The Netherlands Country Update on Geothermal Energy

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ABSTRACT
Background and review of status quo of geothermal energy development in the Netherlands. Market penetration of both deep and shallow geothermal energy. Analysis of past and current policy developments. Expected effects on medium term potential.

1. INTRODUCTION - SETTING AND HISTORY

In the Netherlands geothermal energy emerged later than in some other countries. Major natural gas reserves were discovered in the Netherlands during the middle of the previous century. And as the temperature gradient in the Dutch subsoil is roughly 31 °C per km, the production of geothermal energy was not competitive with the relatively low gas prices and the sophisticated Dutch natural gas distribution infrastructure. In the wake of the oil crises of the 70ties interest in local and/or renewable energy sources rose – as it did in many places around the world and especially in surrounding countries as France and Germany.

In the Netherlands, the first use of geothermal energy thus started in the early 80ties with shallow geothermal applications. In first instance, the objective was cooling & seasonal storage of the energy for space heating in winter. Because of the facts that in the 80ties the R&D efforts were focused on larger scale applications (building applications such as offices rather than individual houses), and that in the Netherlands shallow aquifers can be found almost everywhere, many new utility buildings started using groundwater wells to store and extract thermal energy.

The first attempt to develop deep geothermal energy in the period 1980 – 2000 was basically both unsuccessful and costly, an unfortunate combination. An exploration drilling in the early 80ties to 1.600 meter in Asten, province of Noord-Brabant was chosen as the test case for the feasibility of deep geothermal energy. The choice of the location was encouraged by the support of some 40 horticulturists who could use the heat in their greenhouses. Some geological advice – warnings – were ignored and the end of the story was, that the test well produced only a few cubic meter per hour of water. The second drilling in Asten was cancelled.

It was (correctly) assumed that a second attempt to demonstrate the feasibility of deep geothermal energy really had to be failure proof, as the funding organisations were not amused by the Asten experience. Consequently the whole setup of the second attempt near Naaldwijk in the province of Zuid-Holland in the 90ties was exceptionally thorough – with corresponding huge costs estimates. For this very reason – the high cost levels - this second project was rejected by the ministry of Economic Affairs in the predevelopment stage. All in all some 20 mlr. euro was spent in 1975 – 2000 with remarkably few results. Gas and oil prices at the end of the century were low and showed no trend of increases that could make geothermal (or any other form of renewable energy) profitable. It should be recognized that CO2 emissions were not perceived to be as important as they are today. The government attitude in respect to the renewed geothermal interest in the early years of this century was therefore justifiably chilly.

At the beginning of this century the setting started to change. Heat & Cold Storage (H&CS) applications and the rate of implementation increased spectacularly – even with fairly modest government support. H&CS developed into the regular norm for the energy management of new offices and became competitive without government incentives. Gas prices were rising sharply in these years and public interest in low CO2 energy options increased – driven by climate concerns.

These factors encouraged renewed interest also in deep geothermal energy. A Platform for deep geothermal energy was established at the end of 2002. The Stichting (Foundation) Platform Geothermie (SPG) is composed of most Dutch players in the field of geothermal – both commercial and non-profit – and 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 deep geothermal activities in the Netherlands and to disseminate know how in this field. This renewed interest in the beginning of this century led to the implementation of the first deep projects, mostly for the heat demand of greenhouses.

At the end of 2013 the geothermal development is still in a fairly early development phase – though Heat& Cold Storage can safely be called a mature technology. In 2013 roughly 3.000 H&C systems supplied 830 GWh (3.000.000 GigaJoule) and the 9 deep geothermal plants supplied 268 GWh of heat (960.000 GigaJoule). In 2014 four new deep geothermal doublets were in the process of drilling, testing and/or starting up production. So it can be safely assumed that the production volumes of deep geothermal will increase in coming years.

In both categories – shallow and deep – the production volumes represent an increase of roughly 25% compared to the 2012 data (Source: Central Bureau of Statistics (CBS), the Netherlands). These numbers are to some extend remarkable as the overall use of green energy in the Netherlands showed a decline in 2013 (compared to 2012).

Section 2 deals with Shallow Geothermal Energy (Heat & Cold Storage) and Section 3 describes the developments in the domain of deep geothermal activities (Direct Use applications).
2. SHALLOW GEOTHERMAL

Shallow Geothermal energy (SGE) in the Netherlands goes back to 1985. Starting as a new technology to store solar heat it’s nowadays the most dominant technology for cooling and (low) heating for utility buildings.

