Geothermal Energy Use, Country Update for The Netherlands

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ABSTRACT

This article deals with the Dutch developments and policies in the domain of geothermal energy. This article is an update of the article from 2016 (Bakema & Schoof, 2016) and gives the developments in the period 2016-2018. There are currently 18 DGE projects, with an approximate total capacity of 221 MW_{th}. The amount of SGE systems has also continued to increase. In 2018 2.368 ATES and 54.846 GHPS systems were in operation

1. INTRODUCTION

This article deals with the Dutch developments, status quo and policies in the domain of geothermal energy. It includes deep geothermal energy (DGE) and shallow geothermal (SGE) (including underground storage (UTES) and ground source heat pumps (GHPS)). Section 2 of this article deals with the status 2018, i.e. the actual figures for geothermal installations. Section 3 briefly presents the history and policy backgrounds, while Section 4 attempts to forecast some developments. Each section will discuss the developments for direct use geothermal and shallow geothermal in separate subsections.

2. STATUS 2018

2.1 Status Direct Use Geothermal

Projects. In 2018, 20 geothermal projects were completed and 18 projects operational (See figure 1). Additionally, 7 projects are under construction and 13 projects are under development and working on a financial closure. Two projects in the province of Limburg have been shut down as a precaution by the State Supervision of Mines. All Dutch operational projects produce heat for the greenhouse horticultural sector. There is an increasing interest in DGE in the built environment, but there are still political, financial, and social barriers that prevent these projects from developing.

Capacity. In 2018 the combined capacity of Dutch installations grew to a total capacity of around 3PJ of sustainable heat or 200 MW_{th}. Most projects are operational between 2,000 and 3,000 metres deep. The average year capacity of a doublet is around 180.000 GJ with an estimated CO2-reduction of 10.000 tons per year. The share of renewable energy was 6.6% of

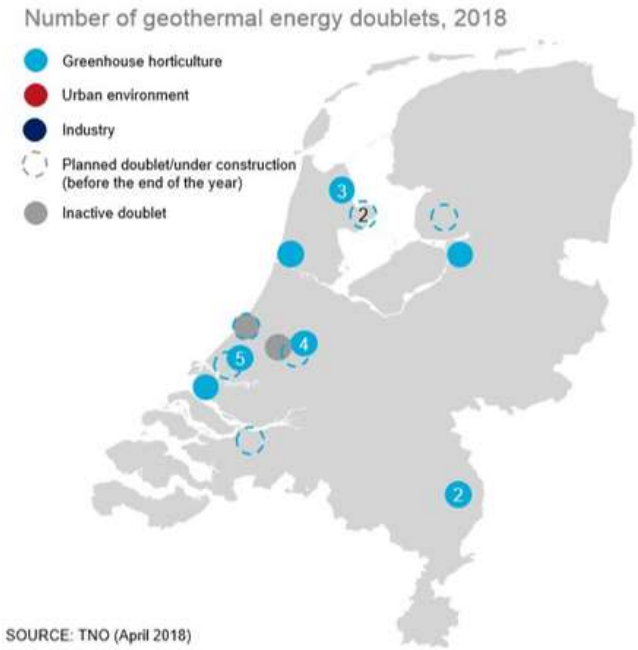


Figure 1: Locations of the present DGE installations.

the total energy consumption in 2017. DGE and SGE together have a 5.15% share in the renewable mix.

2.2 Status Shallow Geothermal energy

Shallow geothermal energy consists of Ground Source Heat Pumps (GSHP) and Underground Thermal Energy Storage (UTES). GSHP systems are focused on only heat or cold abstraction from the soil and energy supply to buildings, while UTES is designed as a seasonal heat and cold storage and works likes a battery. The thermal efficiency is normally higher compared to GSHPs. Prevalent in underground thermal energy storage systems are open systems which uses groundwater wells to store heat and cold. This technology is called Aquifer Thermal Energy Storage (ATES). The closed version is called Borehole Thermal Energy Storage (BTES) and makes use of borehole loops to exchange heat and cold from the soil. Typical

temperature ranges for storing energy are between 7 and 17 ºC. The lower temperature can be used for direct cooling, the higher abstraction temperature will be used by heat pumps to increase the temperature to 45 ºC to be used for heating purposes.

