OPERATING PRINCIPLE

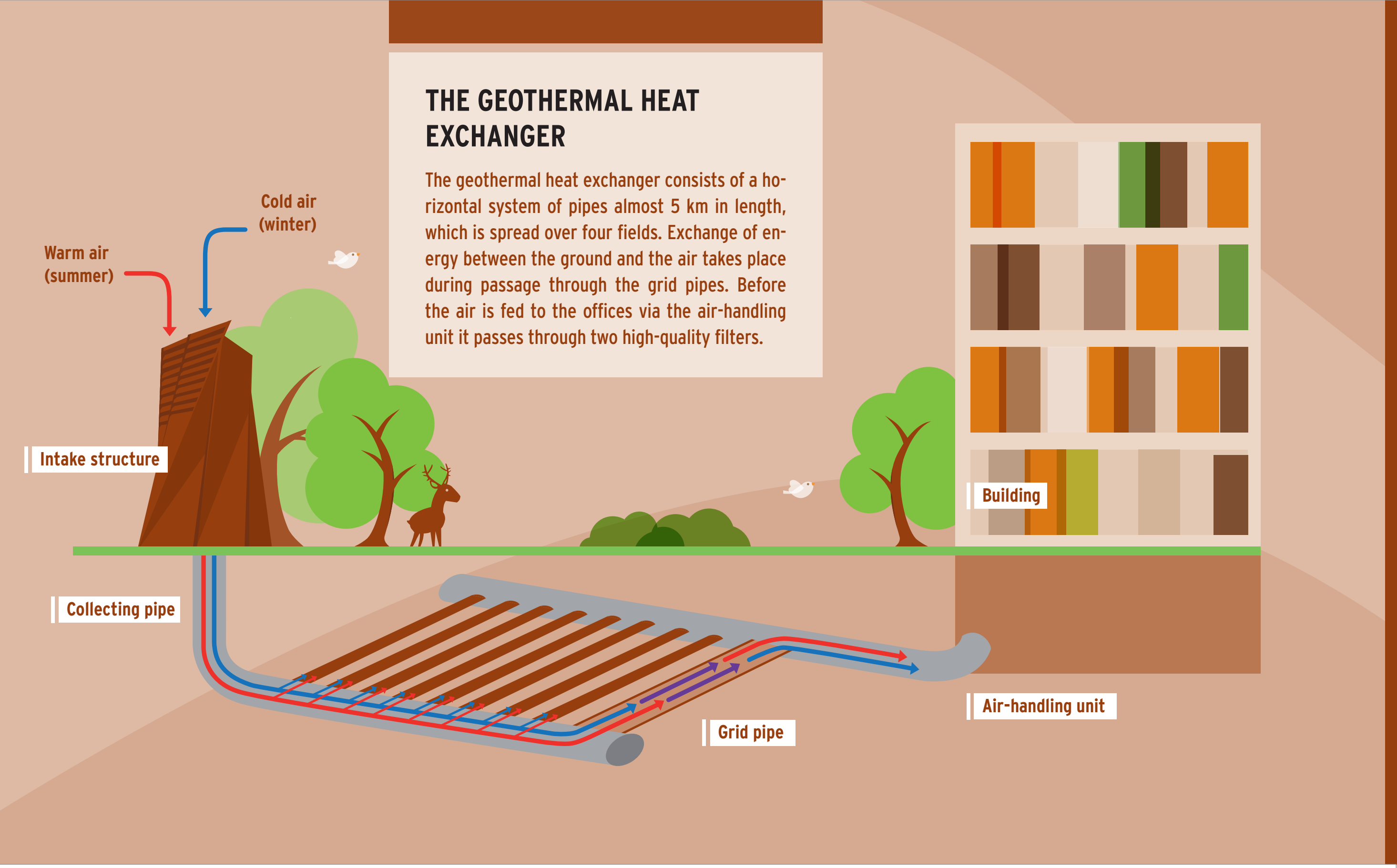
Constant soil temperature to cool or heat air

The geothermal heat exchanger consists of three fields in the western and one larger field in the southern part of the site. They form a subterranean system of pipes with a total length of almost 5 km, through which air flows. Outside air enters the system via three intake structures on the western side of the building. After passage through the heat exchanger pipes, the air is fed to four air-handling units inside the building. Due to the ground's capacity to store heat and the inertness of the system, ambient air is heated in winter and cooled in summer. The size of this effect depends on the velocity of air flow through the system and the temperature differences between the ground and ambient air.

