TECHNOLOGY FACTSHEET

AIR SOURCE HEAT PUMP

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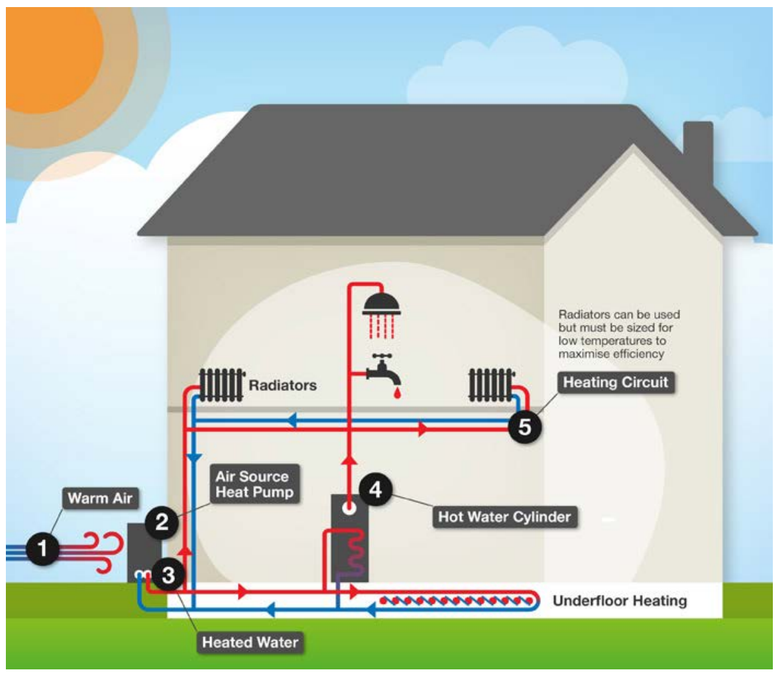
Sector	Households
ETS / Non-ETS	Non-ETS
Type of Technology	Emission reduction
Description	An electric heat pump with air source used for heating a dwelling. This type of heat pump extracts heat from the outside air. It is a system with an outdoor unit (evaporator) where a refrigerant flows through that absorbs thermal energy from the air. The refrigerant has a low boiling point hence evaporates at low temperature. After evaporation, an electric driven compressor (indoor unit) increases the temperature, then the refrigerant condenses back to a liquid (in the condenser) to release heat to a heat exchanger. An expander makes the refrigerant ready for heat absorption (closing the cycle). Heat generated (in the condenser) is transferred to the (central) heating system. The transport medium for heat inside the dwelling can be either water or air, hence the names 'air-water heat pump' and 'air-air- heat pump'. In case of water, the heated water is circulated around the heating circuit and also passed through the hot water cylinder. Hot water is stored in this cylinder and is available for use in baths, showers and taps troughout the dwelling. A storage cylinder is needed because the heat pump can not deliver a lot of hot water instantaneously. For domestic hot water, the complementary options are a separate (electric) boiler or one that is integrated in the indoor unit. In case of air, heat generated is transferred to one or multiple indoor air units, which act as hot air fans. Air-air heat pumps are often reversible which means they can be used for space cooling as well, similar to air conditioning. Air-air heat pumps can not supply hot tap water hence a separate boiler is needed. The efficiency of a heat pump is expressed as the coefficient of performance (COP), the ratio between heat output and electricity input, and is mainly determined by the difference between delivery temperature and source temperature. The higher the source temperature, and the lower the delivery temperature, the higher the COP. In winter, the temperature difference is larger, resulting in a lower COP. A heat pump usually heats the water to 35 to 55°C. At least once a week, the temperature of the hot tap water is increased with an electric heating element (such as an electric boiler) to 60°C (and briefly to 70°C) to prevent the risk of legionella contamination (Milieucentraal, 2018). For performance reasons, an air source heat pump should be used in combination with a low temperature heating system, which requires that the dwelling is sufficiently insulated. The minimum insulation level required corresponds to a dwelling with energy label C (CE, 2018). Usually the insulation level needed will be label A or better. A low temperature heating system consists of under floor heating and/or low temperature radiators/wall heating. According to the Dutch Heat Pump Association air source heat pumps are mostly installed in new buildings (DHPA, 2013).



