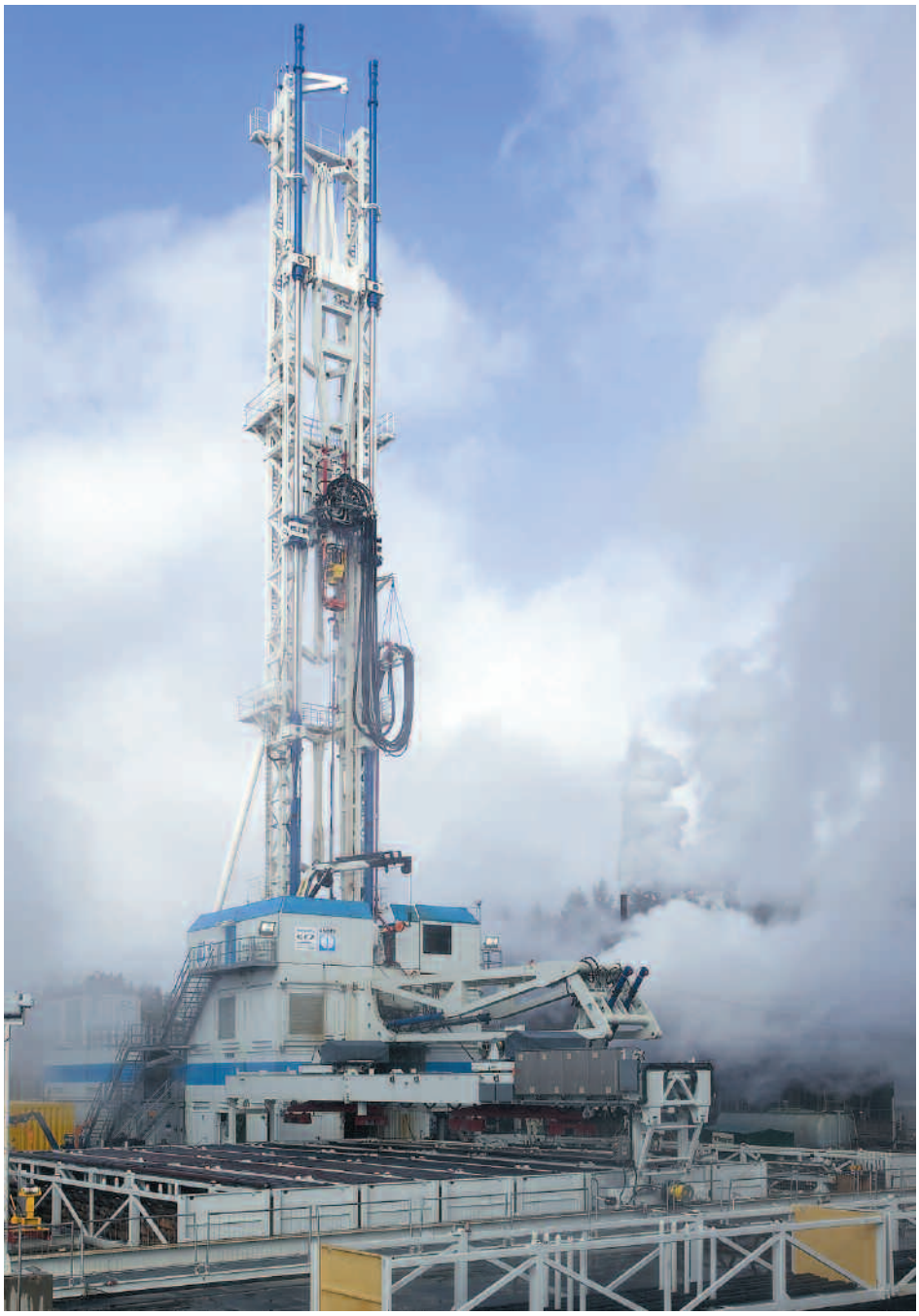
Geothermal Energy
Deep Wells

www.angers-soehne.com

ANGER

seit 1863

Geothermal energy – endless energy



Hot water pumping test
Innova Rig

More than 80% of our primary energy requirements are provided by established mining activities. This includes coal (Bituminous coal and lignite), uranium as well as oil and gas.

