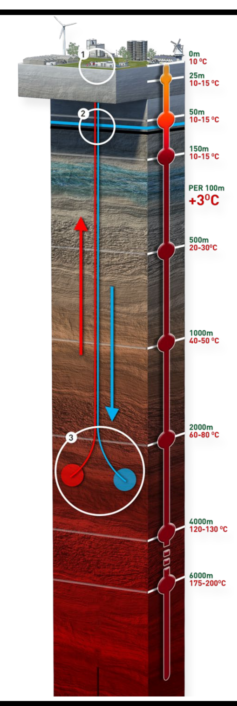
TECHNOLOGY FACTSHEET

Geothermal heat production, deep, (>1500 < 4000 meter)

Date of factsheet	26-7-2021
Author	Geothermal heat production, deep, (>1500 < 4000 meter)
Sector	Agriculture: Horticulture
	Industry, built environment (heat < 100 C)
ETS / Non-ETS	Non-ETS
Type of Technology	Renewable
Description	This technology represents the application of heat production from geothermal formations in The Netherlands. A typical project consists of two wells, a production and an injection well, also called doublet. The wells are either fully vertically drilled or vertical with a curvature deep below. The bottom of the wells is situated in a water holding layer of sand- or limestone, and lies between 1500 and 4000 meters below ground level. Salty hot water (brine) is pumped up through the production well, cooled in a heat exchanger and injected back underground through the injection well. In principle there is no loss of brine water, but some degassing may be needed as natural gas may be dissolved in the brine and needs to be separated. An alternative is to maintain sufficient pressure so that no natural gas escapes and is injected back underground. The warm water production temperature varies typically between 70 and 90ºC (max 100ºC) depending on the depth and the type of layer. For the Netherlands, a temperature gradient of around 30ºC per kilometer is valid. The injection temperature lies between 35ºC or lower. Lowering the injection temperature can increase the heat output of the system. Production volumes can be several hundreds m3 per hour, depending on the heat demand and the well characteristics. The installation consists of two bore holes usually in steel with liners, a production pump (Electric Submersible Pump, ESP), an above ground heat exchanger and an injection pump. An oil and/or gas separator is optional. In some cases, anti-scaling prohibitors may be required. Safety measures like a blow-out prevenator and double tubing to avoid and control gas leakage have recently become mandatory in the Netherlands. To date all existing geothermal projects are situated in the horticultural sector, although some proposals exist for projects in the built environment. A heat network or a heat distribution network may be required, but is not part of this factsheet. Legend: 1) above ground installation ; 2) production and injection wells; 3) brine extraction and injection. 
TRL level 2020	TRL 8
	Only a limited amount of geothermal heat production installations exist in the Netherlands in 2020, of which all are situated in the horticultural sector. About 50 more have applied for SDE subsidy (up to 2020). Although geothermal for heat generation is a fairly young application, much of the knowledge needed on the underground and on drilling exists from the vast amount of experience from oil and gas wells in the Netherlands. Most of the techniques applied (drilling, oil/gas separation, heat exchangers) are mature and commercially available. There is still room for improvement in the use of advanced materials, smarter drilling campaigns and projects' experience, hence a TRL level 8 is chosen. Staatstoezicht op de Mijnen (SoDM) controls the safe working of the projects and the Dutch association of geothermal operators (DAGO) is developing a number of guidelines to professionalise installations and operators. TNO's geology unit approves the project data (expected heat output and volumes) in order to be eligible for subsidy (SDE++). They also monitor and publish production on a monthly basis (nlog.nl).

