YILDIZ TECHNICAL UNIVERSITY
Faculty of Architecture

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THE PURSUIT FOR GLOBAL TRANSFORMATION

EDITORS
PROF. DR. SEMRA ATABAY
DR. ZEYNEP KAÇMAZ

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Atabay Semra, Kaçmaz Zeynep
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METHODS OF TWO-AXIAL GEOTHERMAL APPLICATIONS FOR HEATING AND COOLING OF BUILDINGS

Dr. R. A. HERRMANN
Dr. V. J. HERRMANN

1. Introduction

The use of the earth’s interior heat, generally known as Geothermal Energy or Geothermics, had the heating of buildings as a priority. Such utilization is common and has been focused in countries like Germany which have a long winter season with low temperatures. Thus, the heating of buildings is the main focus for the use of this technology.

However, in countries like Germany, geothermal energy use is currently being developed for certain building types as office buildings or supermarkets with heating & cooling (air conditioning) requirements. Fig. 1 shows the terrestrial and solar influence on the heat flow.

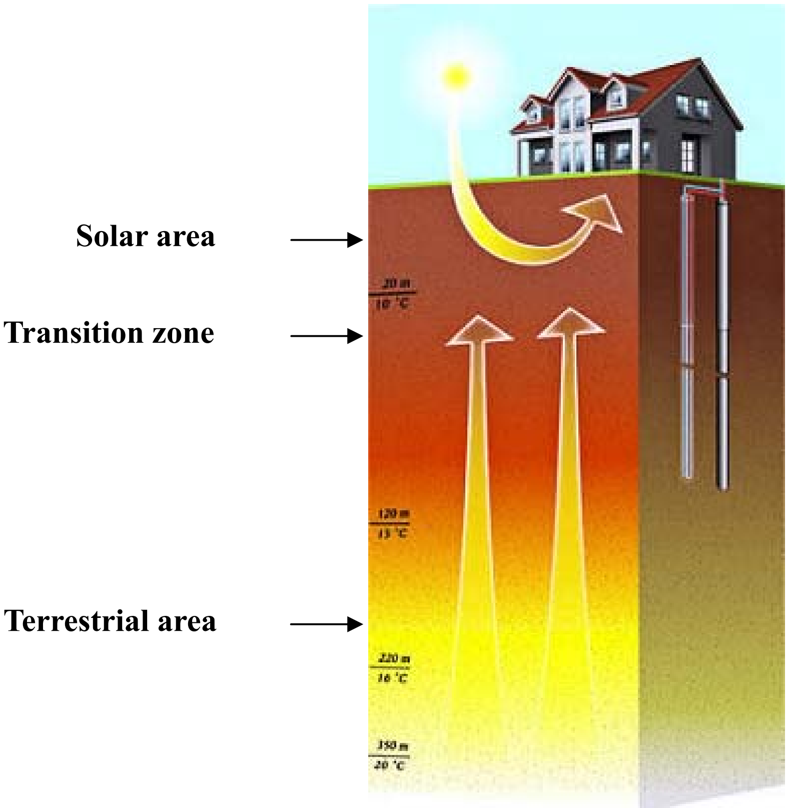

Figure 1: Terrestrial and solar influence on the heat flow (from HLUG, 2010 [1])

At the solar area, the temperatures fluctuate by day and seasons transition. Marginal variations in temperatures appear in the transition zone. At the terrestrial area are no variations in temperatures.

The temperatures in soil vary with the seasons. A temperature distribution in soil is shown in Fig. 2.

