Geothermal energy

20 years of Dutch experience with management of hot and cold groundwater

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Why geothermal energy

Carbon dioxide emission reduction targets are high and energy prices are increasing considerably. This has led to a rise in demand for smart, sustainable systems, at home and abroad.

The Dutch 20 years of experience with earth energy storage offers a proven and financially attractive solution. Though the subsoil abroad can differ very much from that in the Netherlands, there are many densely populated areas in the world where the earth has very suitable characteristics.

How it works

Geothermal systems can be subdivided into shallow systems and deep systems.

The shallow systems can be divided into heat extraction systems (with heat pump, so called ground-coupled heat pumps) and energy storage systems (cold and heat). Deep geothermal systems extract terrestrial heat from the earth and are installed to depths of up to 5,000 m below the surface. If the extracted heat has a temperature above 120 °, electricity can be produced.
**Shallow geothermal energy**

**Low-temperature energy storage**

The energy is stored in the underground in sandy aquifers or water-bearing layers (20 - 500 m below the surface) (ATES, aquifer thermal energy storage). If this water is pumped up, cooled down and then as relatively cold water infiltrated into the soil, the temperature of soil and groundwater near the infiltration well will decrease. After some time, a zone of cold groundwater will develop around the infiltration well.

In summer, groundwater is extracted from the cold water zone (5 – 10 °C). This cold water can be directed towards a cooling plant of a building or process, where it can be used for cooling.

The groundwater is used to absorb energy from the building and is thus warmed up. The temperature of this water is higher than the natural groundwater temperature, and a warm water zone is created (15 - 30 °C), which can be used to heat the building or process in winter.

Whether open energy storage can be applied depends on several factors, such as:
- structure of the subsoil and the suitability of soil layers
- groundwater quality
- groundwater flow.
In general, a sandy structure of the subsoil is preferable. Different types (qualities) of groundwater may also affect the performance of an energy storage project.

Energy storage is applied at depths varying from about 20 to 250 m.

**Applications**

Energy storage is applied in projects at more than 1000 locations in the Netherlands for the direct delivery of cooling and low-temperature heating in combination with heat pumps. Most projects have been realised in large buildings. Residential projects and greenhouses have also seen a considerable growth in the number of projects.

![Diagram of borehole energy storage (BTES)](image)

A borehole energy storage system (BTES) consists of plastic hoses or loops that have been installed in the soil vertically or horizontally, and a heat exchanger. A coolant, and not groundwater, is used as heat carrier. The entire system is made according to a *closed concept* so that direct contact with groundwater or the soil is avoided.

The systems can be used practically everywhere and are mainly applied in residential projects and small-scale commercial and industrial buildings.

**High-temperature energy storage**

Heat which is released in industrial processes, electricity production and waste incineration will be used increasingly for heating buildings. Since direct sales of heat do not occur in summer, the heat is stored temporarily in the underground. In winter, the heat can be extracted from storage and used for heating, together with the direct delivery of heat. Heat at a temperature between 45 and 90 °C is stored in deep underground water-conducting layers. The supply and removal of heat takes place through extraction and infiltration of groundwater.

**Applications**

High-temperature heat storage was applied at two locations during the 1990s in the Netherlands. Rising prices of fossil fuels and the emergence of the use of residual heat have drawn renewed attention to this technology. Important aspects include links to district heating grids and heat supply to greenhouses.
Deep geothermal energy

Energy present in the earth’s core is brought to the surface via conduction. The geothermal or earth’s heat is a potential, and in principle inexhaustible, source of sustainable energy. From the surface of the earth, the temperature increases by approximately 30 °C for each kilometre of depth. So heat can be extracted from a depth of as little as one kilometre, which is then immediately available for heating purposes. This heat is extracted by pumping up groundwater present at the chosen depth and by extracting heat from the groundwater. The water is then returned to the underground, after heat transfer. The volume of energy available is almost unlimited in the Netherlands. If only one percent of available energy was extracted, it could heat approximately ten million homes for a period of thirty years.

Applications
Considerable research is currently being conducted in the Netherlands into the application of geothermics. The first projects is realised in 2007. Main market segments for geothermal energy include large-scale residential projects and greenhouses.

Diagram of a deep geothermal energy system

Why do we utilise it?

Saving of fossil fuels and CO₂ emissions
When compared with conventional heating boilers and cooling units, soil energy, whether in combination with heat pumps or not, significantly contributes to reducing the primary natural gas consumption and the emission of CO₂. All in all, savings of 50 % (energy storage) to 80 % (geothermal energy) are possible.

No NIMBYs
Geothermal energy storage is concealed from sight and its effects on the soil surface are minor. Furthermore, no adverse effects on the underground environment have been observed so far. As a consequence, there are no lengthy objection procedures from people living in the neighbourhood (NIMBY).
Low cost, proven technology

With over 1000 geothermal energy systems in operation in the Netherlands, this is a proven concept. The integration of geothermal energy into a climate control system is well worth considering. A well adjusted plant will economise on your energy bills.

Installation with a long service life

Geothermal energy systems are designed for a life of approx. 30 years, which is substantially more than conventional systems. The first systems installed in the Netherlands in the 1980s are still performing reliably.

Monitoring and management

Geothermal projects have a service life of more than 30 years. Optimum system maintenance is the most important condition for that. Furthermore, proper management is necessary to achieve an optimum saving of energy.
Experience

The Netherlands

The Netherlands has been a pioneer in the development of geothermal energy systems. The first shallow storage systems were realised as early as in 1980s. The number and size of systems increased substantially in the 1990s, which is to be attributed to the reduction of propellants (CFCs, Montreal Protocol). The real market breakthrough has occurred since 2000, as a result of the Kyoto Protocol. At the moment, there are systems in every market segment and of every size (up to 3 MW). More than 1000 systems are operating in The Netherlands. This number is expected to increase to several thousands in a few years’ time.

Projects

Experiences - The Netherlands

TU Eindhoven, University campus. 30 MW, 2002

Overhoeks, Amsterdam, Shell Laboratory and 2000 flats, 15 MW, 2006-2015

European Headquarters of Nike, Hilversum, 1.000 kW, 1996
IKEA Mall, Duiven, 1.000 kW, 1996

Hotel Huis ter Duin, Noordwijk, 400 kW, 2000

ING Bank Head Office, Amsterdam, 1.500 kW, 2004
Experience - Belgium

Supported by Dutch know-how the technique of energy storage was also introduced in Belgium at the end of the 1990s. This decade, about ten more projects have been developed realised, in the commercial and industrial sectors in particular. The technology is expected to grow further in the years to come.

Experience - UK

The UK is an upcoming market for energy storage. In 2006 the first system was completed at Westway. On the basis of the strong sustainability ambitions of the British government, it is expected that about ten systems will have been realised by 2010.
Westway Housing, London, 1.000 kW, low temperature storage 2006

Experience - Norway

In 1995 the first large-scale underground energy storage system was designed in Norway. The limited availability of aquifers has meant that the number of open systems has also been limited.

Gardermoen Airport, Oslo, 10 MW, 1996

Experience - USA

Many ground coupled pumps are used in the USA. In 2005 the first open system with wells was developed. The main advantage compared with the closed system is that cooling can be provided directly, as a result of which energy economy increases substantially. Underground and climate are very suitable and form a good basis for a further growth of this technology.

Richard Stockton College, New Jersey, 1.000 kW, USA, 2008