Prevalent in underground thermal energy storage are open systems (groundwater wells, called Aquifer Thermal Energy Storage, (ATES)), while closed-loop systems (Borehole Thermal energy Storage (BTES)) can mainly be found in ground source heat pump plants. Typical temperature ranges for storing energy are between 7 – 17 °C. Heating is done in combination with heat pumps.

Table 1 shows the number of registered ATES systems in the last five years (2008-2013). It is expected that in 2015 there will be 3500 ATES systems which together pump more than 300 million m³ each year and save up to 3 PJ (Table 2). The number of boreholes for BTES is estimated (not registered) at 50.000 with a growth of 5.000 each year. This number also does not say anything about the number of systems, because one system can have more than one borehole.

Table 1: Development of Aquifer Thermal Energy Storage projects.

Table 2: Development of energy savings (in TJ) by shallow geothermal energy applications; source: CBS, 2014, Renewable energy in the Netherlands.

The size of the ATES systems in the Netherlands varies a lot. The smallest systems are in the order of a few cubic meters per hour. The largest running system is the one of the Technical University of Eindhoven (Figure 1) which has a capacity of 3.000 m³ per hour and 12 million m³ per year.

The size of the closed-loop systems varies from one single loop for one house up to more than 1.000 loops for a complete residential area (Schoenmakers-hoek in Etten-Leur has 1.200 houses with 1 loop per house and some utility buildings).

The main selling point for shallow geothermal energy is that it’s one of the very few sustainable energy technologies with is economical profitable without subsidies. Average pay-back times range from 3 till 6 years. Furthermore it’s proven technology with a track record of over 25 years.

In 2013 a National Energy treaty was signed between the national government, NGO’s, branch organizations and unions. This treaty set a goal for 16 % sustainable energy in 2023. Storing energy was defined as a very important link in the energy transition. The target for 2023 is to deliver 15 PJ of heating and cooling with underground storage technique resulting in a growth to more than 20.000 systems. This growth will set a strong focus on underground spatial planning mainly in city centers.

In busy areas so-called SGE master plans are made. By means of a master plan it is possible to arrange small or large scale areas for the implementation of SGE systems (figure 2). Through organizing the utilization of the subsurface, interference between systems can be prevented and an optimal use of the subsurface can be guaranteed.
3. DEEP GEOTHERMAL

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 (a national research institute) 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 some Tertiary sand units (Lokhorst, Wong, 2007, ref. 1). This potential is continuously updated – under a TNO contract for the ministry of Economic Affairs. Even at very modest utilization levels, this technical potential is very substantial. And this estimate ignores the yet unknown potential of the deeper layers, which may 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 have – regretfully but understandably – been largely ignored by the oil & gas industry.

3.2 Data Infrastructure

The data density of layers up to 3.000 or 4.000 meter depth is unusually good (thanks to oil and gas E&P). Also – not to be underestimated – the access to these data sets is regulated by law. The Dutch Mining Act dictates, that all E&P data of all deep mining activities migrate to the public domain after 5 years. Public access is ensured by government sponsored data storage (through www.NLOG.nl). And again thanks to the considerable Dutch subsoil activities of the oil & gas industry there is an extensive knowledge infrastructure in universities, knowledge institutes and a wide variety of commercial entities active in industrial services and advice.
3.3 Energy Demand

Total energy demand in the Netherlands is roughly 4,000 PJ per year. Geothermal energy in the Netherlands targets the + 350 PJ (± 100,000 GWh) per year, that is consumed in the form of low temperature energy for houses and greenhouses - practically all in the form of natural gas. Approximately one third of this low exergy demand is used in greenhouses. The remaining two-thirds is used for heating of households. The demand of horticultural enterprises is a particularly attractive market for Direct Use geothermal systems as there is usually a high energy demand in a concentrated geographic area (greenhouses are usually clustered in regions). Also energy is an important component of the cost structure of horticultural products. The variation between crops is huge, but for some products the energy costs are 25% of the sales price of the horticultural products.

So even if the temperature gradients in the Dutch subsoil are not outstanding compared to some other regions, some of the surface conditions are particularly supportive for deep geothermal energy.

3.4 Market Development

The first ‘deep’ geothermal project (Minewater project in Heerlen, Limburg, 2007) targeted the lukewarm water in mineshafts of a former coal mine. This Minewater project resembled in many aspects the ‘normal’ ATES (Aquifer Thermal Energy Storage) system. The legal difference was the depth of the wells. Some of these old mineshafts were at depths of 700 meter. In legal terms (i.e. the Mining Act) deep geothermal is defined by depths of > 500 meter. This was therefore the first deep geothermal project in legal terms.

