The status of geothermal energy in the Netherlands

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Summary

The geological prospects for deep geothermal energy for direct use, e.g. for heating buildings, are favourable in the Netherlands. However, because the country has large reserves of natural gas and the price of energy is low, so far only one trial borehole has been drilled for a demonstration project, and it had a negative result. A demonstration project which is expected to become operational in 1997 is currently being prepared. Several more projects may be operational before 2010.

Using heat pumps powered by gas engines to exploit shallow geothermal energy did not get off the ground, partly because the amount of natural gas saved was disappointing and the maintenance costs were high. However, a new heat pump programme is currently being formulated, which is intended to achieve a saving of conventional energy of 5-10 PJ in 2000 and 50 PJ in 2010. The present use of geothermal energy is related to heat pumps and is thought to be approximately 2 MWth.

1. Introduction

The energy situation in the Netherlands is dominated by the presence and cheap production of the country's large reserves of natural gas. Natural gas is currently being extracted from the giant Groningen gas field and about 130 smaller fields on the mainland and offshore: it provides about 50% of the energy used by the nation. The export of natural gas is also appreciable: it is as large as national use. The proved reserves guarantee national gas supplies for several decades to come.

About 95% of Dutch homes are connected to the natural gas network. Furthermore, natural gas supplies energy to almost all the country's commercial greenhouses (about 10 000 ha). industrial complexes and commercial and government buildings. Extremely efficient low-priced boilers are used to produce heat from gas. District heating is hardly applied, also for the reasons mentioned above.

By comparison with many other countries, the Netherlands is in a comfortable position as far as conventional supplies of energy are concerned. Mutatis mutandis, in the Netherlands it is impossible or difficult to achieve what has proved feasible in other countries. This is especially the case for the introduction of unconventional techniques and sources of energy, such as geothermal energy and heat pumps. Prior to 1990. energy saving and the diversification of sources of energy were important goals of the Dutch government. but environmental goals were formulated less clearly. Little has come of the development of unconventional sources of energy in the Netherlands. partly because of the 1986 slump in oil prices which negated any progress made. The national energy policy was reformulated in 1990. this time with environmental issues playing an important role.

The situation as regards deep geothermal energy and the exploitation of shallow geothermal energy by heat pumps before and after 1990 is described below.

2. Deep geothermal energy

2.1 Activities up to 1990

In the Netherlands the first steps to explore the potential of geothermal energy were taken in 1974. the year after the first energy crisis. However, the first research programme was not started until 1979 - the year the European Community's first framework programme on geothermal energy ended. This first national research programme (1979-1984) included the following:

- an inventory of deep (1000-4000 m underground) aquifers suitable for geothermal energy:
- an inventory of aquifers less than 1000 m deep that are suitable for geothermal energy and the storage of heat (including residual heat):
- a study of the technical and economic feasibility of a demonstration project using geothermal heat from greater depths.

The inventory of the deep aquifers was carried out according to plan. Dutch research institutes contributed to the Atlas of Subsurface Temperatures in the European Community and the Atlas of Geothermal Resources in the European Community, Austria and Switzerland. produced under the aegis of the Commission of the European Communities. The inventory of shallow aquifers was also carried out in accordance with the programme. The feasibility study for the demonstration project originally focused on Spijkenisse. a village that has grown into a Rotterdam suburb. However. when the plans for implementing the geothermal project clashed with a plan to use waste heat from nearby refineries, a new location ("Delfland") was chosen in the Westland greenhouse area south of The Hague. The feasibility study for the Delfland project indicated that a geothermal doublet with a capacity of 200 m^3/h and a production temperature of 90 °C could be installed there. However. the project was not implemented. because of the relatively high costs associated with installing a geothermal plant. the falling energy prices in the mid-eighties and other problems. such as having to compensate the supplier of natural gas.

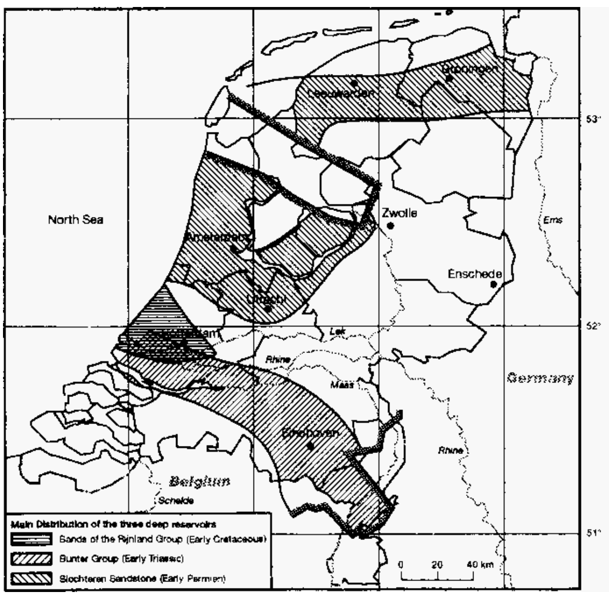
The research programme for the period 1985-1990 focused on the exploitation of geothermal energy from shallower depths (less than 1500 m) and the potential for storing heat and compressed air. In 1987 an experimental borehole was drilled to a depth of 1670 m at Asten in Noord-Brabant, in the context of this programme. The aquifers penetrated were found to be insufficiently permeable and therefore the projected demonstration project was shelved.