TECHNICAL DIMENSIONS

	Functional Unit		Value and Range								
Capacity	MWth		15.00								
			15.00			-			15.00		
Potential	NL	MWth	Current			2030			2050		
			-			2,314.81			9,259.26		
			Min	–	Max	2,314.81	–	2,314.81	9,259.26	–	9,259.26
Market share		%	-			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	6,000.00										
Unit of Activity	MWh th/year										
Technical lifetime (years)	30.00										
Progress ratio	n/a										
Hourly profile	Yes										
Explanation	The current size of a typical geothermal project is 15 MWth, based on an application in horticulture, with a range between 7 and 30 MWth (SDE++ data up to spring 2020 including existing projects and applications). This size does already include a capacity factor based on existing projects, being the ratio of actual heat power (production) compared to the expected power output as estimated in the SDE+ subsidy application (pre-drill). An annual full load production time of 6000 hours is assumed for geothermal applications in the horticultural sector, considered baseload. However actual production time varies between 4000 and 8000 hours. In the built environment, full load hours depend on the size of the heat network: in large networks, 6000 hours are possible, in smaller or new networks, 3500 hours is the default. Much of the amount of full load hours depends on the heat demand profile, quite often this is in U-shape (like a bath tub): higher demand levels in winter compared to intermediate and summer seasons. Geothermal projects in the horticultural sector are designed to run as much as possible as baseload, so with high full load hours. Other sectors, like industry or other applications , could also apply this technology. Lifetime is expected to be up to 30 years, but so far no project has been running more than a few years. Technical or seismic problems have caused some projects to be shut down after a few years. Legislation requires that wells have to be closed up in such a way that gas leakage at the end of their life time is prevented. The sector estimates that geothermal heat could supply 50 PJ in 2030 and 200 PJ in 2050 (13,9 to 55,6 million MWh), or 5% and 22% of the heat demand below 100oC (SPG 2018). Currently (2020) about 6,2 PJ (1,7 million MWh) of heat is delivered by deep geothermal wells (CBS), but so far only to the horticultural sector as main user. Some geothermal projects in horticulture provide excess heat to the built environment nearby.										

COSTS

	Euro per Functional Unit	Current			2030			2050		
Year of Euro	2015									
Investment costs	mln. € / MWth	1.33			-			-		
		1.04	–	1.61	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	–	0.13	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. Drilling costs form the bulk part of the investments. Costs for a heat distribution network are not included in the cost figures. The cost figure of 1352 €2020/kWth represents the average of observed capex from producing projects and those that have applied for a SDE+ subsidy (status up to 2020). Varying with scale, investment costs range between 1614 euro2020/kWth and 1041 euro2020/kW for <20 MWth and >20 MWth respectively. The fixed opex is also based on existing or applied projects and includes costs for electricity. The fixed OPEX cost varies between 99 euro2020/kWth and 126 euro2020/kWth for <20 MWth and >20 MWth respectively. Specific for horticulture - as geothermal heat replaces natural gas based heat production - the need for CO2 fertilisation in the greenhouses remains. The costs for buying external CO2 to compensate own natural gas based CO2 supply are not included in the opex. No information is available about future costs developments, there could be a cost reduction effect from improved drilling campaigns, currently each project sets up its own drilling timeline, and improved components (casing, pumps, gas separators, heat exchangers), which also could reduce the opex. On the other hand, the use of advanced materials, well integrity and increased safety and monitoring issues require higher investments. It is unknown how this combination of effects will influence future costs. Cost are adjusted to euro 2015 using a 1.02 factor.									

ENERGY IN- AND OUTPUTS											
	Energy carrier	**Unit**	**Current**			**2030**			**2050**		
Energy carriers (per unit of main output)	*Main output:* Heat	PJ	-1.00			1.00			1.00		
			-1.00	–	-1.00	1.00	–	1.00	1.00	–	1.00
	Electricity	PJ	0.05			0.04			0.03		
			0.05	–	0.05	0.04	–	0.04	0.03	–	0.03
	Geothermal 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, a Coefficent of Performance (CoP or the ratio of required electricity input per heat output, the combined inputs are the energy required per unit of energy output) of 21,4 is assumed (average of SDE++ data available as of 2020), for 2030, 25 (high end of SDE++ data) and, for 2050, 30. Technically, a CoP up to 50 could be reached but this would require the use of other casing materials, special pumps, etc.										

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 CO_2 emissions could occur while degassing or decompressing the hot brine water from the production well. However, no information is available about the possible leakage rate. TNO is currently doing research on this matter. If the gas separator is not working properly, or the separated gas is not completely combusted, CH_4 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 2021.
2	SPG 2018: Masterplan Aardwarmte in Nederland, SPG, DAGO, WN, EBN, 2018.
3	https://www.geothermie.nl/index.php/nl/
4	CBS: statline.nl
5	nlog.nl