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Overview of the ATES projects in Flanders (Belgium) for air-conditioning in large buildings and industrial process cooling

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ABSTRACT

Thermal energy such as winter cold and summer heat from ambient air can he stored in aquifers (ATES – Aquifer Thermal Energy Storage) and can be used for cooling purpose in summer and **for** preheating in winter. A Cold/heat storage system can be used for cooling a building or an industrial process, resulting in an energy saving of 40-80%. Introducing energy storage increases the use of renewable energy and has a positive impact on the environment compared with conventional cooling installations.

In 1996, the first Aquifer Thermal Energy Storage System was put into effect in Flanders (the northern region **of** Belgium) to serve the CERA **Bank** headquarters in Leuven. Since this date several projects of ATES are in service or under construction in Flanders. The concept of each project is different and illustrates the technical flexibility of an ATES system.

Up to now, two projects are in service and **for** the other ones the decision for realisation has been taken:

CERA Bank headquarters (now KBC Bank): integration of an ATES system with cooling machines and an ice accumulation system.

KLINA Hospital: integration of heat pumps (reversible cooling machine) with ATES.

Janssen Pharmaceutica Offices: combination **of** mechanical ventilation and climate ceilings connected with ATES; the long-term underground cold storage source will be loaded by means of a combination of air handling units, a cooling tower and surface water (pond).

DIDAK: cooling of extrusion machines in the plastic industry by a cold/recirculation storage system.

KEYWORDS

UTES, underground thermal energy storage, ATES, aquifer thermal energy storage, cold and beat storage

1. Belgium market development of ATES

The introduction of ATES in Belgium started in 1994 with a study on the feasibility of ATES in Flanders at the request **of** the Ministry of Economic Affairs of Flanders (DIRVEN & PATYN 1995). This study included a survey of energy storage systems and related activities in Europe (Germany, Switzerland, Sweden and the Netherlands). The purpose was to determine which system would be most convenient for the Flanders region, considering the geological situation, climate and economics. The collection of data was made possible through the participation of Belgium in the Annex **8** experts' working group on the IEA Implementing Agreement Energy Conservation through Energy Storage and in particular through the bilateral co-operation between Belgium and the Netherlands.

2. Cold/heat storage in aquifer

There are three potential categories of users of ATES: industry, agriculture and large buildings (offices, hospitals, etc.). A market analysis (IF TECHNOLOGY 1995) shows that the biggest and most profitable application of this technology is cold storage in large buildings, where it can replace chillers running on electricity. Not only electricity can be saved, but also fuel by pre-heating of the ventilation air. **In** the industry through-flow cooling **of** processes with groundwater can be replaced by ATES to save groundwater. In several countries groundwater become a valuable raw material which should be protected by high taxes. In this market, ATES also will come in competition with mechanical cooling machines but with the advantage of a much lower energy consumption.

2.1 ATES for large buildings

In large buildings the air-conditioning is controlled by air-handling units. The cold is usually produced by chillers and cooling towers; fossil fuel burners deliver the heat. The cold/heat storage system uses cold groundwater **(figure** 1). **In** summer, when cooling is needed, groundwater is withdrawn fiom the cold well to cool the water system **of** the building through a heat exchanger. This groundwater will heat up and is injected into the other well, called the warm well. The building water system cools the incoming air in the air-handling units. In winter the system acts in reverse. Groundwater is withdrawn fiom the warm well, heating up the water system of the building for pre-heating of the cold ventilation air in the air-handling units. The cooled groundwater is then injected into the cold well for later use during summertime. This double action means that the system has no need for an additional cold source like a chiller or a cooling tower: in summer it uses winter cold to cool, and in winter it saves on heating of the building by using summer heat. Furthermore, coldheat storage in aquifer is a flexible system: it can be integrated into an existing air-conditioning installation in order to optimise the working conditions of the chillers.

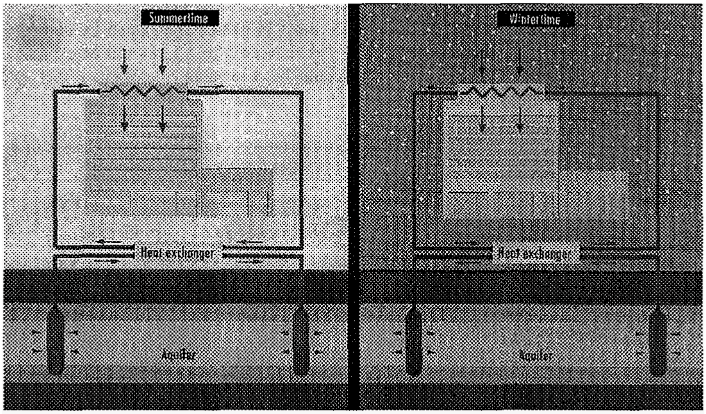

Figure 1: Basic functioning of energy storage in aquifers

2.2 ATES for industrial process cooling

Industrial cooling asks for a constant cooling all over the year. **A** solution will be the cold storage/recirculation variant. With cold storage/recirculation the water is pumped in one direction all the time. The water is pumped ftom the extraction well and used for cooling, during which the water temperature is raised. In summer this heated water is injected into the injection wells. In winter, by means of a supply e.q. by a wet cooling tower, the water temperature is lowered below the natural groundwater temperature and injected into the same injection wells. ***So*** there will be a zero thermal balance between the injected heat in summer and cold in winter (figure **2).**

