Warm Beneath the Wind,
Geothermal Holland

by Susan Fox Hodgson
cosmos@dcn.org

Kingdom of the Netherlands

Population: 16,947,904
Total area: 16,040 square miles
Topography: The land is flat with an average elevation of 37 feet above sea level. Much of the land is reclaimed and protected by about 1,500 miles of dikes.
Chief crops: grains, potatoes, sugar beets, fruits, vegetables
Industries: agro industries, metal & engineering products, electrical machinery & equipment, chemicals
Electrical production: 94.9 billion kWh
Wind electrical generation at the end of 2014: 2,805 MW (+4.2%)

The Greenhouses

Thinking about geothermal Holland, I always recall the two piles of white feathers—swans, as it turned out—hunkered down and eating their way through a lush, green plot of alfalfa almost in the middle of the country. In another hour I, too, would be feasting—but on sweet strawberries picked from the rows of plants thriving in a nearby geothermally heated greenhouse. This greenhouse and four others in the rural town of IJsseluiden—plus the geothermal hot water system warming them—were what I’d come to see.

Aardwarmte means “geothermal” in Dutch and the project is called Aardwarmtepject Koekoekspolder (“The Koekoekspolder Geothermal Project”). To any non-Dutch speaker, the words may look unfamiliar, but the geothermal system speaks for itself.

So how does it work? Everything begins at the production well where the hot waters of 72°C are extracted from a reservoir and piped into a small building located nearby. Here all the particles are filtered out. The hot reservoir waters now are passed through a heat exchanger and their heat is absorbed by the surface waters filling the closed-loop pipeline set throughout the property. The pipeline network is 2.2 km long and buried about 1 to 1½ meters deep.

The numbers in superscript refer to the list of Selected References & Comments at the end of the article.
On reaching 72˚C, the pipeline waters are pumped from the heat exchanger to two greenhouses with cucumbers and one with tomatoes. After a time when the water temperatures have dropped to 37˚C, the waters are moved on to one greenhouse with strawberries and one with biological vegetable seeds (both crops need less heat). When the water temperatures fall to 20˚C, the waters are sent back to the hot water plant near the production well and passed again through the heat exchanger—absorbing the heat from reservoir waters until reaching 72˚C.

Throughout the process, all the cooled reservoir waters are disposed of in an injection well drilled about 1.5 km away. Dual-well systems like these are called doublets. The company would like to connect more greenhouses to the system by 2017. On hot days, greenhouse operators request less heat and on cold nights they need more. “Actually every client asks for different amounts of heat,” said Greenhouse Geo Power Project Director, Radboud Vorage. “When Holland has a very cold winter—every 10 to 20 years, the greenhouses use a backup natural gas system for running the pumps circulating the reservoir waters.

“Our company could buy green electricity from the grid—like wind, solar, Norwegian hydro, and biomass, but green electricity is more expensive and naturally the charges would be passed to the greenhouse owners. Because their customers are not yet willing to pay a higher price for greenhouse produce with a very low carbon footprint, we’ve stopped using green electricity for now. In total, the greenhouse owners pay 10 to 20 percent less for the geothermal heat than they would for heat from natural gas.

“With geothermal energy, our prices are levelized over long periods of time,” he said. “Our main variable is the cost of electricity, and wind and solar projects strongly influence this price. Our project provides heat for 23 hectares of greenhouses, an amount equivalent to the heat demanded for 3,000 homes.”
It was time to see the heat in action. From the hot water plant, we drove a kilometer or so to a 17,000 square meter geothermal greenhouse filled with strawberries and an adjoining, strawberry-themed gift shop. The company, called Kalter Aardbeien, is owned and operated by Richard and Annet Kalter, a young couple who know the business well. When Richard’s father began growing strawberries years ago, he first heated his strawberry greenhouses with coal, then fuel oil, then natural gas—and now his son uses geothermal energy. Richard and Annet moved their strawberry greenhouse to its current location in IJsselmuiden because new housing projects were encroaching on their prior site. Richard is proud to report that in 2014 they needed no natural gas to help run the strawberry greenhouse, that geothermal did the trick.

Of their three annual strawberry crops, the one sold in March is widely anticipated throughout Holland. Strawberries are a sign of spring and people willingly pay top dollar for the baskets of fresh fruit. Richard and Annet do not use sprays on their strawberries for reasons including the health of the greenhouse bees (see below). They offer their customers tours of the greenhouse and explain the geothermal heating system to them.