The four fields were laid at depths between 2.50 m and 3.70 m and with a 2% gradient in order to allow any condensation water that may form to run off. Ground-to-air energy transfer takes place for the most part in the so-called grid pipes, which are 30 cm in diameter and range in length from 30 to 61 m. For improved energy transfer, the grid pipes in the ground are spaced 1 m apart from each other. They all lead to so-called collecting pipes, which are 150 cm in diameter. Via the collecting pipes the air is fed to the air-handling units. For reasons of hygiene, the interior surface of the grid pipes is particularly smooth whilst their exterior surface is large and serrated for improved energy transfer. Due to the presence of radon, the pipe material had to be almost fully radon-proof. That is why pipes made of polypropylene were chosen, which were tested for tightness by the Federal Office for Radiation Protection. The collecting pipes are made of prefabricated, watertight reinforced concrete to prevent infiltration of moisture. For optimum smoothness, the interior surface of the pipes is covered with high-grade steel. Pores of 2-3 mm on the interior surface were closed by application of a mineral silicate repair filler.

THE GEOTHERMAL HEAT EXCHANGER

The geothermal heat exchanger consists of a horizontal system of pipes almost 5 km in length, which is spread over four fields. Exchange of energy between the ground and the air takes place during passage through the grid pipes. Before the air is fed to the offices via the air-handling unit it passes through two high-quality filters.



Umwelt Bundes Amt
For our Environment

Umweltbundesamt
Wörlitzer Platz 1 | D – 06844 Dessau-Roßlau
Postfach 1406 | D – 06813 Dessau-Roßlau
Phone: +49 (0) 340 – 21 03 0
www.umweltbundesamt.de

The forum (entrance hall) is open to visitors during the building's opening hours:

Mon to Fri	6:00 am to 10:00 pm
Sat	6:00 am to 4:00 pm
Sun/hols	8:30 am to 4:00 pm

