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Netherlands Country Update

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ABSTRACT

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 energy (SGE) (including underground storage (UTES) and ground source heat pumps (GHPS)). There are currently 21 DGE projects, with an approximate total capacity of 3,6 PJ or 300 MW_{th}. The amount of SGE systems has also continued to increase. In the beginning of 2019 2.368 ATES and 60.354 GHPS systems were in operation (CBS 2019). 99 % of these projects are low (< 25 °C) temperature storage. However, the interest in HT-ATES (30 - 90 °C) is growing and new pilots have started. The deep geothermal sector published the ‘Master Plan geothermal energy in the Netherlands with ambitions to meet 5% of the total energy demand for heat in 2030 and 23% in 2050.

1. INTRODUCTION

This article deals with the geology background of the Netherlands, 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 2019 and 2020, i.e. the actual figures for geothermal installations and an overview of the field of stakeholders. Section 3 briefly presents the history and policy backgrounds, while Section 4 attempts to forecast some developments and funding. Each section will discuss the developments for direct use geothermal and shallow geothermal in separate subsections.

2. STATUS GEOTHERMAL ENERGY 2020

2.1 Deep geothermal energy

Geology Background

Due to a long history of oil and gas production a lot of information is available on the subsurface, and yet still a lot is unknown, especially on the potential of geothermal energy. The ministry of Economic Affairs and Climate financed a seismic survey of “blanks spots” carried out by EBN in partnership with TNO, to map the subsurface where there is still uncertainty, prioritized based on areas with the highest demand for heat and developed into an updated, public and easily-accessible database (ThermoGIS) by TNO. This project is called SCAN (Seismic Campaign for Geothermal Energy in the Netherlands) and the figure below (see Figure 1) shows which data is already available and where the “blank spots” are located. (EBN, TNO, 2019).

