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Life cycle inventories of heating systems

Heat from natural gas, biomethane, district heating, electric heating, heat pumps, PVT, wood, cogeneration

Incl. correction for borehole inventory, environmental heat input for heat pumps and wood inputs for cogeneration

Client
Commissioned by the Federal Office for the Environment (FOEN)

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1 Introduction

1.1 Goal and Scope

With regard to the heating systems used in Switzerland, much of the data in the ecoinvent and DETEC database is not up-to-date.
This document describes the update and supplement heating system data based on the ecoinvent version v2.2 database .
The aim of this report is to provide an overview of the updates and additions to the data involved, if possible with the reference year 2020. The reader should have a complete overview of the data sets as they are now made available for the DETEC database.
In general, sub-chapters in this report on process steps that are considered relevant in the final LCIA results (ecological scarcity 2013) have been retained or updated. The documentation focuses on aspects relevant to the updated life cycle inventories presented in this report. Where no more recent data were found, data from existing sources, some of which are very old, were still used (in line with the motto "outdated rather than no data").

The following heating systems were updated or newly created for this report:

- Natural gas and biomethane burner
- Heat pump
- District heating
- Photovoltaic thermal hybrid solar collector system
- Electric heater
- Cogeneration system
- Wood burner

Light fuel oil heating systems were already updated in 2018 (see Jungbluth u. a., 2018). Together, these updates cover all relevant heating systems that are installed in Switzerland.

Table 1: Installed heating systems in Switzerland

	1990	2000	2017
	%	%	%
Light fuel oil	60.9	57.8	39.4
Natural gas	9.2	14.6	20.7
Electric heater	10.7	9.8	6.9
Wood	15.5	11.5	10.1
District heating	1.2	1.5	4.2
Thermal collectors	0.0	0.1	0.3
Heat pumps	2.0	4.4	17.9
Others	0.4	0.1	0.3

1.2 Validation process

All inventories are validated by the external reviewer Andy Spörri from EBP according to the ecoinvent v2.0 methodology (Frischknecht u. a., 2007):

- Completeness of the documentation. All investigated datasets should be described in the report, and all necessary meta information and flow data should be available for each dataset.
- Consistency with the quality guidelines. It is checked whether the unit processes have been modelled according to the ecoinvent quality guidelines. The quality guidelines cover for example the estimation of transport distances or the calculation of energy demands in the inventory (see chapters 4 to 7).
- Plausibility check of the life cycle inventory data. Selected input and output flows are controlled for plausibility.
- Completeness of inputs and outputs. The completeness of flows is based on the environmental and technical knowledge of the reviewing person. Reviewers are not necessarily technical experts of the processes reviewed. If necessary they were supported by the person responsible for the report.
- Mathematical correctness of calculations. Selected inputs and outputs are controlled in view of mathematical correctness, e.g. the transport service inputs, the waste heat or CO_2 emissions.

This review procedure is not comparable to the peer review specified in the ISO standards. The validation report is attached in the annex.

2 Heating Systems

2.1 Natural gas and biomethane

The report contains information on furnaces that are operated with natural gas. There exist a variety of burner systems, depending on the application (building heating, industrial heating, power generating). In this study, inventory data for three classes of gas boilers used for residential and commercial heating and one class of industrial furnace were created. The gas boiler inventory was modelled for three different power levels, whereas the power levels should be understood as order of magnitude (+/- 10%). Power generation was not within the scope of this study.

The following inventories were created:

Infrastructure

- Natural gas boiler (condensing, modulating) 15kW/RER
- Natural gas boiler (condensing, modulating) 50kW/RER
- Natural gas boiler (condensing, modulating) 300kW/RER
- Industrial furnace 1 MW/RER

Energy – per MJ burned

- Natural gas, burned in boiler, condensing, modulating, 15kW/CH
- Natural gas, burned in boiler, condensing, modulating, 50kW/CH
- Natural gas, burned in boiler, condensing, modulating, 300kW/CH
- Natural gas, burned in industrial furnace 1 MW/CH
- Biomethane, burned in boiler, condensing, modulating, 15kW/CH
- Biomethane, burned in boiler, condensing, modulating, 50kW/CH
- Biomethane, burned in boiler, condensing, modulating, 300kW/CH
- Biomethane, burned in industrial furnace 1 MW/CH

Energy - heat

- Heat, at natural gas, burned in boiler, condensing, modulating, 15kW/CH
- Heat, at natural gas, burned in boiler, condensing, modulating, 50kW/CH
- Heat, at natural gas, burned in boiler, condensing, modulating, 300kW/CH
- Heat, at natural gas, burned in industrial furnace 1 MW/CH
- Heat, at biomethane, burned in boiler, condensing, modulating, 15kW/CH
- Heat, at biomethane, burned in boiler, condensing, modulating, 50kW/CH
- Heat, at biomethane, burned in boiler, condensing, modulating, 300kW/CH
- Heat, at biomethane, burned in industrial furnace 1 MW/CH

2.1.1 Infrastructure

2.1.1.1 Boiler and burner production

The composition of the main materials and the energy demand for the manufacturing of gas boilers and burners comes from the environmental report of the Mittenwalde production site of Viessmann GmbH (Viessmann Werke Berlin GmbH, 2014). In the environmental report, the data were given per ton of boiler; in this report these data were converted into “per boiler” data using the average boiler weight per heating class. For each boiler class, the average weight was calculated as the mean value from technical datasheets (TDS gas boiler, 2020) from manufacturers such as Buderus, Hoval, elco, Viessmann, Weisshaupt (see Table 3). For information of materials that are less relevant, such as paint, rock wool etc., as well as for the further division of metals into subcategories, data from the existing inventory on oil boilers was extrapolated (Jungbluth u. a., 2018). Metal waste from the manufacturing process was assumed to be recycled and was not assessed further. The land occupation for gas boiler and burner production comes from the environmental report of the Mittenwalde production site of Viessmann GmbH (Viessmann Werke Berlin GmbH, 2014). The size of the production site was divided by the annual production volume.

Table 2: Material and energy demand per ton of boiler production

Inputs	Amount in kg / t of boiler	Source
Metals total Of which Aluminium Brass Steel high alloyed Copper Steel unalloyed	1220 kg 70 kg 0.5 kg 46.7 kg 28.3 kg 1074 kg	(Viessmann Werke Berlin GmbH, 2014) (Jungbluth u. a., 2018) for division
Brazing solder	74 kg	(Viessmann Werke Berlin GmbH, 2014)
Tap water	1090 kg	(Viessmann Werke Berlin GmbH, 2014)
Paint	2.7 kg	(Viessmann Werke Berlin GmbH, 2014)
Rock wool	8 kg	(Jungbluth u. a., 2018)
Electronics for control	4 kg	Own estimation
Electricity	480 kWh	(Viessmann Werke Berlin GmbH, 2014)
Natural gas	3913 MJ	(Viessmann Werke Berlin GmbH, 2014)
Land occupation, industrial area build up	5.8 m2*a	(Viessmann Werke Berlin GmbH, 2014)
Land occupation industrial area vegetation	4.0 m2*a	(Viessmann Werke Berlin GmbH, 2014)

Table 3: Average weight per gas boiler class

Boiler class	Average weight	Source
15kW	117 kg	(TDS gas boiler, 2020)
50kW	217 kg	(TDS gas boiler, 2020)
300kW	513 kg	(TDS gas boiler, 2020)
1MW	2410 kg	(TDS gas boiler, 2020)

2.1.1.2 Chimney

A two-way chimney is necessary for modern gas heating. Combustion air is aspirated via the chimney for pre-warming and thus reducing the heat loss. Therefore, plastic or steel pipes are installed into the existing chimney. The chimney of the oil heating inventories (Jungbluth et al.., 2018) were used under the assumption that the modern chimney systems are very similar for oil and gas.

2.1.1.3 Transports

A standard transport distance for all semi-finished products and resources of 50 km by lorry and 600 km by rail is assumed as in the former inventories due to lack of data. For smaller boilers (15 and 50 kW) additionally 50 km by delivery van are inventoried (Frischknecht u. a., 2007).

2.1.1.4 Heating period, lifetime

The lifetime of the boilers is estimated with 20 years under the assumption that they last as long as oil boilers (Jungbluth u. a., 2018) with 2'100 operating hours per year for the gas boilers and with 5'000 operating hours per year for the industrial furnace.

2.1.1.5 Heat efficiencies

Losses occur during heat generation in the boiler and during distribution in the house. Effective annual efficiencies of modern modulating condensing gas boilers are over 100% (without consideration of distribution losses) related to the lower calorific value. If losses in heat distribution in the house are taken into account, the efficiency of today's modulating condensing systems is approx. 6% lower (Aebischer et al. 2002).
The efficiencies of furnaces are dependent on the output temperature during operation on the one hand and the provided warm water temperature on the other hand. In modern buildings the warm water temperatures tend to be 30 to 40 degrees and thus achieve higher operation efficiencies of the boilers than in older buildings. Larger furnaces in industry have to provide higher output temperatures and thus reach lower efficiencies.
Technical data sheets by elco, Hoval, Buderus, Viessmann and Weisshaupt (TDS gas boiler, 2020) report average norm use efficiencies of condensing modulating boilers of 108 to 110% (lower heating value). This is about 6 % to 8 % higher than in the former inventories. Bigger furnaces (over 1MW) tend to reach lower values mainly because the delivered temperatures are normally higher. The average norm use efficiency of industrial furnaces amounts to 95% (Faist Emmenegger u. a., 2007).
Distribution losses in the house (unheated rooms) are not considered in the inventory for furnaces.
For each size of furnace, the norm use efficiency is considered referring to a partial load of 30%.
For the heating systems in buildings (15kw, 50kW and 300kW) the value for proper dimension without hot water heating at inside air temperature of 20°C is used. This corresponds to a relative turn-on time of just less than 40%, related to the duration of the heating period. Applicable to the average of the residential houses in the region Mittelland, the annual burner running time is 2100 h (BfK, 1982). For industrial furnace an annual operating time of 5000h is estimated (Jungbluth u. a., 2018).

Table 4: Average heat efficiencies for the different gas boiler classes, modulating, condensing

Boiler class	Average efficiency (lower calorific value)	Source
15kW, condensing-modulatiing	109.5%	Factsheets of manufacturers
50kWm, condensing-modulatiing	109.5%	Factsheets of manufacturers
300kW, condensing-modulatiing	109.7%	Factsheets of manufacturers
1MW industrial furnace	95%	Faist Emmenegger et al. 2007

As efficiencies depend largely on operating conditions and less on size or type of heating, the efficiencies should be adapted to known values if datasets for "heat, natural gas, burned in...." are used in a life cycle inventory. This could be easily handled by adapting the amount of "natural gas, burned in..." input of the corresponding "heat, natural gas, burned in ..." inventory.

2.1.1.6 Auxiliary electricity

Information about the energy demand for auxiliary electricity was derived from technical datasheets (TDS gas boiler, 2020). For the 1MW industrial furnace, no electricity demand is reported and the value from Faist Emmenegger et al. (2007) was used.

Table 5: average electricity demand in MJ per MJ heat for the different gas boiler classes

Boiler class	Average electricity demand	Source
15kW	0.00264	TDS gas boiler, 2020
50kW	0.00138	TDS gas boiler, 2020
300kW	0.00112	TDS gas boiler, 2020
1MW	0.00111	Faist Emmenegger et. Al 2007

2.1.2 Emissions to air

Based on a large dataset of more than 200,000 measurements by the official combustion control authorities in six cantons (BE, BS, LU, SZ, UR and ZG) and in the city of Zurich in 2010 and 2011, average emission factors for nitrogen oxides (NOx, expressed as NO2 equivalents) and carbon monoxide (CO) from furnaces operated with natural gas were determined for Switzerland (BAFU, 2015). Three size classes are reported. The class <50kW class was used for the 15kW boiler. The class 50-350kW was used for the 50kW and the 300kW boiler. The class >350kW was used for the 1MW furnace. The emission factors were calculated based on the concentration of pollutants measured in waste gas, taking into account the lower calorific value Hu and the so-called dry waste gas volume. In accordance with the Air Pollution Control Regulation1 (LRV), a reference oxygen content of 3%vol O2 is used for natural gas. The above-mentioned report (BAFU 2015) also reports emission data for CH4, CO2, particulates and SO2. Composition of trace emissions such as BaP, Hg, Cd, Ld, N2O were reported by the Switzerland emission report for gas heating systems (FOEN, 2020) with no distinction being made between boiler sizes. Further trace emissions were derived from Faist-Emmenegger et al. (2007). Table 6 lists the emission data used in this study.