To top off my visit, I ate a strawberry—and then a few more. The pale, orange-red color and the softer outer skins are different from what I’m used to, but so is the exquisite taste. What variety is it? *Elsanta*, which is always the best, Annet said with a smile.

**Venlo Greenhouse Project**

Greenhouse Geo Power is assisting three greenhouse growers to develop a new geothermal project close to the town of Venlo in southeastern Holland, near the German border. A German company, KCA Deutag, is drilling the production and the injection wells to a depth of 2500 meters with a T-49 Bentec drilling rig. The wells penetrate the faulted and fractured, Lower Carboniferous (Mississippian) limestones of the Kohlenkalk Formation.

The production well was completed and tested in January 2016. It penetrates the productive Tegelen fault and yields about 350 m$^3$/hour of hot waters measuring 79°C. The waters will produce about 15 MW of heat, enough for growing 40 hectares of greenhouse vegetables. The project will reduce CO$_2$ emissions by 10 million kg a year compared to greenhouses heated by natural gas—plus offer the growers a sustainable future.

**The Reservoir**

The reservoir is the crux of a geothermal project. In Holland, about one third of the produced geothermal waters come from the Permian Rotliegend Sandstones of the Slochteren
Formation beneath Noord-Holland, Overijssel, Friesland, Drenthe, and Groningen—including the project in IJsselmuiden. The Rotliegend Sandstone depths vary from 2000 to 4500 meters; the gross sand thickness ranges from 10 to 200 meters; the porosity ranges from 11 to 25 percent; the permeability is from 30 to 600 millidarcies; and the maximum temperature is over 100°C.\textsuperscript{8,10} The geothermal gradient in Holland is 31°C to 34°C per kilometer.\textsuperscript{10}

To heat the five geothermal greenhouses in IJsselmuiden, hot waters are produced from a portion of the Rotliegend Sandstones measuring 100 meters thick. The hot water aquifer is 1850 to 1950 meters deep here, and the project wells are drilled to depths of about 1950 meters.\textsuperscript{18}

**Hydrocarbons**

Most of the natural gas produced in Holland comes from the same Rotliegend Sandstones—the gas has migrated into the sandstones from the Carboniferous coal deposits lying beneath.\textsuperscript{2, 4, 5, 17} For this reason, the Rotliegend Sandstones are a well-studied and mapped geological interval.\textsuperscript{10, 17} “The data density is usually good for strata reaching 3,000 to 4,000 meters deep.”\textsuperscript{15}

“Public access to these data sets is regulated by law. The Dutch Mining Act states all exploration and production data for all deep mining activities (including extensive seismic surveys\textsuperscript{10}) must move to the public domain after five years. The data are transported to government-sponsored storage sites. Public access to the data helps to reduce project risk.”\textsuperscript{15}

Scientists confirm the clastic aquifers explored and produced by the hydrocarbon industry are used today for heating greenhouses. They write, “The geothermal doublet systems have encountered associated gas and oil. . .Because of the small hydrocarbon quantities, these have, up to now, been considered as a concern rather than a benefit to a the geothermal project. . .[But] a clear synergy is possible for hydrocarbon and geothermal exploration if exploration wells can be used in a ‘double play’ concept.”\textsuperscript{16}

“Through a simple example [included in our paper], we have demonstrated quantitatively the benefit of the ‘double play’ in monetary risk and reward for an exploration project. Furthermore, we have evaluated the potential effects of synergy for a synthetic portfolio of gas prospects in the Netherlands. It has been shown the potential benefits are considerable and may lead to about 7.5 BCM in additional natural gas production and in the order of 10 additional geothermal doublets developed.”\textsuperscript{16}

“Despite the excellent data density and all of the detailed geological-reservoir models, the newly-drilled geothermal production wells in the Rotliegend Sandstones [still] may have flow rates lower than predicted. . .[For this reason] the existing depositional models need to be refined and detailed to better predict areas with high net-reservoir thickness by avoiding areas with abundant, anhydrite-cemented areas. A refined model will help to optimize well placement.”\textsuperscript{17}

**History**

“In the Netherlands, the first uses of geothermal energy began with shallow geothermal applications in the early 1980s. . .Many new utility buildings began using groundwater wells to store and extract thermal energy. The first attempt to develop deep geothermal energy in the period 1980 to 2000 was basically unsuccessful and costly. . .[Around 2000] heat and cold storage applications and the rate of implementation increased spectacularly, even with fairly modest governmental support. This application became the norm for energy management in new offices and became competitive without governmental incentives. Gas prices were rising sharply in these years and public interest in low carbon dioxide energy options increased, driven by climate concerns. . .These factors encouraged renewed interest in deep geothermal energy.”\textsuperscript{15}