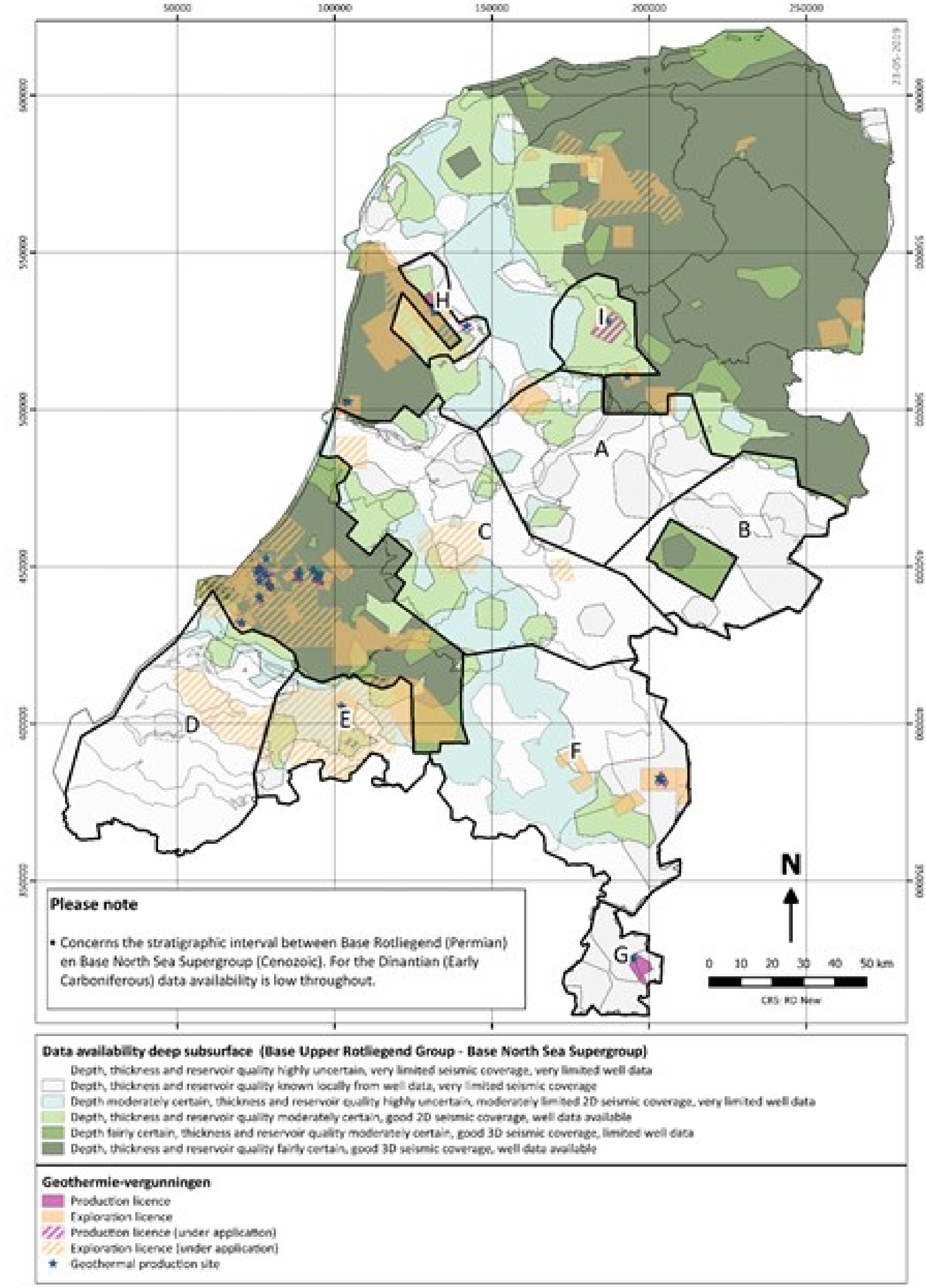


Figure 1: Seismic data The Netherlands

<u>Projects</u>

In 2019, 21 geothermal projects were completed and 19 projects operational (See Figure 2). Additionally, 10 projects are under construction and 10 projects are under development and working on a financial closure. The current growth is approximately 3-5 projects a year. As a precaution by the State Supervision of Mines two projects in the province of Limburg have been shut down in

2019 due to seismic activity and by the end of 2020 one project has filed for bankruptcy. 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. In 2019 the combined capacity of Dutch installations grew to a total capacity of around 3,6 PJ or 300 MW_{th} of sustainable heat. Most projects are operational between 2,000 and 3,000 metres deep (Netherlands Enterprise Agency, 2019, Masterplan, 2019, DAGO, 2019). One shallow geothermal project (27 °C, 600 – 700 m-bs) has been realised at Zevenbergen (IF Technology, 2019). This is the first project using horizontal wells drilled by Geothermal Directional Drilling technique.

Capacity

In 2019, the combined capacity of Dutch installations grew to a total capacity of around 3,6PJ or 300 MW_{th} of sustainable heat. 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 CO_2-reduction of 10,000 tons per year. The share of renewable energy was 8.7% of the total energy consumption in 2017. DGE and SGE together have a 5.7% share in the renewable mix with a total of 10.3 PJ.