Table 6: emissions per MJ heat for the different gas boiler classes

	15kw boiler	50kw boiler	300kw boiler	1Mw furnace	source
Heat, waste	1.08E+00	1.07E+00	1.08E+00	9.80E-01	Factsheets of manufacturer
Acetaldehyde	1.00E-09	1.00E-09	1.00E-09	1.00E-09	Faist Emmenegger et al. 2007
Benzo(a)pyrene	5.60E-13	5.60E-13	5.60E-13	5.60E-13	FOEN 2020
Benzene	4.00E-07	4.00E-07	4.00E-07	4.00E-07	Faist Emmenegger et al. 2007
Butane	7.00E-07	7.00E-07	7.00E-07	7.00E-07	Faist Emmenegger et al. 2007
Methane, fossil	6.00E-06	6.00E-06	6.00E-06	6.00E-06	FOEN 2020
Carbon monoxide, fossil	1.40E-05	1.40E-05	1.10E-05	1.10E-05	FOEN 2020
Carbon dioxide, fossil	5.60E-02	5.60E-02	5.60E-02	5.60E-02	FOEN 2020
Acetic acid	1.50E-07	1.50E-07	1.50E-07	1.50E-07	Faist Emmenegger et al. 2007
Formaldehyde	1.00E-07	1.00E-07	1.00E-07	1.00E-07	Faist Emmenegger et al. 2007
Ammonia	1.00E-09	1.00E-09	1.00E-09	1.00E-09	Faist Emmenegger et al. 2007
Mercury	1.00E-10	1.00E-10	1.00E-10	1.00E-10	FOEN 2020
Cadmium	2.50E-13	2.50E-13	2.50E-13	2.50E-13	FOEN 2020
Lead	1.50E-12	1.50E-12	1.50E-12	1.50E-12	FOEN 2020
Dinitrogen monoxide	3.83E-08	3.83E-08	3.83E-08	3.83E-08	FOEN 2020
Nitrogen oxides	1.80E-05	1.80E-05	1.90E-05	1.90E-05	FOEN 2020
PAH, polycyclic aromatic hydrocarbons	1.00E-08	1.00E-08	1.00E-08	1.00E-08	Faist Emmenegger et al. 2007
Particulates, < 2.5 um	1.00E-07	1.00E-07	1.00E-07	1.00E-07	FOEN 2020
Pentane	1.20E-06	1.20E-06	1.20E-06	1.20E-06	Faist Emmenegger et al. 2007
Propane	2.00E-07	2.00E-07	2.00E-07	2.00E-07	Faist Emmenegger et al. 2007
Propionic acid	2.00E-08	2.00E-08	2.00E-08	2.00E-08	Faist Emmenegger et al. 2007
Sulfur dioxide	5.00E-07	5.00E-07	5.00E-07	5.00E-07	FOEN 2020
Dioxin, 2,3,7,8 Tetrachlorodibenzo-p-	3.00E-17	3.00E-17	3.00E-17	3.00E-17	Faist Emmenegger et al. 2007
Toluene	2.00E-07	2.00E-07	2.00E-07	2.00E-07	Faist Emmenegger et al. 2007

For biomethane heating systems, the carbon dioxide, carbon monoxide and methane emissions were set to biogenic instead of fossil. For all other emissions and amounts it was assumed, that they remain the same.

2.1.3 Condensate emissions to water

Condensing boilers generate emissions to water through the condensate. Other water discharges do not occur with natural gas firing systems. Due to its relative purity, the condensate is usually discharged into the public sewage system. In contrast to oil-fired boilers, neutralisation boxes, e.g. with ion exchange resins, are not necessarily required with natural gas. However, depending on local regulations, neutralisation may also be necessary for condensing natural gas boilers. Here it is assumed that the condensate is discharged into the waste water without neutralisation. Data on condensate quantities and composition were taken from Faist-Emmenegger et al. 2007 as no newer data was found:

- 1.2E-7 kg Nitrate per MJ heat
- 3.0E-9 kg Nitrite per MJ heat
- 5.0E-8 Sulfate per MJ heat
- 5.0E-8 Sulfite per MJ heat.

For 1MW industrial furnace no condensate was considered as such furnaces are normally not condensating.

2.1.4 Summary of life cycle inventory data

In this chapter the life cycle inventories for the newly modelled and updated processes are presented. All data are provided as unit process raw data in the EcoSpold v1 format (unit process in SimaPro). The electronic data is including full EcoSpold v1 documentation.
For each investigated process, two types of tables (X-Process and X-Exchange) are provided in this report. For the biogas and biomethane upstream processes please see Kägi et al. (2021).

Name	gas boiler 15kW	gas boiler 50kW	gas boiler 300kW	industrial furnace, 1MW, natural gas
Location	RER	RER	RER	RER
InfrastructureProcess	1	1	1	1
Unit	unit	unit	unit	unit
IncludedProcesses	Infrastructure of the boiler, including electric and electronic equipment. Energy use for the production. Disposal of the facilities.	Infrastructure of the boiler, including electric and electronic equipment. Energy use for the production. Disposal of the facilities.	Infrastructure of the boiler, including electric and electronic equipment. Energy use for the production. Disposal of the facilities.	Infrastructure of the boiler, including electric and electronic equipment. Energy use for the production. Disposal of the facilities.
LocalName	Heizkessel 15kW, Erdgas	Heizkessel 50kW, Erdgas	Heizkessel 300kW, Erdgas	Industriefeuerung 1MW, Erdgas
Synonyms	Brennwerttechnik // gas thermal value equipment	Brennwerttechnik // gas thermal value equipment	Brennwerttechnik // gas thermal value equipment	Brennwerttechnik // gas thermal value equipment
GeneralComment	Inventory for the production of a gas boiler with a life time of 20 years. Metallic components are assumed to be recycled at the end of life	Inventory for the production of a gas boiler with a life time of 20 years. Metallic components are assumed to be recycled at the end of life	Inventory for the production of a gas boiler with a life time of 20 years. Metallic components are assumed to be recycled at the end of life	Inventory for the production of an industrial furnace with a life time of 20 years. Metallic components are assumed to be recycled at the end of life
InfrastructureIncluded	1	1	1	1
Category	natural gas	natural gas	natural gas	natural gas
SubCategory	heating systems	heating systems	heating systems	heating systems
LocalCategory	Erdgas	Erdgas	Erdgas	Erdgas
LocalSubCategory	Heizungssysteme	Heizungssysteme	Heizungssysteme	Heizungssysteme
Formula				
StatisticalClassification				
CASNumber				
StartDate	2014	2014	2014	2014
EndDate	2020	2020	2020	2020
DataValidForEntirePeriod	1	1	1	1
OtherPeriodText	Materials and energy use based on environmental report from 2014.	Materials and energy use based on environmental report from 2014.	Materials and energy use based on environmental report from 2014.	Materials and energy use based on environmental report from 2014.
Text	Data apply to the supply in Switzerland. Production occurs at Viessmann in Berlin (DE).	Data apply to the supply in Switzerland. Production occurs at Viessmann in Berlin (DE).	Data apply to the supply in Switzerland. Production occurs at Viessmann in Berlin (DE).	Data apply to the supply in Switzerland. Production occurs at Viessmann in Berlin (DE).
Text	Industry data.	Industry data.	Industry data.	Industry data.
Percent				
ProductionVolume				
SamplingProcedure	Data provided by manufacturer	Data provided by manufacturer	Data provided by manufacturer	Data provided by manufacturer
Extrapolations	Data for Germany used with assumptions for Swiss energy supply.	Data for Germany used with assumptions for Swiss energy supply.	Data for Germany used with assumptions for Swiss energy supply.	Data for Germany used with assumptions for Swiss energy supply.

Figure 1: Metadata of gas boiler infrastructure

Name	natural gas, burned in boiler condensing modulating 15kW	natural gas, burned in boiler condensing modulating 50kW	natural gas, burned in boiler condensing modulating 300kW	natural gas, burned in industrial furnace 1MW
Location	CH	CH	CH	CH
InfrastructureProcess	0	0	0	0
Unit	MJ	MJ	MJ	MJ
IncludedProcesses	The module includes fuel input from (CH) network, infrastructure (boiler), emissions to air and water, and electricity needed for operation.	The module includes fuel input from (CH) network, infrastructure (boiler), emissions to air and water, and electricity needed for operation.	The module includes fuel input from (CH) network, infrastructure (boiler), emissions to air and water, and electricity needed for operation.	The module includes fuel input from (CH) network, infrastructure (furnace), emissions to air and water, and electricity needed for operation.
LocalName	Erdgas, in Heizkessel kond. mod. 15kW	Erdgas, in Heizkessel kond. mod. 50kW	Erdgas, in Heizkessel kond. mod. 300kW	Erdgas, in Heizkessel kond. mod. 1MW
Synonyms	In UVEK2018 enthalten	0	0	0
GeneralComment	Inventory for 1 MJ natural gas, burned in a gas boiler condensing modulating with a capacity of 15 kW for an one-family house with 2100 operating hours	Inventory for 1 MJ natural gas, burned in a gas boiler condensing modulating with a capacity of 50 kW for a multi-family house with 2100 operating hours	Inventory for 1 MJ natural gas, burned in a gas boiler condensing modulating with a capacity of 300 kW for an area with several houses with 2100 operating hours	Inventory for 1 MJ natural gas, burned in an industrial furnace with a capacity of 1 MW with 5000 operating hours
InfrastructureIncluded	1	1	1	1
Category	natural gas	natural gas	natural gas	natural gas
SubCategory	heating systems	heating systems	heating systems	heating systems
LocalCategory	Erdgas	Erdgas	Erdgas	Erdgas
LocalSubCategory	Heizungssysteme	Heizungssysteme	Heizungssysteme	Heizungssysteme
Formula	1	1	1	1
StatisticalClassification				
CASNumber				
StartDate	2012	2012	2012	2012
EndDate	2020	2020	2020	2020
DataValidForEntirePeriod	1	1	1	1
OtherPeriodText	Time of publications.	Time of publications.	Time of publications.	Time of publications.
Text	Data apply to the combustion in Switzerland.	Data apply to the combustion in Switzerland.	Data apply to the combustion in Switzerland.	Data apply to the combustion in Switzerland.
Text				
Percent				
ProductionVolume				
SamplingProcedure	based on literature	based on literature	based on literature	based on literature
Extrapolations	none	none	none	none

Figure 2: Metadata of natural gas, burned in boiler or furnace

Name	biomethane, burned in boiler condensing modulating 15kW	biomethane, burned in boiler condensing modulating 50kW	biomethane, burned in boiler condensing modulating 300kW	biomethane, burned in industrial furnace 1MW
Location	CH	CH	CH	CH
InfrastructureProcess	0	0	0	0
Unit	MJ	MJ	MJ	MJ
IncludedProcesses	The module includes fuel input from (CH) network, infrastructure (boiler), emissions to air and water, and electricity needed for operation.	The module includes fuel input from (CH) network, infrastructure (boiler), emissions to air and water, and electricity needed for operation.	The module includes fuel input from (CH) network, infrastructure (boiler), emissions to air and water, and electricity needed for operation.	The module includes fuel input from (CH) network, infrastructure (furnace), emissions to air and water, and electricity needed for operation.
LocalName	Biomethan, in Heizkessel kond. mod. 15kW	Biomethan, in Heizkessel kond. mod. 50kW	Biomethan, in Heizkessel kond. mod. 300kW	Biomethan, in Heizkessel kond. mod. 1MW
Synonyms	0	0	0	0
GeneralComment	Inventory for 1 MJ biomethane, burned in a gas boiler condensing modulating with a capacity of 15 kW for an one-family house with 2100 operating hours.	Inventory for 1 MJ biomethane, burned in a gas boiler condensing modulating with a capacity of 50 kW for a multi-family house with 2100 operating hours.	Inventory for 1 MJ biomethane, burned in a gas boiler condensing modulating with a capacity of 300 kW ifor a area with several houses with 2100 operating hours.	Inventory for 1 MJ biomethane, burned in an industrial furnace with a capacity of 1 MW with 5000 operating hours
InfrastructureIncluded	1	1	1	1
Category	biomass	biomass	biomass	biomass
SubCategory	heating systems	heating systems	heating systems	heating systems
LocalCategory	Biomasse	Biomasse	Biomasse	Biomasse
LocalSubCategory	Brenn- und Treibstoffe	Heizungssysteme	Heizungssysteme	Heizungssysteme
Formula	1	1	1	1
StatisticalClassification				
CASNumber				
StartDate	2012	2012	2012	2012
EndDate	2019	2019	2019	2019
DataValidForEntirePeriod	1	1	1	1
OtherPeriodText	Time of publications.	Time of publications.	Time of publications.	Time of publications.
Text	Data apply to the combustion in Switzerland.	Data apply to the combustion in Switzerland.	Data apply to the combustion in Switzerland.	Data apply to the combustion in Switzerland.
Text				
Percent				
ProductionVolume				
SamplingProcedure				
Extrapolations	This inventory is based on the natural gas, burned in boiler inventory and adjusted regarding the biomethane input and the biogenic CO, CO2 and CH4 emissions.	This inventory is based on the natural gas, burned in boiler inventory and adjusted regarding the biomethane input and the biogenic CO, CO2 and CH4 emissions.	This inventory is based on the natural gas, burned in boiler inventory and adjusted regarding the biomethane input and the biogenic CO, CO2 and CH4 emissions.	This inventory is based on the natural gas, burned in boiler inventory and adjusted regarding the biomethane input and the biogenic CO, CO2 and CH4 emissions.