Source: https://www.princeenergy.co.uk/services/renewables/heat-pumps/

TRL level 2020	TRL 9
	Commercial technology. At the end of 2017 there were 179.365 air source heat pumps used by households (CBS, 2018). The share of households with an air source heat pump is 2,3% in 2017 (based on 7,8 million dwellings in 2017 from CBS).

TECHNICAL DIMENSIONS

	Functional Unit		Value and Range								
Capacity	KWth										6.00
					3.00		-				12.00
Potential	KWth	NL	Current			2030			2050		
					22,469,312			-			-
			18,000,000	-	26,938,624	*Min*	-	*Max*	*Min*	-	*Max*
Market share	%	Households market share			2.32			15.06			-
			2.32	-	2.32	15.06	-	15.06	*Min*	-	*Max*
Capacity utlization factor	-										
Full-load running hours per year	1,640										
Unit of Activity	GJ/year	35									
Technical lifetime (years)	15										
Progress ratio	-										
Hourly profile	Yes										
Explanation	The 'typical' thermal capacity of an air source heat pump used by a household in the Netherlands is between 3 and 12 kWth (Milieucentraal, 2018). The needed (max.) capacity of the heat pump depends on the transmission of the dwelling, whether the heat pump also provides domestic hot water and whether the system is set up in a hybrid configuration (i.e. a gas-fired condensing boiler in combination with a heat pump) or in an all-electric configuration (i.e. only a heat pump). All electric requires a higher capacity than hybrid. The average thermal capacity of a residential air source heat pump according to CBS is 4,7 kWth (CBS, 2018). Average CBS capacity is obtained by dividing total capacity over number of heat pumps (total of air-water and air-air heat pumps for households). This average also includes hybrid systems hence does not fully represent all-electric cases. The average thermal capacity of an air source heat pump in the ISDE subsidy requests is 6,4 kWth (ISDE, 2018). Average ISDE capacity is obtained by dividing total capacity over number of heat pumps (for households). This average also includes hybrid systems hence does not fully represent all-electric cases. At the end of 2017 there were 179.365 air source heat pumps used by households in the Netherlands (CBS, 2018). The share of households with an air source heat pump is 2,3% in 2017 (based on 7,8 million dwellings in 2017 from CBS). It is not known by CBS whether these systems are set up in a hybrid configuration or in an all-electric configuration. CBS also indicated there is a (small) share of gas (driven) heat pumps included in this figure. In 2017 about 44.000 air source heat pumps were installed (added) in dwellings in the Netherlands (CBS, 2018). According to Nationaal Warmtepomp Trendrapport 2018 it is expected that in 2020 there will be more than 200,000 heat pumps in the Netherlands (all heat pump types), and in 2030 almost 1,300,000. This means the total number of heat pumps used in the built environment could multiply with a factor 6,5 compared to 2020 (Nationaal Warmtepomp Trendrapport, 2018). Here the same growth factor for air source heat pumps is assumed toward 2030. The future market share is very uncertain however, as it depends on a.o. technical and system innovations (possible cost reductions) and stimulation through energy policies. The current technical potential is estimated as follows. According to CBS there are about 7,8 dwellings in the Netherlands in 2017. The minimum insulation level needed corresponds to label C. These dwellings are assumed suitable for an air source heat pump (CE, 2018). Based on extrapolation of the label registration of RVO 58% of total dwellings has label C or better and 14% has label A or better in 2017 (RVO, 2018). Taking 6 kWth per heat pump as average capacity and assuming label C as treshold a potential of 27 GWth is calculated. The Nationaal Warmtepomp Trendrapport 2018 indicates a potential for air souce heat pumps of 18 GWth (Nationaal Warmtepomp Trendrapport, 2018). A mean value for the technical potential is then 22 GWth. In the future the amount of dwellings suitable for a heat pump can be expected to increase due to high insulation standards for new buildings and refurbishment of existing buildings. Typical full load hours of an air source heat pump used by a household in the Netherlands are 1.640 hours per year (ISDE, 2018). This number of full load hours is also used in 'Protocol Monitoring Hernieuwbare Energie' (CBS & RVO, 2015). The technical lifetime of an air source heat pump is 15 years (CE, 2018). Other sources indicate 12 years (Startmotor, 2018) and 20 years (ETRI, 2014) as technical lifetime for an air source heat pump.										