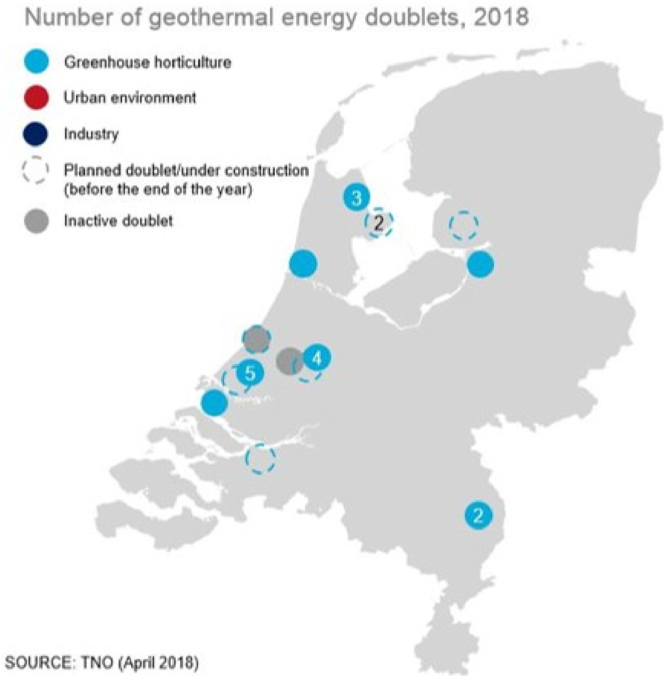


Figure 2: Locations of the present DGE installations.

2.2 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 in open systems are between 5 and 17 °C. 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 °C to be used for heating purposes.

Figure 3 shows the development of deep and shallow geothermal heat and cold which is yearly abstracted from 1990 to 2019. In the first 20 years, the heat and cold supply were almost in balance. Most of the systems were applied for buildings as offices, hospitals and shopping malls. These buildings need heat and cold. The strong increase of the heat delivery by SGE systems from 2006 can be explained by the use of this technology in residential areas, where almost only heat is required.

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.

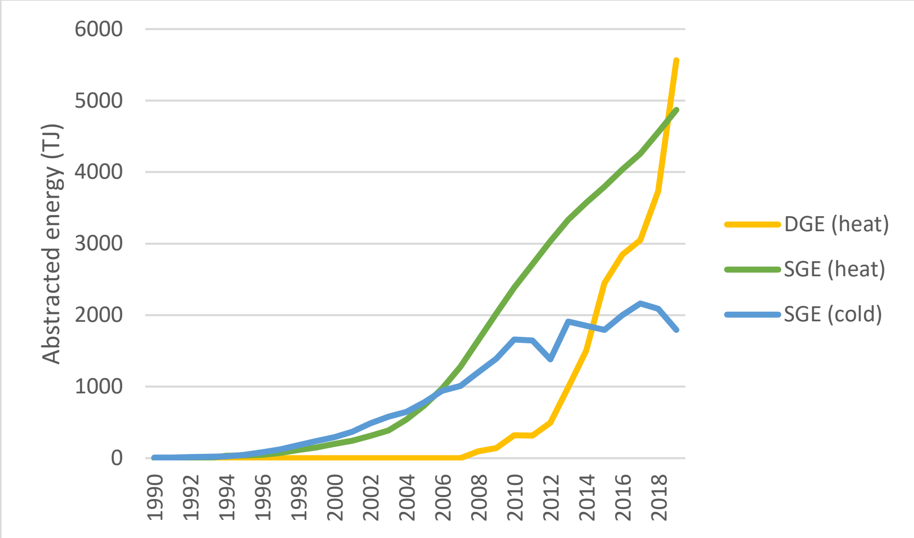


Figure 3. Number of low temperature Aquifer Thermal Energy Storage projects.

In the beginning of 2018, an unexpected revolution took place in the Netherlands. The policy 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 with heat pumps are regarded as a suitable alternative for gas-fired boilers.

High temperature storage HT-ATES

There is also a growing interest for high temperature storage (HT-ATES). High temperature storage is a storage technique, comparable with ATES, but the storage temperature varies from 30 to 90 °C. High temperature storage is suitable at locations with an excess of heat or an expected high demand for heat. It is often combined with deep geothermal wells, where the HT-ATES is charged with geothermal heat during summer time and able to add additional heat capacity in winter time. HT-ATES is also often combined with solar collectors. HT-ATES 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.

