TECHNOLOGY FACTSHEET

LARGE-SCALE HEAT NETWORKS HIGH TEMPERATURE - DISTRICT HEATING

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Sector	Households
	Other sectors
ETS / Non-ETS	Non-ETS
Type of Technology	Network

Description

This factsheet presents generalized information and figures on large scale high temperature (HT) heat networks for households also known as district heating. In district heating homes, buildings and other end users are heated by a central heat source via an underground network of hot water pipes. A distinction can be made between large and small scale heat distribution networks, the first supplying more than 150 TJ of heat per year (ECN, 2017). This factsheet focuses on large scale networks. Large scale district heating consists of main heat source(s), back-up boiler(s), a primary heat transport pipeline, substations and a distribution network including connections to the dwellings. Inside a dwelling a heat delivery kit (with heat exchanger) is installed in order to transfer hot water to the central heating system inside the dwelling. This factsheet considers all components of the heat network but does not include heat losses of the main heat source(s) and heat losses of the heating systems inside the dwellings. Costs in the costs section are excluding costs of the main heat source.

Main heat sources that can be used for large scale HT heat networks are:
- Combined heat and power (CHP) plants fired with gas, coal, muninipal solid waste or biomass
- Heat plants (heat only boilers) fired with biomass, natural gas or other fuels
- Industrial waste heat
- Other renewable sources (e.g. geothermal energy)

Heat from the heat source typically has a temperature of 100-130 °C. A typical large scale network has a primary transport pipeline of about 5km length (based on VESTA model) (PBL/VESTA, 2017). Between primary transport pipeline and distribution network there can be a main substation with a heat exchanger that lowers the temperature. Hot water delivered to consumers typically has a temperature of 90 °C and the return flow to heat source has a temperature of 70 °C (ECN, 2015). A large scale network typically has one main substation and mutiple smaller distribution substations but there are also large scale networks possible without a main substation.

TRL level 2020	TRL 9
	Commercial technology. In 2015, 4 to 5% of total dwellings in the Netherlands was connected to a large scale heat network (ECN, 2017).

TECHNICAL DIMENSIONS

	Functional Unit		Value and Range								
Capacity	PJ		1.00								
			0.15			-			3.40		
Potential	PJ	NL	Current			2030			2050		
			-			-			Unlimited		
			Min	-	*Max*	*Min*	-	*Max*	-	-	-
Market share	%	Share number of	4.53			7.09			25.00		
			4.53	-	4.53	6.00	-	20.00	9.09	-	50.00
Capacity utlization factor	-										
Full-load running hours per year	-										
Unit of Activity	PJ/year	-									
Technical lifetime (years)	40.00										
Progress ratio	-										
Hourly profile	Yes										

Explanation

Currently, there are 18 large scale heat networks in the Netherlands (ECN, 2017). The large scale heat networks in the Netherlands supplied each between 0,15 and 3,4 PJ of heat in 2015 (ECN, 2017). These figures include heat supplied to other sectors such as non-residential buildings, horticulture and industry. The average per network is about 1PJ per year which is enough heat for about 30.000 dwellings (based on VESTA model of PBL) (PBL/VESTA, 2017).

District heating supplied 12 PJ of heat to households in 2015 (ECN 2017). For small and large scale networks combined there were 390.000-410.000 dwellings with district heating in 2015 (ECN, 2017). In the Netherlands there are over 50.000 consumer connections to a small scale district heating network in 2015 (ECN, 2017). For large scale networks, 1,7% of total consumer connections is larger than 100kW (ECN, 2017). The large connections consist of mostly non-residential buildings. The connections smaller than 100kW are mostly dwellings. Based on this it is assumed here that there were 350.000 dwellings connected to large scale heat networks in 2015. Heat supplied by small scale networks was about 2PJ in 2015 (ECN, 2017).

In 2015, heat for large scale district heating originated mainly from natural gas fired CHP plants, which had a 67% share (this figure includes coal fired CHP and onsite heat only boilers) (ECN, 2017). Utilising heat from CHP plants for district heating results in a loss of electricity production though. This loss is about 0,18 GJe per GJ heat supplied at 120 °C (ECN, 2011). Renewable heat from waste incinerators (≈50% of waste input is biogenic) and heat from biomass together accounted for 15% of heat supply in 2015 (ECN, 2017). The remaining share of 18% consists of back up boilers as well as other heat sources, mainly the non-biogenic part of waste input in waste incinerators (ECN, 2017).

The heat demand varies over the year and the heat supply of the source(s) is load following. Heat is always available thanks to back-up boilers which are mainly gas-fired. They supply heat at peak demand (in winter) or when the main heat source is shut down for maintance. Back-up boilers are also used in the event of calamities and also in the transition when switching to a new main heat source (ECN, 2017).

In the future the share of district heating could increase substantially. According to scenario studies done using the VESTA model, a simulation model for heating options in the built environment, district heating has a potential of 220 PJ heat in 2050 out of which 160 PJ is geothermal and 60 PJ is waste heat (CE, 2016; PBL, 2017). Based on a scenario in which tax for natural gas increases to 1,5 euro/m3 in 2050, total supply to households becomes 100PJ in 2050 or about 50% of final heat demand in 2050.

ECN indicates the total amount of connected dwellings increases to 549.000 dwellings in 2030 (ECN, 2015), which is a projection based on expectations from the heat suppliers. This would lead to a share of 7% for district heating (large and small scale networks together). This share is based on current number of households i.e. 7,8 million dwellings in 2017 from CBS.

