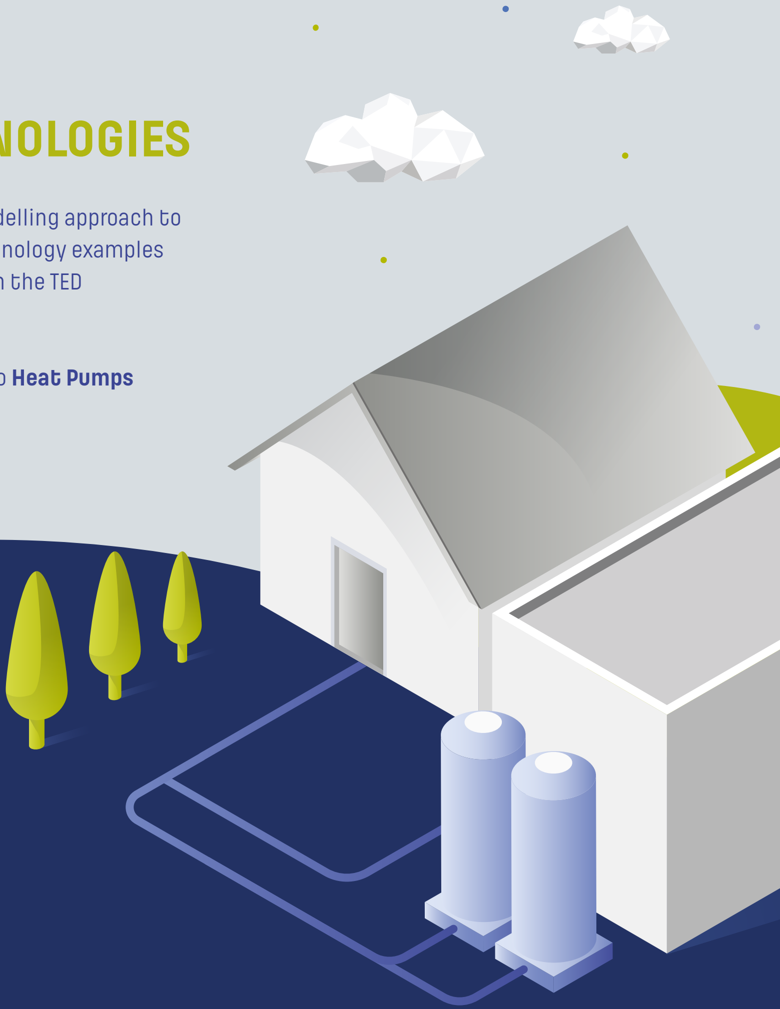
XPRESS LCA FACTSHEET (5/5)

RENEWABLE ENERGY TECHNOLOGIES

The XPRESS project has adopted the LCA attributional modelling approach to look at existing good practice Renewable Energy (RE) technology examples related to past Green Public Procurement tenders found in the TED (Tender Electronic Daily) database.

This factsheet outlines good practices and LCAs related to **Heat Pumps** technologies.