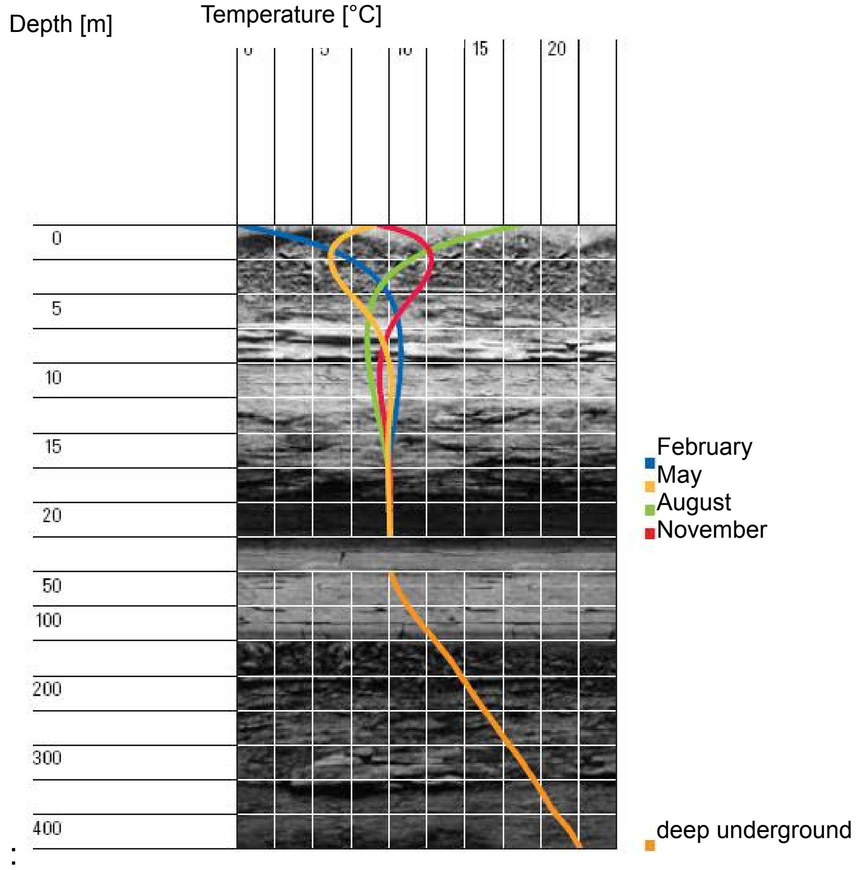

Figure 2: Distribution of temperature (from: http://www.wwa-wm.bayern.de [2])

This two-acial application thus increases the economic efficiency of geothermal energy use in the form that both applications are possible. The investments can thus be amortized within a shorter period of time.

This kind of two-axial geothermal application is therefore of special importance for countries in hot climate zones with short mild winters/cold nights (Mediterranean climate). In these areas a higher energy demand for cooling with air conditioning systems is required. More energy is spent for cooling than for heating (done with electric power). This special type of two-axial application is based on the fact that primarily the cooling of buildings is important and the heating of the buildings only for a short time is needed.

Geothermics is usually applied with the help of the heating cycle (water as a transfer medium) over closed heating systems into the geothermal borehole heat exchanger to the surrounding rock. The "waste heat" from the building in the cooling cycle thus heats the rock and stores energy for the heating season in the ground. During the heating season geothermal energy is extracted from the ground and transported to the building.

2. Systems for energy use

2.1 Borehole heat exchangers (BHE)

What kind of systems are used in practice:

- borehole heat exchanger with vertical loops (Fig. 3)
- heating and cooling elements
- usually vertically drilled up to 50 - 300 m (Fig. 4)
- in Germany up to 99 m