Figure 3: Minewater project Heerlen (2008); the first Mining Act license for geothermal energy.

After this stepping stone project the first Direct Use application was drilled in Bleiswijk in 2007/2008 by a tomato grower for heating 7 hectare of greenhouses – later extended to 14 hectare. This horticultural project created wide interest. But the announcement of a second doublet at the end of 2008 – by the same investor – really drove the message home in horticultural circles, that this option should perhaps not be ignored. Applications for exploration increased rapidly to > 60 in 2010 mostly in the domain of horticultural applications. After 2010 the number of license applications slowed down (see Table 3). This was mainly caused by the discovery that the geothermal wells often co-produced a small percentage of dissolved methane – in the order of 0.1% of the weight of the geothermal fluids. At reduced surface pressures the dissolved methane occasionally reaches the bubble point and the well and surface installations need therefore to be able to deal with free gas. The licensing conditions became more stringent and are – since 2010 – very much comparable to oil & gas standards. The technical response to the methane content is often to separate the gasses from the geothermal fluids and to utilize the energy content in gas heaters or cogeneration equipment. The second method is to keep the geothermal fluids under sufficient pressure – higher than the bubble point pressure - to ensure that the gasses remain in dissolved state and the fluids are re-injected without gas separation. This choice is made on an individual basis depending mostly on the local percentage of methane.

Table 3: Development of deep geothermal license applications in the Netherlands.
The period 2009 up to 2014 witnessed the emergence of several new projects bringing the total number of deep geothermal installations to 13 (of which 4 were in the process of start-up). All wells except the first Minewater project are Direct Use applications. The temperatures of the current deep wells vary between 60 °C (1,600 meter) and 87 °C (2,900 meter). The well temperatures confirm the expected average temperature gradient of 3,1 °C per 100 meter. Production volumes vary roughly between 100 and 200 m³ per hour. All wells - except the Minewater project - are aquifer based systems and the only product is heat (no cooling or electricity). On the web site of Platform Geothermie there is a map (ref 2) of all projects including some technical information (temperatures, production volumes, depth).

Characteristic for the Dutch situation is that the overwhelming application is horticulture. Six projects are owned and operated by individual horticultural companies, five wells are operated by a joint venture between several neighbouring horticultural firms and two were started by the municipality or a joint venture between the municipality and energy companies. Some horticultural operators supply heat to buildings as well (or are planning to do so in the future). This greenhouse application has been a major factor for the fast development of deep geothermal in the Netherlands.

Table 4: Development of deep geothermal installations in the Netherlands.

<table>
<thead>
<tr>
<th>Year</th>
<th>Number of Deep Wells</th>
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</thead>
<tbody>
<tr>
<td>2008</td>
<td>1</td>
</tr>
<tr>
<td>2009</td>
<td>2</td>
</tr>
<tr>
<td>2010</td>
<td>3</td>
</tr>
<tr>
<td>2011</td>
<td>4</td>
</tr>
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<td>2012</td>
<td>5</td>
</tr>
<tr>
<td>2013</td>
<td>6</td>
</tr>
<tr>
<td>2014</td>
<td>14</td>
</tr>
</tbody>
</table>

Table 5: Capacity development of deep geothermal installations in the Netherlands.

<table>
<thead>
<tr>
<th>Year</th>
<th>Capacity in MWth</th>
</tr>
</thead>
<tbody>
<tr>
<td>2009</td>
<td>0</td>
</tr>
<tr>
<td>2010</td>
<td>10</td>
</tr>
<tr>
<td>2011</td>
<td>20</td>
</tr>
<tr>
<td>2012</td>
<td>30</td>
</tr>
<tr>
<td>2013</td>
<td>40</td>
</tr>
</tbody>
</table>

2013 was not particularly productive. Some of the existing wells faced interruptions and downtime for repairs and new wells needed a longer drilling and completion period. In wells, especially those targeting the Slochteren formation, some NORM / LSA materials were detected (Naturally Occurring Radioactive Materials / Low Specific Activity) and procedures to deal with these materials had to be implemented. In 2014 some recently drilled wells are starting up and the expected production in 2014 is approximately 1,600 TJ (445 GWh) – resuming the earlier vigorous development of production (see Table 6).

Table 6: Development of deep geothermal energy production in the Netherlands. 2014 production values based on estimates made July 2014.