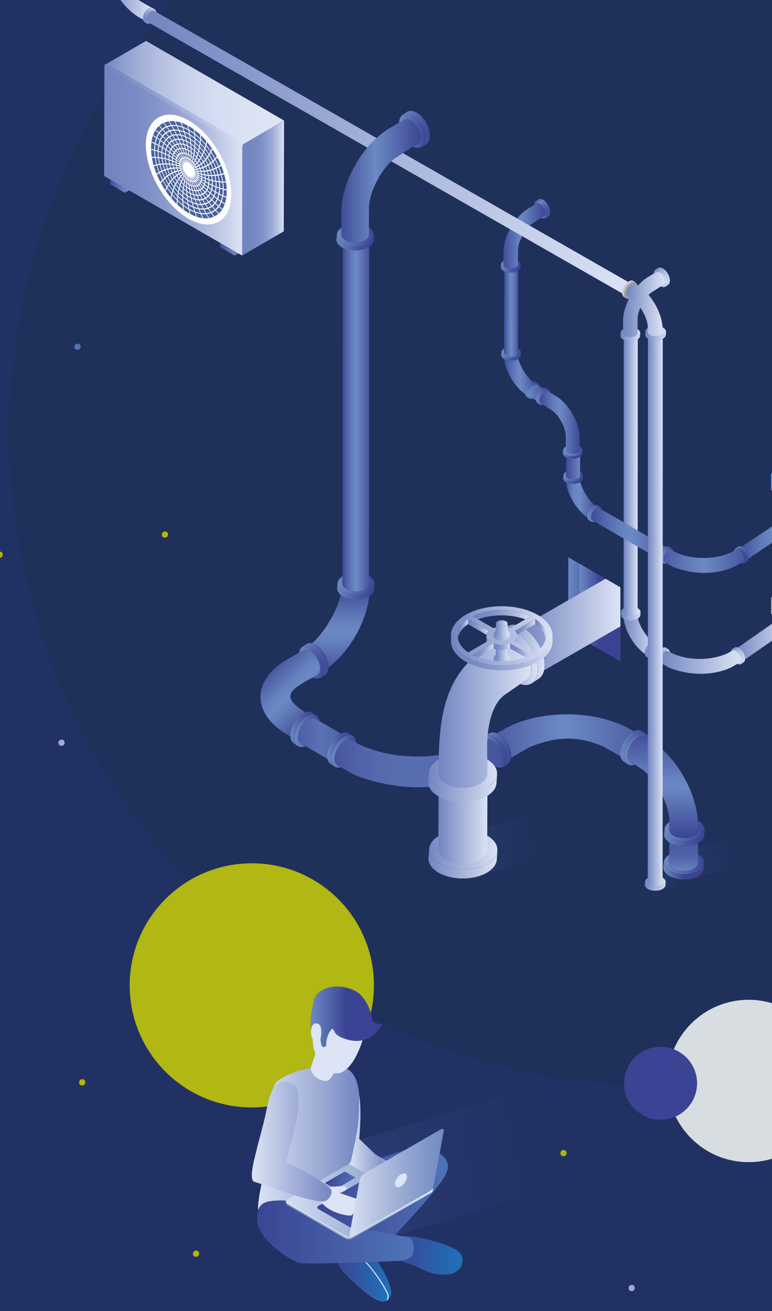
Heat Pumps

Heat pumps can be a very efficient way to heat spaces at a low environmental cost. However, heat pumps are electrically powered and so their ultimate environmental performance depends on how the electricity is supplied. Given the specific configuration of a grid (RE share, technology mix, etc.), a massive shift from traditional heating systems to heat pumps may be challenging or even an extra burden to the electric system, since heat pumps would increase the overall electricity demand. In the best case scenario, heat pumps can be part of the future RE solution, if integrated in a smart-grid where renewable electricity supply technologies can predict their production peaks and communicate them to the system, so that electricity powered devices like heat pumps have their demand turned up (e.g. when cheap and abundant wind power is supplied into the grid) or down (e.g. when the supply is more constrained and the rest of the demand is peaking) accordingly.

The most efficient systems make use of the soil's geothermal heat to warm up the air, which is circulated through a piping system that is drilled down to 80-100 meters below the surface. These are the borehole heat pumps. Air-water heat pumps on the other hand use ambient air as heat source. External ambient air is the most diffuse but the worst from a thermodynamic point of view, as the buildings' heating loads generally increase as the air temperature decreases.

The **Seasonal Performance Factor** (SPF) is an important figure which indicates the ratio between heat delivered by the heat pump (respectively at storage if available) and specific demand for electricity of the heat pump (including all common auxiliaries). New geothermal heat pumps in Europe achieve Seasonal Performance Factors of 4 or even higher. The SPF can also be used for active solar heating systems, being a measure of energy efficiency and utilization of renewables. For EU countries, the minimum value of the SPF should be around 2.875 (considering an efficiency of η=>0.4, SPF > 1.15/η).

Borehole and air-water heat pumps



For this final LCA screening of the good practice cases for heating technologies, two different types of heat pumps for household applications were considered: borehole and air-water heat pumps of 10 kW capacity each. The datasets represent the production of heat with these two heat pumps for an average single-family house in Europe. Switzerland is assumed to represent an average climatological and geological location in Europe.