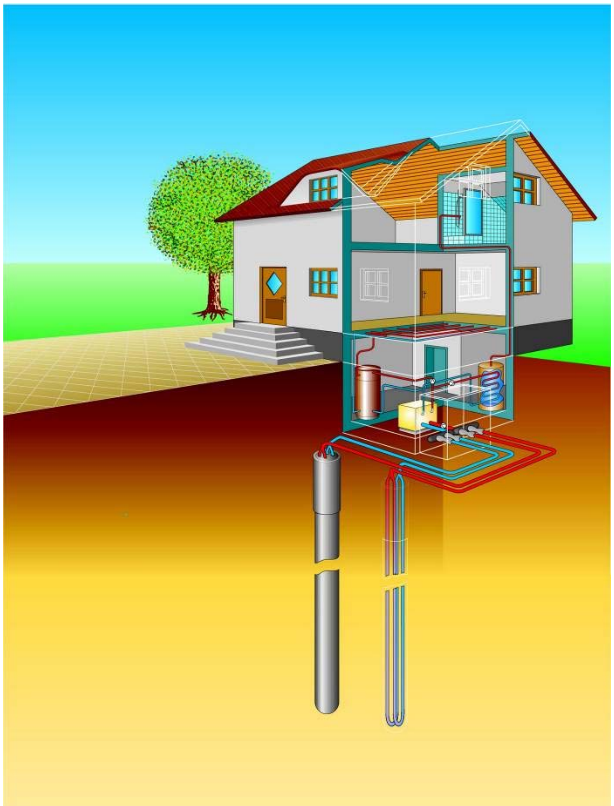

Figure 3: Bohrhole heat exchanger with vertical loops (from http://www.vdi.de [3])

Figure 4: drilling for borehole heat exchanger (from: http://www.Prakla.de [4])

2.2 Ground heat exchangers

Most suitable for heating:

- Use of the shallow underground using horizontal ground heat exchanger (horizontal loops) up to an depth of 1,5 m (Fig. 5)
- The “neutral zone” is not suitable for cooling.

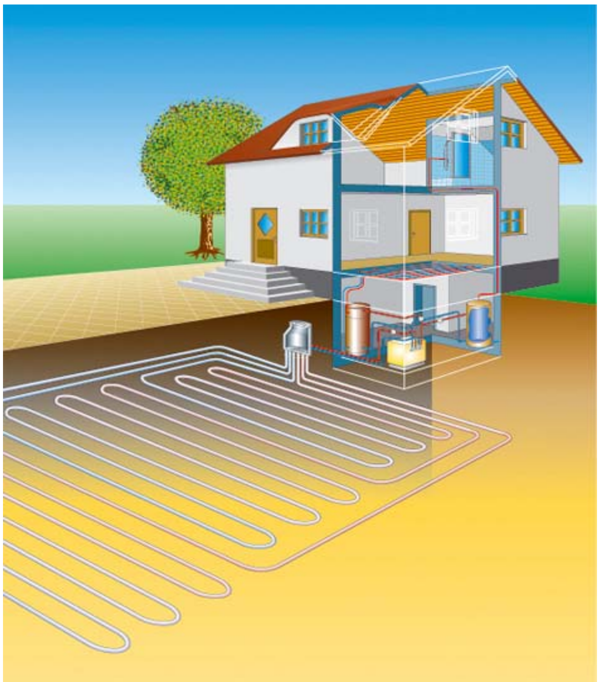

Figure 5: Ground heat collector (from: Bundesverband Wärmepumpe [5])

2.3 Short vertical loops

Most suitable for heating (figure 6):

- Short vertical loops from 3 up to 5 m
- „neutral zone“, not suitable for Cooling

Figure 6: short vertical loops (from http://www.enbw.com [6])

2.4 Energy piles

Energy piles are heat exchangers that are attached to a reinforcement cage. They are most suitable for cooling (Fig. 7).

