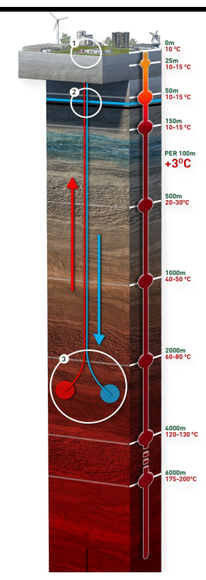
TECHNOLOGY FACTSHEET

Geothermal heat production, ultradeep (> 4000 meter)

Date of factsheet	20-7-2021
Author	Geothermal heat production, ultradeep (> 4000 meter)
Sector	Industry: Generic
ETS / Non-ETS	Non-ETS
Type of Technology	Renewable
Description	This technology represents an application of geothermal heat production which is currently (2020) not yet applied in The Netherlands. The main characteristic is the depth from which one expects to extract hot water : deeper than 4000 meter, hence the name Ultra Deep Geothermal energy (UDG). A typical project exists of two wells, a production and injection well, also called doublet. The wells are or fully vertically drilled or vertical with a curvature deep below. The bottom of the wells is situated in a water holding layer of limestone, called Dinatien, and lies deeper than 4000 meters (6000 to 8000 meters on average) below ground level. Salty hot water (brine) under pressure is pumped up through the production well by an ESP (electric submersible pump), cooled in a heat exchanger and injected back in the same layer through the injection well. In principle there is no loss of water, but some degassing may be needed as natural gas or oil needs to be separated from the brine. The estimated production temperature varies between 120 and 140^{o}C and makes this technology suited for low temperature steam supply for industry. Production rates can vary but are estimated to be lower than the deep geothermal heat projects (few hundreds m3/hour). Subsurface stimulation of the well to increase water volumes is supposed to be part of a typical project. The use of advanced materials to prevent scaling or gas leakage may be required. The installation further consists of a production pump, and oil and/or gas separator, an above ground heat exchanger and an injection pump. A heat network or a heat distribution network is not part of this factsheet. If the return temperature after the first user (industrial steam) would still be relatively high, the geothermal heat could be further used in a cascading application where the first (industrial) user is followed by a second heat exchange with a low temperature user (50-70^{o}C) with a similar or sufficient amount of full load hours (e.g. horticulture). By this, the injection temperature could be further lowered (to 35^{o}C or lower), increasing the heat power of a UDG project. Legend: 1) above ground installation ; 2) production and injection wells; 3) brine extraction and injection.



TRL level 2020	TRL 3
	This technology is not yet applied in the Netherlands. The main obstacle is the lack of geological knowledge of the underground deeper than 4000 meter, since only a handfull of measurement drillings have been done. Although being a fairly young sector, much of the knowledge needed for installing and operating an UDG project exists from the vast amount of experience with oil and gas wells in the Netherlands. Most of the techniques applied (drilling, oil/gas separation, heat exchangers) are mature and commercially available. In order to increase the geological knwoledge, a Green Deal on Ultradeep Geothermal energy (UDG) has been set up in 2017. The original expectation of teh Green Deal was that by 2021/2022 a first UDG pilot project can be reaslised in the Neterlands. Currently, a research programme to gain more information from the underground is carried out (SCAN). Much of the work in the Green Deal will consist of increasing the knowledge of the underground below 4000 meter. Staatstoezicht op de Mijnen (SoDM) controls the safe working of the projects and the association of operators (DAGO) has developed a number of guidelines to professionalise installations and operators. TNO geology approves the project data (expected heat output and volumes). They also monitor and publish production on a monthly basis (nlog.nl).

TECHNICAL DIMENSIONS

	Functional Unit		Value and Range								
Capacity	MWth		17.00								
			17.00			-			17.00		
Potential	NL	MWth	Current			2030			2050		
			-			1,984.13			7,936.51		
			Min	–	*Max*	1,984.13	–	1,984.13	7,936.51	–	7,936.51
Market share	NL	%	-			5.00			22.00		
			Min	–	*Max*	5.00	–	5.00	22.00	–	22.00
Capacity utlization factor	1.00										
Full-load running hours per year	7,000.00										
Unit of Activity	MWth								1.00		
Technical lifetime (years)	15.00										
Progress ratio	n/a										
Hourly profile	Yes										
Explanation	The expected size of a typical UDG project is assumed to be 17 MWth (SDE+ 2021). An annual full load production time of 7000 hours is assumed, supposed to be representative for low temperature steam demand in industry (baseload). Lifetime is expected to be 15 years, but so far no geothermal project has been running more than a few years in the Netherlands, so actual lifetime is unknown. The sector estimates that geothermal heat could supply 50 PJ in 2030 and 200 PJ in 2050 (13,9 tot 55,6 million MWh) (SPG 2018), currently about 3 PJ (0,8 million MWh) is delivered.										

