The Lyon CAF:
A geothermal thermo frigo pump for 13 years

José Naveteur
EDF R&D and
C. Bruss, Lyon CAF,
jose.naveteur@edf.fr

For the last 13 years, the Lyon CAF (Family Allowances Office) has had a ground source heat pump. This system has been subject to energy performance monitoring by EDF R&D, the main results of which are presented here, demonstrating the success of the operation. This article looks at the technology of the thermo frigo pump as well as assessing energy consumption and running costs.

BUILDING DESCRIPTION

– Office building located in Lyon

– Offices, meeting rooms, conference room

– Total floor area of 16 633 m².

– Finished in August 97

– First use in October 97)

At the end of 1997, the Lyon CAF moved into new offices on boulevard Vivier-Merle in Lyon. The building has office space, meeting rooms, a conference room and a reception area for beneficiaries. Concerned about future running costs, the Lyon CAF asked its design division to look into the different heating and cooling systems that could be used for the site. **Research revealed the ground source heat pump to be the most efficient.**

Technical site characteristics

The building has a surface area of 16,633 m² with a coefficient of loss through the walls of 0.42 W/m³°C (for G1 ref. of 0.53 W/m³°C). The installation comprises two water/water heat pumps (600 kW hot, 600 kW cold) which feed a network of 4-pipe fan coils and processing units comprising recuperators to limit energy consumption.

The hydraulic systems are fitted with variable speed pumps. The well comprises two variable speed boring pumps with a maximum flow rate per unit of 100 m³/h.

It is important to mention that investment costs in 1995 stood at €149/m² for heating, ventilation and air conditioning and €21/m² for the BMS, making a total of €170/m².

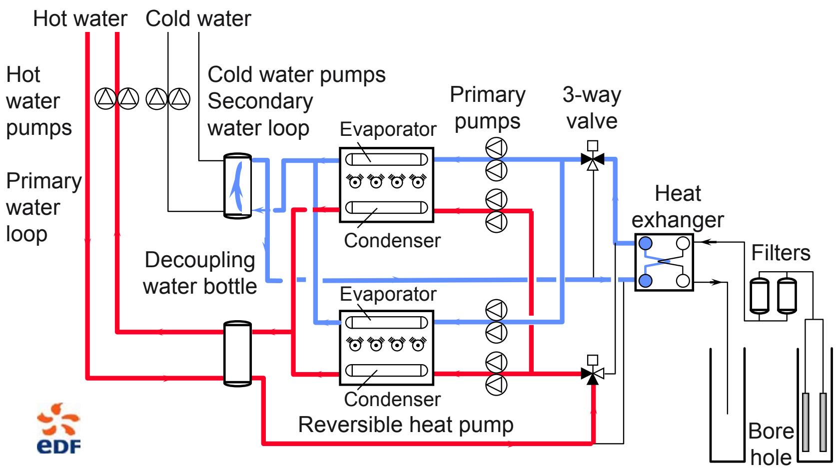
The heat pumps are controlled in thermorefrigerating pump mode. A thermo frigo pump is a reversible heat pump which can be used for both cooling and heating. ▶

HOW A THERMOREFRIGERATING PUMP WORKS

A thermorefrigerating pump has five different modes, including:

1. Heating mode

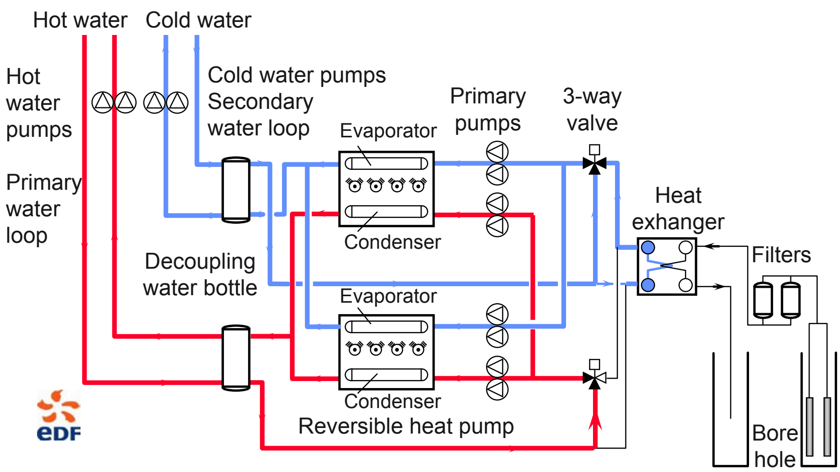
This mode is used during cold spells. To achieve thermal equilibrium, all the cold produced by the units is discharged into the well.



