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The Netherlands Country Update on Geothermal Energy

E. Victor van Heekeren, Marc Koenders

Stichting Platform Geothermie, Jan van Nassaustraat 81, 2596 BR Den Haag, The Netherlands, Telephone : +31 703244043

E-mail : info@geothermie.nl and Web: www.geothermie.nl

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ABSTRACT

Dutch interest and activities in deep geothermal energy – essentially non-existent 5 years ago - increased dramatically in recent years, while the market penetration of shallow geothermal applications showed very healthy growth numbers.

Geology. Aquifers that are developed and/or investigated for heating purposes occur at depths of a few meters to roughly 4.000 m in Permian, Lower Triassic and Lower Cretaceous sandstones and in Tertiary sand units. Less is known of deeper layers, but interest is growing to investigate and exploit the geothermal potential – including the electricity producing potential - of layers > 4.000 meter. The temperature gradients are fairly normal at values slightly over 30^0C per kilometer with a starting value of 10^0C at surface level.

State of development. In the Netherlands, the use of the shallow underground for extraction and storage of thermal energy started in the early 80-ties. The development was fast – as in the Netherlands aquifers can be found almost everywhere. Market penetration is expected to reach 1200 Heat&Cold storage installations end of 2009 and 25.000 GSHP's.

In recent years the first three deep geothermal wells were drilled and went on-stream. Drilling activities are ongoing or foreseen for 2010 on at least two more locations. The number of licence applications for deep drillings increased to > 40 – mostly for aquifers in the range of 1500 – 3500 meter. In the meantime the interest in deeper layers is steadily increasing.

Dutch government policy nowadays takes account of (deep) geothermal but there are yet serious flaws and shortcomings in the Dutch legal framework. The Dutch Platform for Geothermal Energy was established end of 2002 and saw a rise in participants from 6 to > 50 organisations.

1. GEOTHERMAL ENERGY IN THE NETHERLANDS - INTRODUCTION

As a typical oil&gas country The Netherlands interest in geothermal developed later than in some other countries. Early initiatives towards the implementation of deep geothermal (> 1500 meters) in the period 1975 -1985 were not successful and the activities were abandoned at the end of this period. Competition with the incredibly refined natural gas infrastructure and the – relatively – low gas prices was simply not perceived as feasible.

A different picture emerged in the second half of the 80-ties when demand for cold simulated shallow geothermal applications : heat & cold storage (H&CS) in larger offices and similar buildings. The sedimentary geology of the Netherlands proved to be very suitable for these shallow H&CS applications and the rate of implementation increased spectacularly – even with fairly modest government support. The H&CS concept is nowadays the standard for larger utility buildings.

A far more modest increase – in terms of overall capacity - was seen in the field of small Ground Source Heat Pumps for individual houses – again the result of the natural gas infrastructure & modest gas prices.

At the initiative of Novem (nowadays SenterNovem), the Dutch Agency for Energy and Environment, a Platform for deep geothermal energy was established at the end of 2002. The Stichting (Foundation) Platform Geothermie (SPG) is formed by key players in the field of geothermal energy in The Netherlands. The SPG Platform is open to all organisations – both commercial and non-profit – and in fact includes the relevant science community, local & regional authorities, energy companies and a wide variety of industry & services. The SPG objective is to stimulate the development of geothermal activities in The Netherlands and to disseminate know how in this field. A Platform bureau was established to form a focal point both for questions from market actors and government organisations.

SPG stimulated and assisted various feasibility studies and comparable development activities. SPG kept a fairly low profile up to the moment that the first deep geothermal well was actually producing. Public and market interest increased spectacularly after the publication of the first results and geothermal nowadays is 'hot' in the Netherlands.

The current situation in The Netherlands is

- a very modest use of hot water for balneology (hot water baths or thermal baths)
- an established and developing market for Ground Source Heat Pumps
- a huge and still growing presence of seasonal Heat & Cold Storage applications
- two (deep) geothermal energy plants utilised for heating (total capacity 10 – 12 MWth and one set of 5 intermediate depth geothermal wells for heat & cold supply[1]. In addition there are > 40 applications for exploration licenses for deep geothermal wells, which may - or may not - materialise in projects in coming years.