Meanwhile, the generation of electricity from the energy content of the earth, i.e., from geothermal energy, is gaining more and more acceptance in many regions of the world – including central Europe.

This regenerative form of power generation functions on the following basic principle. Next to a power station, a subsurface water supply, with temperatures of > 100° (better > 120°) is required. In Germany this corresponds to hole depths of approximately 3500 – 5000 m. With the help of at least two wells – one production well and one injection well – approx. 2 km apart at final depth, water is circulated through the formation which is permeable or is made permeable.

On its way from the injection well to the production well the water heats up. After its ascent from the production well this energy content is used for the generation of electricity at the power station. Once cooled, the water is then re-fed into the injection well, so that a sustainable process of energy generation occurs.

Drilling depth for oil and gas production can achieve 10.000 m or more. For the use of geothermal energy, wells are planned and carried out up to a depth of 6.000 m today.

Deep wells in classic mining – for energy sources (coal) as well as for other raw materials such as copper or salts – rarely reach depths of more than 2.000 m.

H. Anger's Söhne is equipped with modern deep drilling rigs for every exploitation and exploration method mentioned above, up to a depth of approx. 6.000 m.

On-the-job safety and environmental protection

Our company is certified within the framework of the management system SCC (Safety Certificate Contractors) by Germanischer Loyd. A number-one priority of ours is the highly qualified staff members who have many years of experience with our company. Specialization and clear arrangement of competencies and processes ensure that a high degree of quality is achieved and maintained in the work routine on a long term basis.

Likewise, the reduction of all emissions proceeding from the drilling operations – like noise, tremors, odours, light or dust – is of utmost importance to us and preventive measures are taken in order to avoid such emissions. Therefore, only certified, environmentally friendly equipment (chemicals etc.) are employed.

Noise reduction, for example, also plays an essential role regarding our 410 t drilling rig Innova Rig, which will be subject to closer consideration later on.

The consistent implementation of noise reducing, constructive measurements during the erection and operation of equipment has enabled us to carry out a variety of projects even in close proximity to housing, without any disturbances of the surrounding neighbourhoods.

As a result, no lawsuits or complaints whatsoever have arisen despite the fact that the work runs 24/7 and with an average duration of 3 – 4 months at one site.

Drilling rig MR 8000

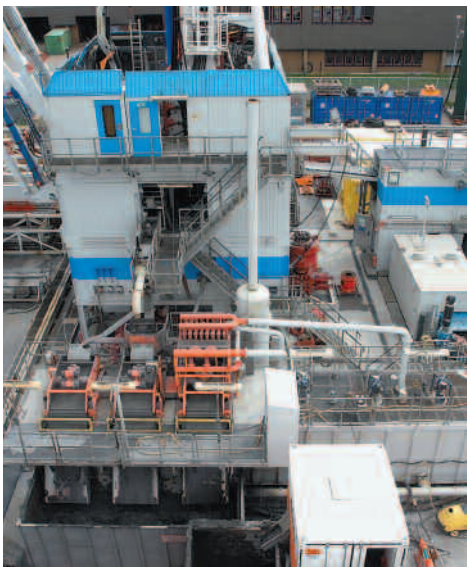
The texts on the following pages concerning the fields of activity most important to us will give you a first impression of the procedures and project execution.

Geothermal Energy –

The term geothermal energy, or geothermal heat, means the energy stored in form of heat below the surface of the solid earth (VDI-guideline 4640). The idea of making use of this geothermal energy, to supply us with heat and energy, has existed for thousands of years.

Geothermal energy is always available and is not subject to any seasonal factors. In addition, neither price nor quantity is dependent on international markets, as is the case with fossil fuels.