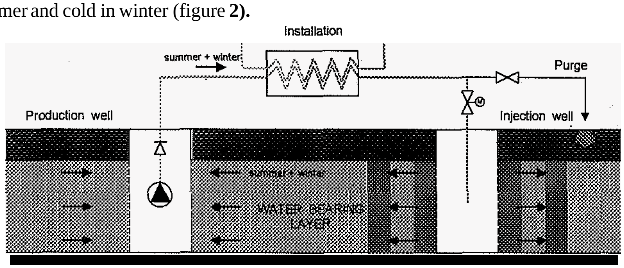

Figure 2: Functioning of cold storage/recirculation

3. Economic prospects

Table 1 illustrates how coldiheat storage has its most profitable application in industry, offices and buildings. On average, a payback period between 3 to 8 years can be expected. The other applications are less profitable, but could become more interesting if fuel and electricity prices were to increase,

Table 1: Economic prospects *of ATES*

SECTOR	ECONOMIC PROSPECTS
Industry	Cost-effective at short notice (< 5 years)
Offices and buildings	In many cases already cost-effective
Agriculture	Very variable depending on sub-sector

4. ATES projects in Belgium

In 1996, the first Aquifer Thermal Energy Storage System was put into effect in Flanders to serve the CERA Bank headquarters in Leuven. Since this date several projects of ATES are in service or under construction in Flanders. The concept of each project is different and illustrates the technical flexibility of an ATES system.

4.1 CERA Bank headquarters

The CERA Bank headquarters building in Leuven was constructed in 1991. More than 1800 persons work there. After five years, this relatively new building already needs additional cooling because the working population has increased and more computers are in use. This has elevated the amount of internal heat production. The original system consisted of ice buffers and chillers (figure 3). The condensers of the chillers were cooled with water from a pond in front of the building. The pond was found to be too small, so the temperature increased. This resulted in the condensers running at a too high temperature and subsequently the chillers dropping out.

A cold/heat storage system has been integrated into the existing infrastructure and increased the cooling capacity by 1000 kW (figure 4). In summer, the incoming ventilation air for the air-handling units will be cooled by groundwater from the cold well, and secondly it cools the pond water flowing to the chiller condensers. During wintertime, the cold well is loaded with cold from the ventilation air @re-heating) and when the temperature of the pond water goes below 6°C. Installation of the ATES system produced a substantial energy saving because the chillers will be used less and will run with a higher COP, plus a reduction of the heating costs of the building during winter through pre-heating of the ventilation air. The total cost for adding this ATES system to the cooling system amounts up to US $ 0.65 million. This system was operational in the winter of 1996-97 and was thus the first building in the world to have a cooling system that integrates the ATES with a cooling system based on chillers and ice buffers.

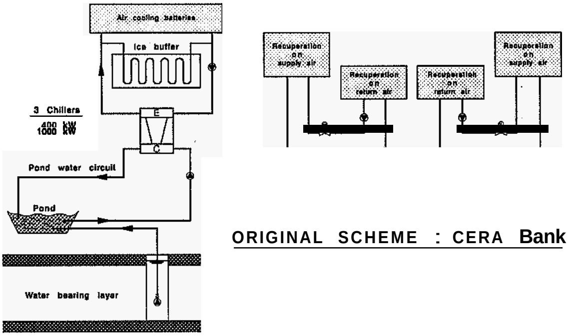

Figure 3: The original cooling system of CERA Bank before ATES

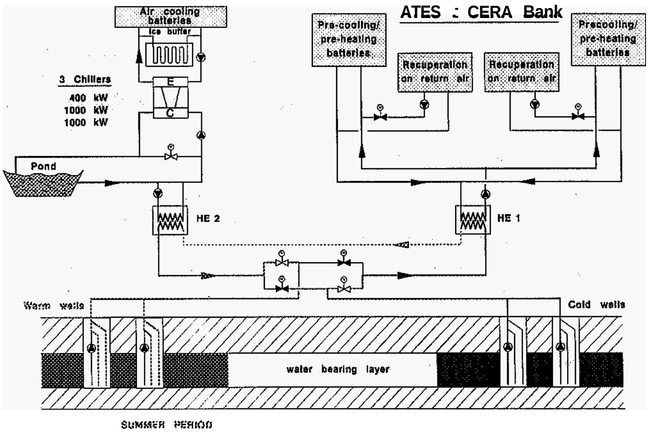

Figure 4: Integrated ATES system of CERA Bank

4.2 KLINA Hospital

In **1997,** activities related to the installation of an **ATES** system will start in the brand-new **KLINA** Hospital with a capacity of 440 beds. The ATES system will be coupled to a chillerheat pump installation (figure 5).