Figure 2 shows the number of registered ATES systems in the last ten years (2008-2017). It is expected that the growth in ATES systems will continue due to contribution of these systems to climate goals, but also because it is an economically attractive alternative to traditional heating and cooling techniques.

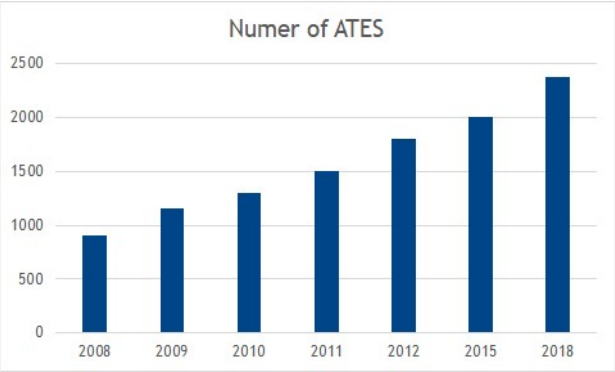


Figure 2. Development of Aquifer Thermal Energy Storage projects.

In the beginning of 2018, an unexpected revolution took place in the Netherlands. The public opinion towards natural gas changed due to the increase of resulting earthquakes in the province of Groningen. Moving away from natural gas is the new point of view. This has given rise to new market opportunities in the geothermal market. UTES systems are regarded as a suitable alternative for gas-fueled boilers.

There is also a growing interest for high temperature storage (HTS) and hydro thermal energy (HTE). High temperature storage is a storage technique, comparable with ATES, but the storage temperature varies from 30 to 90 ºC. High temperature storage is suitable in locations with an excess of heat or an expected high demand for heat. It is increasingly seen as a possibility for residential or horticultural areas.. However, the legal framework is still undefined and most of the running projects were started as a full scale demo to investigate the impact of high temperatures on aquifers. Dutch participation in the European Heatstore project will help to develop technical improvements in the high temperature storage technique and to develop a proper legal framework.

Hydro thermal energy is a solution which uses the heat capacity of water in rivers and lakes. The large water volumes allow enormous amounts of heat to be extracted from the water body with only a small decrease in overall water temperature. Since many Dutch cities are situated close to rivers or lakes, hydro thermal energy has a great potential in the Dutch energy transition.

In order to stimulate the energy transition, some municipalities initiated experimental development in residential areas, creating living labs. Hydro thermal energy has been applied in Drimmelen in the city of Katwijk and ATES in residential areas in Wageningen and Zoetermeer. It is expected that more initiatives will appear in the coming years.

3. POLICY DEVELOPMENT 2015-2018

3.1 Policy Development Direct Use Geothermal

The main trends in energy policy in recent years were a) the growing concern for subsidence caused by natural gas production in the northern parts of the country, b) the highly likely unachievable Agreement on Energy for Sustainable Growth (2013) with the objective that The Netherlands reaches 14% share of renewable energy in the total energy consumption in 2020 and 16% in 2023, c) the Paris Climate Agreement (2015) and the Dutch commitment to a 49% reduction of greenhouse gas emissions in 2030 than in 1990. A national discussion on how to achieve the renewable energy targets started. The geothermal sector is represented in the negotiations between government, industry and civil society on how to reach this goal, especially for heating. The negotiations are ongoing. One point of discussion is that renewable heat is still a relatively unexplored domain, wherein both DGE and SGE can play an important role, but also need the infrastructure to transport the heat to a future user. This has major financial and judicial consequences for the Dutch energy system and its customers.

The main policy instrument for deep geothermal in The Netherlands remains the SDE+ (Stimulering Duurzame Energie, a Feed-in-premium instrument). The SDE+ conditions gradually improved in recent years, both in terms of the contribution per kWh and in terms of scope of the regulation (to include triplets and ‘dual play’ wells - gas and geothermal) (Netherlands Enterprise Agency, 2018).