HT-ATES with storage temperatures > 30 °C has only been implemented in a few projects in the past. The first relevant HT-UTES project in the Netherlands was installed in the Beijum district in Groningen (1985: storage of 60 °C solar heat using BTES). The first HT-ATES projects were made at Utrecht University (1991: storage of 90 °C heat from a CHP installation using ATES) and a health care institution in Zwammerdam in the late nineties (storage of 90 °C heat from a CHP installation using ATES). Furthermore, four medium (< 50 °C) temperature storage systems were built the last 15 years.

The measured recovery efficiency for all the HT-ATES is often lower than designed. The main reason is that the storage temperatures (warm well, cold well and cut-off temperatures) have in many cases not been well fitted to the building system or the other way around: the heating system in the building was not adapted to the extraction temperatures from the heat store (Bakema et al, 2019). Besides better system integration HT-ATES should have a storage volume of at least 250.000 m^3 to obtain a thermal efficiency of 70 %.

Despite the low interest in HT-ATES systems in the past, the interest is growing rapidly at the moment. Actual HT-ATES systems are running at Koppert-Cress (Monster) and at the NIOO institute in Wageningen. In 2020 a new HT-ATES (storage temperature 90 °C) is constructed at ECW Middenmeer and will be taken into operation in the second quarter of 2021. This project will store surplus heat of geothermal wells to be used for heating greenhouses in winter time (IF Technology, 2018 and Drijver et al. 2020).

For 2021, new HT-ATES projects are planned. One of these projects is the HT-ATES Bergenden project in Lingewaard, where in 2020 a test drilling has been done.

3. POLICY DEVELOPMENT 2015-2019

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, d) the Climate Agreement (2019), an agreement between many organisations and companies to combat global warming and contains of 600 measures to reduce CO_2-emissions. It also offers a realistic position for geothermal by aiming at removing the bottlenecks in legislation and regulations and by implementing a mission-driven knowledge and innovation program focused on risk management in the exploitation phase, professionalization of the sector, promotion of standardization, knowledge of the subsurface (seismic) and a cost reduction of 50%. The central government also maintains the RNES guarantee scheme and the SDE + scheme for this technology. An ongoing 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). In 2020 the SDE+ scheme is broadened and will be called SDE++. The difference with the SDE+ is that technologies will compete on the basis of "avoided CO_2" (and other greenhouse gases) instead of "generated sustainable energy". With respect to the policy instrument of government guarantee on drilling risks, the budget was extended and some technical improvements were introduced (Netherlands Enterprise Agency, 2019).

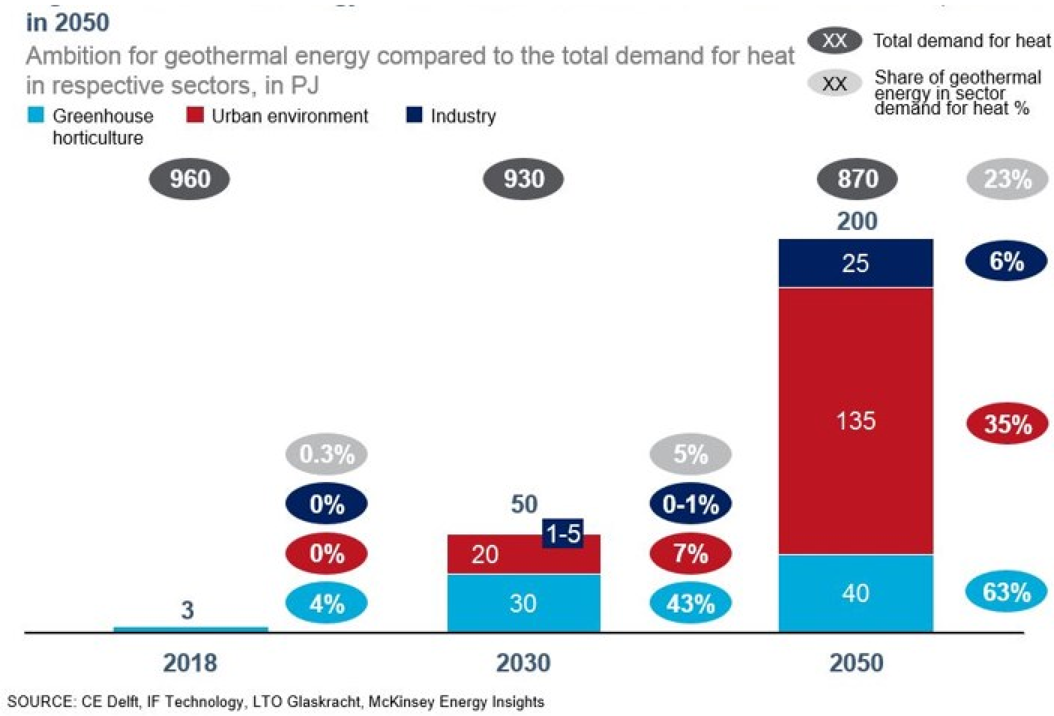
The policy instruments certainly encouraged increases in capacity and production levels of new plants. However, the main goal was to increase the number of new projects from roughly two doublets per year to five. These efforts were frustrated by financing difficulties and slow permitting.