Taking this into consideration, geothermal energy is an environmentally friendly and efficient alternative. Superficial geothermal energy for the exclusive use of heat can be found at depths of between 50 to 400 m.



Tank system 240 m^3

For this purpose, already temperatures of 12 – 40 °C are sufficient.

These near-surface systems are particularly suitable for the construction of decentralized heating systems, that is, for being used in combination with a heat pump.

On the other hand the below ground system can also be used as a source of cold, in order to save cooling costs.

More than 100 °C are necessary to produce electricity. Hence, this requires wells with a depth of up to 3000 m for them to be regarded as economically viable.

energy crises don't exist

Geothermal energy – local energy

Technologies of today allow to make use of the power source 'earth' almost anywhere, which makes geothermal energy a renewable energy source with great potential.

A large variety of possibilities exists to turn this energy into heat and/ or electricity.

With the resources of hydrothermal geothermal energy known today, it would be possible to meet about 29 % of Germany's demand for heat; with those of superficial geothermal energy a further 28 % could be covered.

At a depth of between 3000 – 7000 m below the surface of the Federal Republic of Germany, enough energy could be obtained using hot-dry-rock procedures that the country would be able to support itself with electricity and heat for the next 10 000 years.

Decentralized network of district heating

Geothermal energy is always available for the consumer – or a municipality striving to be self-sufficient – round-the-clock, regardless of time of day or season, independent of weather and climate. It is not damaging to our nature or climate and does not require a lot of space.

Geothermal energy does not require any transport over longer distances, therefore it is the ideal local solution.

Iron roughneck

Systems for geothermal deep wells

Hydrothermal systems

One important field in which geothermal wells are deployed is in the area of the so called hydrothermal geothermal energy, that is, for the production of spa water.

Water-bearing layers, so called aquifers, exist in many parts of the earth's crust. These layers are divided into groups as to whether they consist of hot (more than 100 °C), warm (40 - 100 °C) or low temperature water (25 – 40 °C). A temperature of only 20 °C suffices for the water to be considered thermal water.