With respect to the policy instrument of government guarantee on drilling risks, the budget was extended and some technical improvements were introduced.

The policy instruments certainly encouraged increases in capacity and production levels of new plants. However, the main goal was to increase the number of new projects from roughly two doublets per year to five. These efforts were frustrated by financing difficulties and slow permitting.

The public-private partnership for knowledge development, called ‘Knowledge Agenda’ ended after a four year period. The partnership assigned (small scale) contracts for consulting and research actions. Results are always in the public domain. The agenda was co-funded by the horticultural sector. Geothermal energy, both DGE and SGE, play an important role in the reduction of CO_2 emissions in this sector. A successor of the Knowledge Agenda, funded by the

ministry of Economic Affairs, is in the making. The budget is under discussion (Kas als energiebron, 2018).

There are several Green Deals, mutual agreements between companies, civil society organisation and government focussed on stimulating sustainable innovation, for geothermal energy. In the case of 'Ultra Deep Geothermal Energy', the focus lies on exploration and subsurface modelling of geothermal activities deeper than four kilometres with the possibility of future pilot projects. Another example is 'Participation of the environment in sustainable energy projects' and 'Development decentralised sustainable heat and cold techniques' (Green deals, 2018).

The Dutch government has commissioned a comprehensive seismic survey 'SCAN' to map the subsurface extensively in order to identify the areas with great geothermal potential. The survey will start in 2019 (EBN, 2018).

The geothermal sector made a statement in 2018 by publishing the 'Master Plan geothermal energy in the Netherlands', a collaboration of sectoral partners and government on the future developments and ambitions of geothermal energy in The Netherlands. The ambition is for geothermal energy to meet 5% of the total energy demand for heat in 2030 and 23% in 2050. The ambitions are set at 50 PJ in 2030 and 200 PJ in 2050.

The report also describes the implications on the required legislation, innovation, FTE, above-ground space required and number of buildings connected to a district heating grid (See figure 2) (DAGO, SPG et al., 2018).