Figure 3: Metadata of biomethane, burned in boiler or furnace

Name	heat, natural gas, at boiler condensing modulating 15kW	heat, natural gas, at boiler condensing modulating 50kW	heat, natural gas, at boiler condensing modulating 300kW	heat, natural gas, at industrial furnace 1MW
Location	CH	CH	CH	CH
InfrastructureProcess	0	0	0	0
Unit	MJ	MJ	MJ	MJ
IncludedProcesses	Included are the natural gas burning in a 15kW boiler which in turn includes fuel input, infrastructure (boiler), air and water emissions and electrictiy needed for operation. The inventory uses the average net efficiency for the type of boiler referring to the lower calorific value. The heat distribution ios not included	Included are the natural gas burning in a 50kW boiler which in turn includes fuel input, infrastructure (boiler), air and water emissions and electrictiy needed for operation. The inventory uses the average net efficiency for the type of boiler referring to the lower calorific value. The heat distribution ios not included	Included are the natural gas burning in a 300kW boiler which in turn includes fuel input, infrastructure (boiler), air and water emissions and electrictiy needed for operation. The inventory uses the average net efficiency for the type of boiler referring to the lower calorific value. The heat distribution ios not included	Included are the natural gas burning in an industrial furnace (1 MW), which in turn includes fuel input, infrastructure (furnace), air and water emissions and electrictiy needed for operation. The inventory uses the average net efficiency for the type of boiler referring to the lower calorific value. The heat distribution ios not included
LocalName	Nutzwärme, Erdgas, ab Heizkessel kond. mod. 15kW	Nutzwärme, Erdgas, ab Heizkessel kond. mod. 50kW	Nutzwärme, Erdgas, ab Heizkessel kond. mod. 300kW	Nutzwärme, Erdgas, ab Heizkessel kond. mod. 1MW
Synonyms	0	0	0	0
GeneralComment	Inventory for 1 MJ heat from natural gas, burned in a gas boiler condensing modulating with a capacity of 15 kW for an one- family house with 2100 operating hours. Efficiency depends on use patterns such as input and output temperature and is here estimated at partial load (30% load) with efficiency 109.5 % (Hu)	Inventory for 1 MJ heat from natural gas, burned in a gas boiler condensing modulating with a capacity of 50 kW for a multi- family house with 2100 operating hours. Efficiency depends on use patterns such as input and output temperature and is here estimated at partial load (30% load) with efficiency 109.5 % (Hu)	Inventory for 1 MJ heat from natural gas, burned in a gas boiler condensing modulating with a capacity of 300 kW ifor a area with several houses with 2100 operating hours. Efficiency depends on use patterns such as input and output temperature and is here estimated at partial load (30% load) with efficiency 109.7 % (Hu)	Inventory for 1 MJ heat from natural gas, burned in an industrial furnace with a capacity of 1 MW with 5000 operating hours.Efficiency depends on use patterns such as input and output temperature and is here estimated with efficiency 95 % (Hu)
InfrastructureIncluded	1	1	1	1
Category	natural gas	natural gas	natural gas	natural gas
SubCategory	heating systems	heating systems	heating systems	heating systems
LocalCategory	Erdgas	Erdgas	Erdgas	Erdgas
LocalSubCategory	Heizungssysteme	Heizungssysteme	Heizungssysteme	Heizungssysteme
Formula	1	1	1	1
StatisticalClassification				
CASNumber				
StartDate	2016	2016	2016	2007
EndDate	2020	2020	2020	2020
DataValidForEntirePeriod	1	1	1	1
OtherPeriodText	Time of publications.	Time of publications.	Time of publications.	Time of publications.
Text	Data apply to the combustion in Switzerland.	Data apply to the combustion in Switzerland.	Data apply to the combustion in Switzerland.	Data apply to the combustion in Switzerland.
Text	Industry data.	Industry data.	Industry data.	Industry data.
Percent				
ProductionVolume				
SamplingProcedure	Data from literature	Data from literature	Data from literature	Data from literature
Extrapolations	Some generic datasets from ecoinvent have been used.	Some generic datasets from ecoinvent have been used.	Some generic datasets from ecoinvent have been used.	Some generic datasets from ecoinvent have been used.

Figure 4: Metadata of heat, natural gas, burned in boiler or furnace

Name	heat, biomethane, at boiler condensing modulating 15kW	heat, biomethane, at boiler condensing modulating 50kW	heat, biomethane, at boiler condensing modulating 300kW	heat, biomethane, at industrial furnace 1MW
Location	CH	CH	CH	CH
InfrastructureProcess	0	0	0	0
Unit	MJ	MJ	MJ	MJ
IncludedProcesses	Included are the biogas burning in a 15kW boiler which in turn includes fuel input, infrastructure (boiler), air and water emissions and electrictiy needed for operation. The inventory uses the average net efficiency for the type of boiler referring to the lower calorific value. The heat distribution ios not included	Included are the biogas burning in a 50kW boiler which in turn includes fuel input, infrastructure (boiler), air and water emissions and electrictiy needed for operation. The inventory uses the average net efficiency for the type of boiler referring to the lower calorific value. The heat distribution ios not included	Included are the biogas burning in a 300kW boiler which in turn includes fuel input, infrastructure (boiler), air and water emissions and electrictiy needed for operation. The inventory uses the average net efficiency for the type of boiler referring to the lower calorific value. The heat distribution ios not included	Included are the biogas burning in an industrial furnace (1 MW), which in turn includes fuel input, infrastructure (furnace), air and water emissions and electrictiy needed for operation. The inventory uses the average net efficiency for the type of boiler referring to the lower calorific value. The heat distribution ios not included
LocalName	Nutzwärme, Biomethan, ab Heizkessel kond. mod. 15kW	Nutzwärme, Biomethan, ab Heizkessel kond. mod. 50kW	Nutzwärme, Biomethan, ab Heizkessel kond. mod. 300kW	Nutzwärme, Biomethan, ab Heizkessel kond. mod. 1MW
Synonyms				
GeneralComment	Inventory for 1 MJ heat from biogas, burned in a gas boiler condensing modulating with a capacity of 15 kW for an one-family house with 2100 operating hours. Efficiency depends on use patterns such as input and output temperature and is here estimated at partial load (30% load) with efficiency 109.5 % (Hu)	Inventory for 1 MJ heat from biogas, burned in a gas boiler condensing modulating with a capacity of 50 kW for a multi-family house with 2100 operating hours. Efficiency depends on use patterns such as input and output temperature and is here estimated at partial load (30% load) with efficiency 109.5 % (Hu)	Inventory for 1 MJ heat from biogas, burned in a gas boiler condensing modulating with a capacity of 300 kW ifor a area with several houses with 2100 operating hours. Efficiency depends on use patterns such as input and output temperature and is here estimated at partial load (30% load) with efficiency 109.7 % (Hu)	Inventory for 1 MJ heat from biogas, burned in an industrial furnace with a capacity of 1 MW with 5000 operating hours. Efficiency depends on use patterns such as input and output temperature and is here estimated with efficiency 95 % (Hu)
InfrastructureIncluded	1	1	1	1
Category	biomass	biomass	biomass	biomass
SubCategory	heating systems	heating systems	heating systems	heating systems
LocalCategory	Biomasse	Biomasse	Biomasse	Biomasse
LocalSubCategory	Heizungssysteme	Heizungssysteme	Heizungssysteme	Heizungssysteme
Formula	1	1	1	1
StatisticalClassification				
CASNumber				
StartDate	2016	2016	2016	2016
EndDate	2019	2019	2019	2019
DataValidForEntirePeriod	1	1	1	1
OtherPeriodText	Time of publications.	Time of publications.	Time of publications.	Time of publications.
Text	Data apply to the supply in Switzerland. Production occurs at SAPA Building Systems AG in Bellenberg (DE).	Data apply to the supply in Switzerland. Production occurs at SAPA Building Systems AG in Bellenberg (DE).	Data apply to the supply in Switzerland. Production occurs at SAPA Building Systems AG in Nenzing (AT) and Bellenberg (DE).	Data apply to the supply in Switzerland. Production occurs at SAPA Building Systems AG in Nenzing (AT) and Bellenberg (DE).
Text				
Percent				
ProductionVolume				
SamplingProcedure	heat efficieny based on literature	heat efficieny based on literature	heat efficieny based on literature	heat efficieny based on literature
Extrapolations	none	none	none	none

Figure 5: Metadata of heat, biomethane, burned in boiler or furnace

	Name	Location	Infrastructure Process	Unit	gas boiler 15kW	gas boiler 50kW	gas boiler 300kW	industrial furnace, 1MW, natural gas	Uncertainty Type	Standard Deviation 95%	General Comment
	Location				RER	RER	RER	RER			
	Infrastructure Process				1	1	1	1			
	Unit				unit	unit	unit	unit			
product	gas boiler 15kW	RER	1	unit	1	0	0	0			
	gas boiler 50kW	RER	1	unit	0	1	0	0			
	gas boiler 300kW	RER	1	unit	0	0	1	0			
	industrial furnace, 1MW, natural gas	RER	1	unit	0	0	0	1	0		
technosphere	electricity, medium voltage, production ENTSO, at grid	ENTSO	0	kWh	5.63E+1	1.04E+2	2.46E+2	1.16E+3	1	1.14	(2,4,1,3,1,3,BU:1.05); ;
	natural gas, burned in industrial furnace >100kW	RER	0	MJ	4.59E+2	8.49E+2	2.01E+3	9.43E+3	1	1.14	(2,4,1,3,1,3,BU:1.05); ;
	light fuel oil, burned in industrial furnace 1MW, non-modulating	RER	0	MJ	0	0	0	0	1	1.14	(2,4,1,3,1,3,BU:1.05); ;
	aluminium, production mix, cast alloy, at plant	RER	0	kg	8.22E+0	1.52E+1	3.59E+1	1.69E+2	1	1.20	(3,4,3,1,1,3,BU:1.05); ;
	alkyd paint, white, 60% in solvent, at plant	RER	0	kg	3.17E-1	5.86E-1	1.39E+0	6.51E+0	1	1.20	(3,4,3,1,1,3,BU:1.05); ;
	tap water, at user	RER	0	kg	1.28E+2	2.37E+2	5.59E+2	2.63E+3	1	1.14	(2,4,1,3,1,3,BU:1.05); ;
	brass, at plant	CH	0	kg	5.48E-2	1.01E-1	2.40E-1	1.13E+0	1	1.20	(3,4,3,1,1,3,BU:1.05); ;
	brazing solder, cadmium free, at plant	RER	0	kg	8.68E+0	1.61E+1	3.80E+1	1.78E+2	1	1.56	(3,4,3,1,4,3,BU:1.05); ;
	chromium steel 18/8, at plant	RER	0	kg	5.48E+0	1.01E+1	2.40E+1	1.13E+2	1	1.20	(3,4,3,1,1,3,BU:1.05); ;
	copper, at regional storage	RER	0	kg	3.32E+0	6.14E+0	1.45E+1	6.82E+1	1	1.20	(3,4,3,1,1,3,BU:1.05); ;
	polyethylene, HDPE, granulate, at plant	RER	0	kg	0	0	0	0	1	1.20	(3,4,3,1,1,3,BU:1.05); ;
	rock wool, packed, at plant	CH	0	kg	6.25E+0	1.16E+1	2.74E+1	1.29E+2	1	1.20	(3,4,3,1,1,3,BU:1.05); ;
	corrugated board, mixed fibre, single wall, at plant	RER	0	kg	0	0	0	0	1	1.20	(3,4,3,1,1,3,BU:1.05); ;
	steel, low-alloyed, at plant	RER	0	kg	1.26E+2	2.33E+2	5.51E+2	2.59E+3	1	1.20	(3,4,3,1,1,3,BU:1.05); ;
	transport, freight, light commercial vehicle	RER	0	tkm	5.86E+0	1.09E+1	2.57E+1	1.21E+2	1	2.01	(3,na,na,na,1,na,BU:2); ;
	transport, freight, lorry 16-32 metric ton, fleet average	CH	0	tkm	5.86E+0	1.09E+1	2.57E+1	1.21E+2	1	2.09	(4,5,na,na,na,na,BU:2); ;
	transport, freight, rail	RER	0	tkm	7.04E+1	2.65E+2	3.08E+2	1.45E+3	1	2.09	(4,5,na,na,na,na,BU:2); ;
	electronics for control units	RER	0	kg	4.69E-1	8.68E-1	2.05E+0	9.64E+0	1	1.24	(1,4,2,1,1,5,BU:1.05); ;
	disposal, packaging cardboard, 19.6% water, to municipal incineration	CH	0	kg	0	0	0	0	1	1.20	(3,4,3,1,1,3,BU:1.05); ;
	disposal, plastics, mixture, 15.3% water, to municipal incineration	CH	0	kg	3.13E+0	5.79E+0	1.37E+1	6.43E+1	1	1.20	(3,4,3,1,1,3,BU:1.05); ;
	disposal, mineral wool, 0% water, to inert material landfill	CH	0	kg	0	1.16E+1	2.74E+1	0	1	1.20	(3,4,3,1,1,3,BU:1.05); ;
	disposal, hazardous waste, 25% water, to hazardous waste incineration	CH	0	kg	1.56E+0	2.89E+0	6.84E+0	3.21E+1	1	1.20	(3,4,3,1,1,3,BU:1.05); ;
	treatment, pig iron production effluent, to wastewater treatment, class 3	CH	0	m3	1.06E-1	1.96E-1	4.64E-1	2.18E+0	1	1.14	(2,4,1,3,1,3,BU:1.05); ;
resource, land	Occupation, industrial area, built up	-	-	m2a	6.88E-1	1.27E+0	3.01E+0	1.41E+1	1	1.58	(1,4,2,1,1,5,BU:1.5); ;
	Occupation, industrial area, vegetation	-	-	m2a	4.68E-1	8.65E-1	2.05E+0	9.61E+0	1	1.58	(1,4,2,1,1,5,BU:1.5); ;
air, high population density	Heat, waste	-	-	MJ	1.87E+2	3.46E+2	8.19E+2	3.85E+3	1	1.20	(3,4,3,1,1,3,BU:1.05); ;