The air-water heat pump has a Seasonal Performance Factor (SPF) of 2.8 (year 1998 data). The SPF values rose continuously until 1995 but then have remained rather constant, according to measurements of Roth 2001. The estimation of the SPF of the borehole heat pump is based on a COP (Coefficient of Performance) value range of 3.47 to 4.84, which averaged it amounts to 3.83.

For the borehole heat pump, a system with a heating output of 10,25 kW (at a supply temperature of 40°C), a mean cooling capacity of 8,25 kW (to dimension the borehole heat exchanger) and an extraction performance of 55 W/m, taken as in Ecoinvent 3.6. The system is assumed to be operated without an auxiliary heating system.

Finally, a small-scale heat pump was also considered for bigger space applications like a municipal building or a small industry. The modelled heat pump has a capacity of 30 kW and it is installed at a 160 kW cogeneration unit. This setup makes this heat pump type the most efficient of the modelled heating systems.

• Environmental footprint of 1 MJ heat production from an **air-water heat pump**

Impact Category	Unit	BE	DE	DK	ES	IT
Climate change	kg CO_2 eq	0.032682	0.066139	0.041596	0.041545	0.050306
Ozone depletion	kg CFC11 eq	1.1E-08	8.11E-09	7E-09	9.49E-09	1.16E-08
Ionising radiation	kBq U-235 eq	0.038479	0.010154	0.005052	0.02355	0.005163
Photochemical ozone formation	kg NMVOC eq	4.38E-05	8.16E-05	7.26E-05	0.000133	0.000101
Particulate matter	disease inc.	4.88E-10	7.48E-10	7.34E-10	8.23E-10	9.57E-10
Human toxicity, non-cancer	CTUh	4.49E-10	7.58E-10	6.26E-10	6.79E-10	5.62E-10
Human toxicity, cancer	CTUh	1.35E-11	1.84E-11	1.75E-11	1.91E-11	1.73E-11
Acidification	mol H+ eq	7.69E-05	0.000182	0.000149	0.000314	0.000243
Eutrophication, freshwater	kg P eq	8.04E-06	8.36E-05	2.58E-05	1.58E-05	1.37E-05
Eutrophication, marine	kg N eq	1.63E-05	4.35E-05	2.82E-05	4.7E-05	3.27E-05
Eutrophication, terrestrial	mol N eq	0.000168	0.000421	0.000334	0.000494	0.000434
Ecotoxicity, freshwater	CTUe	0.569457	0.789151	0.898924	0.77118	0.686192
Water use	m3 depriv.	0.009536	0.003216	0.005297	0.023028	0.02456
Resource use, fossils	MJ	0.980322	0.78447	0.438155	0.775973	0.621353
Resource use, minerals and metals	kg Sb eq	3.79E-07	5.71E-07	3.91E-07	3.67E-07	4.22E-07

Impact Category	Unit	NO	PT	SK	SE	UK
Climate change	kg CO2 eq	0.010497	0.048343	0.059597	0.013524	0.046432
Ozone depletion	kg CFC11 eq	6.03E-09	7.91E-09	1.01E-08	8.33E-09	9.76E-09
Ionising radiation	kBq U-235 eq	0.001253	0.002656	0.035991	0.04151	0.030608
Photochemical ozone formation	kg NMVOC eq	1.16E-05	0.000139	0.00013	2.12E-05	8.54E-05
Particulate matter	disease inc.	2.01E-10	8.77E-10	1.29E-09	3.97E-10	6.11E-10
Human toxicity, non-cancer	CTUh	3.35E-10	6.49E-10	8.01E-10	3.87E-10	5.89E-10
Human toxicity, cancer	CTUh	1.05E-11	1.72E-11	2.28E-11	1.23E-11	1.59E-11
Acidification	mol H+ eq	3.44E-05	0.000352	0.000383	4.88E-05	0.000164
Eutrophication, freshwater	kg P eq	3.86E-06	1.83E-05	7.25E-05	5.34E-06	1.11E-05
Eutrophication, marine	kg N eq	3.36E-06	4.75E-05	5.63E-05	8.49E-06	3.06E-05
Eutrophication, terrestrial	mol N eq	4.05E-05	0.000507	0.000467	8.77E-05	0.000333
Ecotoxicity, freshwater	CTUe	0.287662	0.841751	0.769833	0.454829	0.729946
Water use	m3 depriv.	0.002693	0.021397	0.013	0.007658	0.00193
Resource use, fossils	MJ	0.040093	0.505916	1.144016	0.59823	0.938053
Resource use, minerals and metals	kg Sb eq	2.71E-07	3.51E-07	4.95E-07	2.97E-07	3.76E-07

