TECHNOLOGY FACTSHEET

HYBRID HEAT PUMP HOUSEHOLDS

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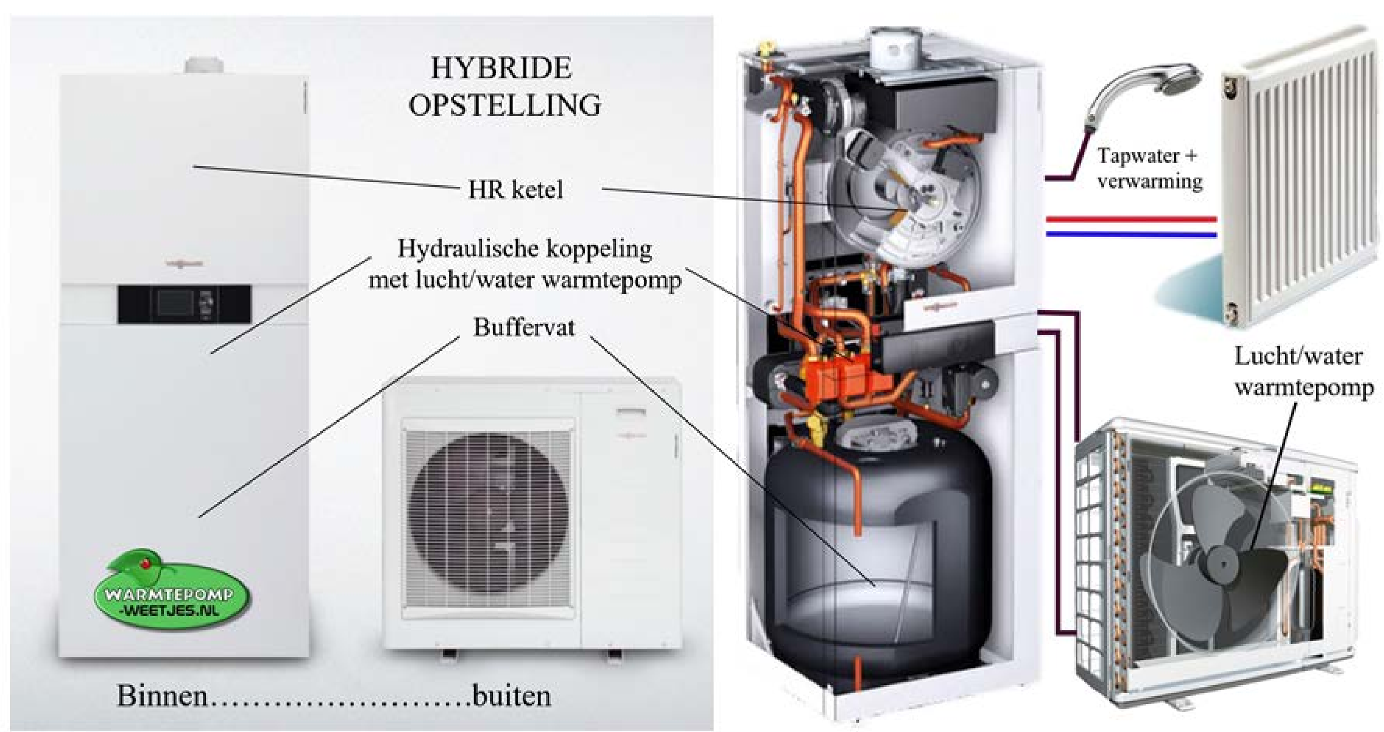
Sector	Households
	0
ETS / Non-ETS	Non-ETS
Type of Technology	Emission reduction
Description	A hybrid heating system consists of an electric heat pump in combination with a gas-fired (condensing) boiler. The two are coupled hydraulically and supply heat to the central heating system in a dwelling. This factsheet considers a heat pump that utilises outside air as heat source. This type of heat pump extracts heat from the outside air and upgrades it to a usable temperature. 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 is water, hence the name 'air-water heat pump'. For space heating the heat pump is used for the majority of time in a year. The gas boiler runs at peak demand moments such as on cold winter days (in which case the efficiency of the heat pump would drop substantially). This is when the heat pump does not have sufficient capacity to cover the entire heat demand. In contrast to all-electric air source heat pumps (i.e. dwellings using only a heat pump), there is no minimum insulation level required for hybrid heating systems (CE, 2018). The better the dwelling is insulated, the higher share of heat demand the heat pump can cover. Usually the gas boiler supplies all domestic hot water (DHW). It is also possible to have an air source heat pump that supplies hot water (Warmtepompplein.nl). In that case the gas boiler often will help to supply DHW at peak demand. 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 in the central heating system to 45 to 55°C, a central heating boiler is usually set at 60 to 80°C (Milieucentraal, 2018). A heat pump therefore works with a lower temperatures. The question is whether existing radiators are suitable for this. In older homes existing radiators are often suitable since the radiators have a larger capacity since the heating system is designed for a house without good insulation (Milieucentraal, 2018). In order to improve performance (and coverage) a heat pump should be used in combination with a low temperature heating system, which requires that the dwelling is sufficiently insulated. A low temperature heating system consists of under floor heating and/or low temperature radiators/wall heating (Milieucentraal, 2018). An alternative hybrid system consists of a gas boiler and a ventilation heat pump, which recovers heat from outgoing ventilation air for heating water. Outgoing ventilation air (mostly) has a higher temperature compared to outside air hence leads to a higher average COP. A ventilation heat pump is only applicable in dwellings with a mechanical ventilation system. The ventilation heat pump has other characteristics (e.g. costs and performance) and is not elaborated further in this factsheet.