Figure 6: Unit process raw data of the boiler and furnace infrastructure

	Name	Location	Infrastructure Process	Unit	natural gas, burned in boiler condensing modulating 15kW	natural gas, burned in boiler condensing modulating 50kW	natural gas, burned in boiler condensing modulating 300kW	natural gas, burned in industrial furnace 1MW	Uncertainty Type	Standard Deviation 95%	General Comment
	Location				CH	CH	CH	CH			
	Infrastructure Process				0	0	0	0			
	Unit				MJ	MJ	MJ	MJ			
product	natural gas, burned in boiler condensing modulating 15kW	CH	0	MJ	1	0	0	0			
	natural gas, burned in boiler condensing modulating 50kW	CH	0	MJ	0	1	0	0			
	natural gas, burned in boiler condensing modulating 300kW	CH	0	MJ	0	0	1	0			
	natural gas, burned in industrial furnace	CH	0	MJ	0	0	0	1	0		
technosphere	natural gas, low pressure, at	CH	0	MJ	1.00E+0	1.00E+0	1.00E+0	1.00E+0	1	1.22	(1,3,2,1,1,5,BU:1.05); ;
	electricity, low voltage, production ENTSO, at grid	ENTSO	0	kWh	7.34E-4	3.84E-4	3.11E-4	3.08E-4	1	1.22	(1,3,2,1,1,5,BU:1.05); ;
	gas boiler 15kW	RER	1	unit	4.41E-7				1	3.05	(1,3,2,1,1,5,BU:3); ;
	gas boiler 50kW	RER	1	unit		1.3228E-07			1	3.05	(1,3,2,1,1,5,BU:3); ;
	gas boiler 300kW	RER	1	unit			2.20E-8		1	3.05	(1,3,2,1,1,5,BU:3); ;
	industrial furnace, 1MW, natural gas	RER	1	unit				2.78E-9	1	3.05	(1,3,2,1,1,5,BU:3); ;
	chimney	CH	1	m	8.82E-7	5.95E-7	9.92E-8	8.27E-8	1	3.05	(1,3,2,1,1,5,BU:3); ;
air, high population density	Heat, waste	-	-	MJ	1.08E+0	1.07E+0	1.08E+0	9.80E-1	1	1.25	(2,3,3,1,1,5,BU:1.05); ;
	Acetaldehyde	-	-	kg	1.00E-9	1.00E-9	1.00E-9	1.00E-9	1	1.83	(2,3,5,1,1,5,BU:1.5); ;
	Benzo(a)pyrene	-	-	kg	5.60E-13	5.60E-13	5.60E-13	5.60E-13	1	3.28	(2,3,5,1,1,5,BU:3); ;
	Benzene	-	-	kg	4.00E-7	4.00E-7	4.00E-7	4.00E-7	1	3.28	(2,3,5,1,1,5,BU:3); ;
	Butane	-	-	kg	7.00E-7	7.00E-7	7.00E-7	7.00E-7	1	1.58	(2,3,3,1,1,5,BU:1.5); ;
	Methane, fossil	-	-	kg	6.00E-6	6.00E-6	6.00E-6	6.00E-6	1	1.58	(2,3,3,1,1,5,BU:1.5); ;
	Carbon monoxide, fossil	-	-	kg	1.40E-5	1.40E-5	1.10E-5	1.10E-5	1	5.07	(2,3,3,1,1,5,BU:5); ;
	Carbon dioxide, fossil	-	-	kg	5.60E-2	5.60E-2	5.60E-2	5.60E-2	1	1.22	(2,1,1,1,1,5,BU:1.05); ;
	Acetic acid	-	-	kg	1.50E-7	1.50E-7	1.50E-7	1.50E-7	1	1.83	(2,3,5,1,1,5,BU:1.5); ;
	Formaldehyde	-	-	kg	1.00E-7	1.00E-7	1.00E-7	1.00E-7	1	1.83	(2,3,5,1,1,5,BU:1.5); ;
	Ammonia	-	-	kg	1.00E-9	1.00E-9	1.00E-9	1.00E-9	1	1.62	(2,3,5,1,1,5,BU:1.2); ;
	Mercury	-	-	kg	1.00E-10	1.00E-10	1.00E-10	1.00E-10	1	5.32	(2,3,5,1,1,5,BU:5); ;
	Cadmium	-	-	kg	2.50E-13	2.50E-13	2.50E-13	2.50E-13	1	5.32	(2,3,5,1,1,5,BU:5); ;
	Lead	-	-	kg	1.50E-12	1.50E-12	1.50E-12	1.50E-12	1	5.32	(2,3,5,1,1,5,BU:5); ;
	Dinitrogen monoxide	-	-	kg	3.83E-8	3.83E-8	3.83E-8	3.83E-8	1	1.83	(2,3,5,1,1,5,BU:1.5); ;
	Nitrogen oxides	-	-	kg	1.80E-5	1.80E-5	1.90E-5	1.90E-5	1	1.83	(2,3,5,1,1,5,BU:1.5); ;
	PAH, polycyclic aromatic hydrocarbons	-	-	kg	1.00E-8	1.00E-8	1.00E-8	1.00E-8	1	3.28	(2,3,5,1,1,5,BU:3); ;
	Particulates, < 2.5 um	-	-	kg	1.00E-7	1.00E-7	1.00E-7	1.00E-7	1	3.06	(2,3,3,1,1,5,BU:3); ;
	Pentane	-	-	kg	1.20E-6	1.20E-6	1.20E-6	1.20E-6	1	1.83	(2,3,5,1,1,5,BU:1.5); ;
	Propane	-	-	kg	2.00E-7	2.00E-7	2.00E-7	2.00E-7	1	1.83	(2,3,5,1,1,5,BU:1.5); ;
	Propionic acid	-	-	kg	2.00E-8	2.00E-8	2.00E-8	2.00E-8	1	1.83	(2,3,5,1,1,5,BU:1.5); ;
	Sulfur dioxide	-	-	kg	5.00E-7	5.00E-7	5.00E-7	5.00E-7	1	1.25	(2,3,3,1,1,5,BU:1.05); ;
	Dioxins, measured as 2,3,7,8-tetrachlorodibenzo-p-dioxin	-	-	kg	3.00E-17	3.00E-17	3.00E-17	3.00E-17	1	3.06	(2,3,3,1,1,5,BU:3); ;
	Toluene	-	-	kg	2.00E-7	2.00E-7	2.00E-7	2.00E-7	1	1.83	(2,3,5,1,1,5,BU:1.5); ;
water, river	Nitrate	-	-	kg	1.30E-7	1.30E-7	1.30E-7		1	1.83	(2,3,5,1,1,5,BU:1.5); ;
	Nitrite	-	-	kg	3.00E-9	3.00E-9	3.00E-9		1	1.83	(2,3,5,1,1,5,BU:1.5); ;
	Sulfate	-	-	kg	5.00E-8	5.00E-8	5.00E-8		1	1.83	(2,3,5,1,1,5,BU:1.5); ;
	Sulfite	-	-	kg	5.00E-8	5.00E-8	5.00E-8		1	1.83	(2,3,5,1,1,5,BU:1.5); ;

Figure 7: Unit process raw data of natural gas, burned in boiler and furnace

	Name	Location	Infrastructure Process	Unit	biomethane, burned in boiler condensing modulating 15kW	biomethane, burned in boiler condensing modulating 50kW	biomethane, burned in boiler condensing modulating 300kW	Uncertainty Type	Standard Deviation 95%	General Comment
	Location				CH	CH	CH			
	Infrastructure Process				0	0	0			
	Unit				MJ	MJ	MJ			
product	biomethane, burned in boiler condensing modulating 15kW	CH	0	MJ	1	0	0			
	biomethane, burned in boiler condensing modulating 50kW	CH	0	MJ	0	1	0			
	biomethane, burned in boiler condensing modulating 300kW	CH	0	MJ	0	0	1	0		
	biomethane, burned in industrial furnace 1MW	CH	0	MJ	0	0	0			
technosphere	methane, 96 vol-%, from biogas, low pressure, at consumer	CH	0	MJ	1.00E+0	1.00E+0	1.00E+0	1	1.22	(1,3,2,1,1,5,BU:1.05); ;
	electricity, low voltage, at grid	CH	0	kWh	7.34E-4	3.84E-4	3.11E-4	1	1.22	(1,3,2,1,1,5,BU:1.05); ;
	gas boiler 15kW	RER	1	unit	4.41E-7			1	3.05	(1,3,2,1,1,5,BU:3); ;
	gas boiler 50kW	RER	1	unit		1.32E-7		1	3.05	(1,3,2,1,1,5,BU:3); ;
	gas boiler 300kW	RER	1	unit			2.20E-8	1	3.05	(1,3,2,1,1,5,BU:3); ;
	industrial furnace, 1MW, natural gas	RER	1	unit				1	3.05	(1,3,2,1,1,5,BU:3); ;
	chimney	CH	1	m	8.82E-7	5.95E-7	9.92E-8	1	3.05	(1,3,2,1,1,5,BU:3); ;
air, high population density	Heat, waste	-	-	MJ	1.08E+0	1.07E+0	1.08E+0	1	1.25	(2,3,3,1,1,5,BU:1.05); ;
	Acetaldehyde	-	-	kg	1.00E-9	1.00E-9	1.00E-9	1	1.83	(2,3,5,1,1,5,BU:1.5); ;
	Benzo(a)pyrene	-	-	kg	5.60E-13	5.60E-13	5.60E-13	1	3.28	(2,3,5,1,1,5,BU:3); ;
	Benzene	-	-	kg	4.00E-7	4.00E-7	4.00E-7	1	3.28	(2,3,5,1,1,5,BU:3); ;
	Butane	-	-	kg	7.00E-7	7.00E-7	7.00E-7	1	1.58	(2,3,3,1,1,5,BU:1.5); ;
	Methane, biogenic	-	-	kg	6.00E-6	6.00E-6	6.00E-6	1	1.58	(2,3,3,1,1,5,BU:1.5); ;
	Carbon monoxide, biogenic	-	-	kg	1.40E-5	1.40E-5	1.10E-5	1	5.07	(2,3,3,1,1,5,BU:5); ;
	Carbon dioxide, biogenic	-	-	kg	5.60E-2	5.60E-2	5.60E-2	1	1.22	(2,1,1,1,1,5,BU:1.05); ;
	Acetic acid	-	-	kg	1.50E-7	1.50E-7	1.50E-7	1	1.83	(2,3,5,1,1,5,BU:1.5); ;
	Formaldehyde	-	-	kg	1.00E-7	1.00E-7	1.00E-7	1	1.83	(2,3,5,1,1,5,BU:1.5); ;
	Ammonia	-	-	kg	1.00E-9	1.00E-9	1.00E-9	1	1.62	(2,3,5,1,1,5,BU:1.2); ;
	Mercury	-	-	kg	1.00E-10	1.00E-10	1.00E-10	1	5.32	(2,3,5,1,1,5,BU:5); ;
	Cadmium	-	-	kg	2.50E-13	2.50E-13	2.50E-13	1	5.32	(2,3,5,1,1,5,BU:5); ;
	Lead	-	-	kg	1.50E-12	1.50E-12	1.50E-12	1	5.32	(2,3,5,1,1,5,BU:5); ;
	Dinitrogen monoxide	-	-	kg	3.83E-8	3.83E-8	3.83E-8	1	1.83	(2,3,5,1,1,5,BU:1.5); ;
	Nitrogen oxides	-	-	kg	5.00E-6	5.00E-6	5.28E-6	1	1.83	(2,3,5,1,1,5,BU:1.5); ;
	PAH, polycyclic aromatic hydrocarbons	-	-	kg	1.00E-8	1.00E-8	1.00E-8	1	3.28	(2,3,5,1,1,5,BU:3); ;
	Particulates, < 2.5 um	-	-	kg	1.00E-7	1.00E-7	1.00E-7	1	3.06	(2,3,3,1,1,5,BU:3); ;
	Pentane	-	-	kg	1.20E-6	1.20E-6	1.20E-6	1	1.83	(2,3,5,1,1,5,BU:1.5); ;
	Propane	-	-	kg	2.00E-7	2.00E-7	2.00E-7	1	1.83	(2,3,5,1,1,5,BU:1.5); ;
	Propionic acid	-	-	kg	2.00E-8	2.00E-8	2.00E-8	1	1.83	(2,3,5,1,1,5,BU:1.5); ;
	Sulfur dioxide	-	-	kg	5.00E-7	5.00E-7	5.00E-7	1	1.25	(2,3,3,1,1,5,BU:1.05); ;
	Dioxins, measured as 2,3,7,8-tetrachlorodibenzo-p-dioxin	-	-	kg	3.00E-17	3.00E-17	3.00E-17	1	3.06	(2,3,3,1,1,5,BU:3); ;
	Toluene	-	-	kg	2.00E-7	2.00E-7	2.00E-7	1	1.83	(2,3,5,1,1,5,BU:1.5); ;
water, river	Nitrate	-	-	kg	1.30E-7	1.30E-7	1.30E-7	1	1.83	(2,3,5,1,1,5,BU:1.5); ;
	Nitrite	-	-	kg	3.00E-9	3.00E-9	3.00E-9	1	1.83	(2,3,5,1,1,5,BU:1.5); ;
	Sulfate	-	-	kg	5.00E-8	5.00E-8	5.00E-8	1	1.83	(2,3,5,1,1,5,BU:1.5); ;
	Sulfite	-	-	kg	5.00E-8	5.00E-8	5.00E-8	1	1.83	(2,3,5,1,1,5,BU:1.5); ;