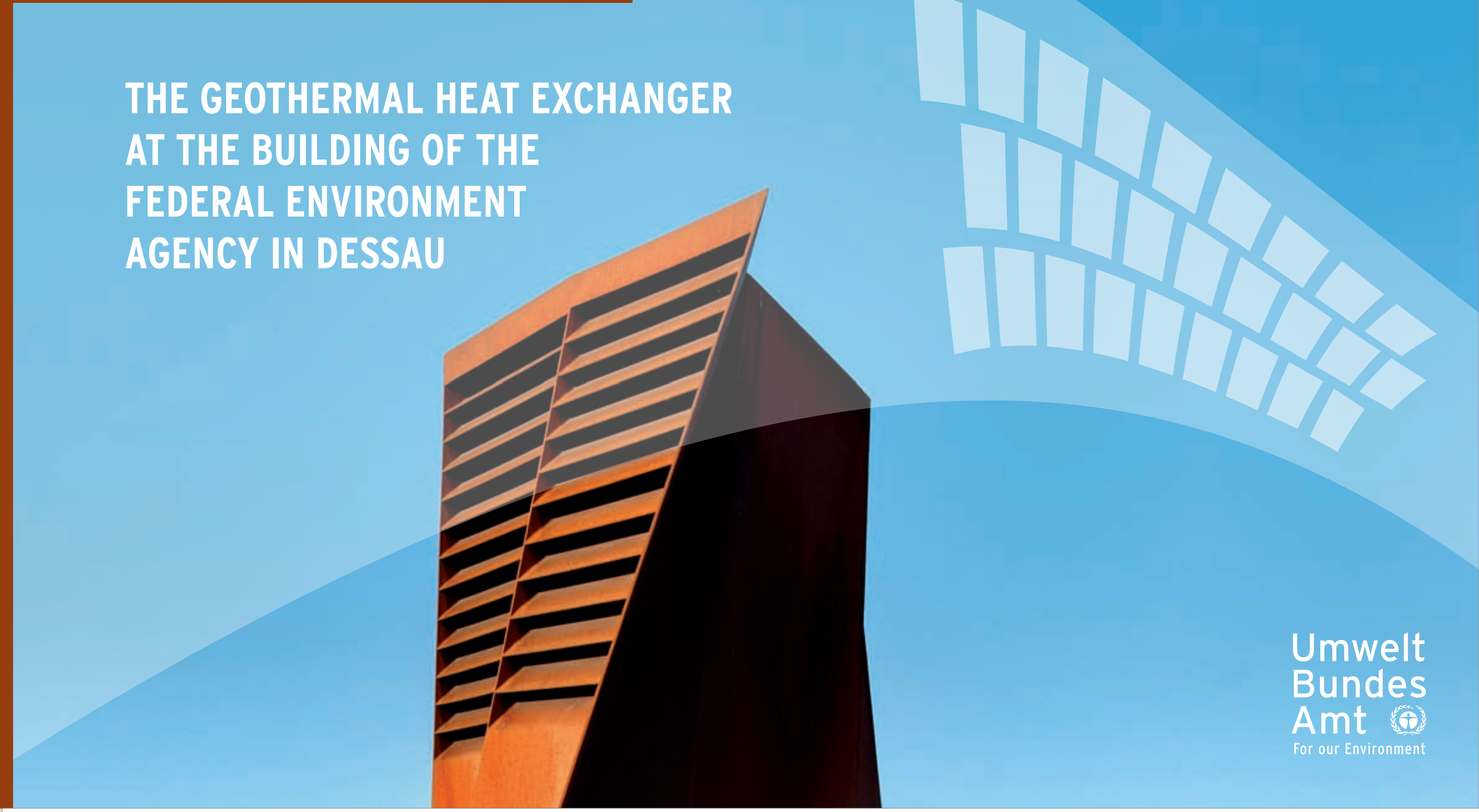
The visitors' room (information material) and the library in the forum are open:

Mon to Weds	9:00 am to 3:30 pm
Thu	9:00 am to 5:00 pm
Fri	9:00 am to 2:00 pm

Visitors who would like to learn more about the architectural and ecological design of the new building and visit the atrium can join a guided tour. For more information about this, ask at our visitors centre or visit our website (www.uba.de).

Photo credits: Jan Bitter, ZWP; diagrams: Cyntia Kraus, BTU Cottbus
Text: Federal Environment Agency, Z 5

THE GEOTHERMAL HEAT EXCHANGER AT THE BUILDING OF THE FEDERAL ENVIRONMENT AGENCY IN DESSAU



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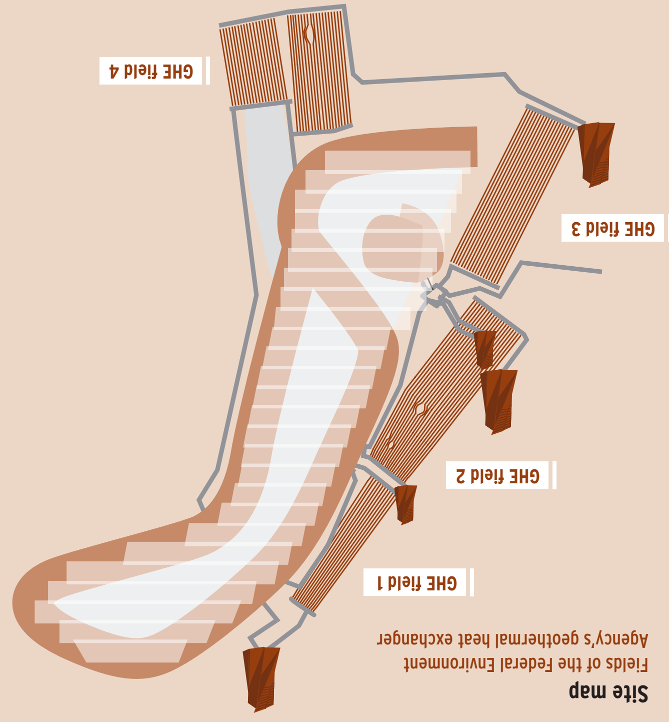
TERRESTRIAL HEAT