ENERGY SYSTEM DIAGRAM – « THERMO FRIGO PUMP » (Heating mode)

2. Majority heat and minority cold

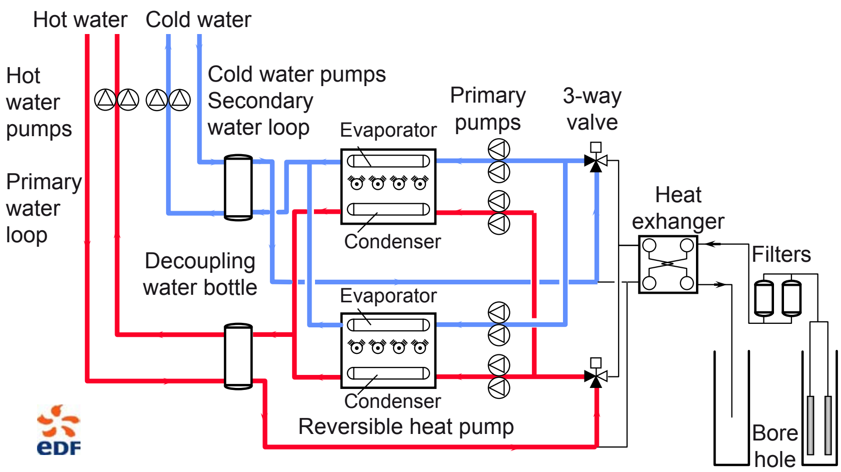
The building consumes more heat than cold (mid-season and start of winter). Surplus cold is discharged into the well.



ENERGY SYSTEM DIAGRAM – « THERMO FRIGO PUMP » (heating and cooling modes with cool sent to the underground water, heat > cool)

3. Heat equal cold

This mode is used when the building consumes all the cold and heat produced. The COP is at its maximum and no energy is discharged into the well.

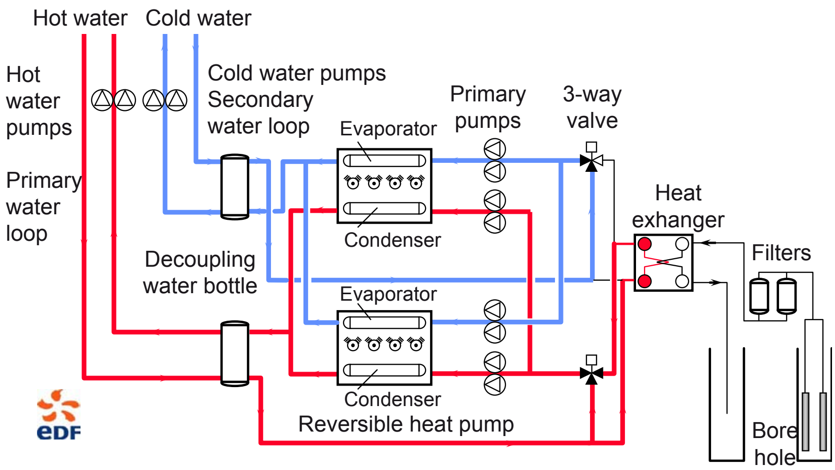


ENERGY SYSTEM DIAGRAM – « THERMO FRIGO PUMP » (heating and cooling modes, no energy exchange with the ground, heat = cool)

4. Majority cold and minority heat.

The building consumes more cold than heat (mid-season and end of winter). Surplus heat is discharged into the well.

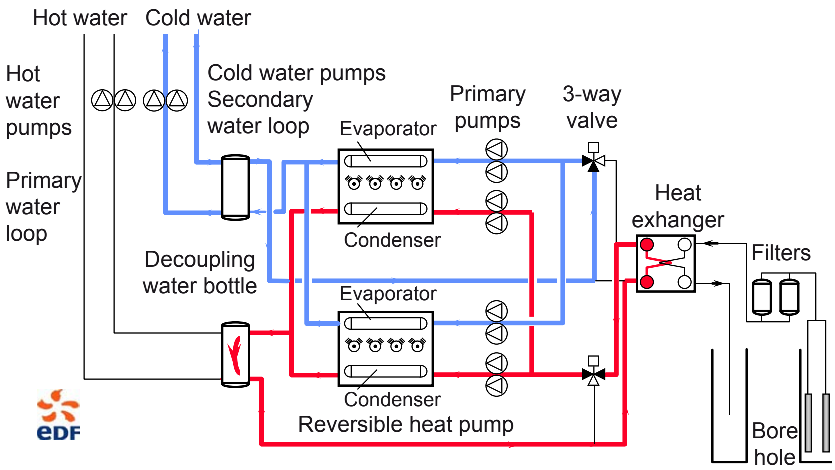
ENERGY SYSTEM DIAGRAM – « THERMO FRIGO PUMP » (heating and cooling modes with heat sent to the underground water, cool > heat)



5. Cooling mode

This mode is used during summer. To achieve thermal equilibrium, all the heat produced by the units is discharged into the well.