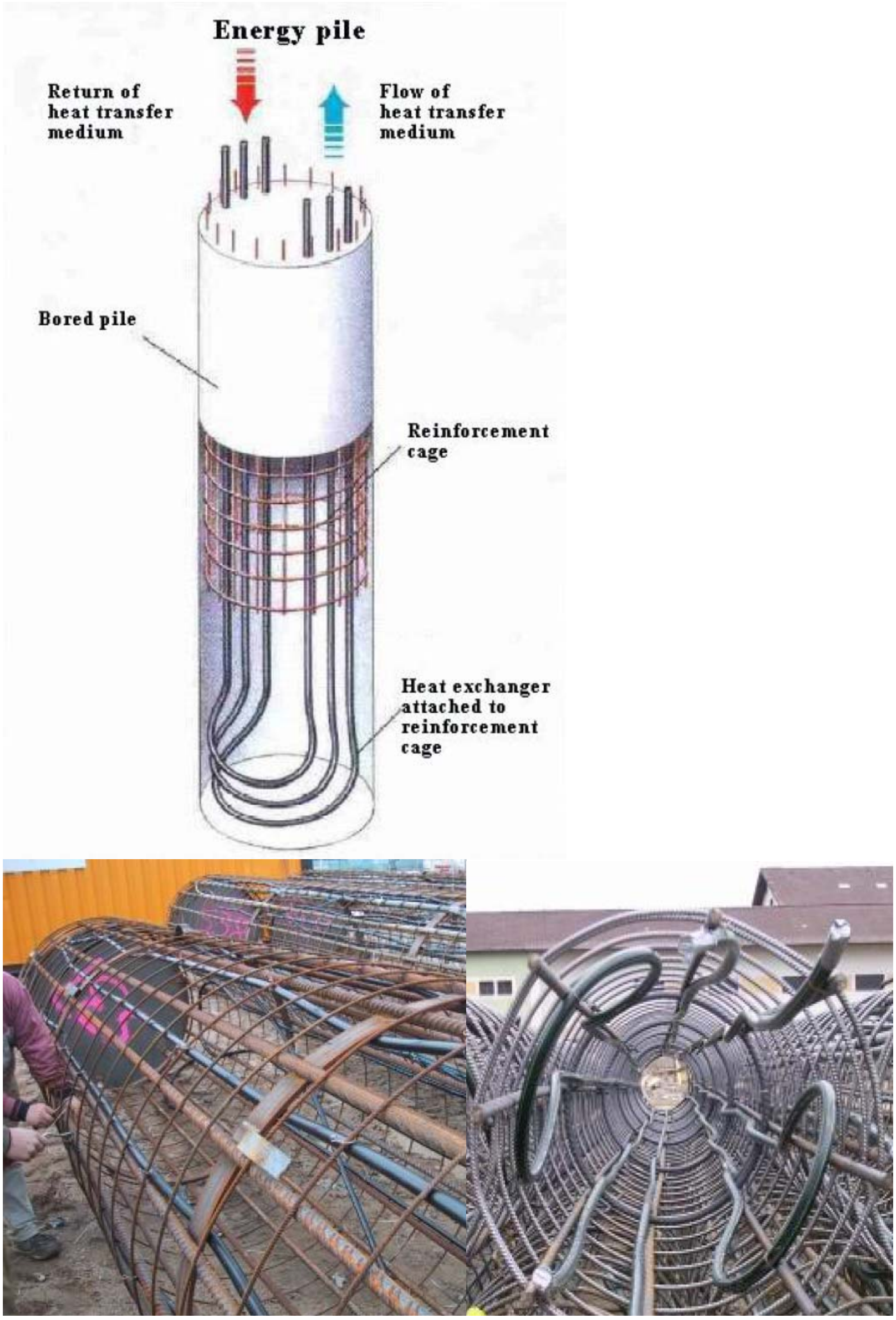

Figure 7: Sketch of an energy pile and view in a rebar cage for an energy pile (from http://www. spezialtiefbau.bilfingerberger.de [7])

2.5 Heating and cooling Panels

However, the energy storage/management can also be distributed throughout the building within various construction units (e.g. walls, floors and ground floors). The storage of the energy in the rock is accomplished through construction units such as so-called energy piles.
The aforementioned procedure is followed for the required supply of heat into the building (heating) as described, only in reverse flow (two-axial application of Geothermics).

Heating and cooling panels (Fig. 8) are suitable for buildings that do not need radiators, for example Food-Markets and buildings that need exclusively cooling.