Renewable energy as an integral part of the ecological energy concept

The geothermal heat exchanger (GHE) is used to precondition the air supply to the offices, auditorium, library and canteen. The necessary air volume for these areas is 76,000 m^3/h. The offices are ventilated, not air-conditioned.

For heat supply to the building, the geothermal heat exchanger is operational at ambient temperatures below 5°C. During the summer, economic operation starts when ambient temperature exceeds 25°C. At ambient temperatures between 5°C and 25°C the various areas are ventilated naturally, via the windows.

Site map
Fields of the Federal Environment Agency's geothermal heat exchanger



Large intake structure – Passes air through grid pipes
Small intake structure – Passes air directly into building
Grid pipe
Collecting pipe

AIR HYGIENE MONITORING

Air from geothermal heat exchanger cleaner than ambient air

In addition to energy efficiency, air hygiene aspects play a key role. Only air that poses no health risk may be passed into the building from the geothermal heat exchanger. Therefore, air hygiene measurements are carried out regularly at five points of the ventilation system: outside, before, between and behind the filters of the air-handling system, and in the ventilation ducts before the offices. The parameters measured are total counts of mould, bacteria and thermophilic moulds.

The results obtained so far in these investigations show very low concentrations, which after the first filter stage are below the detection limit. The air that reaches the offices via the geothermal heat exchanger and the air-handling system is many times cleaner than ambient air.

INTAKE STRUCTURES

The geothermal heat exchanger system has five intake structures, 3 to 4 m high, which are designed as sculptures. Three feed the air to the collecting and grid pipes for pre-conditioning whilst the other two pass it directly into the building during transitional periods, at certain ambient air temperatures.

FAVOURABLE CONDITIONS

Soil remediation as an opportunity for the horizontal geothermal heat exchanger

The site of the UBA lies in the former Gasviertel (gas quarter), which between 1855 and 1991 contained a gasworks and numerous factories and businesses. This use led to considerable contamination of soil and groundwater by volatile halogenated hydrocarbons and petroleum hydrocarbons, so that extensive soil and groundwater remediation had to be carried out before construction was started.

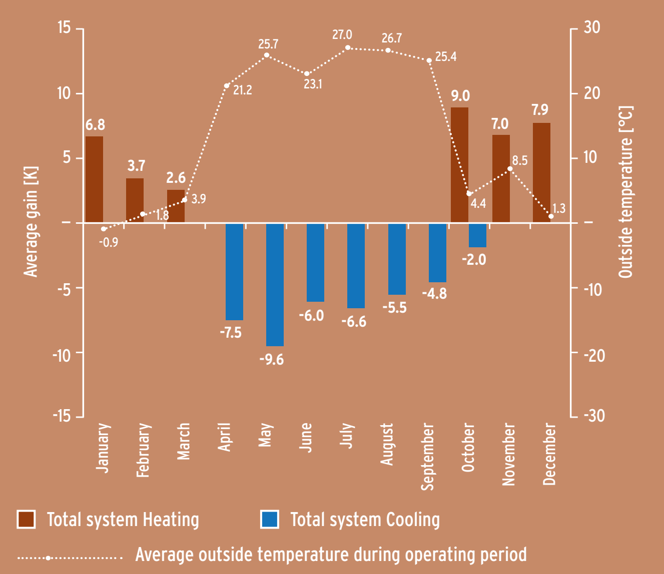
The need for soil excavation opened up the opportunity to install a horizontal geothermal heat exchanger (GHE) for utilisation of geothermal energy. For technical reasons, these areas of the site were not built up but instead are covered with footpaths and vegetation.