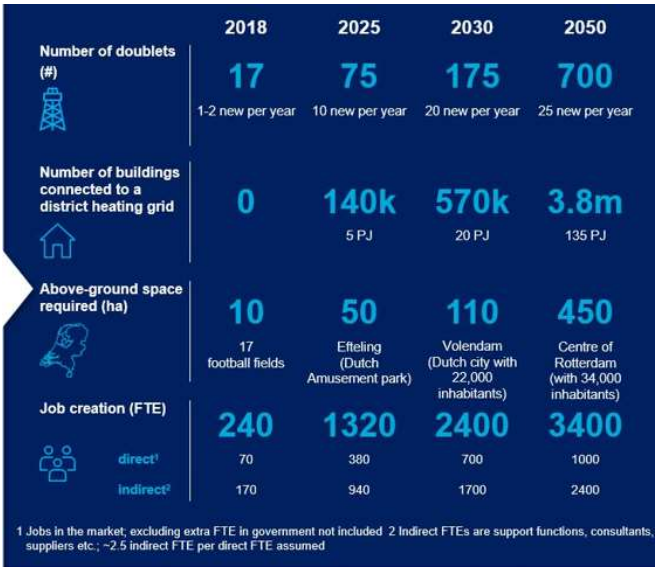
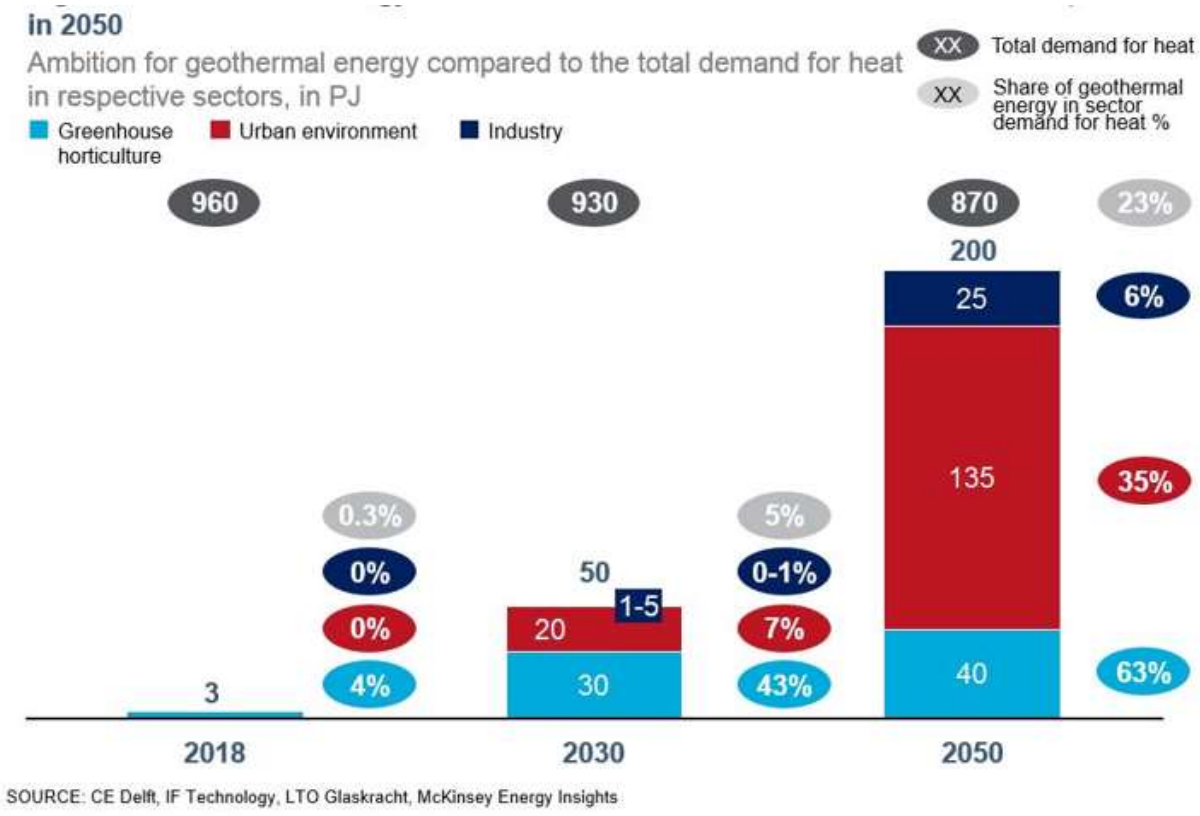


Figure 3: Ambitions for geothermal energy as stated in the 'Master Plan geothermal energy in the Netherlands'.



3.2 Policy Developments Shallow Geothermal energy 2015-2018

SGE is economically very feasible for the utility sector and besides some tax advantage has no subsidiaries. To promote SGE in the housing sector, a new subsidy for heat pumps was introduced in 2016. The support starts at € 2.800 up to 10 kW and an extra € 100 for each kW added.

The main policy instrument for SGE in The Netherlands remains the ISDE (investeringssubsidie

voor Duurzame Energie, a Feed-in-Premium instrument). The ISDE conditions gradually improved in recent years, both in terms of the contribution per kWh and in terms of scope of the regulation.

Recently, the Dutch government set a target at zero CO_2 emission in 2050 for the heating of residential buildings. Since the first of July 2018, newly built houses may no longer be connected to the gas grid. Heat pumps are currently the most favourable alternative for gas boilers. SGE offers great potential in creating neighbourhoods that are no longer connected to the gas grid, both in new and existing residential areas. The government started the project "Aardgasvrije wijken (Gas-free neighbourhoods)" in 2018/2019. For 2018 and 2019 the government selected 27 neighbourhoods for this project with a total budget of 120 million euros. (Rijksoverheid, 2018), (HIER opgewekt, 2018)

Furthermore, the government invests in research in the field of high temperature storage. The current policy limits the maximum ground storage temperature to 25 °C, but storing more at higher temperatures would offer an increased capacity for heat storage in SGE systems. The research investigates the biological impact, the water quality and possible stratification effects of such an increased temperature (KWR, 2017).