The public-private partnership for knowledge development, called 'Knowledge Agenda' ends with two final research publications in 2021. 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 called KIRA - Knowledge and Innovation Roadmap Geothermal Energy. The budget is under discussion (Kas als energiebron, 2019).

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 Minister of Economic Affairs and Climate has given EBN (Energie Beheer Nederland: a state-owned company focussing on underground activities) the option to voluntarily participate in geothermal projects until the entry into force of the Mining Act in 2021. When the Mining Act comes into force, EBN can financially participate for 20 to 40% in geothermal energy projects as a non-operating partner. The role of EBN will be evaluated after five years (Kamerbrief, 2019 and 2020).

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 4) (DAGO, SPG et al., 2018).



The ministry of Economic Affairs and Climate initiated a so-called acceleration trajectory with the geothermal sector to identify the main issues for growth in the urban environment and develop a call for action on three themes: business case, public acceptance and governance. In the first half of 2021, this acceleration trajectory should result in a letter to parliament including an action plan for further growth of geothermal projects in the urban environment.

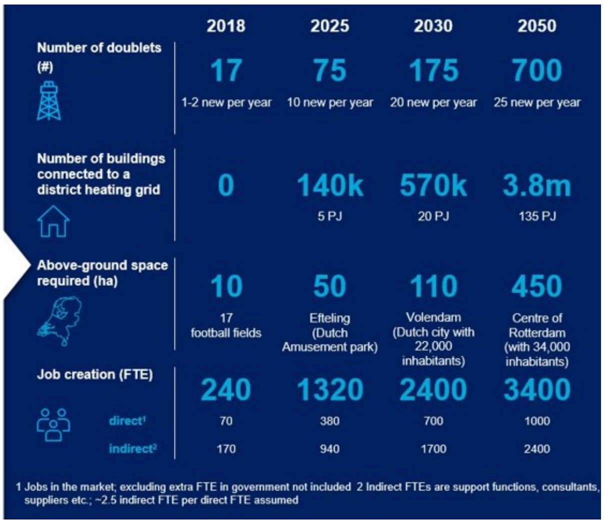


Figure 4: Ambitions for geothermal energy as stated in the 'Master Plan geothermal energy in the Netherlands'.

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 at higher temperatures would offer an increased capacity for heat storage in SGE systems. Besides the international program HEATSTORE a national program WINDOW is started. The WINDOW project includes the realisation of two or three additional HT-ATES projects and a new legal framework for HT-ATES.

4. FUTURE POLICY DEVELOPMENTS > 2019

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 2022.

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. The Mining Act has been a part of a consultation round by market parties and organisation and was amended in 2019 and 2020 to come to effect in 2021.

The Heating Act was for consultation in 2020 and aims to facilitate the anticipated greater role of heat networks in the Dutch heat supply and to set criteria to the sustainability of heat networks. It is amended in 2020 to come to effect in 2022.