Based on current policy, the total share of district heating will only increase slowly. The National Energy Outlook scenario reaches a share of 6% in 2030 and 7% in 2035 for district heating in the final energy demand of households (Schoots et al., 2017).

Based on a PBL study (PBL, 2017) the share of households district heating could become as much as 20% by 2030 and 50% by 2050. Another scenario made by Ecofys (Ecofys, 2015) reaches a share of 25% in 2050. Assuming a slow increase of 0,1% per year an estimate for the minimum share of households with disctrict heating is 9% by 2050.

Technical potential of HT district heating is unlimited as there are no technical restrictions for heating systems inside dwellings.

Main components of a heat network (pipeline infrastructure) have a technical lifetime of 40-60 years (CE, 2009b).

COSTS

Year of Euro	2015

	Euro per Functional Unit	Current			2030			2050		
Investment costs	mln. € / PJ	271.37			249.66			217.09		
		192.54	-	426.17	177.14	-	392.08	154.03	-	340.94
Other costs per year	mln. € / PJ	-			-			-		
		Min	-	*Max*	*Min*	-	*Max*	*Min*	-	*Max*
Fixed operational costs per year (excl. fuel costs)	mln. € / PJ	6.78			6.24			5.43		
		4.81	-	10.65	4.43	-	9.80	3.85	-	8.52
Variable costs per year	mln. € / PJ	-			-			-		
		Min	-	*Max*	*Min*	-	*Max*	*Min*	-	*Max*

Costs explanation	In this example of a cost calculation a heat network with 30.000 dwellings and 1 PJ heat supply per year is considered. A mix of 26% apartment dwellings and 74% rowhouses in considered which is based on the ratio in the Netherlands between these two types of dwellings obtained from CBS (CBS, 2016). All components of the heat network (see description) are included in the investment costs except for the main heat source. The reason for this is different sources can be used which leads to different costs. Depending on type of heat source (e.g. waste heat or geothermal) this leads to an additional investment of 200-2000 euros per dwelling based on the VESTA model (PBL/VESTA, 2017). Components included in the investment costs are the primary heat transport pipeline (5km length), main substation (with heat exchanger), substations, distribution network and connections to the dwellings including heat delivery kits, and back-up boilers (with sufficient capacity to take over heat supply from main source). The cost range is based on the cost range for the different components as given by INEK/Energieakkoord and the Vesta model of PBL (INEK/Energieakkoord, 2018; PBL/VESTA, 2017). In this case present average investment costs amount to 6k euros per appartment dwelling and 13 k euros per rowhouse. A higher share of apartments compared to ground based dwellings leads to lower average investments costs per dwelling and vice versa. The fixed operational costs per year consists of maintenance costs for the different components of the network (PBL/VESTA, 2017). In the supporting calculations for the Dutch climate agreement proposal (INEK/Energieakkoord, 2018) the fixed operational costs are assumed 2,5% of the initial investment. Costs can be further reduced by innovation and design optimization. Design optimization means for instance to adjust the pipe diameters to the peak demand over the year. In the calculation for the Dutch climate agreement proposal (INEK/Energieakkoord, 2018) costs reductions for heat networks in 2030 are assumed between 0% and 15% (avg. 8%). In the VESTA model (VESTA/PBL, 2017) a costs reduction of between 17%-24% (avg. 20%) is assumed in the long run. Costs reduction factors used above are 8% in 2030 and 20% in 2050.

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
	Heat	PJ	1.25			1.20			1.15		
			1.10	-	1.30	1.20	-	1.20	1.15	-	1.15
		PJ	-			-			-		
			Min	-	*Max*	*Min*	-	*Max*	*Min*	-	*Max*
		PJ	-			-			-		
			Min	-	*Max*	*Min*	-	*Max*	*Min*	-	*Max*

Energy in- and Outputs explanation	Energy in- and outputs associated with the total network losses (from source to end consumer) are given here. Losses associated with the heat production are not included as they belong to the heat source. Heat losses in networks depend on temperature of the heat in comparison to the temperature of the surroudings. Heat losses occur in primary transport pipelines and in secondary distribtution networks (e.g. convection, conduction and radiation losses). Heat loss in primary network are generally a few %. It is well known that heat losses in the secondary distribution network can be substantial. Total network losses generally account for 10-30% (average about 25%) (ECN, 2017) This is depending on length of network/how densily the network is clustered. Losses for future heat networks can possibly be reduced due to innovation and/or improved energy control systems/ flow management systems. Here it is assumed, losses are 20% in 2030, and 15% in 2050, on average.

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		
Pump energy primary transport network	GJe/GJth	0.02			0.02			0.02		
		0.02	-	0.02	0.02	-	0.02	0.02	-	0.02
Pump energy secondary distribution network	GJe/GJth	0.05			0.05			0.05		
		0.05	-	0.05	0.05	-	0.05	0.05	-	0.05
		-			-			-		
		Min	-	*Max*	*Min*	-	*Max*	*Min*	-	*Max*
		-			-			-		
		Min	-	*Max*	*Min*	-	*Max*	*Min*	-	*Max*

Explanation	An electric pump is required in order to transport heat from the source through the primary and secondary heat distribution network. The amount of pump energy in GJe per GJth is given above. Pump energy requirement for the primary network is based on (ECN, 2011; BCRG, 2015) and for secondary network on BCRG (BCRG, 2015).

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