4. FUTURE POLICY DEVELOPMENTS > 2018

A future policy development for the geothermal sector is, among others, the Environment and Planning Act – a simplification of all environmental and planning legislation in a single Act. The Act will replace 15 existing laws, including the Water Act, the Crisis and Recovery Act and the Spatial Planning Act. The Act will take effect in 2021.

The Mining Act still needs some adjustments to be fully applicable for geothermal energy production. There is still a division between SGE and DGE in terms of policy, laws and project development.

National and local governments will work on regional energy strategies, a partnership for spatial integration of the energy transition in 33 Dutch regions. This includes a translation of the Agreement on Energy for Sustainable Growth and the future outcomes of the Climate Agreement.

5. CONCLUSIONS

As this country update has illustrated, there are many developments concerning geothermal energy in the Netherlands. The total capacity of DGE projects is still increasing, and research is being executed to advance the field. Moreover, 'Masterplan geothermal energy in the Netherlands' has set ambitious objectives for the DGE sector.

The total number of UTES systems in the Netherlands is still increasing rapidly. The two latest mayor developments in the SGE sector are the application of hydro thermal energy and the research in high temperature storage. In residential applications hydro thermal energy can be used for the regeneration of UTES systems (gas-free neighbourhoods). High temperature storage would be particularly interesting as heat buffer in a district heating or DGE network for large scale heating purposes as residential areas or horticultural areas. Research should indicate the ecological impact of high temperature ground water in high temperature storage systems.

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Tables A-G

Table A: Present and planned geothermal power plants, total numbers

Not applicable.

Table B: Existing geothermal power plants, individual sites

Not applicable.

Table C: Present and planned deep geothermal district heating (DH) plants and other uses for heating and cooling, total numbers

	Geothermal DH plants		Geothermal heat in agriculture and industry		Geothermal heat for buildings		Geothermal heat in balneology and other	
	Capacity (MW_{th})	Production (GWh_{th}/yr)	Capacity (MW_{th})	Production (GWh_{th}/yr)	Capacity (MW_{th})	Production (GWh_{th}/yr)	Capacity (MW_{th})	Production (GWh_{th}/yr)
In operation end of 2018			186	1011				
Under construction end 2018			93	604,5 *				
Total projected by 2020	36 **	180 **	313	2035 *				
Total expected by 2025	240 ****	1200 **	429	2789 *				

* Based on an estimation of 6500 full load hours

** Estimation of 3 plants at 12 MW

*** Estimation of 5000 full load hours

**** Estimation based on 4 new doublets per year

Table D1: Existing geothermal district heating (DH) plants, individual sites

Not applicable

Table D2: Existing geothermal large systems for heating and cooling uses other than DH, individual sites

Locality	Plant Name	Year commissioned	Cooling	Geoth. capacity installed (MW_{th})	Total capacity installed (MW_{th})	2018 production (GWh_{th}/y)	Geoth. share in total prod. (%)	Operator
Heerlen	Heerlen	2007		0,5		2*		Heerlen Municipality
Bleiswijk	VDB 1&2	2008		6,1		52		A+G Van den Bosch

Table D2: Existing geothermal large systems for heating and cooling uses other than DH, individual sites

