbopump systems for geothermal oil wells and seawater desalination applications.

This line of business is undergoing a slowdown at present, but there is a very large potential for applications with this kind of pump for tapping medium-enthalpy geothermal fluid in hostile environments.