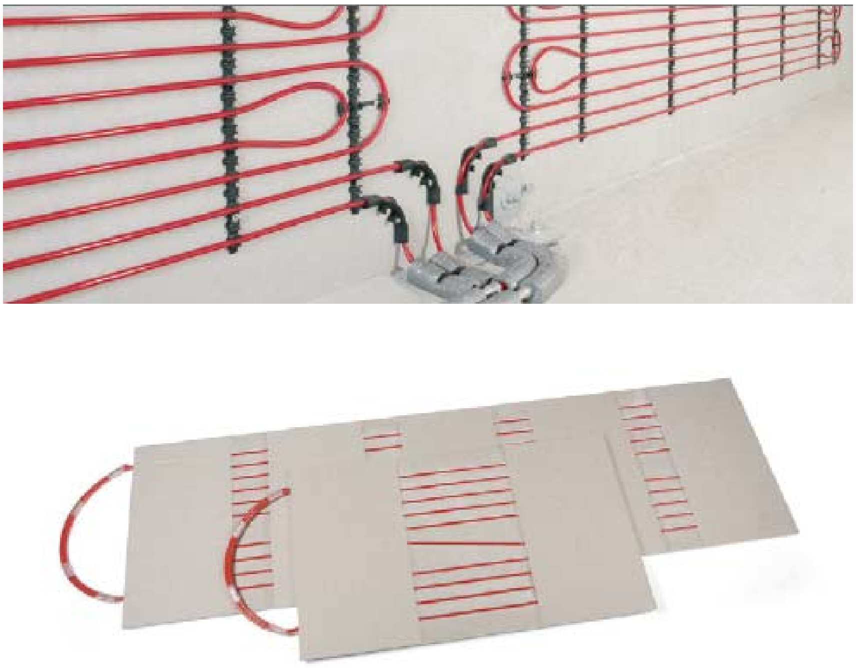

Figure 8: Heating and cooling panels (from http://www.rehau.de [8])

The following attributes are important:

- Low flow temperature
- The use of alternative energy and waste heat is possible
  Combination floor heating/cooling panels
- Walls and ceiling offer additional choices for panel location

A fast reversal between cooling & heating and heating & cooling is of importance.

2.6 Concrete core activation

- Modern architecture, climatic influences, increasing computer use and an increased need of comfort provides high demands on the innovative building services engineering.
- **7)** The concrete core activation supports the storage properties of the massive concrete sections of the cooling or heating water flow through pipes.
- An "infinite storage" will be realized.
- The concrete core activation is an ecologically sensitive and comfortable option for temperature control of buildings
- The use of alternative energy and waste heat is possible