“In 2013, roughly 3,000 heat and cold storage systems in Holland supplied 3,000,000 gigajoules and the 9 deep geothermal plants supplied about 960,000 gigajoules. In 2014, four new, deep geothermal doublets were in the process of drilling, testing, and/or starting production.”\textsuperscript{15}

“A substantial, theoretical potential for direct-use geothermal projects exists in the Netherlands at depths that are common to normal oil and gas operations. TNO, the Dutch national research
institute, roughly estimates the direct-use potential at about 820,000 petajoules (heat-in-place) in some of the major, target formations; “...the estimate ignores the yet unknown potential of the deeper layers that may be investigated in the coming years.”

**Regulation & Policy**

In the beginning the existing guides developed for oil and gas production, like the *Dutch Mining Act* and the subsoil data infrastructure, proved good starting points for geothermal regulations and policies. Interpretations of these guidelines left room enough to help geothermal develop at the speed it did. However by 2000, it was clear that some specific geothermal guidelines were needed, as well. In 2011, the Dutch Ministry of Economic Affairs published a *National Action Plan for Geothermal Energy*.3,15

What steps do various Dutch agencies require for each geothermal project? First a *Quickscan*, geothermal potential-site evaluation is requested. Next come the application for an exploration license; site-specific research using software and an explanatory manual, titled *DoubletCalc 1.4*, to efficiently calculate the geothermal-power range; an application, if desired, for monies from the *Geothermal Guarantee Fund* and from exploitation subsidy schemes; a drilling plan for the *State Supervision on Mines*; drilling and testing the first well (production or injection); drilling and testing the second well (production or injection); application for a production license; and finally, project operation.12

The *DoubletCalc* software guidelines are available in Dutch and English. The reservoir parameters include uncertainty ranges and subsequent calculations for the expected amounts of geothermal power—based, of course, on the assessment.10

Operators drilling wells below 500 meters must, by mining law, prepare and file all of the necessary documents and give the *State Supervision on Mines* scientific supporting documents. In every oil and gas project, the Dutch State is a 40 percent participant, determining on behalf of its own self-interest if an oil and gas project is economically viable. With geothermal projects, there is no state participation; however, the government still requires an operator to submit solid exploration plans. When a geothermal production license is requested, exact boundaries for heat extraction must be defined.10

To stimulate the development of geothermal energy, the Dutch Government has instigated schemes for 1) *geothermal investment*, 2) *guarantee/insurance*, and 3) *exploitation subsidy*.12
“The geothermal investment subsidy was granted for proposed, innovative-energy concepts in the horticultural sector—the application of geothermal energy for heating greenhouses is one such innovative investment.”

“The Geothermal Guarantee Fund is an insurance scheme focused on geological risk: the underperformance of a doublet with respect to the pre-drill P90 geothermal power estimate due to disappointing aquifer characteristics. [P90 means a 90 percent certainty exists for a given amount of geothermal fluid to be produced]. . . . Operators can apply for fund monies with a request and supporting documents, including a geothermal evaluation and geothermal-power calculations. The fund helps to cover the geological risks and encourage banks to finance the project.”

“The exploitation subsidy (SDE+) is a scheme to level the difference between conventional heat costs and the costs of produced geothermal heat.” The plan adds geothermal sustainable heat to the feed-in-tariff program already in place for other forms of renewable energy, including wind and solar. A feed-in premium subsidy is provided to cover the difference between the wholesale market price of electricity and the cost price of electricity from renewable sources. Contracts are signed for 15 year periods.

“The support schemes have attracted a relatively large number of applications and can be regarded as successful instruments for the development of geothermal energy.” “The incentive for sustainable, geothermal heat amounts to €5 to €7 per GJ. . . . Over 30 applications were submitted in the first year (2012) when some €830 million—about half of the Dutch budget for renewable energy—was allocated to deep geothermal projects. This level of application and budget allocation was exceptional.” In 2013, there were 13 applications; in 2014 about 4 applications; in 2015 about 6 applications; and in 2016, 12 applications are expected.