ENERGY MONITORING

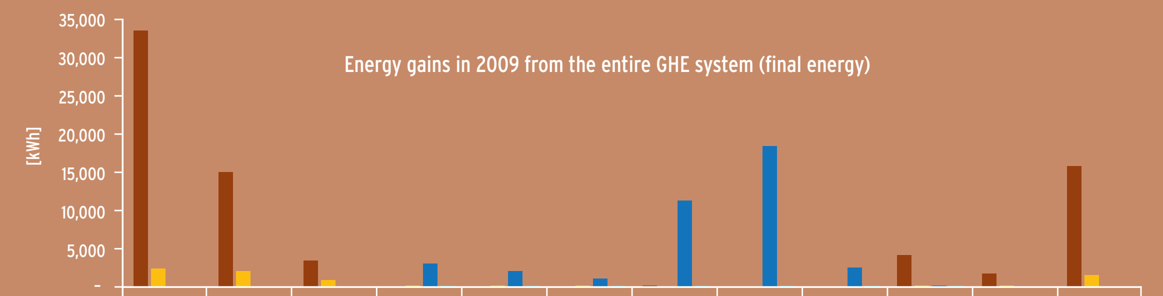
The EnBau research project

The aim of this monitoring was to determine the energy gain from the geothermal heat exchanger and, in so doing, to optimise its operation in energy and economic terms. This was done by drawing up energy balances for cooling and heating. The data for this were generated using extensively installed measuring equipment. Temperature gain and volume flow per field are key variables for drawing up energy balances. Volume flow indicates how much air per hour passes through the geothermal heat exchanger. Temperature gain gives the extent to which air is heated or cooled during passage through the GHE.