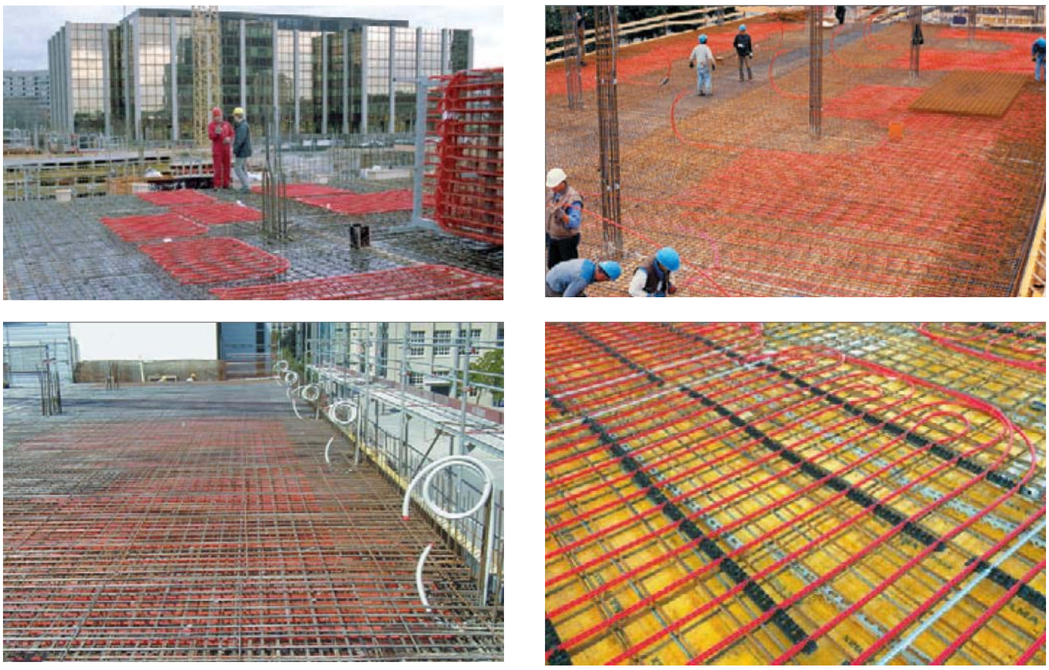

Figure 9: Pictures of concrete core activation from http://www.rehau.de [8]

3. Geothermal Heat Pump

The increasing global warming and associated impacts on humans and nature, steadily rising energy prices and the growing dependence on fossil energy demand sustainable solutions for the delivery of the required energy. The heat pump provides the link between heating- and cooling panels and systems for the use of geothermal and solar energy. Heat pumps are also available as reversible execution and without any additional accessories suitable for active cooling.

The main principle of an heat pump is shown in the following sketch (Fig. 10):

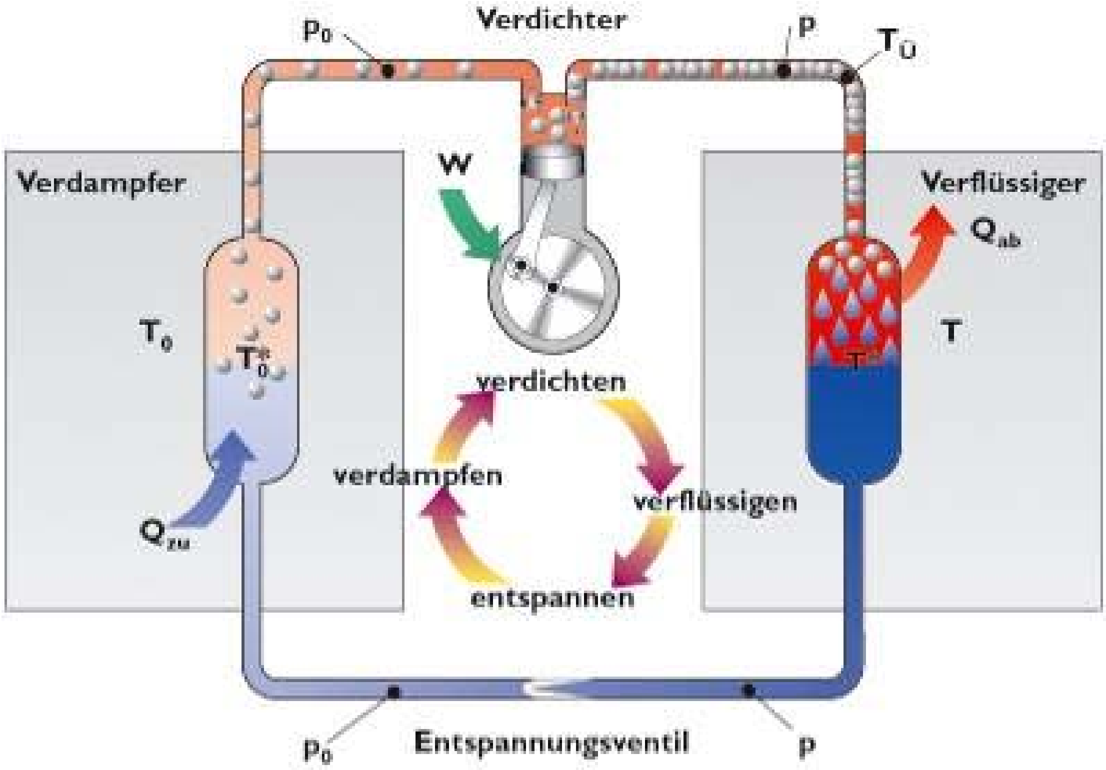

Figure 10: Sketch of the main principle of an heat pump with evaporator, compressor, condenser and relaxation value (from Bundesverband Wärmepumpe [5])