[1] Minewater project Heerlen at depths of 300 to 800 meters, legally a deep project (>500 meter) but no 'direct use' source temperatures

This country update will deal with the new initiatives for deep geothermal energy as well as the emerging market for shallower depth geothermal energy. The situation with respect to balneology is unchanged and the contributions are expected to remain modest.

2. GROUND SOURCE HEAT PUMPS

2.1 General

In first instance, the objective was to store solar energy for space heating in winter. Later on, the scope of application broadened to the storage of thermal energy (both heat and cold) from other sources than solar and to geothermal heat pumps. Because of the fact that in the 80-ties the R&D efforts were focused on larger scale applications (utility building applications rather than individual houses), almost all early projects are using groundwater wells to store and extract thermal energy. In the late 90-ties, borehole heat exchangers started to play a more important role in geothermal heat pump applications.

2.2 Geothermal heat pump applications

By the end of 2009, most of the geothermal heat pump projects are using vertical borehole heat exchangers. Over 10.000 of this type of geothermal projects are now in operation, mainly for small scale applications like single family houses and small size office buildings and commercial buildings. In the housing sector, most of the heat pumps are used for heating only purposes. In the utility building sector, however, the geothermal heat pumps are applied for both heating and cooling in most situations, using the underground both as a heat source and a heat sink.

The situation with respect to geothermal heat pump projects using groundwater is somewhat different. The number of applications for individual houses is very limited. The small scale applications are found in office buildings and commercial buildings. The heat pump capacity is in the range 50 - 100 kW_{th}, limiting the groundwater flow rate to 10 m³/h. Up to this groundwater flow rate, no groundwater permit is required for the project. Comparable with the application of borehole heat exchangers for small scale buildings, the underground (aquifer) is used for both heat extraction and heat re-injection. Because of the limited groundwater flow rate involved, many aquifers allow for a single well to abstract and inject the groundwater. In this situation, the well has two screened zones on top of each other. About 200 projects of this kind have been realised in the Netherlands.

The most important application, not by number but by annual thermal energy flows, are the medium to large scale projects applying geothermal heat pumps combined with groundwater wells. The considerable success of this technique in the Netherlands can first of all be attributed to the fact that most of the subsurface is highly suitable for energy storage, also on a large scale. Usable aquifers can be found almost everywhere in the Netherlands. In the Amsterdam region it is even possible to extract and infiltrate over 250 m3/h (2000 kW_{th}) with only one well. By the end of 2009, about 1200 projects of this type were in operation. The typical heat pump capacity for these projects is about 1000 kW_{th}. The heating capacity provided by heat pumps ranges between 200 kW_{th} and 20.000 kW_{th} for these projects. Most of the applications are found in the field of office buildings and commercial buildings. Due to the involvements of energy utilities, offering their clients heating and cooling, an increasing number of applications is found in the areas of building parks, industrial zones, green houses and housing developments, which are equipped with a district heating and cooling system. The 20.000 kW_{th} project mentioned before, relates to a University Campus with a district heating and cooling system, supplying cooling and low temperature heat for the heat pumps to the buildings on the campus site.

A common characteristic of the medium to large scale geothermal heat pump projects is the application of direct groundwater cooling. The heat pump is using the groundwater as a low temperature heat source, thus lowering the temperature in the aquifer to 5 - 7ºC in wintertime. This low temperature groundwater is extracted in summertime and used for direct cooling of the building, i.e. without running the heat pump in chiller mode or running the heat pump in chiller mode at cooling peak load conditions only. Using groundwater for a medium to large scale geothermal heat pump project, will require a groundwater permit. One of the most important requirements to obtain a groundwater permit, is that the amounts of thermal energy extracted from and recharged to the aquifer will balance each other over a longer period of time (several years). This requirement is aiming at a sustainable groundwater use and can be met by allowing for flexibility in the operation of the geothermal heat pump system.

Because of the huge growth of systems using groundwater wells, clearer regulations for the use of the subsurface are required. Currently the first come, first served principle applies. The consequence is a high risk of negative interference between different systems, which causes lower thermal performance. For that reason local authorities are increasingly taking the lead in subsoil spatial planning to ensure that the baselines are defined in subsoil master plans. At this moment about ten of these master plans have been made in the Netherlands.