2.2 Potential

The inventory of the deep (1000-4000 m) subsurface made use of the seismic research done by various oil companies since World War II and the many hundreds of boreholes these companies had drilled. The findings of the inventory are summarized below.

Three aquifers under the Netherlands offer good prospects for the exploitation of geothermal energy (Milius et al., 1985):

- The Slochteren Sandstone. dating from the Lower Permian, in which the Groningen natural gas field lies. In much of central, nonh and west Netherlands, where this sandstone occurs, it consists of well-sorted fine-grained aeolian sands. It occurs at depths varying from less than 2000 m to more than 3500 m and attains a maximum thickness of 250 m. The reservoir properties vary geographically, and with depth and height in the profile. In Groningen province the mean porosity is 15-2070 and the permeability is 25-290 mD; in Noord-Holland province the equivalent values are 16% and 30-600 mD. The best prospects appear tu he in the centre of Noord-Holland: there the maximum temperature of the formation water is expected to be 110 "C.
- Triassic sandstone belonging to the Bunter Group. The most important occurrence is a strip in the south of the country. running northwest-southeast. The maximum thickness is about 700 m and the depth to the top of this aquifer ranges from 2000-3000 m. Few boreholes have been drilled in this area and therefore the porosity and permeability values are not well known. Permeability values of 300-400 mD have heen found in the west.
- Lower Cretaceous sands that occur throughout most of Zuid-Holland province and belong to the Vlieland Formation. Much information is availahle on the reservoir properties of these sands. thanks to the many operational oilfields. The Vlieland Formatinn consists of alternating sandstones and shales. The base is the Rijkswijk sandstune which is 30-50 m thick and has a porosity of 20-28%; the mean permeahility is 500 mD. Nearer the surface other sandstones occur, such as the Berkel sandstone which can attain a maximum thickness of 200 m. The permeability of this sandstone varies. heing 500-1000 mD in the most permeable zones. The depth of the Lower Cretaceous sands varies from about 750 m to ahout 2500 m. The maximum formation water temperature is expected to he 90 °C



The prospects for deep geothermal energy are good in one-third to half of the land area of the Netherlands.

3. Shallow geothermal energy

The first energy crisis in 1973 sparked interest in heat pumps in the Netherlands too. It was nevertheless clear that certain types of heat pump used successfully abroad for space heating did not stand a chance in the Nerherlands. because the Dutch need was for special heat pumps that would fit into the excellent natural gas infrastructure. Moreover. heat pumps driven hy gas engines were thought desirable.

Many projects became operational in the early eighties, thanks to the national heat pump programme. In 1986 almost 100 heat pump installations driven hy gas engines were operational, with a total thermal capacity of 45 MW (Visser. 1986). Of these installations, 61% extracted heat from the air and 39% from surface water. groundwater, the soil or the subsurface. Groundwater or the subsurface was chosen as a hrat source for the following projects, most of which were implemented hy Heat Pump Netherlands Ltd (Wormgoor & Menkveld. 1986; Knipscheer & Tummers. 1990).

		Type of heat pump	Capacity
Deventer	wells	gas engine	1500
Eindhoven	vert. heat exchangers	gas engine	YO
Gorinchem	wells	gas engine	360
Rotterdam	wells	gas engine	350
Vlaardingen	wells	gas engine	1000
Huizen	vert heat exchangers	elctrical	220

** Nominal thermal capacity of the heat pumps*

In these projects the heat pumps are operated in combination with hack-up boilers. Stand-alone electric heat pumps that obtain their hedt from groundwater or vertical heat exchangers were installed in ten individual homes.

The projects involving heat pumps driven by gas engines were implemented in such rapid succession that it was not possible to make use of the experience gained along the way. Consequently, many projects suffered from the same problems, and as a result the savings of natural gas were only 20-25% compared with gas-fuelled boilers, i.e. 55-60% of the anticipated saving. Furthermore. the maintenance costs turned out to he double what had heen expected. Fourteen of the 17 gas engine projects of Warmtepomp Nederland PLC functioned poorly. More than half were modified and worked satisfactorily thereafter (Stuij & Stene, 1994).