COSTS										
Year of Euro	2015									
	Euro per Functional Unit	**Current**			**2030**			**2050**		
Investment costs	€2015 / KWth			1,616.62			1,366.66			850.00
		784.16	-	1,817.88	733.89	-	1,366.66	653.46	-	850.00
Other costs per year	€2015 / KWth			-			-			-
		Min	-	*Max*	*Min*	-	*Max*	*Min*	-	*Max*
Fixed operational costs per year (excl. fuel costs)	€2015 / KWth			22.19			21.04			-
		6.49	-	22.19	7.34	-	21.04	*Min*	-	*Max*
Variable costs per year	€2015 / KWth			-			-			-
		Min	-	*Max*	*Min*	-	*Max*	*Min*	-	*Max*
Costs explanation	Cost unit: Euros2015/kWthermal In order to compute the costs per kW, we divided the reported costs as given by the source by the typical capacity of the heat pump (i.e. 6 kWth, which is an assumption, see 'Capacity'). In ETRI report (ETRI, 2014) investment costs were already given in euros/kWth. However, which value was assumed for the capacity is not stated. The table above gives costs excluding VAT. In case VAT was included in the source, 21% VAT was subtracted. In Startmotor (Startmotor, 2018) the investment (purchasing) costs for the heat pump are 11.500 euro including VAT at present (2018). In 2020 costs are 10% lower compared to present, and in 2030, costs are 25% lower compared to present. Labor installation costs amount to 1.300 euro. Measurement and controlsystems costs are 800 euro in 2020 and expected to be 600 euro in 2030. Fixed operational costs (i.e. maintenance costs) per year are 135 euros in 2020 and 128 euros in 2030. No costs given in Startmotor beyond 2030. ETRI (2014) presents investment/CAPEX costs in euros2013/kWth (excluding VAT) for a residential air source heat pump (ETRI, 2014). The CAPEX estimate takes into account the heat source system and the heat pump costs without considering the cost of the distribution system (ETRI, 2014). ETRI indicates the 'quality of CAPEX estimate' as 'medium'. In ETRI data, average costs of an air source heat pump (CAPEXref) amount to 780 euros/kWth in 2020 (range: 490 - 1.070 euros/kWth), 730 euros/kWth in 2030 (range: 460 - 1.000 euros/kWth) and 650 euros/kWth in 2050 (range: 400 - 890 euros/kWth). Fixed operational costs are 2% of the CAPEXref in 2020, and 1% of the CAPEXref in 2030 and 2050 (ETRI, 2014). Ecofys (2015) indicates investment costs for an air source heat pump of 7.600 euros excluding VAT in 2020 (Ecofys, 2015). For 2030 investment costs reported are 6.400 euros excluding VAT. For 2050 investment costs reported are 5.100 euros excluding VAT. These costs consist of purshasing cost for the heat pump (it is not specified whether or not including installation costs). The report does not state fixed operational costs per year. Nationaal Warmtepomp Trendrapport (2018) indicates investment costs for an air source heat pump of 5.000 - 10.000 euros including VAT (Nationaal Warmtepomp Trendrapport, 2018). These costs consist of purshasing cost for the heat pump including installation costs. The report does not state fixed operational costs per year. CE (2018) indicates investment costs of 6.500 - 14.500 euros including VAT for an air source heat pump (CE, 2018). These costs consist of purchasing cost for the heat pump including installation costs. Original source of these costs is Milieucentraal which reports a range of 6,500 to 14,000 euros (Milieucentraal, 2018). Maintenance costs amount to 50 euros per year (CE, 2018). Furthermore the grid connection costs (not included in table above) are as follows (CE, 2018): Adjustments electrical meter box: approximately 200 euros (one-time). Increased size of grid connection: 0 to 700 euros per year (depending on capacity of heat pump, usually not necessary for cases with very good insulation).									