• Environmental footprint of 1 MJ heat production from a **borehole (air-brine water) heat pump**

Impact Category	Unit	BE	DE	DK	ES	IT
Climate change	kg CO2 eq	0.023469	0.047482	0.029867	0.02983	0.036118
Ozone depletion	kg CFC11 eq	7.44E-09	5.38E-09	4.59E-09	6.37E-09	7.87E-09
Ionising radiation	kBq U-235 eq	0.027655	0.007325	0.003663	0.01694	0.003743
Photochemical ozone formation	kg NMVOC eq	3.82E-05	6.54E-05	5.89E-05	0.000102	7.92E-05
Particulate matter	disease inc.	4.79E-10	6.66E-10	6.56E-10	7.2E-10	8.15E-10
Human toxicity, non-cancer	CTUh	3.12E-10	5.35E-10	4.4E-10	4.78E-10	3.93E-10
Human toxicity, cancer	CTUh	9.7E-12	1.32E-11	1.25E-11	1.37E-11	1.24E-11
Acidification	mol H+ eq	5.95E-05	0.000135	0.000111	0.00023	0.000179
Eutrophication, freshwater	kg P eq	5.68E-06	5.99E-05	1.84E-05	1.12E-05	9.75E-06
Eutrophication, marine	kg N eq	1.39E-05	3.34E-05	2.25E-05	3.6E-05	2.57E-05
Eutrophication, terrestrial	mol N eq	0.000144	0.000326	0.000263	0.000378	0.000335
Ecotoxicity, freshwater	CTUe	0.402795	0.560478	0.639267	0.54758	0.48658
Water use	m3 depriv.	0.006961	0.002425	0.003919	0.016645	0.017744
Resource use, fossils	MJ	0.714855	0.574284	0.325719	0.568186	0.457208
Resource use, minerals and metals	kg Sb eq	2.67E-07	4.04E-07	2.76E-07	2.58E-07	2.97E-07

Impact Category	Unit	NO	PT	SK	SE	UK
Climate change	kg CO2 eq	0.007546	0.03471	0.042787	0.009718	0.033338
Ozone depletion	kg CFC11 eq	3.89E-09	5.24E-09	6.81E-09	5.54E-09	6.57E-09
Ionising radiation	kBq U-235 eq	0.000936	0.001943	0.025869	0.029831	0.022006
Photochemical ozone formation	kg NMVOC eq	1.51E-05	0.000106	1E-04	2.21E-05	6.81E-05
Particulate matter	disease inc.	2.73E-10	7.58E-10	1.05E-09	4.13E-10	5.67E-10
Human toxicity, non-cancer	CTUh	2.31E-10	4.56E-10	5.65E-10	2.68E-10	4.13E-10
Human toxicity, cancer	CTUh	7.49E-12	1.23E-11	1.63E-11	8.84E-12	1.14E-11
Acidification	mol H+ eq	2.9E-05	0.000257	0.000279	3.93E-05	0.000122
Eutrophication, freshwater	kg P eq	2.68E-06	1.3E-05	5.2E-05	3.75E-06	7.91E-06
Eutrophication, marine	kg N eq	4.6E-06	3.63E-05	4.26E-05	8.29E-06	2.41E-05
Eutrophication, terrestrial	mol N eq	5.29E-05	0.000388	0.000359	8.67E-05	0.000263
Ecotoxicity, freshwater	CTUe	0.200538	0.598232	0.546613	0.320521	0.517984
Water use	m3 depriv.	0.002049	0.015474	0.009447	0.005613	0.001502
Resource use, fossils	MJ	0.040013	0.374355	0.832346	0.440612	0.684517
Resource use, minerals and metals	kg Sb eq	1.89E-07	2.47E-07	3.5E-07	2.08E-07	2.65E-07

Consortium

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