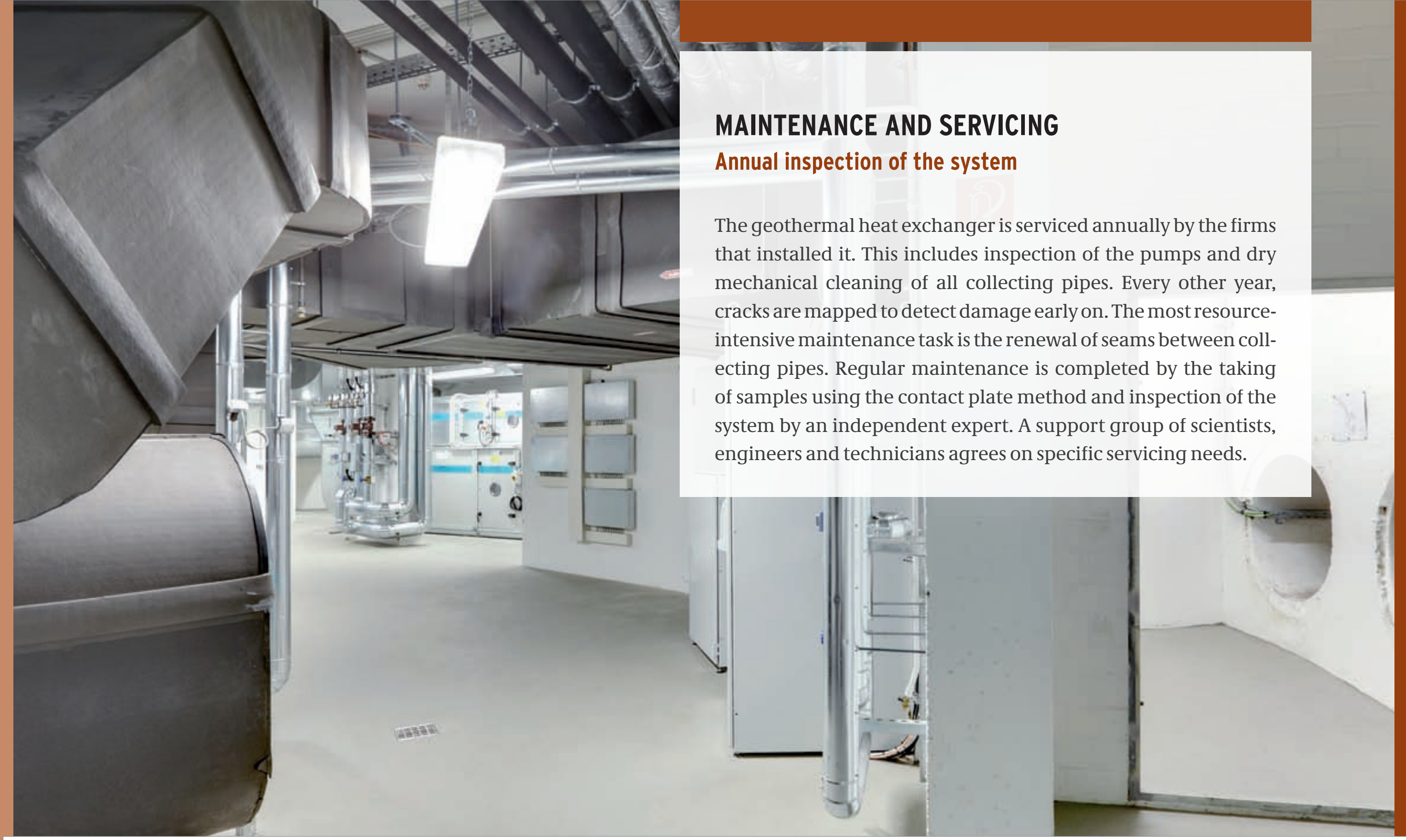
For instance, in summer the geothermal heat exchanger cools 32°C warm air to 20°C, which is sent to the offices to make ventilation by opening office windows unnecessary and even ineffective during that time. In winter, outside air with a temperature of e.g. -10°C has been warmed to 4°C when it reaches the air-handling unit.



The gross heat gains from the entire geothermal heat exchanger system for the calendar year 2009 were 74 MWh and the gross cooling yield totalled 39 MWh, which covers about 5 % of total energy consumption. The yields are lower than the yields simulated during planning – 58 % lower for cooling and 21 % lower for heating. The reason for this is that the heating limit was adjusted from 10°C to 5°C and the cooling limit from 20°C to 25°C. This reduces the number of hours the geothermal heat exchanger is in operation by 34 % for heating and 77 % for cooling. However, from an overall energy perspective, this step is justified because otherwise the electricity requirement for drawing in ambient air and for filtering it in the air-handling units would be higher than the energy yield from the geothermal heat exchanger. The average temperature gain in 2009 for the entire system was 5.5 K over the heating period and 7 K over the cooling period. The values depend on the climatic conditions in summer and winter and therefore vary significantly.



	January	February	March	April	May	June	July	August	September	October	November	December
Heat yield	33,371	15,013	3,409	-	-	-	75	-	-	4,160	1,779	15,877
Energy consumption for heating	2,206	2,072	852	36	1	0	-	-	-	29	8	1,509
Cooling yield	-	-	-	3,044	2,040	1,148	11,266	18,395	2,835	76	-	-
Energy consumption for cooling	-	-	-	93	11	11	133	194	38	0	-	-



MAINTENANCE AND SERVICING

Annual inspection of the system

The geothermal heat exchanger is serviced annually by the firms that installed it. This includes inspection of the pumps and dry mechanical cleaning of all collecting pipes. Every other year, cracks are mapped to detect damage early on. The most resource-intensive maintenance task is the renewal of seams between collecting pipes. Regular maintenance is completed by the taking of samples using the contact plate method and inspection of the system by an independent expert. A support group of scientists, engineers and technicians agrees on specific servicing needs.