Afbeeldingen: Viessmann

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 using 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 which share of heat pumps is installed in a hybrid configuration or in an all-electric configuration. CBS also indicated there is a (small) share of gas driven heat pumps (gas heat pumps) included in this figure.

TECHNICAL DIMENSIONS

	Functional Unit		Value and Range								
Capacity	kWth		5.00								
			2.50			-			5.00		
Potential	kWth	NL	Current			2030			2050		
			Unlimited			Unlimited			Unlimited		
			-	-	-	-	-	-	-	-	-
Market share	%	Share of households	2.32			18.75			50.00		
			2.32	-	2.32	18.75	-	18.75	50.00	-	50.00
Capacity utlization factor	-										
Full-load running hours per year	1,424										
Unit of Activity	GJ/year	26									
Technical lifetime (years)	15										
Progress ratio	-										
Hourly profile	Yes										
Explanation	The typical thermal capacity of a heat pump in a hybrid system is ≤5 kWth (Nationaal Warmtepomp Trendrapport, 2018). A hybrid heat pump of 5 kW is sufficient in most homes (Milieucentraal, 2018). The capacity of the heat pump is generally smaller in a hybrid system compared to an all-electric system. The thermal capacity of the condensing boiler can be 24kWth in case of a combination with a heat pump with a nominal capacity of 2,5kWth which does not provide domestic hot water (Ecofys, 2015). At the end of 2017 there were 179.365 air source heat pumps used by households (CBS, 2018). The share of households using an air source heat pump is 2,3% in 2017 (based on 7,8 million dwellings in 2017 from CBS) (CBS, 2018). It is not known by CBS which share of heat pumps is installed in a hybrid configuration or in an all-electric configuration. CBS also indicated there is a (small) share of gas driven heat pumps (gas heat pumps) included in this figure. The technical potential for hybrid heating systems is unlimited as there are no technical constraints. According to a study by Berenschot the amount of dwellings using hybrid heat pumps could become 0,5 million by 2023, 1,5 million by 2030 and 4 million by 2040 (Berenschot, 2017). 4 million dwellings is about half of the current housing stock and it could become the share by 2050 if the housing stock does not change much compared to present. The future market share is very uncertain however, as it depends on amongs others technical and system innovations (possible cost reductions) and stimulation through energy policies. The ratio between capacity of the heat pump (kW) and transmission of the dwelling envelope (kW) is called beta factor and determines the annual energy supplied by the heat pump. Running hours of the heat pump depends on the temperature profile over the year. If a household has a beta factor of 0.5 then about 90% of the annual heat demand (space heating) is delivered by the heat pump (Greenhome, 2018). Assuming 28 GJ heat demand (space heating) per year and assuming a capacity of 5kWth, the heat pump runs around 1.400 full load hours per year. The high efficiency boiler and air heat pump both have an expected technical lifetime of 15 years (CE, 2018).										

COSTS

Year of Euro	2015									
	Euro per Functional Unit	**Current**			**2030**			**2050**		
Investment costs	€2015 / kWth			561			744			510
		561	-	1,044	640	-	744	510	-	510
Other costs per year	€2015 / kWth			-			-			-
		Min	-	*Max*	*Min*	-	*Max*	*Min*	-	*Max*
Fixed operational costs per year (excl. fuel costs)	€2015 / kWth			30			27			-
		30	-	30	27	-	27	*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 (costs divided by 5 kWth, which is an assumption, see 'Capacity').
The table above gives costs excluding VAT. In case VAT was included in the source, 21% VAT was subtracted.

Ecofys (2015) investment costs for a hybrid heat pump are 3.800 euros excluding VAT in 2020 (Ecofys, 2015). For 2030 investment costs reported are 3.200 euros excluding VAT. For 2050 investment costs reported are 2.550 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.

CE (2018) indicates 3.600-4.600 euros as purchasing costs including VAT for a hybrid heat pump, excluding gas boiler, including installation costs (CE, 2018). Including a new gas boiler the costs are 4.700-6.700 euros incl VAT and including installation costs. Original source of these costs is Milieucentraal (Milieucentraal, 2018). Maintenance costs amount to 150 euros per year (including maintenance of the high efficiency boiler) (CE, 2018). CE indicates there is no adjustment required for the electricity connection (CE, 2018).

