TECHNOLOGY FACTSHEET

HEAT NETWORKS NON-RESIDENTIAL BUILDINGS - DISTRICT HEATING

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Sector	Non-residential
	Other sectors
ETS / Non-ETS	Non-ETS
Type of Technology	Network
Description	This factsheet presents generalized information and figures on heat networks for the built environment also known as district heating. In district heating homes, non-residential buildings and other end users such as horticulture, are heated by a central heat source via an underground network of hot water pipes. In terms of number of end users with district heating in the Netherlands, the number of households with district heating is much larger than the number of other end users (ECN, 2017; ECN, 2015). District heating consist of main heat source(s), back-up boiler(s), a primary heat transport pipeline, substations and a distribution network including connections to the buildings. Inside a building a heat delivery kit (with heat exchanger) is installed in order to transfer hot water to the central heating system inside the building. This factsheet considers all components of the heat network. It does not include heat losses of the main heat source(s) and heat losses of the heating systems inside the buildings. Costs in the costs section are excluding costs of the main heat source. Main heat sources that can be used for large scale high temperature heat networks are: - CHP plant (fired with gas, coal, municipal solid waste or biomass) - Heat plants (heat only boilers) fired with biomass, natural gas or other fuels - Industrial waste heat sources - Other renewable sources (e.g. geothermal) A small scale network consists of a heat source (currently mostly natural gas fired CHP) and a distribution network including connections to the end users, which can also consist of non-residential buildings. Heat from the heat source typically has a temperature of 100-130 °C (steam or water under pressure). Heat delivered to consumers has a temperature of 90 °C and the return flow to heat source has a temperature of 70 °C (ECN, 2015).
TRL level 2020	TRL 9
	Commercial technology. District heating supplied about 6 PJ of heat to the non-residential sector in 2015 (ECN, 2017).

TECHNICAL DIMENSIONS

	Functional Unit		Value and Range								
Capacity	PJ		1								
			0			-			3		
Potential	NL	PJ	Current			2030			2050		
			-			-			Unlimited		
			Min	–	*Max*	*Min*	–	*Max*	-	–	-
Market share	Share of non-residential buildings	%	4			-			-		
			4	–	4	*Min*	–	*Max*	*Min*	–	*Max*

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	There are large scale and small scale networks, the first supplying more than 150 TJ of heat per year (ECN, 2017). The large scale heat network in the Netherlands supply each between 0,15-3,4 PJ heat per year (ECN, 2017 Table 1). Average heat demand for a large scale network is about 1PJ. An annual supply of 1 PJ is enough to fullfil to the demand of about 30.000 dwelling-equivalents based on VESTA model of PBL (PBL/VESTA, 2017). In 2015, the share of non-residential buildings with district heating can be assumed about the same as for residential buildings (about 4% of the number of buildings in non-residential sector has district heating) (ECN, 2017). This 4% is not a precise figure. In terms of final energy consumption, district heating supplied 12 PJ of heat to dwellings and about 6 PJ to the non-residential sector in 2015 (ECN, 2017 table 7). Total heat supplied with district heating to all sectors was about 21 PJ (18PJ for built environment and around 3 PJ for agriculture) in 2015 (ECN, 2017; Nationaal Warmtenet Trendrapport, 2018). There were about 350.000 consumer connections in 2015, out of which 345.000 small consumers (<100kW) (ECN, 2017). This leaves about 5.000 large consumers, which are mostly non-residential buildings, but can also be dwellings grouped under one large connection. However, non-residential buildings can also be small consumers. A small consumer can be either a dwelling or a small building (e.g. barber or small shop). Heat suppliers do not make a distinction between these connection types. For this reason, it is not possible to indicate the exact shares of dwellings and non-residential buildings with district heating (RVO, 2017; ECN, 2017). In 2015, heat for large scale district heating mainly originated from natural gas (and coal) fired CHP plants, which together have a 67% share (ECN, 2017). There is also a substantial share of waste incinerators (waste consists of ≈50% biogenic waste) and biomass, together accounting for 15% (ECN, 2017). The remaining 18% is back up boilers and other heat sources, which mainly consists of the non-biogenic part of waste input in incinerators (ECN, 2017). Currently, small scale heat networks in the Netherlands are mainly fed with heat from natural gas-fired CHPs, biomass heat plants and collective aquifer thermal energy storage (ECN, 2017). The heat demand of buildings varies over time during the year and the heat supply 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). Technical potential is unlimited as there are no technical restrictions with regard to the heating systems inside buildings. Main components of a heat network 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	226.46			208.34			181.17		
		187	–	266	172	–	245	149	–	213
Other costs per year	mln. € / PJ	-			-			-		
		Min	–	*Max*	*Min*	–	*Max*	*Min*	–	*Max*
Fixed operational costs per year (excl. fuel costs)	mln. € / PJ	5.66			5.21			4.53		
		5	–	7	4	–	6	4	–	5
Variable costs per year	mln. € / PJ	-			-			-		
		Min	–	*Max*	*Min*	–	*Max*	*Min*	–	*Max*