Figure 8: Unit process raw data of biomethane, burned in boiler and furnace

	Name	Location	Infrastructure Process	Unit	heat, natural gas, at boiler condensing modulating 15kW	heat, natural gas, at boiler condensing modulating 50kW	heat, natural gas, at boiler condensing modulating 300kW	heat, natural gas, at industrial furnace 1MW	Uncertainty Type	Standard Deviation 95%	General Comment
	Location				CH	CH	CH	CH			
	Infrastructure Process				0	0	0	0			
	Unit				MJ	MJ	MJ	MJ			
product	heat, natural gas, at boiler condensing modulating 15kW	CH	0	MJ	1	0	0	0			
	heat, natural gas, at boiler condensing modulating 50kW	CH	0	MJ	0	1	0	0			
	heat, natural gas, at boiler condensing modulating 300kW	CH	0	MJ	0	0	1	0			
	heat, natural gas, at industrial furnace 1MW	CH	0	MJ	0	0	0	1	0		
technosphere	natural gas, burned in boiler condensing modulating 15kW	CH	0	MJ	9.13E-1				1	1.21	(1,1,1,1,1,5,BU:1.05); ;
	natural gas, burned in boiler condensing modulating 50kW	CH	0	MJ		9.13E-1			1	1.21	(1,1,1,1,1,5,BU:1.05); ;
	natural gas, burned in boiler condensing modulating 300kW	CH	0	MJ			9.12E-1		1	1.21	(1,1,1,1,1,5,BU:1.05); ;
	natural gas, burned in industrial furnace 1MW	CH	0	MJ				1.05E+0	1	1.21	(1,1,1,1,1,5,BU:1.05); ;

Figure 9: Unit process raw data of heat, natural gas, burned in boiler and furnace

	Name	Location	Infrastructure Process	Unit	heat, biomethane, at boiler condensing modulating 15kW	heat, biomethane, at boiler condensing modulating 50kW	heat, biomethane, at boiler condensing modulating 300kW	heat, biomethane, at industrial furnace 1MW	Uncertainty Type	Standard Deviation 95%	General Comment
	Location				CH	CH	CH	CH			
	Infrastructure Process				0	0	0	0			
	Unit				MJ	MJ	MJ	MJ			
product	heat, biomethane, at boiler condensing modulating 15kW	CH	0	MJ	1	0	0	0			
	heat, biomethane, at boiler condensing modulating 50kW	CH	0	MJ	0	1	0	0			
	heat, biomethane, at boiler condensing modulating 300kW	CH	0	MJ	0	0	1	0			
	heat, biomethane, at industrial furnace 1MW	CH	0	MJ	0	0	0	1	0		
technosphere	biomethane, burned in boiler condensing modulating 15kW	CH	0	MJ	9.13E-1				1	3.05	(2,3,1,1,1,5,BU:3); ;
	biomethane, burned in boiler condensing modulating 50kW	CH	0	MJ		9.13E-1			1	3.05	(2,3,1,1,1,5,BU:3); ;
	biomethane, burned in boiler condensing modulating 300kW	CH	0	MJ			9.12E-1		1	3.05	(2,3,1,1,1,5,BU:3); ;
	biomethane, burned in industrial furnace 1MW	CH	0	MJ				1.05E+0	1	3.05	(2,3,1,1,1,5,BU:3); ;

Figure 10: Unit process raw data of heat, biomethane, burned in boiler and furnace

2.1.5 Data quality

The data quality of the relevant data is general very good. Emission factors for the main air pollutants and the efficiency was updated for this study. Other inputs and outputs which have not been updated during this study are normally of very low relevance for the calculated environmental impacts.

2.1.6 Life cycle impact assessment

At the infrastructure level, the results for industrial furnace are comparable with the old values. The former gas boiler inventory corresponded with the former oil boiler inventory. The results of the new gas boiler inventories are much higher than the former inventories but hardly comparable due to size and data quality.
At the level of MJ input (natural gas, burned in…) the new inventories show very similar results to the former inventories. The reason is that there is the same amount of natural gas as input and the same amount of CO_2 emissions.
At the level of MJ heat delivered (heat, natural gas, burned in…) the new inventories for 15kW to 300kW boilers show about 10 % lower impacts than the former inventories. The reason is higher efficiency levels of the heating systems. For 1MW industrial furnace the results are similar to the former ones due to similar efficiency level.

Table 7: LCIA results of gas heating inventories

Inventory name/unit	Ecological Scarcity 2013	IPCC 2013, GWP 100a	former inventory (UVEK 2018) that most closely matches the update	Ecological Scarcity 2013	IPCC 2013, GWP 100a	UBP ratio	kg CO2eq ratio
	UBP	kg CO2eq		UBP	kg CO2eq	%	%
Gas boiler 15kW/p/RER/I U	1.25E+06	4.06E+02	n.a.				
Gas boiler 50kW/p/RER/I U	2.32E+06	7.56E+02	Gas boiler/RER/I U	9.77E+05	3.84E+02	237%	197%
Gas boiler 300kW/p/RER/I U	5.46E+06	1.78E+03	n.a.				
industrial furnace, 1MW, natural gas/p/RER/I U	2.57E+07	8.35E+03	Industrial furnace, natural gas/RER/I U	2.33E+07	1.03E+04	110%	81%
natural gas, burned in boiler condensing modulating 15kW/MJ/CH U	4.19E+01	6.94E-02	n.a.				
natural gas, burned in boiler condensing modulating 50kW/MJ/CH U	4.14E+01	6.91E-02	Natural gas, burned in boiler condensing modulating <100kW/RER U	4.27E+01	7.05E-02	97%	98%
natural gas, burned in boiler condensing modulating 300kW/MJ/CH U	4.12E+01	6.90E-02	Natural gas, burned in boiler condensing modulating >100kW/RER U	4.10E+01	6.87E-02	101%	100%
natural gas, burned in industrial furnace 1MW/MJ/CH U	4.12E+01	6.90E-02	Natural gas, burned in industrial furnace >100kW/RER U	4.11E+01	6.86E-02	100%	101%
heat, natural gas, at boiler condensing modulating 15kW/MJ/CH U	3.82E+01	6.33E-02	n.a.				
heat, natural gas, at boiler condensing modulating 50kW/MJ/CH U	3.78E+01	6.31E-02	Heat, natural gas, at boiler condensing modulating <100kW/RER U	4.19E+01	6.91E-02	90%	91%
heat, natural gas, at boiler condensing modulating 300kW/MJ/CH U	3.76E+01	6.29E-02	Heat, natural gas, at boiler condensing modulating >100kW/RER U	4.02E+01	6.73E-02	94%	93%
heat, natural gas, at industrial furnace 1MW/MJ/CH U	4.34E+01	7.26E-02	Heat, natural gas, at industrial furnace >100kW/RER U	4.32E+01	7.20E-02	101%	101%
biomethane, burned in boiler condensing modulating 15kW/MJ/CH U	2.55E+01	3.90E-02	n.a.				
biomethane, burned in boiler condensing modulating 50kW/MJ/CH U	2.51E+01	3.88E-02	n.a.				
biomethane, burned in boiler condensing modulating 300kW/MJ/CH U	2.49E+01	3.87E-02	n.a.				
biomethane, burned in industrial furnace 1MW/MJ/CH U	2.48E+01	3.87E-02	n.a.				
heat, biomethane, at boiler condensing modulating 15kW/MJ/CH U	2.33E+01	3.56E-02	n.a.				
heat, biomethane, at boiler condensing modulating 50kW/MJ/CH U	2.29E+01	3.55E-02	n.a.				
heat, biomethane, at boiler condensing modulating 300kW/MJ/CH U	2.27E+01	3.53E-02	n.a.				
heat, biomethane, at industrial furnace 1MW/MJ/CH U	2.61E+01	4.08E-02	n.a.				

2.1.7 Outlook

The LCIA of the different heating systems shows only very small differences for the datasets. However, the classification (15kW – 1MW) is useful by providing processes that mirror the reality in their name and should be maintained in the future.

Furthermore it would be recommended to provide also a European dataset for the combustion of natural gas for room heating.

More differences can be encountered for the datasets in relation to the heat provided. It would be recommended to provide more options for different levels of output temperatures which have a direct influence on the efficiency of the heating devices.

2.2 Electric storage heating

In many older households in Switzerland, electric storage heaters are still in operation. For this reason, the following processes were assessed:

- Electric storage heater, 5kW, at home, CH (Nachtspeicher)
- Heat, at electric storage heater, 5kW at home, CH electricity mix
- Heat, at electric storage heater, 5kW at home, CH certified electricity mix

2.2.1 Infrastructure: Electric storage heater, 5 kW

Electric storage heaters are individual storage heaters, which are located directly in the rooms to be heated. They are all similar in design.
A model from *AEG Haustechnik* was chosen as the baseline for the inventory of such an electric storage stove (Viessmann Werke Berlin GmbH, 2014).

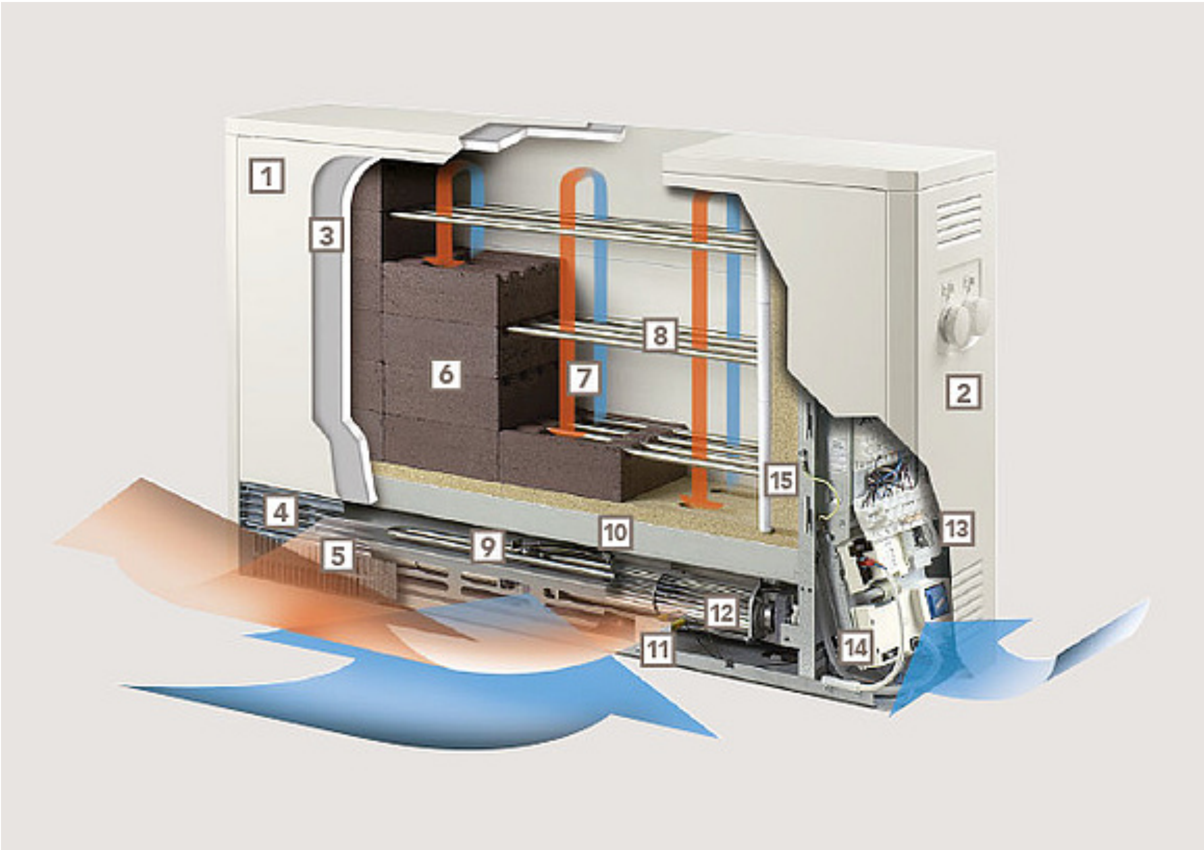

Figure 11: Schematic representation of the structure and components of an AEG night storage heater (Energie Experten, Greenhouse Media GmbH, 2016)

This model is a night storage stove, as often installed in the past. Today, new electric stoves may only be installed in Switzerland under strict regulations. The new generation of electric stoves differs from the model investigated, but because hardly any new electric storage heaters are installed in Swiss households, this older model was investigated in a study by Oriovich (2018).

