TECHNOLOGY FACTSHEET

AQUATHERMAL - LOW TEMPERATURE HEAT FROM SURFACE WATER

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Sector	Built environment
ETS / Non-ETS	Non-ETS
Type of Technology	Renewable
Description	Research shows that surface water can be a substantial source of sustainable heat, as an alternative to natural gas. It is a potential source for heating and cooling of buildings (STOWA, 2018). Aquathermal is a technology that enables to extract thermal energy from water, store it, upgrade it to a higher temperature using a heat pump, and finally deliver it to buildings. There are three different heat sources that can be used: 1) surface water such as lakes or rivers 2) waste water and 3) drinking water. Waste water and drinking water have lower potentials compared to surface water (CE, 2018). This factsheet focuses on aquathermal from surface water. Surface water has a temperature varying between 7 and 25°C over the year making it a very low temperature heat source (CE, 2018). Aquathermal comprises a storage technique that works in a way similar to aquifer thermal energy storage (ATES). Thermal energy extracted during summer months is stored in a reservoir and used for heating in winter months. Cooled down water is stored (in another spot of the aquifer) and can be used for cooling during summer months. The warmed up water is stored again, closing the cycle. The technique makes use of heat exchangers at the reservoir. A heat network is used to transport heat to consumers. A collective heat pump is used to increase the temperature to a suitable level for space heating and hot water. Alternatively, an individual heat pump can be used. This factsheet includes the above mentioned system components: heat extraction, storage, heat network and heat pump.
TRL level 2020	TRL 9 The technology to extract, store and distribute heat or cold from surface water is mature. It is already being exploited on various locations on a commercial basis (STOWA, 2018).

TECHNICAL DIMENSIONS

	Functional Unit		Value and Range								
Capacity	PJ										0.01
					0.00		-				0.04
Potential	PJ	NL	Current			2030			2050		
					150			150			150
			35	-	150	35	-	150	35	-	150
Market share	%	Share of final heat			0			-			-
			0	-	0	*Min*	-	*Max*	*Min*	-	*Max*

Capacity utlization factor		-
Full-load running hours per year		1,500.00
Unit of Activity	PJ/year	-
Technical lifetime (years)		30.00
Progress ratio		-
Hourly profile	Yes	
Explanation	The capacities of aquathermal are taken from the sample projects included the financial cockpit of STOWA. The amount of connections per network varies between 1 building and 5.500 dwellings and buildings (STOWA, 2018). On average a project has a heat demand of 8,5 TJ per year (equal to the heat demand of 500-1000 dwellings). Currently, the only existing project is "De Mossen" in Houten with a heat supply of 2,1 TJ per year. Compared to the total heat demand of the built envrironment of around 400 PJ (RVO, 2017), there is a negligible small share for aquathermal at present. Aquathermal has a high potential as heat source in the Netherlands though. Figures found in literature for the economical potential of "energy from surface water" are 42 PJ (IF Technology, 2016) and 150 PJ (CE, 2018). Ecofys indicates a technical potential of 90 PJ and economic potential of 35 PJ (Ecofys, 2017). The typical full load hours for aquathermal are 1.500 hours per year (ECN part of TNO, 2018). IF technology indicates 2.000 full load hours per year for aquathermal (IF Technology, 2016). The technical lifetime of an ATES, a heat transport network and heat exchangers is 25 to 30 years (Agentschap NL, 2011).	

COSTS

Year of Euro	2015

	Euro per Functional Unit	Current			2030			2050		
Investment costs	mln. € / PJ			281			196			154
		166	-	395	117	-	276	92	-	217
Other costs per year	mln. € / PJ			-			-			-
		Min	-	*Max*	*Min*	-	*Max*	*Min*	-	*Max*
Fixed operational costs per year (excl. fuel costs)	mln. € / PJ			6			4			3
		3	-	8	2	-	6	2	-	4
Variable costs per year	mln. € / PJ			-			-			-
		Min	-	*Max*	*Min*	-	*Max*	*Min*	-	*Max*

Costs explanation	At the moment there is still a lot unclear about the costs and cost breakdown of the different types of aquathermal (CE, 2018). Ongoing or finished initiatives and existing projects about aquathermal can be viewed in the project cockpit on the STOWA site (STOWA, 2018). A cost indication for different aquathermal projects can be obtained from here, one of these projects, "De Mossen" in Houten, is an existing project. In the table above, an investment cost range is calculated based on cost data from a study by CE (CE, 2018). The 'Main source' indicates average costs, Source 2 refers to minimum costs and Source 3 refers to maximum costs. The costs are calculated based on the cost ranges for the system components. The investment costs consist of costs for an aquifer thermal energy storage system (ATES), a surface-water installation, a collective heat pump and heat transport (network) pipelines. The size of the chosen project is 8,5 TJ heat supply per year (≈ 800 dwellings) which is the average of nine projects from the project cockpit of STOWA. The annual operational and management costs of a transport and distribution network are often expressed as a percentage of the initial costs of capital and amount to about 1% to 5% for transport and distribution (STOWA, 2018b). In the table above, operation and maintenance costs for the whole system are assumed at 2% of the investment costs per year (CE, 2018). In a yet to appear background document of SDE+ 2019, production costs of 748 euro/kWth and fixed operational costs of 71 euro/kWth/year are calculated for aquathermal (ECN part of TNO, 2018). For the cost reduction in future years a steep learning curve can be assumed for aquifer thermal energy storage (CE, 2016). Following this learning curve results in a 30% costs reduction in 2030 and 45% in 2050.

ENERGY IN- AND OUTPUTS

	Energy carrier	Unit	Current			2030			2050		
Energy carriers (per unit of main output)	*Main output:*	PJ			-1.00			-1.00			-1.00
	Heat		-1.00	-	-1.00	-1.00	-	-1.00	-1.00	-	-1.00
	Electricity	PJ			0.29			0.28			0.27
			0.27	-	0.30	0.26	-	0.29	0.25	-	0.28
	Ambient heat	PJ			1.04			1.05			1.06
			0.98	-	1.10	0.99	-	1.11	1.00	-	1.12
		PJ			-			-			-
			Min	-	*Max*	*Min*	-	*Max*	*Min*	-	*Max*

Energy in- and Outputs explanation

The energy in- and outputs of the system, from heat extraction to end consumer, depends on a number of assumptions regarding heat losses and the COP of the (collective) heat pump. These assumptions are given below:
Losses for heat extraction and seasonal storage of heat in an aquifer are assumed at 15-30%.
Losses in the heat transport network are assumed at 10%. For comparison, heat losses in high temperature heat networks (temperature range 70-90°C) are 10-30%, with 25% as average (ECN, 2017). Due to much lower temperature differences with the surroundings, losses are relatively low for aquathermal.
We consider a system using a collective heat pump. The coefficient of performance (COP) of the heat pump is the ratio between electricity input and heat output. The COP depends on the temperature difference between source and heating temperature. The annual average COP is called Seasonal COP (or SCOP). Assumed here is a heat pump with SCOP of 4,6 in 2020 (IF Technology, 2017). Furthermore we assume a SCOP of 4,8 in 2030 and SCOP of 5,0 in 2050.

Using the figures given above, the in- and outputs for the system are calculated. The 'Main source' assumes total heat losses of 32,5%, Source 2 assumes losses of 25% and Source 3 losses of 40%.

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											

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

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