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			0.32			0.30			0.29
			0.25	-	0.32	0.19	-	0.30	0.29	-	0.29
	Ambient heat	PJ			0.68			0.70			0.71
			0.68	-	0.75	0.70	-	0.93	0.71	-	0.71
		PJ			-			-			-
			Min	-	*Max*	*Min*	-	*Max*	*Min*	-	*Max*
Energy in- and Outputs explanation	The efficiency of a heat pump is expressed as the coefficient of performance (COP). For example, a COP of 3 means that 1 unit of electricity is used in order to produce 3 units of heat and 2 units are ambient heat. The COP mainly depends on the difference between source temperature and delivery temperature. The higher the source temperature and the lower the delivery temperature the higher the COP. In winter, the temperature difference is larger, resulting in a lower COP. The annual average COP is called the seasonal coefficient of performance (SCOP). In the table energy in- and ouputs associated to the mean COP / SCOP for space heating are given. Different assumptions from different sources are given below: NTA 8800 is a new determination method for the energy performance of buildings in the Netherlands that will be implemented in 2020 (NTA 8800, 2018). The mean COP of an air source heat pump is 3,15 in case of a delivery temperature of 35-40°C (NTA 8800, 2018). ETRI (2014) indicates a COP of 3,2 for an air source heat pump in 2020, COP = 3,3 in 2030 and COP = 3,5 in 2050 (ETRI, 2014). Startmotor (2018) indicates a SCOP of 3,5 for space heating and an SCOP of 2,0 for hot water in 2020 (Startmotor, 2018). Startmotor (2018) indicates a SCOP of 5,25 (times 1,5) for space heating and an SCOP of 3,0 (times 1,5) for hot water in 2030 (Startmotor, 2018). CE (2018) indicates the SCOP of an air source heat pump is between 3,5 and 4,5 in case of a delivery temperature of 35°C (CE, 2018). For domestic hot water the SCOP is between 2,0 and 2,6 (CE, 2018).									

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**		
Insulation costs label E or D to A or A+	euro2015			16,361			13,907			11,453
		9,349	-	16,361	7,947	-	13,907	6,544	-	11,453
Low temperature heating - radiators	euro2015			1,558			1,324			1,091
		1,558	-	1,558	1,324	-	1,324	1,091	-	1,091
Low temperature heating - floor heating	euro2015			8,570			7,285			5,999
		8,570	-	8,570	7,285	-	7,285	5,999	-	5,999
				-			-			-
		Min	-	*Max*	*Min*	-	*Max*	*Min*	-	*Max*
Explanation	In order to realise a low temperature heating system in a dwelling sufficient insulation, low temperature radiators and/or under floor heating are needed. Costs for insulation measures, under floor heating and low temperature radiators are taken from Startmotor (Startmotor, 2018). The table above gives costs excluding VAT. In case VAT was included in the source, 21% VAT was subtracted. For a terraced house with label E or D, current insulation costs to achieve label A amount to 12.000 euros (incl. VAT). In case of label A+ costs are about 21.000 euros (incl. VAT). Costs are expected to decrease with 15% in 2030 (Startmotor, 2018). For 2050 a costs decrease of 30% is assumed.									

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