3. GEOTHERMAL ENERGY FROM DEEPER LAYERS (DIRECT USE & ELECTRICITY)

3.1 Potential

The theoretical potential for deep geothermal energy (direct use) in The Netherlands is substantial. There are some important aquifers to be found in The Netherlands – at depths which are common to normal oil and gas producing operations. TNO roughly estimated the direct use potential at approximately 90.000 PetaJoule HIP (Heat In Place) in some major target formations in Permian, Lower Triassic and Lower Cretaceous sandstones and in two Tertiary sand units[i]. Even at very modest utilisation levels, this technical potential is very substantial. And this estimate ignores the yet unknown potential of the deeper layers, which will be investigated in coming years. Interest in the potential of the production of electricity is increasing and this will require the analysis of the deeper formations, which are – regretfully - largely ignored by the oil & gas industry.

Various scenario's have been developed to estimate the medium term development (2020) of deep geothermal in the Netherlands. The current SPG forecast indicates a level of 3 PetaJoule (roughly 30 installations) in the year 2020. This may prove to be conservative against the background of the current level of requests for exploration licences. However, the rate of development is very dependent on both government policies and fossil fuel prices.

Apart from these factors – government policy and fossil fuel prices – the main constraint for the development of deep geothermal is the geological risk. The geological risks involved with the implementation of a geothermal project are believed to be modest – but not to be neglected - and are mainly related to the permeability of the aquifers (influencing the volumes of water produced). The risk of low or zero water production is estimated to be normally less than 5% - if the geological conditions of the aquifer are well known - as usually is the case in the Netherlands.

Also some developments occurred, which may affect the application potential. The most important change is the revision of the Mining Act. The crucial difference is that all drilling and seismic data become public domain after five years. This implies that vast information resources on the geological conditions in practically all Dutch regions are accessible for users.

Other changes are more on the technical level. An external development is the general trend in building and construction towards the use of lower temperature ranges for heating (e.g. floor heating) in new or renovated buildings. This allows the use of lower temperature ranges of the geothermal source, which in its turn increases the potential of suitable geothermal aquifers (including aquifers at lesser depths).

The perception is consequently that these developments may substantially contribute to the economics and application potential of geothermal projects. The experience in Germany and France – with comparable geological conditions in some regions – is a relevant example for the Netherlands. The German and French examples have shown, that a substantial contribution from geothermal energy can be expected, given the right legal framework (including comparable incentive levels - a level playing field - to other forms of sustainable energy).

3.2 Constraints

The current situation in The Netherlands is that until now only few (deep) geothermal energy have been developed – and those only for heating. When analysing the reasons of the late start, various causes and aspects become apparent. Geothermal projects are relatively complex in the sense that a variety of disciplines are needed for successful implementation. Fossil energy based systems are quicker and easier to install. But this aspect is also true for various other forms of sustainable/renewable energy. So this should not necessarily discriminate against geothermal activities.

Another point raised in the discussions is that early action is required. At the early stages of decision forming on energy supply steps must be made to keep the option of a sustainable alternative open. For instance the costs of a geothermal project can be drastically lower (partly compensated) in those applications where no natural gas infrastructure is yet installed. If the natural gas infrastructure is installed in every building/greenhouse etc., all costs for geothermal energy are additional costs. The same goes for the heating system in buildings. Once the choice for low temperature heating in buildings is made, the option for geothermal heating is kept open and made easier, without preventing other forms of energy sources (including heat pumps). Though not particularly difficult, this requires a positive or at least open mind of the owner/developer of the building, the municipality or other key actors involved. Though nobody will deny the complexity of these processes it must again be concluded that the same goes for other forms of low temperature – e.g. ground source heat pumps, waste heat et cetera.

The size of a geothermal installation has implications for its scope of application. The capacity of a deep geothermal doublet, being usually in the range of > 3,5 MWth, requires a demand for heat which is equivalent to 1000 houses or more. These numbers are obviously subjected to type and size of the houses (old/new, stand alone/flats, small/large et cetera) but nevertheless they give an indication of the minimum size of the demand. As water should not be transported over too long distances (too costly), this implies that the application potential is focused on sizeable urban development projects (residential buildings), district heating grids and greenhouses.