ENVIRONMENTAL MONITORING

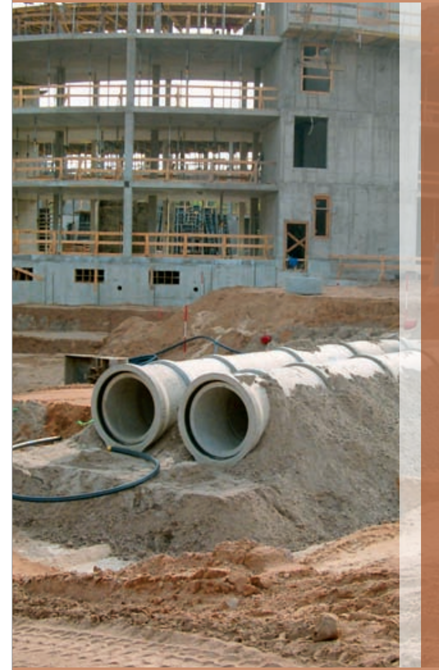
Long-term investigations to ensure sustainable operation of the GHE

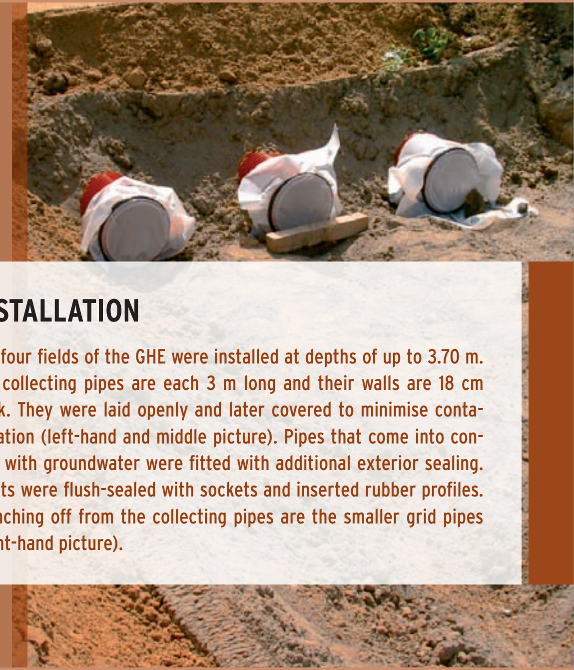
At the time the geothermal heat exchanger was planned and realised, no comparable system existed worldwide. To ensure that this geothermal energy is used in a sustainable manner, environmental monitoring investigations were launched to study the interactions between the GHE and the soil. Due to its specific characteristics such as its location and the depth at which it was installed, Field 2 was chosen for these investigations.

Parameters analysed are soil temperature around the system, soil moisture, groundwater table and groundwater temperature. To carry out the measurements, extensive measuring equipment was installed. For example, to determine the horizontal temperature profile, optical fibre cables were laid on four levels, three above and one below the pipes of the GHE.

After the first five operating years, no influence on soil due to the operation of the geothermal heat exchanger can be observed. Conversely, a strong influence from changing natural conditions is evident. As a result of the changing groundwater table in the Elbe and Mulde catchment area, the thermal conductivity of the soil varies considerably.

The average groundwater level lies at a depth of about 3.5 m. This means that the grid pipes in part have contact with groundwater, especially those of Field 2, which causes the soil to regenerate quickly. This in turn makes for a high cooling and heating capacity and, thus, for the high yield of Field 2.





INSTALLATION

The four fields of the GHE were installed at depths of up to 3.70 m. The collecting pipes are each 3 m long and their walls are 18 cm thick. They were laid openly and later covered to minimise contamination (left-hand and middle picture). Pipes that come into contact with groundwater were fitted with additional exterior sealing. Joints were flush-sealed with sockets and inserted rubber profiles. Branching off from the collecting pipes are the smaller grid pipes (right-hand picture).