Table 8: List of material inputs for the inventory of the electric storage heater (Energie Experten, Greenhouse Media GmbH, 2016)

No.	Component and material	Comment	Amount	Unit
1	sheet steel case, enameled, Steel, sheet rolled	Width of the sheet = 2mm	28.27 1.77	kg m_2
2	Control elements, plastics	Estimation	0.50	kg
3	intermediate front with thermal insulation, mineral fibre board	90% of the covering, width = 3cm	16.70	kg
4	Extruded profile air outlet grille, Steel, sheet rolled	1/10 of the surface in front, width = 2mm	0.42	kg
5	Air intake grille with lint filter, Steel, sheet rolled	1/10 of the surface in front, width = 2mm	0.42	kg
6	heat storage core, chamotte	¾ of the height, 90% of length, width minus 7 cm multiplied with ¾ (¼ inside is air for circulation)	95.04	kg
7	Air flow in the storage core			
8	Stainless steel radiator Stainless steel	4 times 3 of 90% oft he length multiplied with 0.4 cm_2	6.70	kg
9	Additional heating Stainless steel	Same like in No. 8	6.70	kg
10	Bimetal for air mixing flap (temperature limitation) Zinc and Steel	Estimation	1.00	kg
11	Safety temperature monitor electronics	Estimation	0.20	kg
12	Tangential fan for air distribution electronics	Estimation	0.20	kg
13	Pivoting terminal strip plastics	Estimation	0.50	kg
14	Electronic charging regulator electronics	Estimation	2.00	kg
15	Hard-shell thermal insulation mineral fibre board	¾ of the height multiplied with width multiplied with cm	1.13	kg
	Total		160	kg

In addition to the material requirements for the construction of the electric storage heater, the energy requirement for production was estimated. The energy consumption for producing the electric storage heater was extrapolated from the energy consumption of the gas boiler production (Viessmann Werke Berlin GmbH, 2014). Due to the much lower complexity of an electric storage heater, the energy requirement was estimated to be four times lower than producing a 5 kW gas boiler.

The standard transport distances of the materials used for producing the electric storage heater in Switzerland are assumed at 600 km by rail and 50 km by truck 16-32 t. (Frischknecht u. a., 2007)

2.2.2 Reference unit, energy demand and losses

For the thermal energy coming from the heating system, 1 MJ of thermal energy output is calculated.

An efficiency of the heating of 100 % was assumed. The losses from the conversion of electrical energy to thermal energy would occur in the form of heat, which in this context is also useful energy. Therefore an efficiency of 100 % is plausible.

2.2.3 Heat at electric storage heater

The share of the infrastructure (electric storage heater) for 1 MJ thermal energy was calculated by means of the life span of an electric storage heater of 20 years on average (IZES gGmbH, 2007) and the assumed heating time per year of 2'100 hours (Jungbluth & Faist Emmenegger, 2003) over the heating capacity of 5 kW of the electric storage heater. With this calculation (1 piece /(5 kW x 2100 h x 20 y x 3.6 MJ/kWh)), the share of an electric storage heater for the production of 1 MJ heat energy is 1.32*e^{-06} piece/MJ.

2.2.4 Disposal

The dipsosal of electric storage heater was assumed to take place as industrial devices to WEEE treatment.

2.2.5 Summary of life cycle inventory data

In this chapter the life cycle inventories for the newly modelled and updated processes are presented. All data are provided as unit process raw data in the EcoSpold v1 format (unit process in SimaPro). The electronic data is including full EcoSpold v1 documentation.
For each investigated process, two types of tables (X-Process and X-Exchange) are provided in this report.

Name	electric storage heater, 5kW
Location	CH
InfrastructureProcess	1
Unit	unit
IncludedProcesses	Infrastructure of the electric storage heater, including all material input. Basic transportations of materials for the production included. No transportation to user, no end of life waste treatment included.
LocalName	Elektrospeicherofen, 5kW
Synonyms	Elektrospeicherheizung
GeneralComment	Inventory for the production of an electric storage heater, 5kW, usage at home, with a life time of 20 years and 2'100 hours of heating within one year. Efficiency of 100% is assumed.
InfrastructureIncluded	1
Category	heat pumps
SubCategory	heating systems
LocalCategory	Elektronik
LocalSubCategory	Heizungssysteme
Formula	
StatisticalClassification	
CASNumber	
StartDate	2009
EndDate	2020
DataValidForEntirePeriod	1
OtherPeriodText	Materials and energy use based on AEG Nachtspeicherofen/ electric storage heater published in 2016.
Text	Data apply to the supply in Switzerland. Production occurs at AEG Haustechnik / STIEBEL ELTRON GmbH & Co. KG (DE).
Text	Industry data.
Percent	
ProductionVolume	
SamplingProcedure	Data provided by manufacturer
Extrapolations	Data for Germany used with assumptions for Swiss energy supply.

Figure 12: Metadata of electric storage heater

Name	heat at electric storage heater, 5kW, CH electricity mix	heat at electric storage heater, 5kW, CH certified electricity
Location	CH	CH
InfrastructureProcess	0	0
Unit	MJ	MJ
IncludedProcesses	Share of the electric storage heater infrastructure (calculated with a lifetime of the heater of 20y and 2'100 hours of heating in a year) and electric energy input with an assumed efficiency of 100%.	Share of the electric storage heater infrastructure (calculated with a lifetime of the heater of 20y and 2'100 hours of heating in a year) and electric energy input with an assumed efficiency of 100%.
LocalName	Nutzwärme, Elektrospeicherofen, 5kW, CH Strommix	Nutzwärme, Elektrospeicherofen, 5kW, CH zertifizierter Strom
Synonyms	Elektrospeicherofen / Nachtspeicher	Elektrospeicherofen / Nachtspeicher
GeneralComment	Heat from an electric storage heater at home, 5kW by using swiss electricity mix. Efficiency assumed at 100%.	Heat from an electric storage heater at home, 5kW by using certified electricity mix. Efficiency assumed at 100%.
InfrastructureIncluded	1	1
Category	heat pumps	heat pumps
SubCategory	heating systems	heating systems
LocalCategory	elektronik	elektronik
LocalSubCategory	heizungssysteme	heizungssysteme
Formula		
StatisticalClassification		
CASNumber		
StartDate	2020	2020
EndDate	2020	2020
DataValidForEntirePeriod	1	1
OtherPeriodText	Materials and energy use based on AEG Nachtspeicherofen/ electric storage heater published in 2016. Report from: https://www.energie-experten.org/heizung/elektroheizung/speicherheizung/nachtspeicheroefen.html	Materials and energy use based on AEG Nachtspeicherofen/ electric storage heater published in 2016. Report from: https://www.energie-experten.org/heizung/elektroheizung/speicherheizung/nachtspeicheroefen.html
Text	Data apply to the supply in Switzerland. Production occurs at AEG Haustechnik / STIEBEL ELTRON GmbH & Co. KG (DE).	Data apply to the supply in Switzerland. Production occurs at AEG Haustechnik / STIEBEL ELTRON GmbH & Co. KG (DE).
Text	Industry data.	Industry data.
Percent		
ProductionVolume		
SamplingProcedure	Data provided by manufacturer	Data provided by manufacturer
Extrapolations	Data for Germany used with assumptions for Swiss energy supply.	Data for Germany used with assumptions for Swiss energy supply.

Figure 13: Metadata of electric storage heater

	Name	Location	Infrastructure Process	Unit	electric storage heater, 5kW	Uncertainty Type	Standard Deviation 95%	General Comment
	Location				CH			
	Infrastructure Process				1			
	Unit				unit			
product	electric storage heater, 5kW	CH	1	unit	1	0		
technosphere	steel, low-alloyed, at plant	RER	0	kg	28.27	1	1.30	(1,1,2,2,3,5,BU:1.05); ;
	sheet rolling, steel	RER	0	kg	28.27	1	1.30	(1,1,2,2,3,5,BU:1.05); ;
	enamelling	RER	0	m2	1.7669	1	1.31	(2,2,2,3,3,5,BU:1.05); ;
	polyester resin, unsaturated, at plant	RER	0	kg	0.5	1	1.62	(5,2,2,2,3,5,BU:1.05); ;
	rock wool, packed, at plant	CH	0	kg	8.35	1	1.32	(3,1,2,2,3,5,BU:1.05); ;
	expanded perlite, at plant	CH	0	kg	4.17	1	1.62	(5,2,2,2,3,5,BU:1.05); ;
	light clay brick, at plant	DE	0	kg	4.17	1	1.62	(5,2,2,2,3,5,BU:1.05); ;
	steel, low-alloyed, at plant	RER	0	kg	0.84	1	1.62	(5,2,2,2,3,5,BU:1.05); ;
	sheet rolling, steel	RER	0	kg	0.84	1	1.62	(5,2,2,2,3,5,BU:1.05); ;
	steel product manufacturing, average metal working	RER	0	kg	0.84	1	1.62	(5,2,2,2,3,5,BU:1.05); ;
	refractory, high aluminium oxide, packed, at plant	DE	0	kg	95.04	1	1.30	(1,1,2,2,3,5,BU:1.05); ;
	steel, electric, chromium steel 18/8, at plant	RER	0	kg	13.4	1	1.30	(1,1,2,2,3,5,BU:1.05); ;
	chromium steel product manufacturing, average metal working	RER	0	kg	13.4	1	1.30	(1,1,2,2,3,5,BU:1.05); ;
	zinc, from combined metal production, at refinery	SE	0	kg	0.5	1	1.31	(2,1,2,2,3,5,BU:1.05); ;
	sheet rolling, aluminium	RER	0	kg	0.5	1	1.31	(2,1,2,2,3,5,BU:1.05); ;
	steel, low-alloyed, at plant	RER	0	kg	0.5	1	1.31	(2,1,2,2,3,5,BU:1.05); ;
	sheet rolling, steel	RER	0	kg	1	1	1.31	(2,1,2,2,3,5,BU:1.05); ;
	electronic component, passive, unspecified, at plant	GLO	0	kg	0.4	1	1.35	(3,4,2,2,3,5,BU:1.05); ;
	polyester resin, unsaturated, at plant	RER	0	kg	0.5	1	1.35	(3,4,2,2,3,5,BU:1.05); ;
	electronic component, passive, unspecified, at plant	GLO	0	kg	2	1	1.35	(3,4,2,2,3,5,BU:1.05); ;
	rock wool, packed, at plant	CH	0	kg	0.565	1	1.30	(1,1,2,2,3,5,BU:1.05); ;
	expanded perlite, at plant	CH	0	kg	0.282	1	1.30	(1,1,2,2,3,5,BU:1.05); ;
	light clay brick, at plant	DE	0	kg	0.282	1	1.30	(1,1,2,2,3,5,BU:1.05); ;
	transport, freight, lorry 16-32 metric ton, fleet average	CH	0	tkm	8	1	3.04	(4,5,5,5,5,5,BU:2); ;
	transport, freight, rail	RER	0	tkm	96	1	3.04	(4,5,5,5,5,5,BU:2); ;
	electricity, medium voltage, production CH, at grid	CH	0	kWh	5.52	1	1.84	(5,4,2,2,4,5,BU:1.05); ;
	natural gas, burned in industrial furnace low-NOx >100kW	RER	0	MJ	45.002	1	1.84	(5,4,2,2,4,5,BU:1.05); ;

Figure 14: Unit process raw data of electric storage heater

	Name	Location	Infrastructure Process	Unit	heat at electric storage heater, 5kW, CH electricity mix	heat at electric storage heater, 5kW, CH certified electricity	Uncertainty Type	Standard Deviation 95%	General Comment
	Location				CH	CH			
	Infrastructure Process				0	0			
	Unit				MJ	MJ			
product	heat at electric storage heater, 5kW, CH electricity mix	CH	0	MJ	1	0	0		
product	heat at electric storage heater, 5kW, CH certified electricity	CH	0	MJ	0	1	0		
technosphere	electric storage heater, 5kW	CH	1	unit	1.32275E-06	1.32275E-06	1	1.32	(3,2,1,3,3,5,BU:1.05); ;
	electricity, low voltage, at grid	CH	0	kWh	0.278	0	1	1.30	(1,1,1,1,3,5,BU:1.05); ;
	electricity, low voltage, certified electricity, at grid	CH	0	kWh	0	0.278	1	1.30	(1,1,1,1,3,5,BU:1.05); ;