A typical Dutch constraint is the generally rather low prices for natural gas. Natural gas prices may well increase in coming years, whereas the costs of geothermal energy, once installed and running, are practically negligible. It might be argued that geothermal energy shares this problem with other forms of renewable energy. However, there is a difference here. Financial instruments are in place for practically all forms of renewable energy. A very important instrument is the financial incentive (SDE grant for feed-in tariffs) on green electricity produced in the Netherlands. This greatly encourages renewable energy based electricity production. Geothermal electricity (or heat) is *not actually excluded* in the scheme, but the SDE scheme operates with calls for proposals and geothermal has not yet been included in any call. A similar condition exists in the field of incentives for green and/or sustainable heat for buildings. Alternatives involving micro-cogeneration or heat pumps in existing buildings qualify for grants, but there is no equivalent grant for deep geothermal energy for housing projects. This implies that for most forms of deep geothermal there is no level playing field compared to other renewable/sustainable options. So even in spite of the advantages of near zero nuisance levels, geothermal energy tends to lose the financial competition with options such as wind, biomass and cogeneration. Calculations indicate, that, given the same support (per house or ton of avoided CO_2), geothermal energy development would see drastic improvement. The case is supported by the horticultural market development for deep geothermal in the Netherlands. In the horticultural environment, geothermal receives identical benefits to other sustainable options. The market reaction has been spectacular: > 90% of the current exploration licence applications are aimed at greenhouses and the first two deep geothermal wells supply heat to greenhouses. A similar development was seen in Germany. Once the German government instated the new feed-in tariffs for geothermal electricity, the event fired a stream of new projects.

3.3 Key issues to be addressed

Nowadays an increasing awareness of the advantages of geothermal energy is evident. In articles and meetings it is pointed out that also for the Dutch scene geothermal energy could offer a clean source of energy with practically no emissions of carbon dioxides and a nearly complete lack of other emissions either to air, water and land (no waste production). The noise levels are negligible and there is no creation of visual nuisance. Important from the demand point of view: it is easy to control and regulate in terms of capacity and without too many limiting outside factors. The production obviously depends on the permeability of the aquifer, but within its site specific range the volumes can be controlled and regulated and the capacity is totally independent of any seasonal fluctuation, weather conditions, etcetera.

Therefore, the promotion of a level playing field for geothermal energy incentives (compared to other forms of renewable energy) is an important issue to be addressed.

Further analysis of the financial aspects is desired and the results should be published and used in discussions with the Dutch Government authorities.

Another lesson from the German scene is the need for strong and continued public relations. Without support from political powers and the public opinion, the chances of broader market deployment are modest. The role of the German association (Geothermische Vereinigung) has been crucial for the dissemination of information on the benefits of geothermal technology to decision makers and the public at large. Continuous lobbying at all levels, from local to supranational, has to be done to ensure the political backing of geothermal energy use. The current success in Germany could not be imagined without the perseverance of the Geothermische Vereiniging in lobbying over more than decades.

In general terms it can safely be assumed that the development of geothermal energy can only be successful in an environment with a solid legal framework. The term legal framework in this context includes all the relevant national or regional regulations, be it in the domain of permits, access to data, administrative (governmental or regional) costs, taxes & levies, incentives and/or organisational structures. SPG has actively participated in a European consortium of geothermal stakeholders – supported by the EU Altener/IEE programme – to identify the key elements of a sound legal framework[ii] in the GTR-H project. One of the SPG deliverables of this project was the 'Dutch Country Report Legal Framework & Geothermal Policy Issues'[iii], intended both as input for less regulated countries as well as an analysis of strong and weak points in the Dutch legal framework.

On a process/organisational level, and consistent with the GTR-H findings, the key issue for SPG is to establish a task force or national committee to identify constraints for the development of deep geothermal. This group of stakeholders from government and the geothermal community should formulate the required actions and policies to address the unnecessary constraints and the development of deep geothermal.

On a more technical level some issues and solutions have already been identified. A crucial step forward was the formulation in 2008-2009 of a guarantee scheme to cover the geological risk involved with the implementation of geothermal wells. At the time of the drafting of this country update the guarantee scheme is ready for publication – but seriously delayed by EU State Aid procedures.