The capacity of gas-driven heat pumps currently in use on wells or vertical heat exchangers to heat houses cannot he estimated accurately. but is a maximum of 2-3 MW. Heat pumps are also used on a modest scale in industry. It is impossible to estimate the capacity of the installations based on groundwater or the subsuriace from the published daw; it is pmhahly negligible, because of the widespread use of waste heat.

4. Dutch policy on sustainable energy since 1990

In 1990, influenced by the rapid growth in environmental awareness. the Dutch government decided to give more encouragement tu saving energy and the use of sustainable energy. In the light of new findings on the carbon dioxide problem, it was proposed to stabilize the emissions of that gas in 1994-1995 at the 1990 level (Ministry of Economic Affairs, 1990). This requires a 2% saving of conventional energy per annum. equivalent to the savings achieved in the period 1973-1985 and double the savings in the years immediately prior to 1990.

A new target of 150 PJ to be supplied by sustainable sources of energy by 2310 was proposed: this is equivalent to 5% of national use in 1990. The relevant sources are anucipated to yield the following contributions:

	fossil fuel saved (in PJ)
wind energy	33
photovoltaic solar energy	2
thermal solar energy	5
geothermal heat (excl. heat pumps)	5
hydro-power	5
total production management and energy production from waste and biomass	100 +
Total	150

In the government policy document. geothermal energy is seen as an option for saving natural gas for heating greenhouses and homes. The option of using heat from total energy installations (Combined Heat and Power) and from waste incinneration for space heating is given higher priority. To realize the geothermal targets for the year 2010, ten geothermal projects using the doublet well concept are anticipated between 2000 and 2010. According to the policy document two demonstration projects will have to be implemented before the year 2000, in order to acquire the necessary experience.

In a supplementary policy document issued in 1993 (Ministry of Economic Affairs. 1993), the geothermal targets have been adjusted downwards: it is anticipated that 2 PJ of fossil fuel will be saved in 2010. This policy document also *slates* that the first geothermal project, at De Lier. is expected to be operational in 1997.

The energy policy documents mentioned above accord an imponant rule in energy saving to heat pumps that bring amhicnt heat to a usahle temperature. The 1993 policy document sets a target of a 5-10 PJ saving of primary energy to he achieved in the year 2000 by the use of hcat pumps. A further growth in savings to a maximum of 50 PJ in 2010 is deemed feasible.

It is expected that heat pumps will be applied primarily in the following sectors:

- horticulture and commercial and industrial building
- homes. possibly via district heating
- industry, in the context of process integration and the use of residual heat.

A heat pump programme is currently being formulated and the organizational measures necessary to ensure its success are being ascertained. The part that will he played by the subsurface in supplying ambient heat to the heat pumps that are to be installed cannot therefore he indicated yet.

5. De Lier demonstration project

In 1993 a feasibility study commissioned by Westland Utility Company. the largest distributer of natural gas in the Netherlands. was carried out for a demonstration project near De Lier in the Westland area. The feasibility study focused on the Rijswijk and Berkel sandstones of Lower Cretaceous age.

The occurrence of these sandstone strata and their reservoir properties are known. thanks to the activities of the oil industry. Oil has been extracted from the Lower Cretaceous sands in a dozen fields in Zuid-Holland province since the fifties: in some fields production has now ceased. hecause the reserves have become exhausted. Several hundred boreholes have been drilled for exploration and production purposes. and a 3-D seismic study was conducted recently. Extensive experience has been obtained with the reinjection of the co-produced water: this stared about 30 years ago.

At the De Lier site the top of the geothermal reservoir is at a depth of about 2200 m: the transmissivity calculated from geophysical well logs and measurements of porosity and permeability performed on rock cores is about 30 Dm (Darcy metres). The water to be abstracted has a temperature of about 87°C and will be used to heat about 15 ha of greenhouses and to pre-heat natural gas in a decompression station. Geothermal heat will be used to meet base demand: the extant gas boilers in the greenhouses which remain needed (e.g. fur the production of carbon dioxide). will be used to meet the peak demand. It is expected that the well douhlet will be drilled in 1995 and the geothermal plant will become operational in 1996 or 1997.

6. Conclusion

Geologically. the prospects are good for deep geothermal energy for direct use. Nevertheless, it is unlikely that deep geathermal energy will be used to a substantial degree until some time in the twenty-first century, hecausc of the availability of Dutch natural gas and the low energy prices. However. some demonstration projects will probably be implemented before 2000. The De Lier project is at an advanced stage of preparation and may be operational in 1997. Thanks to the application of heat pumps. the use of shallow geothermal heat will probably increase more rapidly. Policy targets are currently being incorporated into a concrete plan of operation which is not yet available and therefore it is impossible to indicate the amount of geothermal heat that will be obtained in this manner.

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