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 over 600 measures of the Climate Agreement This is expected to accelerate the increase of geothermal projects and combinations with high temperature storage and aqua thermal energy.

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. The latest mayor development in the SGE sector is the application and the research in high temperature storage HT-ATES. High temperature storage would be particularly interesting as heat buffer in a district heating or DGE networks for large scale heating purposes as residential areas or horticultural areas. Research will indicate the ecological impact of high temperature groundwater in high temperature storage systems and lead to a new legal framework.

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TABLE 5. SUMMARY TABLE OF GEOTHERMAL DIRECT HEAT USES AS OF 31 DECEMBER 2019

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)]			
Air Conditioning (Cooling)			
Greenhouse Heating	230	5,564	
Fish Farming			
Animal Farming			
Agricultural Drying[5)]			
Industrial Process Heat[6)]			
Snow Melting			
Bathing and Swimming[7)]			
Other Uses (specify)			
Subtotal			
Geothermal Heat Pumps	1,600	4,870	
TOTAL	1830	10,434	

TABLE 3.	**UTILIZATION OF GEOTHERMAL ENERGY FOR DIRECT HEAT AS OF 31 DECEMBER 2019 (other than heat pumps)**

Locality	Type[1)]	Maximum Utilization					Capacity[3)]	Annual Utilization		
		Flow Rate	Temperature (ºC)		Enthalpy[2)] (kJ/kg)			Ave. Flow	Energy[4)]	Capacity
		(kg/s)	Inlet	Outlet	Inlet	Outlet	(MWt)	(kg/s)	(TJ/yr)	Factor[5)]
Heerlen	D						3,15		?	
A&G van den Bosch I Lansingerland	G						6,1		194,4	
A&G van den Bosch II Lansingerland	G						4,3		151,2	
Venlo/Grubbenvorst	G						11,2		162	
Pijnacker Ammerlaan	G						6,9		0	
The Hague / Aardwarmte Den Haag	G						0		0	
Green Well Westland	G						11,4		162	
Koekoekspolder / Kampen	G						7,4		0	
Pijnacker Duijvestijn	G						8		0	
Floricultura Heemskerk	G						5,5		0	
ECW I Agriport Middenmeer	G		91	35			16		403	
ECW II Agriport Middenmeer	G		91	35			9		227	
ECW III Agriport Middenmeer	G		91	35			16		403	
VoF Geothermie De Lier	G						16		478,8	
Vierpolders	G						15,7		0	
Venlo/Grubbenvorst	G						10,6		0	
Aardwarmte Vogelaer	G						10,2		424,8	
Maasland Geopower Exploitatie B.V.	G						13,2		0	
Bergschenhoek Wayland Energy	G						9,9		97,2	
Kwintsheul Nature's Heat B.V.	G						17		0	
ECW III Agriport Middenmeer	G						14,9		82,8	
Hoogweg Aardwarmte Luttelgeest	G						30,3		0	
Greenbrothers Zevenbergen	G						8,2		0	
ECW Geo Andijk I	G		81	35			15		378	
ECW Geo Andijk II	G		81	35			15		378	
Trias Westland	G						20			
TOTAL							300,95		3542,2	

TABLE 6. WELLS DRILLED FOR ELECTRICAL, DIRECT AND COMBINED USE OF GEOTHERMAL RESOURCES FROM JANUARY 1, 2015 TO DECEMBER 31, 2019 (excluding heat pump wells)

Purpose	Wellhead Temperature	Number of Wells Drilled				Total Depth (km)
		Electric Power	Direct Use	Combined	Other (specify)	
Exploration[1)]	(all)					
Production	>150° C					
	150-100° C					
	<100° C		20			50
Injection	(all)		20			50
Total			40			100

TABLE 8. TOTAL INVESTMENTS IN GEOTHERMAL IN (2019) 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						
2000-2004						
2005-2009						
2010-2014			200			
2015-2019			300			