Also it became apparent that the very sophisticated Dutch Mining Act – developed for oil & gas – needs some adaptations to streamline the procedure for geothermal applications.

Ongoing tasks for the Dutch Platform for geothermal energy are:

- To analyse the financial position of geothermal projects (heat and/or electricity) in comparison with other forms of renewable energy;
- To provide information on the benefits of geothermal energy to decision makers and the public at large;
- To promote the creation of a level playing field of financial instruments for green heat and electricity;
- To bring together consortia of actors around potential geothermal projects.

The second decade of this century will be dedicated to these priorities. It is envisaged that at least 30 large deep geothermal projects will be developed in the Netherlands in this period – in addition to the already strong development of shallow geothermal.

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[i] A. Lokhorst & Th. E. Wong, Geology in The Netherlands – Geothermal Energy section, 2007 (http://www.geothermie.nl/img/images_inline.php?id=120">).

[ii] GTR-H project (Geothermal Regulations – Heat), IEE/Altener project EIE/06/007/S12.442647, 2006 – 2009, web site www.gtrh.eu)

[iii] E.V. van Heekeren, Dutch Country Report Legal Framework & Geothermal Policy Issues, 2008 (http://www.geothermie.nl/img/images_inline.php?id=180">).

Attached : Tables (IGA/WGC2010 numbering and format)

TABLE 3. UTILIZATION OF GEOTHERMAL ENERGY FOR DIRECT HEAT AS OF 31 DECEMBER 2009 (other than heat pumps)

1) I = Industrial process heat; H = Individual space heating (other than heat pumps)
C = Air conditioning (cooling); D = District heating (other than heat pumps)
A = Agricultural drying (grain, fruit, vegetables); B = Bathing and swimming (including balneology)
F = Fish farming; G = Greenhouse and soil heating
K = Animal farming; O = Other (please specify by footnote)
S = Snow melting

2) Enthalpy information is given only if there is steam or two-phase flow

3) Capacity (MWt) = Max. flow rate (kg/s)[inlet temp. (°C) - outlet temp. (°C)] x 0.004184 (MW = 10^6 W)
or = Max. flow rate (kg/s)[inlet enthalpy (kJ/kg) - outlet enthalpy (kJ/kg)] x 0.001

4) Energy use (TJ/yr) = Ave. flow rate (kg/s) x [inlet temp. (°C) - outlet temp. (°C)] x 0.1319 (TJ = 10^{12} J)
or = Ave. flow rate (kg/s) x [inlet enthalpy (kJ/kg) - outlet enthalpy (kJ/kg)] x 0.03154

5) Capacity factor = [Annual Energy Use (TJ/yr)/Capacity (MWt)] x 0.03171
Note: the capacity factor must be less than or equal to 1.00 and is usually less, since projects do not operate at 100% of capacity all year.

Note: please report all numbers to three significant figures.

Locality	Type[1]	Maximum Utilization					Capacity[3]	Annual Utilization			
		Flow Rate	Temperature (°C)		Enthalpy[2] (kJ/kg)			Ave. Flow	Energy[4]	Capacity	
		(kg/s)	Inlet	Outlet	Inlet	Outlet	(MWt)	(kg/s)	(TJ/yr)	Factor[5]	notes
Bleiswijk	G	44	60	30			5,52	26	102,9	0,591	operational since end 2007
Lansingerland	G	50	52	30			4,60	30	87,1	0,600	drilled 1st and 2nd quarter '09 and on stream 4th quarter '09?
Den Haag	D	41	74	40			5,83	20	89,7	0,488	in development phase and on stream > December '09
											production volumes estimated on full year basis
											(shaded) = educated guess / estimate
TOTAL		135					15,96	76	279,6	0,556	

TABLE 4. GEOTHERMAL (GROUND-SOURCE) HEAT PUMPS AS OF 31 DECEMBER 2009

This table should report thermal energy used (i.e. energy removed from the ground or water) and report separately heat rejected to the ground or water in the cooling mode. Cooling energy numbers will be used to calculate carbon offsets.