In Startmotor (2018) the investment (purchasing) costs for the hybrid heat pump are 4.500 euros including VAT at present (2018) (Startmotor, 2018). In 2020 costs are 10% lower compared to present, and in 2030, costs are 25% lower compared to present. Labor and installation costs amount to 1.100 euro. Measurement and controlsystems costs are 400 euro in 2020 and expected to be 300 euro in 2030. Maintenance costs are 146 euros in 2020 and 138 euros in 2030. No costs given in Startmotor beyond 2030.

Nationaal Warmtepomp Trendrapport (2018) indicates investment costs of 4.000 - 7.000 euros including VAT for a hybrid heat pump (Nationaal Warmtepomp Trendrapport, 2018). These costs consist of purchasing cost for the heat pump including installation costs. The report does not state fixed operational costs per year.

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			0.26			0.15			0.13
			0.09	-	0.26	0.08	-	0.23	0.07	-	0.20
	Ambient heat	PJ			0.64			0.45			0.47
			0.21	-	0.64	0.23	-	0.68	0.23	-	0.70
	Natural gas	PJ			0.11			0.44			0.44
			0.11	-	0.78	0.11	-	0.78	0.11	-	0.78

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 1 unit of electricity is used 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). The efficiency of a hybrid heating system depends on the share of the heat demand generated with the heat pump and the share that needs to be provided with the gas boiler. The share of heat demand delivered by the heat pump is called the coverage rate. The ratio between capacity of the heat pump (kW) and transmission of the dwelling envelope (kW) is called beta factor and determines the coverage rate. If a household has a beta factor of 0.4 or higher then more than 90% of the energy is delivered by the heat pump (Greenhome, 2018). In case of a beta factor of 0.2 the coverage is 60% (Greenhome, 2018). In case of a beta factor of 0.1 the coverage is 30% (Greenhome, 2018).

In the table above, annual mean energy in- and outputs of a hybrid system for space heating are given. (A dwelling is considered that uses 900m3 gas per year for space heating and 300m3 gas per year for hot water).

The assumptions used for the calculation are given below:
The mean COP for space heating is 3,5-4,5 at a supply temperature below 50 °C (CE, 2018).
Startmotor indicates a SCOP of 3,5 for space heating in 2020 (Startmotor, 2018).
A heat pump with SCOP for space heating of 3,5 in 2020 and 4,0 in 2030 and 4,5 in 2050 is assumed here.
The efficiency of the condensing boiler for space heating is 90% (Startmotor, 2018)
The 'Mean value' in the table above refers to a coverage of 60% for the heat pump (beta factor 0.2). 'Minimum value' refers to a coverage of 30% (beta factor 0.1) and 'Maximum value' to a coverage of 90% (beta factor 0.4 or higher).

For domestic hot water provision the mean COP is 2,0-2,6 (CE, 2018).
Startmotor indicates a SCOP of 2,0 for domestic hot water provision (Startmotor, 2018).
The efficiency of the gas boiler for domestic hot water provision is 72% (CE, 2018)
The combined efficiency for domestic hot water provision is 72% if only the gas boiler is used. In case the gas boiler supplies 20% of hot water demand, the combined efficiency will be 83%.

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	0									

REFERENCES AND SOURCES

Startmotor (2018). Calculations natural gas free dwellings. (Scenario tussenwoning vloeroppervlak 98 m2)
CBS statline (2018) Warmtepompen met buitenluchtwarmte
CE (2018). Factsheet hybride warmtepomp
Warmtepompplein.nl (2018) Viewed at 30-11-2018. URL: https://warmtepompplein.nl/hybride-warmtepomp/
Nationaal Warmtepomp Trendrapport 2018 (2018). Dutch New Energy (Rolf Heynen, Peter Groot, Henriette Vrisekoop, Daan Witkop, Kevin Kolenbrander). Partners: Duurzaam Verwarmd, UNETO-VNI, DHPA and knowledge partners BDH and company sponsors. p. 11, 12
Available at: https://www.installatie.nl/wp-content/uploads/2018/09/Nationaal-Warmtepomp-Trendrapport-2018-LR.pdf
Berenschot (2017). Routekaart Hybride Warmtepomp.
ISDE (2018). Figures about Investeringssubsidie Duurzame Energie (ISDE); number of requests, installed installations and capacity. Registered by RVO.
Ecofys (2015). De systeemkosten van warmte voor woningen
Milieucentraal (2018). Available at: https://www.milieucentraal.nl/energie-besparen/energiezuinig-huis/energiezuinig-verwarmen-en-warm-water/hybride-warmtepomp/
Greenhome (2018). Betafactor warmtepomp. Available at: https://kennis.greenhome.nl/warmtepomp/beta-factor-warmtepomp/