What about the pace of geothermal development? Thanks to several greenhouse owners, by November 2015 Holland had 12 geothermal projects and a 13th was being formalized. Even so, “. . . . it has become quite clear that the 2011 Action Plan target for 11 to 14 PJ of deep geothermal heat in the year 2020 is not realistic. . . . In 2014, the Dutch authorities announced the Geothermal Energy Acceleration Plan in Horticulture (‘Versnellingsplan Aardwarmte Glastuinbouw’). The new target is 5 PJ of deep geothermal heat per year. . . . based on the yearly construction of 4 to 5 new geothermal plants (doublets). . . . Compared to the 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.”

Besides geothermal greenhouse projects, other geothermal projects in Holland include a district heating project completed for office and residential areas in Heerlen, located in the southeastern end of the country. The hot waters for the project fill the horizontal passageways of some abandoned mines in the area. The waters are 1 to 2 kilometers deep, and the temperatures range from 30˚C to 50˚C. Heat can be stored here in the summer and extracted in the winter. In the early 2000s, a geothermal district heating and cooling project was underway in The Hague, but the project was ended during the financial crisis of 2008.

Where is the Dutch geothermal program headed? “Today we are looking at deeper targets,” Harmen Mijnlieff said. “The temperatures we use now are all below 100˚C, but the process industries, like dairies, factories, and paper mills, need higher temperatures. Thus we have to drill deeper. At such depths the sediments often change—the permeability becomes much lower and we may need to stimulate the wells. We have to drill to depths of 5 kilometers to find the proper temperature ranges. This is our challenge in the next 10 years.”

About TNO Mr. Mijnlieff works as a Senior Geologist in geothermal development for the Geological Survey of the Netherlands and the Advisory Group for Economic Affairs. Both of these agencies fall under TNO, the Netherlands Organization for Applied Scientific Research, an umbrella organization partially funded by the Dutch Government. Contact Mr. Mijnlieff at: harmen.mijnlieff@tno.nl.
Dutch Geothermal Assoc.  

The Dutch Geothermal Association, also known as (“Stichting Platform Geothermie” or SPG), was created in 2002. Today, about 80 members work to develop geothermal energy in The Netherlands.

The members include governmental organizations (provinces, regions, and municipalities), educational institutions, and a wide variety of companies. The companies supply products and services—both technical and financial/organizational, and include energy companies and a growing group of the owners of future geothermal installations (both license holders and applicants) connected with the Dutch Ministry of Economic Affairs and the State Supervision of Mines. The SPG has an affiliation agreement with the International Geothermal Association and is an association member of the European Geothermal Energy Council.

The SPG Chairman of the Board is Frank Schoof, who resides in Delft. When asked for a short summary of geothermal development in Holland, he said, “Geothermal energy in The Netherlands is developing rapidly. Nowadays the main focus is on heating greenhouses; but, in the near future an expansion is foreseen in district heating and industry. The demand for green energy is the driving force. Both the steep learning curve from the past and the research and standardization plans of today optimally position the industry for growth.” Contact Dr. Schoof at: frank.schoof@geothermie.nl.

Acknowledgments

Many thanks to Huubert and Elly Van Lier, Radboud Vorage, and Harmen Mijnlieff for their kind help.

Selected References & Comments


14. TNO, 2013. For two excellent geothermal websites, Google: www.nlog.nl/nl/geothermalEnergy/geothermalEnergy.html & www.thermogis.nl/thermogis_en.html. The first site offers an overview of geothermal in Holland, including publications; an online literature reference base; and explanations of regulations, incentives, permits, data, online tools, plus national & international institutions, partnerships, and projects. The second site offers a public, web-based information system, called ThermoGIS, providing depth, thickness, porosity, and permeability maps for many potential aquifers in The Netherlands. Users can assess generated power, expected flow rate, coefficient of performance, and economic variables for specific locations and economic variables.


The GRC Bulletin

The premier geothermal energy magazine

The Geothermal Resources Council (GRC) Bulletin is a periodic publication (6 issues per year) that reaches the association’s worldwide membership and paid subscribers. Current circulation is 1,200.

The GRC Bulletin provides a technology and issues forum for professionals involved in geothermal resource research, exploration, development and utilization. The GRC Bulletin also provides news and information that highlights the environmental and economic benefits of geothermal resource development.

Keep up-to-date with news from the global geothermal community by becoming a member of the GRC and receive your GRC Bulletin free, or subscribe for six issues a year.

Annual Subscription rates are:

Domestic - $90
International - $140 (includes additional cost to cover postage)

Back issues are available for $10 per issue.