Costs explanation	There are connection costs associated to dwellings and to non-residential buildings, therefore the infrastructure costs should be calculated for a combination of the two. Due to the heterogenety of the non-residential sector (e.g. small shop vs. large office) there exists a range in connection costs for these building types. Here it is assumed that connection costs for a large multilevel non-residential building are the same as the connection costs for an apartment due to their similar shape (office building v.s. apartment). For smaller non-residential buildings the connection costs are expected to be equal to dwellings. Out of a typical heat network of 1 PJ, 2/3 of heat supply is for dwellings and 1/3 for non-residential (based on the 12 and 6 PJ for the Netherlands). In this example of a cost calculation, a heat network with 7.000 ground based dwellings and 23.000 apartment dwellings (i.e. 30.000 dwelling-equivalents in total) and around 1 PJ heat supply per year is considered. In this example 30% of total heat demand goes to ground based dwellings. All components of the heat network (see description) are included in the investment costs presented here 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-equivalent (based on VESTA model of PBL). Components included in the investment costs above are the primary heat transport pipeline (5km length), substation (with heat exchanger), distribution network including connections in the dwellings, 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 4 k euros per apartment dwelling and 13 k euros per rowhouse. It can be seen that the higher the share of apartments and non-residential buildings the lower the average investments costs per dwelling-equivalent become and vice versa. The costs of heat networks are lower at locations with a higher heat demand density (GJ/hectare) (Ecofys, 2015). Multi level non-residential buildings as well as apartments have a higher heat demand per m2 floor area than households which contributes to a higher heat demand density. Also, multi level buildings have lower connection costs per dwelling-equivalent compared to ground based dwellings (INEK/Energieakkoord, 2018; PBL/VESTA, 2017). 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 (PBL/VESTA, 2017) a costs reduction 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	–	-1	-1	–	-1	-1	–	-1
	Heat	PJ	1.25			1.20			1.15		
			1	–	1	1	–	1	1	–	1
		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 network losses are given here. Losses associated with the heat production are not included as they belong to the heat source. Heat losses depend on the temperature of the heat in comparison to the temperature of the surroudings. Heat losses occur in primary transport pipelines and in secondary distribution networks (e.g. convection, conduction and radiation losses). 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	GJe/GJth	0.02			0.02			0.02	
		0	–	0	0	–	0	0	–	0
		-			-			-		
		Min	–	*Max*	*Min*	–	*Max*	*Min*	–	*Max*
		-			-			-		
		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 heat distribution network (ECN, 2011). The required amount of pump energy in GJe per GJth is given above.									

REFERENCES AND SOURCES

ECN (2017). Monitoring Warmte

INEK/Energieakkoord (2018). Calculations for the Dutch Climate Agreement/Doorrekening hoofdlijnen akkoord. Standard factors/Standaardfactoren

ECN (2015). Developments of heat distribution networks in the Netherlands

CE (2016). Een klimaatneutrale warmtevoorziening voor de gebouwde omgeving – update 2016

PBL (2017). Toekomstbeeld klimaatneutrale warmtenetten in Nederland

PBL/VESTA (2017). Model examples/Validatievoorbeelden VESTA

Nationaal Warmtenet Trendrapport (2018).

CE (2009). Warmtenetten in Nederland - Overzicht van grootschalige en kleinschalige warmtenetten in Nederland, Delft, CE Delft, 2009

RVO (2017). Monitoring Energiebesparing Gebouwde Omgeving 2016

CE (2009b). Cost drivers warmtelevering in Nederland.

Ecofys (2015). De systeemkosten van warmte voor woningen

ECN (2011). Restwarmtebenutting. Potentielen, besparing, alternatieven