Figure 15: Unit process raw data of heat, at electric storage heater

ReferenceFunction	401	Name	disposal, electric storage heater, 5kW
Geography	662	Location	CH
ReferenceFunction	493	InfrastructureProcess	1
ReferenceFunction	403	Unit	unit
DataSetInformation	201	Type	1
	202	Version	1.0
	203	energyValues	0
	205	LanguageCode	en
	206	LocalLanguageCode	de
DataEntryBy	302	Person	101
	304	QualityNetwork	1
ReferenceFunction	400	DataSetRelatesToProduct	1
	402	IncludedProcesses	Infrastructure of the electric storage heater, including all material input. Basic transportations of materials for the production included. No transportation to user, no end of life waste treatment included.
	404	Amount	1
	490	LocalName	Entsorgung, Elektrospeicherofen, 5kW
	491	Synonyms	0
	492	GeneralComment	Inventory for the disposal of an electric storage heater, 5kW, 160 kg, usage at home, with a life time of 20 years and 2'100 hours of heating within one year. Efficiency of 100% is assumed.
	494	InfrastructureIncluded	1
	495	Category	heat pumps
	496	SubCategory	disposal
	497	LocalCategory	Elektronik
	498	LocalSubCategory	Entsorgung
	499	Formula	
	501	StatisticalClassification	
	502	CASNumber	
TimePeriod	601	StartDate	2009
	602	EndDate	2020
	603	DataValidForEntirePeriod	1
	611	OtherPeriodText	Materials and energy use based on AEG Nachtspeicherofen/ electric storage heater published in 2016.
Geography	663	Text	Data apply to the supply in Switzerland. Production occurs at AEG Haustechnik / STIEBEL ELTRON GmbH & Co. KG (DE).
Technology	692	Text	Industry data.
Representativeness	722	Percent	
	724	ProductionVolume	
	725	SamplingProcedure	Data provided by manufacturer
	726	Extrapolations	Data for Germany used with ass
	727	UncertaintyAdjustments	none

Figure 16: Unit Metadata of disposal of electric storage heater

		Input Group	Output Group	Name	Location	Infrastructure Process	Unit	disposal, electric storage heater, 5kW	Uncertainty Type	Standard Deviation 95%	General Comment
	401			Name							
	662			Location				CH			
	493			Infrastructure Process				1			
	403			Unit				unit			
product		-	1	disposal, electric storage heater, 5kW	CH	1	unit	1	1		
technosphere		5	-	disposal, industrial devices, to WEEE treatment	CH	0	kg	1.6E+02	1	1.84	(5,4,2,2,4,5,BU:1.05); ;

Figure 17: Unit process raw data of disposal of electric storage heater

2.2.6 Data quality

The data quality is medium for the electric heater production and good for the electric heating system. No emission inputs were inserted for the heat inventories as there are no chemicals used for this kind of heating. Other inputs and outputs which have not been taken into account during this study are normally of very low relevance for the calculated environmental impacts.

2.2.7 Life cycle impact assessment

Until now there was no electric storage heating inventory. The results are slightly higher than if only the corresponding amount of electricity was assessed.

Table 9: LCIA results of electric storage heating system

Inventory name/unit	Ecological Scarcity 2013	IPCC 2013, GWP 100a	former inventory (UVEK 2018) that most closely matches the update	Ecological Scarcity 2013	IPCC 2013, GWP 100a	UBP ratio	kg CO2eq ratio
	UBP	kg CO2eq		UBP	kg CO2eq	%	%
electric storage heater, 5kW/p/CH/I U	1.10E+06	3.85E+02	n.a.				
heat at electric storage heater, 5kW, CH certified electricity/MJ/CH U	1.41E+01	4.32E-03	n.a.				
heat at electric storage heater, 5kW, CH electricity mix/MJ/CH U	9.91E+01	5.09E-02	n.a.				

2.2.8 Outlook

The LCIA shows that the results heavily depend on the used electricity mix. Therefore we recommend to provide also a European dataset for the electric storage heating.

2.3 Heat pump systems

The heat pump basically consists of four parts:
- the evaporator,
- the compressor,
- the condenser and
- the expansion valve (throttling element).

A working fluid (refrigerant such as R410A) circulates in the heat pump circuit, whose boiling point is lower than the temperature in the heat source circuit (brine in the case of the geothermal probe). The working fluid heats up and becomes gaseous. In its gaseous form it enters the compressor and is compressed. By increasing the pressure the gas is heated and the temperature rises from the source temperature to the usage temperature. The working fluid is then led to the liquefier which allows for a temperature exchange between the working fluid and the water of the heating circuit. The increases the temperature of the water of the heating circuit and cools down the working fluid. The working fluid becomes liquid again and flows to the expansion valve, where the pressure is reduced. It is then again able to absorb heat from the evaporator.

The following inventories were created:

Infrastructure
- Heat pump, air-water 7kW/CH
- Heat pump, air-water 15kW/CH
- Heat pump, air-water 50kW/CH
- Heat pump, brine water 7kW/CH
- Heat pump, brine water 15kW/CH
- Heat pump, brine water 50kW/CH
- Borehole heat exchanger, 300m/CH
- Ice storage tank/CH
- Delivery and return well/CH

Energy – heat
- Heat, at air-water heat pump 7kW, in new building, CH electricity mix/CH
- Heat, at air-water heat pump 7kW, in new building, certified electricity mix/CH
- Heat, at air-water heat pump 7kW, in new building, CH electricity mix/CH
- Heat, at air-water heat pump 7kW, in new building, certified electricity mix/CH
- Heat, at air-water heat pump 15kW, in old building, CH electricity mix/CH
- Heat, at air-water heat pump 15kW, in old building, certified electricity mix/CH
- Heat, at air-water heat pump 15kW, in new building, CH electricity mix/CH
- Heat, at air-water heat pump 15kW, in new building, certified electricity mix/CH
- Heat, at air-water heat pump 15kW, in old building, CH electricity mix/CH
- Heat, at air-water heat pump 15kW, in old building, certified electricity mix/CH
- Heat, at air-water heat pump 15kW, in new building, CH electricity mix/CH
- Heat, at air-water heat pump 15kW, in new building, certified electricity mix/CH
- Heat, at air-water heat pump 50kW, in old building, CH electricity mix/CH
- Heat, at air-water heat pump 50kW, in old building, certified electricity mix/CH
- Heat, at air-water heat pump 50kW, in new building, CH electricity mix/CH
- Heat, at air-water heat pump 50kW, in new building, certified electricity mix/CH
- Heat, at air-water heat pump 50kW, in old building, CH electricity mix/CH
- Heat, at air-water heat pump 50kW, in old building, certified electricity mix/CH
- Heat, at air-water heat pump 50kW, in new building, CH electricity mix/CH
- Heat, at air-water heat pump 50kW, in new building, certified electricity mix/CH

The same inventories were also created for ground water heat pump, brine water heat pump with borehole exchanger and ice water storage heat pump. The additional tow inventories were created for district heating systems:

- Heat, at ground water heat pump 50kW, for district heating, CH electricity mix/CH
- Heat, at borehole heat pump 50kW, for district heating, CH electricity mix/CH

2.3.1 Infrastructure

The following sections describe the resource, material and energy inputs of the inventories for different heat pumps and heat sources.

2.3.1.1 Brine water heat pump

The amount of material used is estimated based on material composition and dimensions of the heat pumps. An average weight of 158 kg for the 7 kw heat pump, 182 kg for the 15 kw heat pump and 383 kg for the 50 kw heat pump was used based on average values from technical datasheets (TDS heat pumps, 2020). Average refrigerant amount is estimated using average values of technical datasheets.

The compressor and the heat pump housing are made of unalloyed steel. Evaporators and condensers are made of low-alloy steel. Copper is used for the compressor, the heat pump pipes and the electrical cables for the control system. The heat pump uses insulation material and white refrigerating machine oil is used to lubricate the compressor (Heck, PSI, 2003). The amounts of the different materials got scaled by the average of the total weight from a variety of brine-water heat pumps. Those are listed in the column "Source" in Table 10.

For the production energy data from Viessmann Werke GmbH & Co. KG is used (Viessmann Werke GmbH & Co. KG, 2019a).

The standard transport distances used in this project for consumption in Switzerland are 600 km by rail, 50 km by truck 16-32 t (Frischknecht u. a., 2007).

It is assumed that the materials steel, copper and the coolant R410A are recycled. The plastics are deposited in a municipal incineration (insulation, PVC) (Heck, PSI, 2003).

During the manufacture of the heat pump, refrigerant emissions are caused by losses of approx. 3 % of the filling quantity, while during scrapping approx. 19 % of the filling quantity is emitted (Federal Office for the Environment (FOEN), 2020). Therefore 22 % of the filling quantity is accounted for as emissions into the air. Other emissions to air are the electricity input converted into MJ, which is assumed to be waste heat.

Table 10: Material, resource and energy inputs for the production of brine-water heat pumps

	Unit	Brine-water heat pump 7 kw	Brine-water heat pump 15 kw	Brine-water heat pump 50 kw	Source
Tube insulation,	kg / pcs	12.1	13.9	29.2	Estimations based on (alpha innotec deutschland GmbH, 2017, 2020; Heck, PSI, 2003; Hoval AG, o. J.; Stiebel Eltron AG, 2020; Vaillant GmbH, 2019; Viessmann (Schweiz) AG, 2020; Viessmann Werke GmbH & Co. KG, 2019)
R410A (50 % Trifluoromethane instead of Diflluormethane / 50 % Difluoroethane instead of Pentafluorethane	kg / pcs	2.0	2.8	9.6	
Copper,	kg / pcs	26.5	31.0	64.3	
Polyvinylchloride	kg / pcs	1.2	1.4	2.9	
Steel, low-alloyed	kg / pcs	114.6	132.0	278.0	
Reinforcing steel	kg / pcs	0	0	0	
Lubricating oil, at plant/RER U	kg / pcs	1.9	2.2	4.7	
Electronic control	kg / pcs	1.5	2.0	5.0	
Water	m^3 / pcs	0.6	0.7	1.4	(Viessmann Werke GmbH & Co. KG, 2019a)
Electricity	kWh / pcs	343.9	396.1	833.6	
Natural gas, burned in industrial furnace	kWh / pcs	256.9	295.9	622.7	
Light fuel oil, burned in industrial furnace	kWh / pcs	8.1	9.3	19.7	
Biomethan, heat at industrial furnace	kWh / pcs	120.8	139.1	292.7	
Woodchips, at furnace	kWh / pcs	97.9	112.8	237.3	
Occupation industrial area vegetation	m^2*a	5.1	5.9	12.4	
Occupation industrial area build up	m^2*a	1.4	1.6	3.4	

2.3.1.2 Air-water heat pump

The amount of material used is estimated based on material composition and dimensions of the heat pumps. An average weight of 256 kg for the 7 kw heat pump, 271 kg for the 15 kw heat pump and 781 kg for the 50 kw heat pump was used based on average values from technical datasheets (see Table 9). Average refrigerant amount is estimated using average values of technical datasheets.

The compressor and the heat pump housing are made of unalloyed steel. Evaporators and condensers are made of low-alloy steel. Copper is used for the compressor, the heat pump pipes and the electrical cables for the control system. The heat pump uses insulation material and white refrigerating machine oil is used to lubricate the compressor (Heck, PSI, 2003). The amounts of the different materials got scaled by the average of the total weight from a variety of air-water heat pumps. Those are listed in the column “Source” in Table 11.

For the production energy data from Viessmann Werke GmbH & Co. KG is used (Viessmann Werke GmbH & Co. KG, 2019a).

The standard transport distances used in this project for consumption in Switzerland are 600 km by rail, 50 km by truck 16-32 t (Frischknecht u. a., 2007).
It is assumed that the materials steel, copper and the coolant R410A are recycled. The plastics are deposited in a municipal incineration (insulation, PVC). (Heck, PSI, 2003)
During the manufacture of the heat pump, refrigerant emissions are caused by losses of approx. 3 % of the filling quantity, while during scrapping approx. 19 % of the filling quantity is emitted (Federal Office for the Environment (FOEN), 2020). Therefore 22 % of the filling quantity is accounted for as emissions into the air. Other emissions to air are the electricity input converted into MJ, which is assumed to be waste heat.