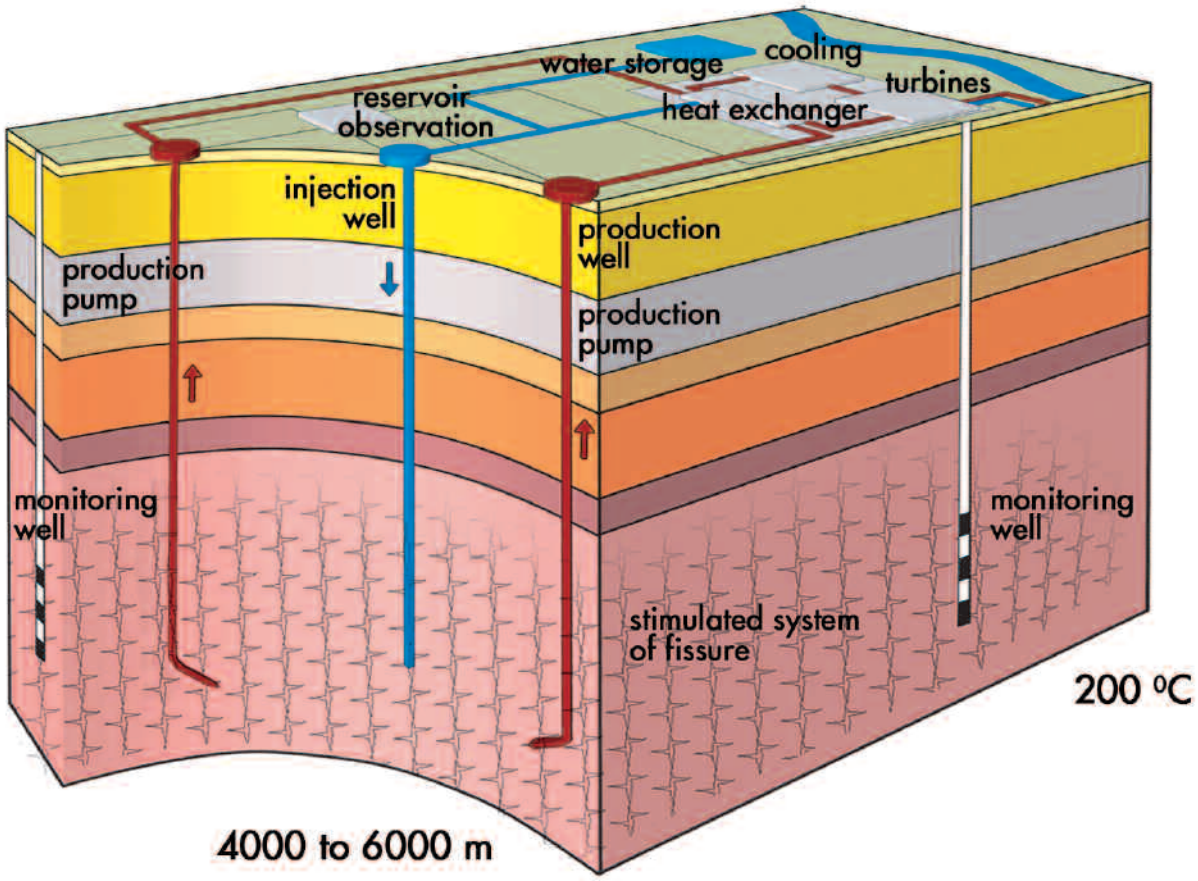
In Germany subterranean geothermal-aquifers can be found, for example, in the North German Lowlands between the Polish and the Dutch border, in the Upper Rhine valley and in southern Germany between the Danube and the Alps, as well as at the Swabian Mountains.

In order to be able to exploit and use these aquifers, a so called doublet is needed, i.e. a coherent system of two wells that have been drilled at a sufficient distance from each other: the production well and the injection well.

Through the production well the hot water that exists in the subsurface aquifer is brought to the surface.

A heat exchanger extracts the water's energy, which then can be used to produce electricity and warmth.

Via the injection well the cooled water is then re-fed into the underground again, thus creating a closed cycle.
The aquifer continues to give off warmth to the circulating water.



Petrothermal systems

Meanwhile, some attempts have been taken to produce electricity and heat from dry rock, in places where no underground hot steam reservoirs exist.

The basis for these so-called Hot-Dry-Rock-power-stations is formed by a coherent system. Like is the case with the hydrothermal systems, the first step here also consists of drilling an injection well and a production well.

Of primary importance is the injection well, since it is via this well that water is pressed down into the heat reservoir with the help of injection pumps. From that point on the process is similar to that of the hydrothermal systems: the water heats up while moving through the fissured rock and is then pumped back to the surface via the production well. Then the water's energy is available for usage.

In contrast to hydrothermal systems, however, petrothermal systems require higher temperatures and thus, most of the time, greater depths.

That is to say that wells for the Hot-Dry-Rock-procedure can reach down as deep as 3000 m, where there are temperatures of 150 °C - 200 °C. Approximately 200 °C is desirable in order to be able to use the HDR-technique in an economically sound manner.

Important for the method is, apart from sufficiently high temperatures, that the bedrock is sufficiently permeable. This permeability can also be generated artificially. The more the rock is fissured the more surface there is available for the exchange of heat.