ENERGY SYSTEM DIAGRAM – « THERMO FRIGO PUMP » (cooling mode)



▶ It is an ideal solution in terms of energy costs for buildings which have both cooling and heating needs.

Operating conditions:

- Chilled water is 7-12 C in summer and 10-12 C in winter.
- Hot water is 35°C when it is above 20°C outside and 45 °C when it is 0°C outside. The whole installation is managed by a BMS (Building Management System).

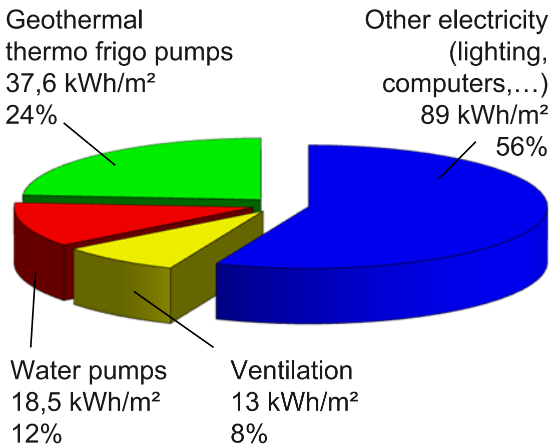
Control

This is based on a fundamental principle: *"always satisfy the highest demand"*. The BMS must continuously measure the differences in temperature between the two systems (hot and cold). Depending on which system has a higher demand, it determines the operating conditions for the thermorefrigerating pump by prioritising hot or cold operation.

Measurement results (1998-2010)

This site has been monitored for energy performance since 1998 with installation carried out by EDF R&D using 9 electricity meters (6 with remote reading), 1 calorie meter, 1 frigorie meter and 1 BMS remote investigation and monitoring system.

Below can be found the average consumptions and performances over 13 years (1998 to 2010).



Maximum power needed =
760 kW in July 2003 (50 W/m²)

Electricity consumption average
between 1998-2010
Total consumption =
2 623 198 kWh (158 kWh/m²)

- The total average consumption is 158 kWh/m² for an average cost of €8.8/m² excluding taxes and the maximum demand is 760 kW.

Consumption ranged from 145 kWh/m² in 2000 to 170 kWh/m² in 2008.

It should be noted that the average annual consumption ratio in the office sector is approximately 250 kWh/m².

- Operating costs ranged from €7.7/m² excluding taxes in 2000 to €10.45/m² excluding taxes in 2010.

For information, we can regard a building as having satisfactory energy operating costs if its operating costs are no more than €11/m².

- The consumption of the geothermal thermo frigo pump and the well pumps is 40 kWh/m² (€2.6/m² excl. taxes), supplying an average of 67 kWh/m² of heat and 83 kWh/m² of cold.

The average cost of producing MWh of heat/cold is **€17/MWh** excluding taxes.

Compared to a traditional system (gas heating and refrigeration unit), the ground source heat pump solution gives an annual saving of €2.2/m² excluding taxes, i.e. a reduction in energy costs for heating and cooling of 48%.

It results in a fall in CO_2 emissions of 14.8 kg/m², i.e. a 72% reduction.

The system's Coefficient of Performance (COP)* over the 10 years is 3.73 on average, **meaning that for every kWh of electricity consumed, the system supplied 3.73 in the form of heat or cold.**

Return on investment after 3 years for the variable speed pumps !

EDF recommended the installation of variable speed pumps for the hot and cold systems and for the boring pumps. The savings made from these variable speed drive units are as follows:

- For the bore hole pumps: 86,338 kWh or €4,055.
- For the cold water system pumps: 82,684 kWh or €4,179.
- For the hot water system pumps: 90,099 kWh or €4,277.

This gives an average saving of 259,121 kWh p.a. and €12,512 p.a. excluding taxes, which represents 10% of the building's annual consumption and 40% of the annual consumption of the reversible heat pumps.

The additional cost for hydraulic disconnection and the variable speed drive units was €36,000 excluding taxes, meaning a 3-year return on investment! Monitoring has shown that a ground source heat pump system is efficient in the long term and saves energy and money while reducing the impact on the environment.

*COP = Hot and cold energy supplied to the building / Electrical energy consumed by the heat pumps + the well pump.

Conclusion

With this monitoring, you can observe that the geothermal thermo frigo pump is economically efficient and respect the environment.