<table>
<thead>
<tr>
<th>Year</th>
<th>Production in TJ/yr</th>
</tr>
</thead>
<tbody>
<tr>
<td>2009</td>
<td>200</td>
</tr>
<tr>
<td>2010</td>
<td>400</td>
</tr>
<tr>
<td>2011</td>
<td>800</td>
</tr>
<tr>
<td>2012</td>
<td>1,200</td>
</tr>
<tr>
<td>2013</td>
<td>1,600</td>
</tr>
<tr>
<td>2014</td>
<td>1,600</td>
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</table>
3.5 Policy Development

In the beginning of this century the Dutch legal framework for deep geothermal had to be build up from scratch. The only existing elements were the existing Mining Act and the sub-soil data infrastructure. Both were developed for oil & gas, but proved to be a good starting point for geothermal licensing and environmental permit conditions. The Geothermal Platform suggested three major policy issues: a national vision and/or roadmap for development of deep geothermal energy, a guarantee scheme for geological risks and a level playing field with other renewable energy options in term of incentives.

In 2007 a governmental risk guarantee scheme was developed to insure the geological risk of insufficient production volumes. Although the scheme was – and still is - inadequate in some respects, it was nevertheless crucial for the financing of the early projects.

A second major step was the publication of the ‘National Action Plan for Geothermal Energy’ (2011, Ref 3). Though perhaps not visionary, the document was a solid analysis of the strengths and weaknesses and included an analysis of the potential that could be achieved in 2020. This potential was estimated (in 2011) to be 11 – 14 PJ per year in 2020 (≈ 3.300 to 3.900 GWh of heat).

The third milestone was the inclusion in 2012 of sustainable heat in the Feed In Tariff programme (SDE+) that already existed for other forms of renewable energy. The incentive for geothermal heat amounts to 5 to 7 euro per GJ (1.5 to 2 eurocent per kWh of heat). Over 30 applications were submitted in the first year (2012). In that year some 830 mln euro – approximately half of the Dutch budget for renewable energy – was allocated to deep geothermal projects. This level of applications and budget allocation was exceptional. The influx was caused by the fact, that 2012 was the first year that geothermal projects could apply for this Feed In Tariff programme. In 2013 the intake was reduced to 16 geothermal submissions and the expectations are that in 2014 and later the number of new applications may be anywhere near five to ten per year.

The implications are that the Dutch government policies have certainly contributed to an emerging new renewable energy source.

On the other hand it has also become also quite clear, that the 2011 Action Plan target for 11 to 14 PJ of (deep) geothermal heat in 2020 is not realistic. This would require a yearly growth of 45% in the period 2014 – 2020. This is regrettable as it is now fairly widely recognised that geothermal heat is one of the least expensive forms of renewable energy in the Dutch context. Therefore the Dutch authorities announced in 2014 the ‘Versnellingsplan aardwarmte glastuinbouw’ (Acceleration Plan Geothermal Energy in Horticulture (ref. 4). The new target is 5 PJ of deep geothermal heat per year (≈ 1,400 GWh heat per year). Lower than the previous 11-14 PJ target, fixed in 2011, but probably more realistic. The new target is based on a yearly crop of 4 to 5 new geothermal plants, whereas in recent years the growth rate has been two deep wells per year. The ministry proposes to achieve the acceleration by a combination of efforts and improvements in three domains, where policy shortcomings were identified:

- Knowledge development and dissemination – including an additional yearly budget of 500.000 euro for studies;
- Addressing the financing constraints – including improvements in the Feed-in Tariff programme and new financing mechanisms;
- Reducing the risk exposure by improving and extending the budget of the Guarantee scheme.

It is too early to assess the effects of these measures on future production levels but the new target of 5 PJ appears to be achievable.

4. CONCLUDING REMARKS

The five years since the last WGC witnessed an increase in both shallow and deep geothermal energy. In the relatively mature market environment of shallow geothermal (ATES) applications, the 2009 – 2014 growth amounted to roughly 1.300 TJ (360 GWh thermal energy). And in the newer domain of deep geothermal, the production increased in this period approximately 1.100 TJ (300 GWh thermal energy). Compared to Dutch market demand for low temperature heat these values are still relatively modest. Nevertheless geothermal energy is one of the fastest rising sources of renewable energy in the Netherlands.

REFERENCES

Map of Dutch deep geothermal installations and description of deep geothermal projects (Dutch language), http://geothermie.nl/geothermie/projecten/.