1) Report the average ground temperature for ground-coupled units or average well water or lake water temperature for water-source heat pumps
2) Report type of installation as follows: V = vertical ground coupled (TJ = 10^{12} J)
H = horizontal ground coupled
W = water source (well or lake water)
O = others (please describe)
3) Report the COP = (output thermal energy/input energy of compressor) for your climate
4) Report the equivalent full load operating hours per year, or = capacity factor x 8760
5) Thermal energy (TJ/yr) = flow rate in loop (kg/s) x [(inlet temp. (°C) - outlet temp. (°C)] x 0.1319
or = rated output energy (kJ/hr) x [(COP - 1)/COP] x equivalent full load hours/yr

Note: please report all numbers to three significant figures

Locality	Ground or water temp. (°C)[1]	Typical Heat Pump Rating or Capacity (kW)	Number of Units	Type[2]	COP[3]	Heating Equivalent Full Load Hr/Year[4]	Thermal Energy Used (TJ/yr)	Cooling Energy (TJ/yr)
Netherlands	11	1006	1212	W	40	3000	1028	1028
Netherlands (see note 1)	9	7	25000	V	100	2250	25	10
TOTAL								

Note 1 : estimate, no data registered

TABLE 5. SUMMARY TABLE OF GEOTHERMAL DIRECT HEAT USES AS OF 31 DECEMBER 2009

1) Installed Capacity (thermal power) (MWt) = Max. flow rate (kg/s) x [inlet temp. (°C) - outlet temp. (°C)] x 0.004184
or = Max. flow rate (kg/s) x [inlet enthalpy (kJ/kg) - outlet enthalpy (kJ/kg)] x 0.001

2) Annual Energy Use (TJ/yr) = Ave. flow rate (kg/s) x [inlet temp. (°C) - outlet temp. (°C)] x 0.1319 (TJ = 10^{12} J)
or = Ave. flow rate (kg/s) x [inlet enthalpy (kJ/kg) - outlet enthalpy (kJ/kg) x 0.03154

3) Capacity Factor = [Annual Energy Use (TJ/yr)/Capacity (MWt)] x 0.03171 (MW = 10^6 W)
Note: the capacity factor must be less than or equal to 1.00 and is usually less, since projects do not operate at 100% capacity all year

Note: please report all numbers to three significant figures.

Use	Installed Capacity[1] (MWt)	Annual Energy Use[2] (TJ/yr = 10^{12} J/yr)	Capacity Factor[3]
Individual Space Heating[4]			
District Heating [4]	5,83 *	89,7	0,488
Air Conditioning (Cooling)			
Greenhouse Heating	10,13	189,9	0,595
Fish Farming			
Animal Farming			
Agricultural Drying[5]			
Industrial Process Heat[6]			
Snow Melting			
Bathing and Swimming[7]			
Other Uses (specify)			
Subtotal	16,0	279,6	0,556
Geothermal Heat Pumps			
TOTAL			

* start up delayed to 2010

4) Other than heat pumps
5) Includes drying or dehydration of grains, fruits and vegetables
6) Excludes agricultural drying and dehydration
7) Includes balneology

TABLE 7. ALLOCATION OF PROFESSIONAL PERSONNEL TO GEOTHERMAL ACTIVITIES (Restricted to personnel with University degrees)

(1) Government
(2) Public Utilities
(3) Universities
(4) Paid Foreign Consultants
(5) Contributed Through Foreign Aid Programs
(6) Private Industry

Year	Professional Person-Years of Effort					
	(1)	(2)	(3)	(4)	(5)	(6)
2005	80	8	0	0	0	122
2006	120	16	1	0	0	160
2007	151	30	2	0	0	210
2008	182	60	4	0	0	255
2009	204	90	9	0	0	310
Total	737	204	16	0	0	1057

TABLE 8. TOTAL INVESTMENTS IN GEOTHERMAL IN (2009) US$

Period	Research & Development Incl. Surface Explor. & Exploration Drilling	Field Development Including Production Drilling & Surface Equipment	Utilization		Funding Type	
			Direct	Electrical	Private	Public
	Million US$	Million US$	Million US$	Million US$	%	%
1995-1999	0	0	0			
2000-2004	0,3	0	0,3	0	40	60
2005-2009	4,5	30	34,5	0	92	8