COSTS

Year of Euro	2015									
Investment costs	Euro per Functional Unit		Current			2030			2050		
	mln. € / MWth		2.66			-			-		
			2.66	–	2.66	*Min*	–	*Max*	*Min*	–	*Max*
Other costs per year	mln. € / MWth		-			-			-		
			Min	–	*Max*	*Min*	–	*Max*	*Min*	–	*Max*
Fixed operational costs per year (excl. fuel costs)	mln. € / MWth		0.10			-			-		
			0.10	–	0.10	*Min*	–	*Max*	*Min*	–	*Max*
Variable costs per year	mln. € /		-			-			-		
			Min	–	*Max*	*Min*	–	*Max*	*Min*	–	*Max*
Costs explanation	Investment costs include all the elements which are subsidiable under the SDE+ subsidy regulation. Costs for site preparation, licencing and costs of capital are not included. Investment costs do include costs for the above ground elements : heat exchanger, oil/gas separator, connections, safety measures. Drilling costs form the bulk part of the investments. The cost figure of 2717 €2020/kWth represents the expected capex from the SDE+ subsidy (status up to 2021). Cost of a heat (distribution) network are not included. The opex is also an estimation and includes costs for well stimulation. The original cost were in €2020, a conversion ratio of 1,02 is used for converting the costs into €2015. No quantitative information is available about future costs developments. The expectation is that by scaling up, the specific costs for geothermal could decrease, on the other hand additional requirements about well integrity, monitoring and safety wil increase specific costs										

ENERGY IN- AND OUTPUTS

	Energy carrier	Unit	Current			2030			2050		
Energy carriers (per unit of main output)	*Main output:* Geothermal heat	PJ	1.00			1.00			1.00		
			1.00	–	1.00	1.00	–	1.00	1.00	–	1.00
	Electricity	PJ	0.05			0.05			0.03		
			0.05	–	0.05	0.05	–	0.05	0.03	–	0.03
	Heat	PJ	-1.00			-1.00			-1.00		
			-1.00	–	-1.00	-1.00	–	-1.00	-1.00	–	-1.00
		PJ	-			-			-		
			Min	–	*Max*	*Min*	–	*Max*	*Min*	–	*Max*
Energy in- and Outputs explanation	For 2020 and 2030, a Coefficent of Performance (CoP or the ratio of required electricity input per heat input, the combined inputs are the energy required per unit of energy output) of the system of 22 is assumed (SDE+ 2021), and for 2050, a CoP of 30.										

MATERIAL FLOWS (OPTIONAL)												
	Material	Unit	Current			2030			2050			
Material flows			-			-			-			
			Min	–	Max	Min	–	Max	Min	–	Max	
			-			-			-			
			Min	–	Max	Min	–	Max	Min	–	Max	
Material flows explanation												

EMISSIONS (Non-fuel/energy-related emissions or emissions reductions (e.g. CCS)												
	Substance	Unit	Current			2030			2050			
Emissions			-			-			-			
			Min	–	Max	Min	–	Max	Min	–	Max	
			-			-			-			
			Min	–	Max	Min	–	Max	Min	–	Max	
			-			-			-			
			Min	–	Max	Min	–	Max	Min	–	Max	
			-			-			-			
			Min	–	Max	Min	–	Max	Min	–	Max	
Emissions explanation	Some CO2 emissions could occur while degassing or decompressing the hot water from the production well. However, no information is available about the possible leakage rate. If the gas separator is not working properly, or the separated gas is not completely combusted, CH4 emissions could also occur.											

OTHER												
Parameter	Unit	Current			2030			2050				
		-			-			-				
		Min	–	Max	Min	–	Max	Min	–	Max		
		-			-			-				
		Min	–	Max	Min	–	Max	Min	–	Max		
		-			-			-				
		Min	–	Max	Min	–	Max	Min	–	Max		
		-			-			-				
		Min	–	Max	Min	–	Max	Min	–	Max		
Explanation												

REFERENCES AND SOURCES

1	SDE+2021: EINDADVIES BASISBEDRAGEN SDE+ 2021 , PBL 2022
2	SPG 2018: Masterplan Aardwarmte in Nederland, SPG, DAGO, WN, EBN, 2018
3	https://www.geothermie.nl/index.php/nl/
4	UDG : https://www.ebn.nl/wp-content/uploads/2018/02/Veel-gestelde-vragen-Green-Deal-UDG.pdf