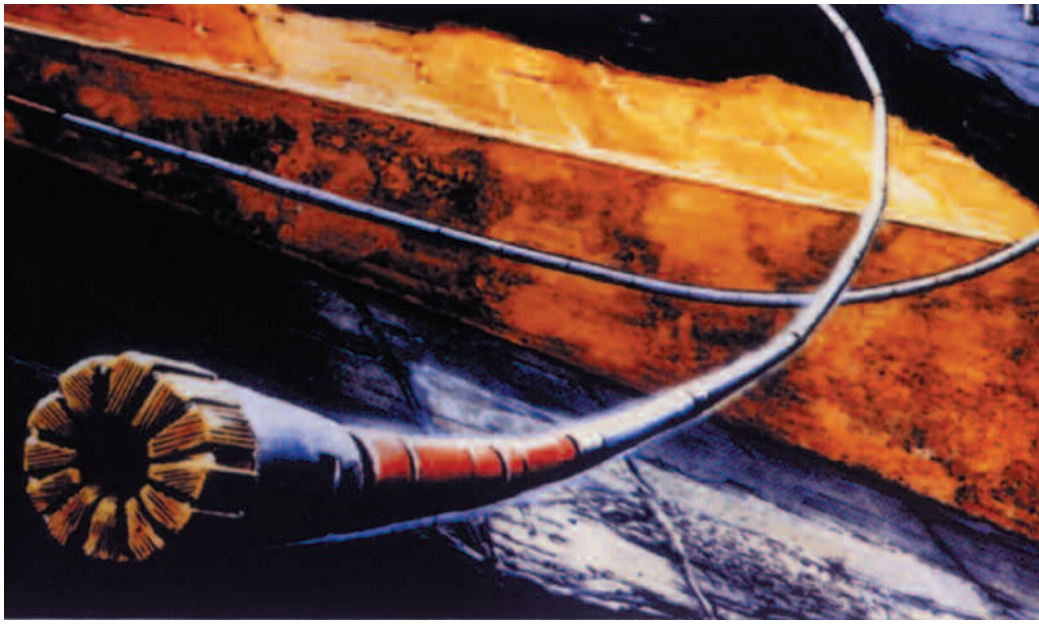
Coaxial wells

These deep wells develop heat at depths of up to 4000 m.

In contrast to the Hot-Dry-Rock-procedure their efficiency is lower, with only about 750 kW – 1 mW. However, these coaxial wells stand out due to considerably lower costs regarding investment, operations, and maintenance.

Furthermore, they can basically be applied regardless of location; i.e. they make it possible that deep geothermal energy can be used as a source of heat anywhere in Germany. Similar to hydrothermal systems, these coaxial wells are also coherent systems though, in contrast to those, in a one-hole-concept. That is to say that an inner core barrel and an outer core barrel are installed in one single well. In the annulus cold water flows downward and, in doing so, heats up on the rock that is bordering on the metal pipe. Once the water has reached the deepest point of the well, it is brought back up to the surface again through the insulated inner core barrel. There it can be used for the generation of energy and/or heat. Subsequently, the water, which by then has cooled down to about 15 °C, is re-fed into the outer core barrel and heated once again.

By applying this coherent one-hole-principle one can be sure that no mixture of inserted water and possibly existing ground water occurs.



source: Weatherford Energy Services GmbH

Innova Rig

For the tasks described above Anger's Söhne offers you a variety of possible solutions.
Below you will find details about our largest and most powerful drilling rig, the Innova Rig.

The Innova Rig has been designed by our company in co-operation with Herrenknecht Vertical and the German Research Centre for Geosciences (GFZ) Potsdam, in order

to meet all current and future drilling requirements – on a scientific as well as an industrial level. Its most noticeable advantage lies in the reduction of both required manpower and of operating costs.

Basic data:

- the hook load of Innova Rig is 4100 kN
- mast and hoist system consist of a hydraulic double cylinder system
- usage up to a depth of approx. 4000 – 6000 m
- the rig is automated for most operations which are relevant to safety and which would normally be manual operations. These works are substituted by hands-off-technology.

Thus, strenuous work on the drilling platform is reduced to a minimum.

- Four drilling techniques are integrated: rotary drilling, standard coring, wireline coring and underbalanced air-lift drilling.
- mud system, pumps and tanks are modularly adjustable to the four drilling techniques mentioned above.