During summer the cold/heat storage will be used to cool the water system of the hospital. If necessary, supplementary cooling can be produced by the chillerheat pump installation. The heat produced by the chiller will **be** stored in the warm well, increasing the aquifer temperature **up** to **18°C.**

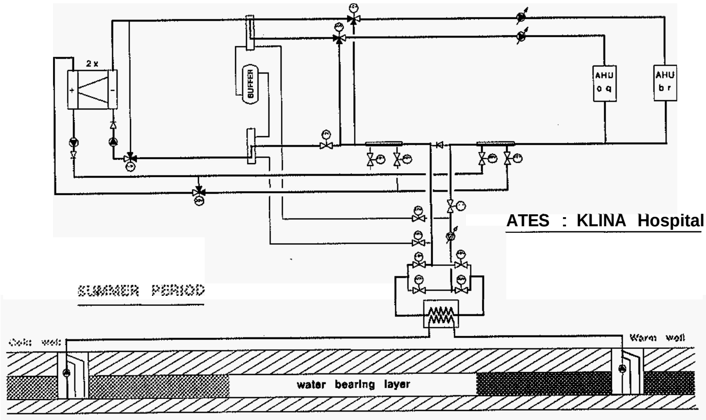

Figure 5: ATES system of KLINA Hospital

During spring and autumn when it isn't warm enough for cooling and not cold enough for loading of the cold well, the chiller/heat pump will be used for beating. The cold of the evaporator will then be stored in the cold well.

In winter the cold well will be loaded with cold through air-handling units when the outside temperature will be below **6°C.** The mean withdrawal temperature of the cold well is **9°C.**

4.3 Janssen Pharmaceutica Offices

Janssen Pharmaceutica has the intention to set up an administrative campus in Beerse (Belgium). In a fust phase, an office building will be constructed. Later on, a second office building and a Guest House **are** foreseen **(figure 6).** During the first phase, a cooling capacity of **1300 kW** is necessary. For the second phase, the capacity will be extended to 3000 kW.

In summer, the cold well will provide the air handling unit and the chilled ceilings with cold water. By using chilled ceilings, the amount of ventilation air isn't enough to load the cold wells during wintertime. Therefore a pond and a cooling tower will be incorporated to load the cold wells. The volume of **the** pond was calculated in such a manner that during a normal winter period the pond is capable to load the cold well for a fully 100%. In a mild winter, the temperature of the pond isn't low enough to cover the total demand. The cooling tower comes in and covers the rest of the demand.

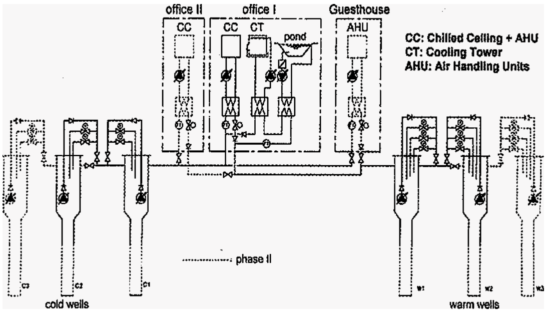

Figure 6: ATES system of Janssen Pharmaceutica Offices and Guesthouse

4.4 Didak Injection NV

The company Didak Injection NV produces all kind of plastic objects by means of mould injection. Two cooling circuits **are** in operation now, one to cool down the mould by means of chillers and the other to cool the oil circuit by means of a cooling tower.

The optimum temperature for the cooling of **the** oil circuit is 15°C with a maximum allowed temperature of 22°C. A cooling tower isn't able to guarantee this optimum temperature for the whole year. During warm days, the temperature goes even beyond 22°C.

Although only a 290 kW cooling capacity is needed, the investment of an ATES in comparison with a conventional chiller is worth while. The payback period on the surplus investment will be less than **3** years.

To supply the demand for constant cooling the cold storage/recirculation variant (see § 2.2) is suggested. In winter, a cooling tower lowers the temperature below the natural groundwater temperature (12°C) to establish a zero thermal balance in the injection well (figure 7).

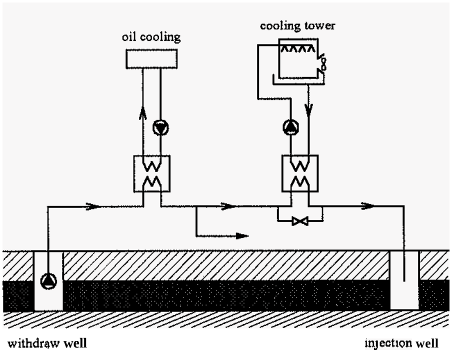

Figure 7: Cooling of the oil circuit of a mould injection machinery

5 Conclusions

ATES can be used for cooling purpose in buildings and industrial processes, resulting in an energy saving of 40-80% and with a positive impact on the environment compared with conventional cooling installation. ATES will be a profitable application of a durable technology with a relatively short payback period between 3 to 8 years.

Acknowledgements

The introduction of ATES in Belgium has been realised through an exchange of knowledge and experience with other countries through the participation of Belgium in ANNEX 8 (Implementing Underground Thermal Energy Storage System) of the IEA Implementing Agreement of Energy Conservation through Energy Storage.

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