Locality	Plant Name	Year commis-sioned	Cooling	Geoth. capacity installed (MW_{th})	Total capacity installed (MW_{th})	2018 produc-tion (GWh_{th}/y)	Geoth. share in total prod. (%)	Operator
Lansingerland	VDB 3&4	2009		4,3		40		A+G Van den Bosch
Pijnacker	Ammerlaan	2012		6,9		0		Ammerlaan
Pijnacker	Duijvestijn	2012		8,0		54		Duijvestijn
Venlo/Grubbenvorst	Wijnen Square Crops	2012		11,2		45		Wijnen Squ. Crops
Koekoekspolder	Greenhouse Geopower	2012		7,4		43		Greenhouse Geopower
Honselersdijk	Greenwell Westland	2012		11,4		45		GreenWell Westland
Heemskerk	Floricultura Heemskerk	2014		5,5		48		Floricultura
Middenmeer	ECW I Agriport Middenmeer	2014		14,1		89		ECW Netw./ Agriport A7
Middenmeer	ECW II Agriport Middenmeer	2014		13,8		81		ECW Netw./ Agriport A7
De Lier	VoF Geothe-rmie de Lier	2014		16		133		2 horticult.l companies
Vierpolders	Vierpolders	2016		15,7		66		Several hort. companies
Poeldijk	Aardwarmte Vogelaer	2017		10,2		118		Several hort. companies
Luttelgeest	Hoogweg Aardwarmte	2018		10		0		Wieringer-meer Geo-thermie B.V.
Kwintsheul	Nature's Heat B.V.	2018		17		57		Nature's Heat B.V.
Middenmeer	ECW III Agriport Warmte B.V.	2018		14,9		23		Agriport Warmte B.V.
Bergschenhoek	Wayland Energy	2018		10,9		27		Bergschenho ek B.V.
Maasland	Geopower Exploitatie B.V.	2018		13,2		48		Geopower Exploitatie B.V.
total								

Table E1: Shallow geothermal energy, ground source heat pumps (GSHP)

	Geothermal Heat Pumps (GSHP), total			New (additional) GSHP in 2017		
	Number	Capacity (MW_{th})	Production (GWh_{th}/yr)	Number	Capacity (MW_{th})	Share in new constr. (%)
In operation end of 2017	54846[1]	1387[1]	1526[1]	4806[1]	95[1]	8
Projected total by 2020[2]	66000	1700	1850			

Table E2: Shallow geothermal energy, Underground Thermal Energy Storage (UTES)

	Aquifer Therma Energy Storage (ATES)			Borehole Thermal Energy Storage (BTES)		
	Number	Capacity (MW_{th})	Production (GWh_{th}/yr)	Number	Capacity (MW_{th})	Production (GWh_{th}/yr)
In operation end of 2018	2368[3]	1011*[1]	1112*[1]	10606[3]	377*[1]	414*[1]
New (additional) in 2018	73[3]	55*[1]	-	4553[3]	40*[1]	-
Projected total by 2020[2]	2600	1200	1300	14000	540[4]	600[4]

* Numbers at the end of 2017.

1 Statline (CBS): Warmtepompen; aantallen, thermisch vermogen en energiestromen, 20 December 2018.

2 Annual growth 10 % (estimation).

3 WKOtool, wkotool.nl.

4 Annual growth 30 % (estimation).

Table F: Investment and Employment in geothermal energy

	in 2018		Expected in 2020	
	Expenditures (million €)	Personnel (number)	Expenditures (million €)	Personnel (number)
Geothermal electric power				
Geothermal direct uses	75 *	572 **	120	820
Shallow geothermal	N/A	N/A	N/A	N/A
total				

* Based on an investment of 15 million per project

** 4,5 fte for an operational project, 100 fte for a project under construction.

Table G: Incentives, Information, Education

	Geothermal electricity	Deep Geothermal for heating and cooling	Shallow geothermal
Financial Incentives – R&D	None	DIS	Limited, in high-temperature
Financial Incentives – Investment	None	RC	Only for small HP
Financial Incentives – Operation/Production	None	FIP	None
Information activities – promotion for the public	Limited	www.geothermie.nl www.hoewerktaardwarmte.nl	www.bodemenergienl.nl www.sikb.nl
Information activities – geological information	www.nlog.nl www.thermogis.nl	www.nlog.nl www.thermogis.nl	www.wkotool.nl www.dinoloket.nl
Education/Training – Academic	Universities	Universities	www.bodemenergienl.nl
Education/Training – Vocational	None	Yes	Yes

Key for financial incentives:

DIS	Direct investment support	FIT	Feed-in tariff	-A	Add to FIT or FIP on case the amount is determined by auctioning
LIL	Low-interest loans	FIP	Feed-in premium		
RC	Risk coverage	REQ	Renewable Energy Quota	O	Other (please explain)