What makes Innova Rig so innovative is, above all, the possibility to switch between the different drilling methods, like rotary drilling or wireline coring.

The rig's high level of automation allows for great adaptability and therefore ensures compliance with high safety standards.

Consequently, H. Anger's Söhne has been working with this 410 t plant accident- and incident-free since bringing it into service in 2007.

What should also be stressed here is the advantage that the Innova Rig ensures minimal environmental impact.

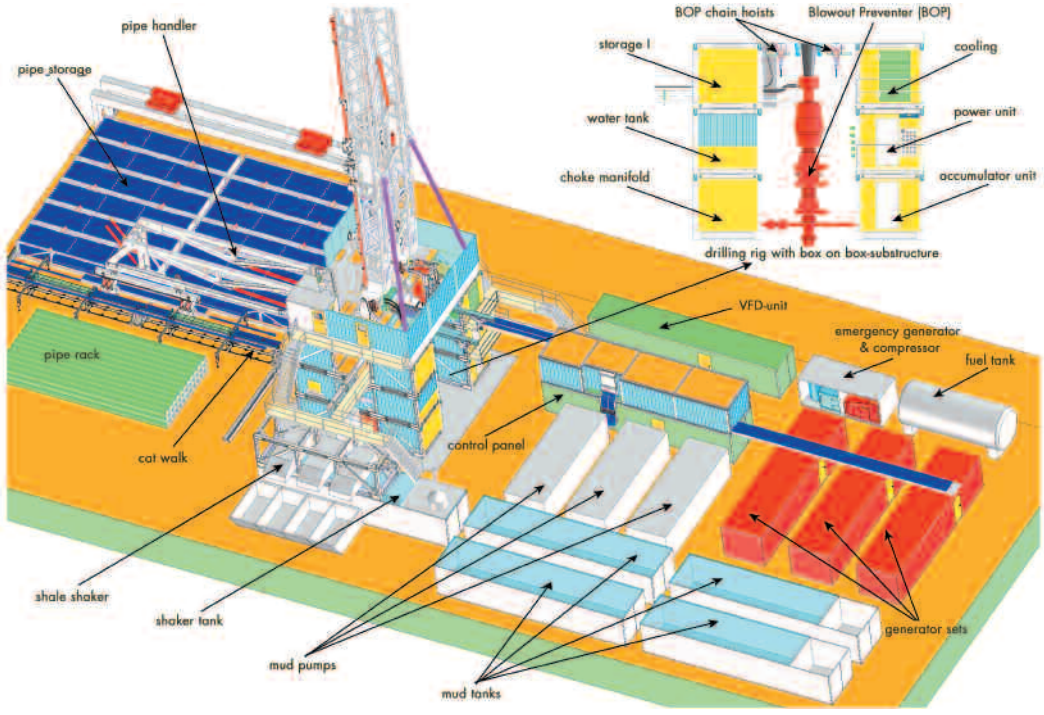
Thus, the space needed for the building site is much smaller than the one necessary for conventional drilling rigs, for example. Furthermore, during the construction phase all machines and equipment parts were examined with regard to their possible production of noise. In this process, all necessary measures for the reduction of noise were taken.

The lack of the so called monkey board results in considerably less noise at high altitudes during trip action. This, therefore, enables us to drill in an inner-city area, even in close proximity to housing.

For the project GeneSys in Hannover, for example, a noise barrier which originally was designed to be 15 m high, could be reduced to 10 m. Measurements revealed that the plant was working below 50 decibel during the entire drilling time.