According to the requirements, several types of heat pumps are installed:

- Heat pump GEO (Brine/Water-heat pump)
- Heat pump AQUA (Water/Water- heat pump)
- Heat pump AERO (Air/Water-heat pump)
- Automatic control technique
- Storage technology and fresh water stations
- Extensive accessories

4. Examples of buildings with geothermal energy use

4.1 Berlin: Reichtagsgebäude (German parliament)

M. Seasonal Storage and Aquifer storage (Fig. 11)
N. A distribution system of two geothermal Aquifer storages was installed for the Reichstag and other legislative buildings.
O. Excess heat arising from the power-driven machinery is fed into an underground aquifer heat store in summer which is recovered at times of peak demand in winter.
P. A second ground-water-bearing bed situated is used as a cold store. The Cold is stored in winter feeding the cooling systems of the building in summer without any additional drive power.

- Boiler units, compression- and absorption-type chillers and heat pumps are installed to cover the medium and peak load as well as for redundancy reasons.
- 2 heat storage drilling and 12 cold storage drillings

<u>Summer (heat input)</u>

- Outcoming temperature: 25°C
- Injection temperature: 70°C
- Amount of heat storage: 2.650 MWh/a

<u>Summer (removal of cold)</u>

- Outcoming temperature : 6 - 10°C
- Injection temperature : 15 - 30°C
- Amount of cold storage: 3.950 MWh/a

<u>Winter (removal of heat)</u>

- Outcoming temperature: 65°C - 25°C
- Injection temperature: 30°C
- Ammount of heat storage: 2.050 MWh/a

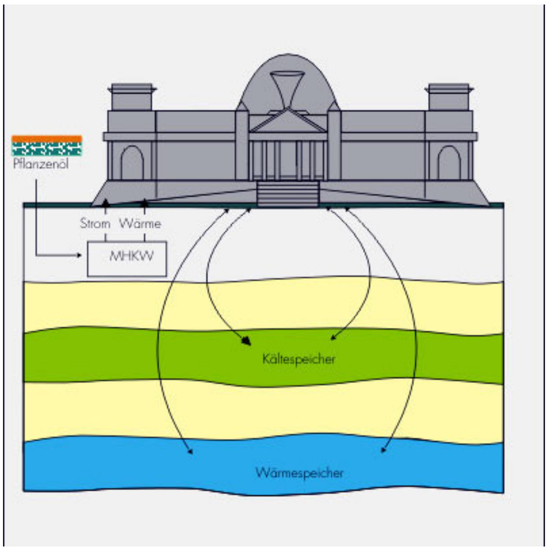

Figure 11: Pictures of Reichstag Aquifer storage (from http:// www.guenterschneider.de, geothermie neubrandenburg [9])

4.2 Aachen, Balanced Office Building (BOB), **Schurzelter Straße**

Vertical loops concrete core activation

Figure 12: Pictures of vertical loops and concrete core activation (from VIKA [10])

The data was provided by VIKA Ingenieure GmbH

- Borehole heat exchanger system
- Effective area: 2100 m²
- Passive house (ultra low energy buildings)
- Heating and cooling by an borehole heat exchanger system
- Placed under the parking lot
- Borehole heat exchanger: 28, depth: 43 m

Heating

- Maximum evaporation capacity: 55,40 kW
- Annual heating energy requirement: 59,34 MWh
- Average brine temperature: up +1 °C

Cooling

- Maximum cooling capacity: 47,00 kW
- Annual cooling energy requirement : 61,60 MWh
- maximum brine temperature: up +19 °C

4.3 Bonn, Federal Agency for Nature Conservation

- Borehole heat exchanger system (Figure 13)
- The building was constructed according to latest ecological guidelines.

