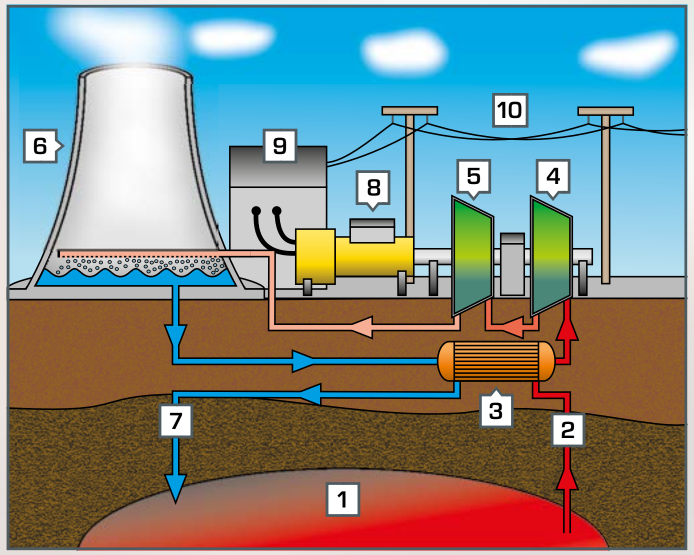
Basic Knowledge
Deep Geothermal Energy

Fundamental principle

Deep geothermal energy, like shallow geothermal energy, is also based on the fundamental principle of solar thermal energy. The difference is that the ground, and not the sun, is used as a heat source. Unlike shallow geothermal energy, the earth's heat can be used directly. Depending on the temperature level of the geothermal field, there is either direct conversion to electricity or direct use for heating purposes.



1 heat reservoir
2 transport
3 steam generator
4 first turbine stage
5 second turbine stage
6 cooling tower
7 return
8 generator
9 transformer
10 public power grid

Differentiating geothermal fields

There are different ways of distinguishing between the various geothermal fields attributed to deep geothermal energy. Criteria for the different deposits include the necessary drilling depth, the origin of the geothermal energy, the type of usage or the temperature level. From the point of view of technical usage of the geothermal energy, distinction by temperature level of the geothermal field is usually chosen. In this case, distinction is made between two different types of deposits.

The highest temperatures occur in areas known as thermal anomalies. These are mainly active or formerly active volcanic regions, but may also occur without volcanism. The deposits are referred to as high enthalpy deposits. The advantages of these deposits are direct conversion of the hot steam and low depth. The deeper the borehole, the warmer the earth. Thermal anomalies with comparable temperatures are usually reached at depths of 4000 – 5000 m. These deposits no longer have the advantage of lower drilling costs.

Low enthalpy deposits are somewhat colder. It is only profitable to operate a geothermal energy source with low temperature level when using the heat for heating purposes. Converting the geothermal energy of these deposits into electricity is only carried out in special cases. In these cases, closed Organic Rankine Cycle (ORC) systems are employed in order to use temperatures from 80 °C onwards for electrical purposes.

There are several technical solutions available to exploit both deposit types. The following systems are differentiated by the pressure and temperature conditions, any gases contained in the deposits, or by the quantity of water:

- hydrothermal systems
- petrothermal systems
- deep geothermal probes
- geothermal energy from tunnels
- geothermal energy from mining installations

Technical implementation

Apart from deep geothermal probes, these are open systems which are designed as dual well systems for environmental reasons. A power station site is equipped with up to four boreholes. After pumping and using the hot water or steam, the cold working medium is pumped back into the holes. Doing so does not reduce the operating pressure, and the efficiency and capacity remain largely unaffected.

Outlook

At present, an electrical output of 10 GW_{el} is installed worldwide. Using currently available technology for hydrothermal systems, this could be increased to 70 GW_{el} by 2050.

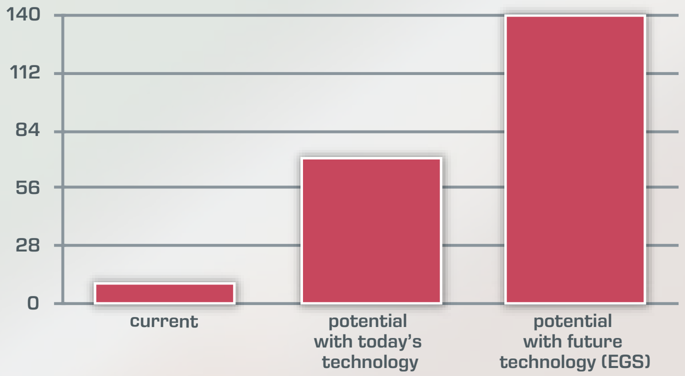
Including Enhanced Geothermal Systems (EGS), i.e. petrothermal systems, it could even be possible to reach 140 GW_{el}. However, these systems are not yet state of the art.

Converting thermal energy into kinetic energy

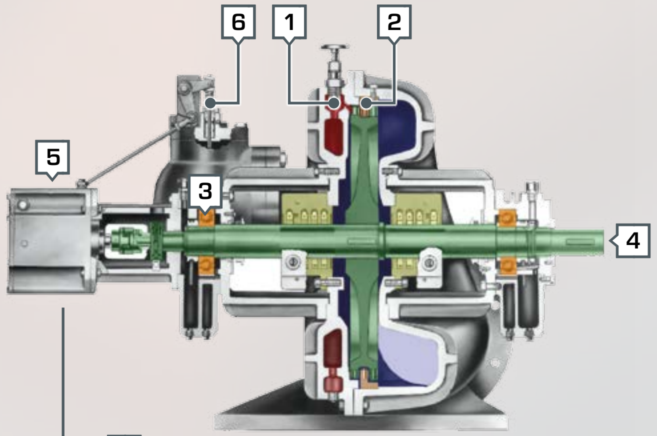
It is necessary to use steam turbines in the field of deep geothermal energy in order to convert the thermal energy extracted from the ground into electricity. The steam turbine converts the energy of the steam from the ground into rotational kinetic energy. A generator then produces electric current from the kinetic energy of this rotation.

A typical industrial steam turbine is the impulse turbine, shown in cross section, with a Curtis wheel. The turbine is designed to drive generators directly and does not have any gearing.

Globally installed power in gigawatts



Source: Bertani 2010 Geothermal Power Generation in the World



1 nozzle
2 deflection in the impeller
3 roller bearing
4 impeller shaft
5 speed controller
6 flow control valve