Technical data and additional details:

- nominal rotary speed 220 rpm
- rotary torque 40-75 kNm
- wireline coring speed 500 rpm
- wireline coring torque 12-18 kNm
- tripping speed Ø 500 m/hr
- hoist cylinder stroke 22 m
- drive power up to 4000 kW
- rig weight approximately 3700 kN
- mud pumps 3x1000 kW
- wireline coring mud pump 1x350 kW
- mud pressure max. 350 bar
- mud tank system 240 m^3
- generator set 3x1540 kVA
- wireline coring winch 5000 m, d = 12.7 mm



source: HV

Constant discharge pumping test

In deep drilling, airlift pumping tests are conducted in order to analyse and evaluate the productivity of aquifers. Furthermore, these tests are applied to clean the completed geothermal well in the best possible manner. Apart from that, the results of tests can provide essential data for subsequent long-term pumping tests, regarding both the construction of the pump and a possible capital decision.

The planing and carrying out of such pump tests require the participation of specialized and experienced engineering firms as well as of competent drilling firms.

H.Anger's Söhne has completed many geothermal projects in the past years, and has successfully applied the airlift procedure for the test execution.

In addition, we have always been able to combine the necessary components, like stackable bins, cooling towers, pipelines and distributory pumps, with the digital surveying in such a way as to achieve the best results possible.

Principle

The fundamental principle of today's airlift pump procedure goes back to the 1797 invention by Carl Emmanuel Löscher – namely a pump which was able to transport thermal fluids or even solids through a pipe.

This happens with the help of compressed air which allows a vertical production with a high volume flow.

Since this pump has a very high resistance to wear, it is often also called "mammoth pump".

Design and procedure

The pump generally consists of four main components, namely the production pipe, the mixing unit, the base and the separator.

The pump drive mainly results from compressed gas, primarily air or nitrogen. This gas is injected into a pipe (open on both ends) and exits underneath the fluid level.

Thus, the resulting fluid-gas-mixture rises upwards as a result of the lower density. The diameter of the production pipe determines the air intake that has to be injected into the input-pipe.

In case solids are to be extracted as well, it is advisable to bring the pipe close to those solids.

Only when the water's speed in the sub-pipe exceeds the decantation rate of the solids, can solids get lifted and moved upwards.

Further proceedings

Finally, the separator divides air and water. This is done to keep the water drops included in the steam to a minimum, although a certain release of steam or steam-water-mixtures into the atmosphere cannot be completely avoided.

The resulting loss of the originally produced amount of water, however, is negligible.

H. Anger's Söhne has at its disposal the equipment to meet such high demands. Furthermore, our company developed, in co-operation with our partners, corresponding units necessary for cooling.

The result was cooling towers that are used to cool down the water. In this process they are able first to take the water that has been cooled down to 85 °C in special containers and to cool it down even further to 35 °C with a production rate of 133m³/hr.

Subsequently, the water either can be stored in another pond, or it can be discharged directly into the sewage system.

Safety

All of the parts which are exposed to water, for example seals or paint, have to be tested in advance with regard to their temperature resistance. Generally, pumping tests like these should only be carried out by experienced and well-trained personnel, which is informed about precautionary measures and demands on technical safety.