45. Heating and cooling by geothermal energy

- Effective area: 3.700 m²
- Borehole heat exchangers: 16, depth: 85 – 120 m
- Heating capacity: 116 kW
- Cooling capacity : 90 kW
- Annual energy requirement : ca. 22.374 kWh

The Data was provided by Bundesverband Geothermie e.V. [12]

Figure 13: Picture of Federal Agency for Nature Conservation, Bonn (from Bundesamt für Naturschutz [11])

4.4 Wien, Subway 2

The following data was provided by the Bundesverband Geothermie e.V.

- System of concrete construction units and Energy piles (Fig. 14)
- Heating and cooling with geothermal energy for four stations
- Absorbed surfaces that includes heat exchange pipes:
- Bored Pile walls
- Slott walls
- Base plates of the stations
- Base plate of the tunnel tubes

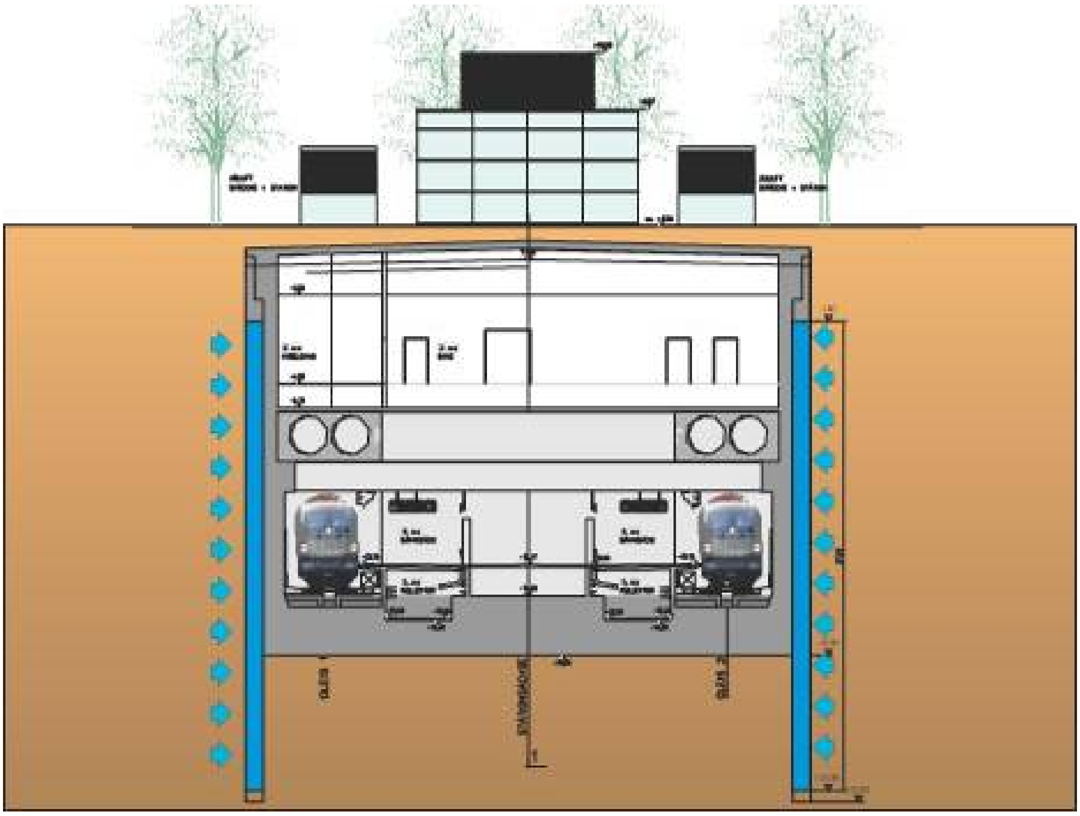

Figure 14: Sketch of subway in Vienna

5. Conclusion

The two-acial application of Geothermics for heating and cooling of buildings increases the economic efficiency of geothermal energy use. Both applications are possible and the investments can thus be amortized within a shorter period of time.
In countries like Germany and others in western Europe, geothermal energy use is currently being developed for certain building types as office buildings or supermarkets with heating & cooling (air conditioning) requirements. The examples show new and still running systems and collect interesting operating data for future designs.

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