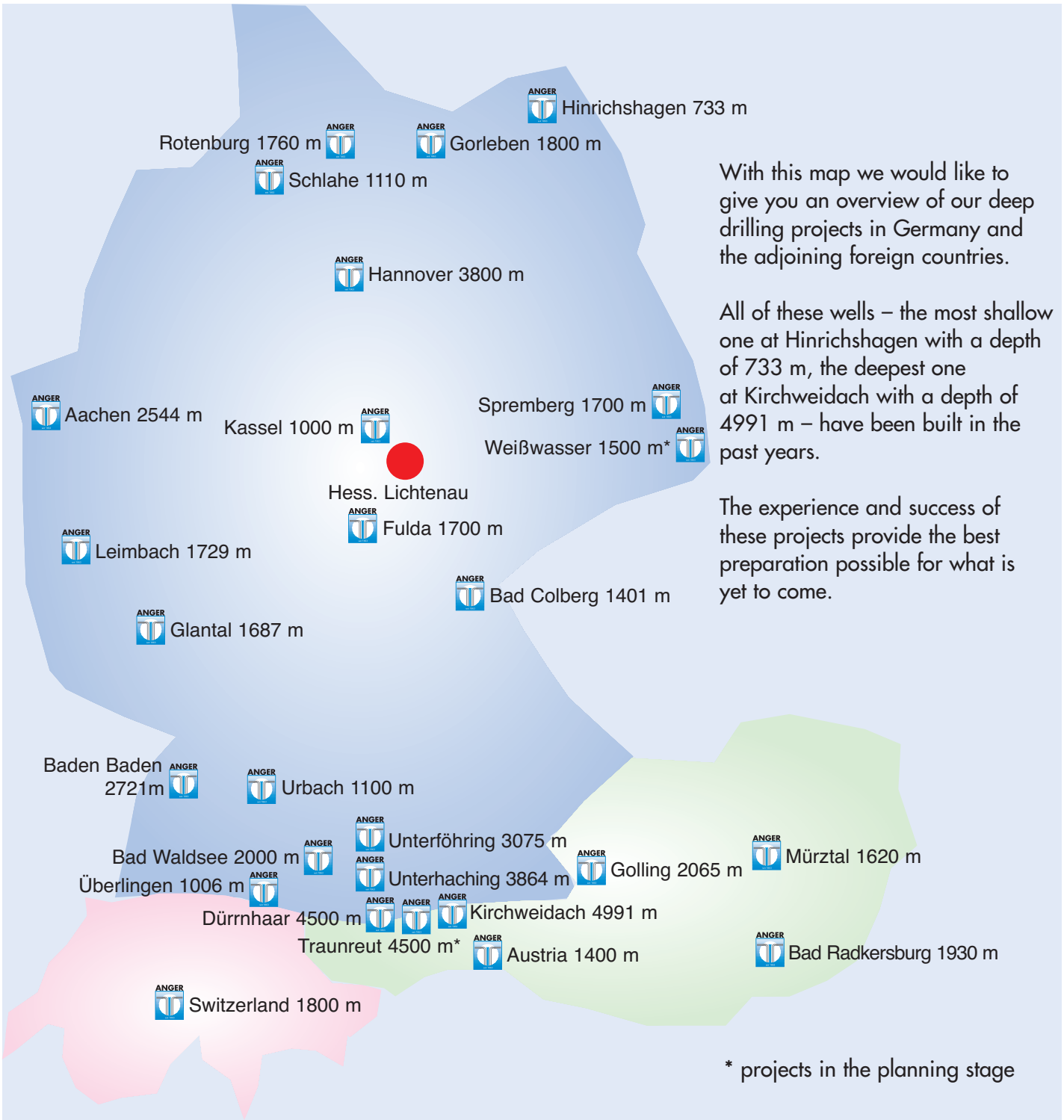
In this respect, H.Anger's Söhne can rely on its long-standing qualified employees.
Further training especially in the field of technical safety is a number one priority for all of our staff.

Likewise, we keep technology and machines up-to-date, in order to get the best result possible for every single commission.

Using the airlift procedure, we were able to lift solids from a geothermal well at a depth of approximately 3400 m and therefore successfully restore and guarantee the flow paths of that particular well.

Cooling capacity approx. 21 MW, temperature difference 80 °C to 35 °C

Selected References - Deep Wells



With this map we would like to give you an overview of our deep drilling projects in Germany and the adjoining foreign countries.

All of these wells – the most shallow one at Hinrichshagen with a depth of 733 m, the deepest one at Kirchweidach with a depth of 4991 m – have been built in the past years.

The experience and success of these projects provide the best preparation possible for what is yet to come.

* projects in the planning stage

ANGER seit 1863

H. Anger's Söhne
Bohr- und Brunnenbau-gesellschaft mbH
Gutenbergstraße 33
37235 Hessisch Lichtenau

Tel. +49(0)5602/9330-0
Fax +49(0)5602/9330-70

info@angers-soehne.de
www.angers-soehne.com