Table 11: Material, resource and energy inputs for the production of air-water heat pumps

	Unit	Air-water heat pump 7 kw	Air-water heat pump 15 kw	Air-water heat pump 50 kw	Source
Tube insulation,	kg / pcs	12.1	13.9	29.2	Estimation, based on (alpha innotec deutschland GmbH, 2017, 2020; CTA AG, 2017; CTC Giersch AG, 2018, 2019; Heck, PSI, 2003; Vaillant GmbH, 2019; Viessmann Werke GmbH & Co. KG, 2019, 2020b, 2020a)
Rock wool	kg / pcs	4.0	5.0	5.0	
R410A (50 % Trifluoromethane instead of Diflluormethane / 50 % Difluoroethane instead of Pentafluorethane)	kg / pcs	3.5	4.5	20.0	
Copper,	kg / pcs	59.2	60.2	196.7	
Polyvinylchloride	kg / pcs	1.2	1.4	2.9	
Steel, low-alloyed	kg / pcs	146.9	159.7	410.1	
Reinforcing steel	kg / pcs	0	0	0	
Aluminium	kg / pcs	32.3	30.0	132.3	
Lubricating oil, at plant/RER U	kg / pcs	2.2	2.2	4.7	
Electronic control	kg / pcs	1.5	2.0	5.0	
Water	m^3 / pcs	0.95	1.0	2.9	(Viessmann Werke GmbH & Co. KG, 2019a)
Electricity	kWh / pcs	557.2	589.8	1'697.7	
Natural gas, burned in industrial furnace	MJ / pcs	1’498.4	1'586.2	4'565.5	
Light fuel oil, burned in industrial furnace	MJ/ pcs	47.3	50.0	144.0	
Biomethan, heat at industrial furnace	MJ / pcs	704.4	745.6	2’048.4	
Woodchips, at furnace	MJ / pcs	571.0	604.4	1'739.9	
Occupation industrial area vegetation	m^2*a	8.3	8.7	25.16	
Occupation industrial area build up	m^2*a	2.3	2.4	6.94	

2.3.1.3 Refrigerant

Although the heat pump has a hermetically sealed circuit, the possibility of the working fluid escaping into the environment in the event of a breakdown cannot be excluded. For this reason, the amount of working fluid should be kept as low as possible. The Ordinance on Environmentally Hazardous Substances of 14 August 1991 provided for a general ban on substances that deplete the ozone layer from 1994 onwards. R22 (HCFCs) were the successor of the fully halogenated CFCs (e.g. dichlorodifluoromethane R12) which had been banned since January 1994. Since 2001, the use of R22 is also no longer permitted in new plants in Switzerland. In 1996 almost all heat pumps in Switzerland used R22 as a refrigerant. In 2000, the main refrigerants used in new heat pumps in Switzerland were R134a (1,1,1,2-tetrafluoroethane), R404A, R407C, R407D, R410A, R417A and R290 (propane) (WPZ 2003). Today, the most common refrigerant used in new heat pumps according to the technical datasheets of modern heat pumps is R410A that consists of 50 % difluoromethane and 50 % pentafluoroethane. Therefore, in this study R410A is assumed to be the refrigerant. For the material input of the refrigerant there were no inventories for difluoromethane and pentafluoroethane available. Hence, the inventories of 50 % trifluoromethane and 50 % difluoroethane were used as approximation. But more importantly, the correct emission to air elementary flows were used.

2.3.1.4 Borehole

One possible heat source for a brine-water heat pump is the geothermal probe. The inventory of the borehole heat exchanger has been updated with current data from manufacturers. A 300 m deep geothermal probe is suitable for a brine-water heat pump with a capacity of 15 kW assuming an average 50 W/m borehole. A 50 kw brine-water heat pump requires a 1'000 m geothermal probe and a 7 kw brine-water heat pump requires a 150 m geothermal probe. A borehole with a diameter of 152mm and a dual u-tube was assumed. In the following table all material inputs which were changed in the inventory are listed.

Table 12: Material and energy input for the production and construction of borehole heat exchanger

Material	Unit	Borehole heat exchanger 300 m	Source
Bentonite,	kg / pcs	1148	Ebert, 2018 + Küchler 2022: 24% CH-mix and 76% Inktherm 110. CH-mix: 0.9t water/m3, 0.2t cement/m3 and 0.1 bentonit/m3. Inktherm 110: 0.65t water/m3, 0.22t cement/m3, 0.59t bentonite/m3
Polyethylene, HDPE	kg / pcs	258	(AWP - Arbeitsgemeinschaft Wärmepumpen, 2007a): 4 tubes per borehole, 40mm diameter, 3.7mm thickness
Cement	kg / pcs	519	Ebert, 2018 + Küchler 2022: 24% CH-mix and 76% Inktherm 110. CH-mix: 0.9t water/m3, 0.2t cement/m3 and 0.1 bentonit/m3. Inktherm 110: 0.65t water/m3, 0.22t cement/m3, 0.59t bentonite/m3
Water	kg / pcs	1726	Ebert, 2018 + Küchler 2022: 24% CH-mix and 76% Inktherm 110. CH-mix: 0.9t water/m3, 0.2t cement/m3 and 0.1 bentonit/m3. Inktherm 110: 0.65t water/m3, 0.22t cement/m3, 0.59t bentonite/m3
Brine water: Ethylene glycol Water	kg / pcs kg / pcs	279 754	(AWP - Arbeitsgemeinschaft Wärmepumpen, 2007b): 0.838l/m per tube = 3.352l/m borehole, glycol concentration in brine water: 25%. density glycol 1.11kg/l
Diesel burned in building machine	MJ / pcs	39'566	3.5l/m (average of four companies according to personal communication from Fachvereinigung Wärmepumpen Schweiz -FWS), 0.83kg/l, 45.4MJ/kg
Disposal inert waste to landfill	kg / pcs	13609	Assumptions: 0.14m diameter of borehole, densitiy of material in ground: 2'500 kg / m3

The standard transport distances of the materials used for producing and building the borehole heat exchangers in Switzerland are assumed at 600 km by rail and 50 km by truck 16-32 t (Frischknecht u. a., 2007).
No waste treatment processes are included in this inventory, except the landfill disposal of inert wastes from drilling the hole in the ground.

2.3.1.5 Groundwater: Delivery and return well

Another source of thermal energy for the heat pump is the groundwater. In this system an underground delivery well and a return well is needed to use the thermal energy of the groundwater (Martin Bachner GmbH, o. J.). An inventory for the delivery and return wells were created accordingly. The infrastructure is based on the plan for the wells from Martin Bachner GmbH. The delivery well has a depth of 9 m; the return well 7 m. The distance between both of them needs to be at least 15 m to avoid the mixing of the two water streams. The system therefore includes delivery pipes between the two wells and the heat pump which is assumed to be 13 m long with an outer diameter of 0.05 m and an inner diameter of 0.045 m. All pipes are made of PVC.
The inventory further includes all the materials used for the wells and also the energy input for the building machines which are used to construct the holes for the wells. The amount of the energy use got derived from the energy input used by the construction machines from the borehole process (Heck, PSI, 2003).

In the following table all material inputs in the inventory for the infrastructure of a delivery and return well are listed. In the UVEK-Database it is created as one inventory.

Table 13: Material and energy input for the production and construction of delivery and return well

Material	Unit	Delivery well, 9 m	Return well, 7 m	Source
Polyvinylchloride (connecting pipe for in between the two wells)	kg / pcs	3.4	3.4	(Martin Bachner GmbH, o. J.), estimation
Clay plaster	kg / pcs	50.8	70.1	(Martin Bachner GmbH, 2009a, 2009b)
Gravel round	kg / pcs	228.6	289.0	(Martin Bachner GmbH, 2009a, 2009b)
Polyvinylchloride	kg / pcs	28.5	10.7	(Martin Bachner GmbH, 2009a, 2009b)
Aluminium (lit for well)	kg / pcs	0	0.3	(erdbohrer de, 2020; Martin Bachner GmbH, 2009a, 2009b)
Steel, low-alloyed (end of pipe)	kg / pcs	0	1.9	(Martin Bachner GmbH, 2009a, 2009b; Sanitär, 2020)
Diesel burned in building machine	MJ / pcs	1'051.3	817.7	(Heck, PSI, 2003), estimation

The standard transport distances of the materials used for producing and building the delivery and return well in Switzerland are assumed at 600 km by rail and 50 km by truck 16-32 t (Frischknecht u. a., 2007).
No waste treatment processes are included in this inventory except the landfill disposal of inert wastes from drilling the hole into the ground.

2.3.1.6 Ice Storage

It is also possible to gain heat energy for a heat pump from a so-called ice storage tank. Such a system includes (beside the actual ice storage tank) an evacuated tube collector. In summer, this absorbs the heat that is fed to the heat pump and used for heating or hot water preparation. The ice storage consists mainly of an underground cistern, filled with water and equipped with polyethylene tubes. In addition, the connecting pipes between the solar collector, the brine-water heat pump and the ice storage tank were estimated and taken into account in the inventory. The following table provides an overview of the materials used in the inventory for an ice storage heating system without heat pump.

Material	Unit	Amount	Source
Concrete, exacting	m^3 / pcs	3.3	(Kägi & Dinkel, 2012)
Polyethylene, HDPE (pipes in the tank)	kg / pcs	30.0	(Kägi & Dinkel, 2012)
Evacuated tube collector	m^2 / pcs	12.0	(Kägi & Dinkel, 2012)
Polyethylene HDPE (pipes for connecting the different components)	kg / pcs	5.2	(pumpe24 Wassertechnik GmbH, 2020)
Tap water	m^3 / pcs	10.0	(Viessmann Werke GmbH & Co. KG, 2020)

As energy input for digging the hole into the ground for putting the tank into position, the process "excavation, hydraulic digger, with particle filter" was used with the amount of 12 m^3 (Kägi & Dinkel, 2012).
Furthermore the standard transport distances of the materials used for producing and building this system with the evacuated tube collector, pipes and the tank are assumed at 600 km by rail and 50 km by truck 16-32 t (Frischknecht u. a., 2007).

2.3.2 Reference unit

For the thermal energy coming from the heat pump heating systems, 1 MJ of thermal energy output is calculated.

2.3.3 Use phase

2.3.3.1 Use of Infrastructure

An annual running time of 2'100 hours is assumed for all systems (Heck, PSI, 2003). The service life for an air-water and brine-water heat pump is approx. 20 years. This means that a 7 kW heat pump will generate 1'058 GJ of useful heat over its entire service life, a 15 kW heat pump will generate 2'268 GJ of useful heat over its entire service life and a 50 kW heat pump 7'560 GJ of useful heat over its entire service life.
The complementary components such as the geothermal probe, the ice reservoir and groundwater pumps have a different service life. For the geothermal probe, a service life of 50 years was expected, for the ice reservoir 25 years and for the groundwater pumps 20 years.
Those numbers were used to calculate the share of used infrastructure for 1 MJ useful heat. Calculation:

$$Share\ of\ Infrastructure = \frac{1}{a_{lifetime} * P_{heat\ pump} * 3.6 * 2'100\ h}$$

2.3.3.2 Use of electricity

Heat pump systems run with electricity. Therefore, the electricity production is of high relevance from an environmental perspective. For this reason, two different electricity mixes were considered:

- Average swiss electricity mix, low voltage
- Certified swiss electricity mix, low voltage

2.3.3.3 Energy efficiency

Seasonal Performance Factor (SPF)

The decisive parameter for practical operation is the so-called Seasonal Performance Factor (SPF). It is defined as the ratio of the useful heat Q_N generated throughout the year to the electrical energy E_{el} required by the heat pump:
$SPF = Q_N / E_{el}$

For this reason, different types of heat pump systems and different types of houses each have a different SPF. The SPF's that are used in the heat inventories are listed in the table below. The SPF for the different heat pump systems for old and new buildings were mainly taken from Dinkel et al. (2019) and cross referenced for plausibility with SPF from technical datasheets and documented values in the internet (Prinzing et al. 2018, Prinzing et al. 2019, TDS heat pumps 2020).. For the ice storage heat pump systems (that were not assessed in Dinkel et al. 2019) it was estimated that they have similar SPF as the borehole heat pump systems. For heat pumps for district heating a low temperature of 60 degrees was used leading in a somewhat lower SPF than for old buildings.

Table 14: SPFs for different heat pump systems in different kinds of houses

Heating system and house type	SPF
Air-water heat pumps:	
Single house, old building, GEAK E	2.7
Single house, new building, GEAK B	4.4
Apartment building, old building, GEAK E	3
Apartment building, new building, GEAK B	4.6
Brine-water heat pumps (with borehole / ice storage tank / groundwater usage):	
Single house, old building, GEAK E	3.2
Single house, new building, GEAK B	5.3
Apartment building, old building, GEAK E	3.4
Apartment building, new building, GEAK B	5.5
For district heating	3.1

The GEAK (Gebäudeenergieausweis der Kantone / Swiss cantonal building energy certificate) provides information on the energy standard of houses with a rating from A (very good) to G (very poor). It mainly assesses the efficiency of the building envelope and energy use. Based on this assessment, a SPF can be assumed. In this case, energy standard E was chosen for an old building and energy standard B for a new building to determine the SPF. (Verein GEAK, 2020).

- GEAK B: New building standard regarding building envelope and building services. Use of renewable energies. New buildings achieve category B due to the legal requirements.
- GEAK E: Partially renovated old buildings, e.g. new heat generation and possibly new equipment and lighting. Old buildings with considerable improvement in thermal insulation, including new thermal insulation glazing.

The SPF allowed to estimate the electricity consumption per MJ heat output (E_{el}=1 MJ / 3.6 / SPF).

2.3.3.4 Emissions during use phase

Emissions such as waste heat and coolant losses occur during the use of the heat pump systems.
According to Heck (2003) the waste heat is calculated by feeding electrical energy into the system. This means that the energy of the waste heat corresponds to the energy of the electricity in MJ. Compared to the old inventories, the waste heat has changed in the same proportion as the SPF, because the electricity consumption depends on the SPF.
The refrigerant losses are about 2 % per year (assumed as 2 % of initial charge) according to Switzerland's national inventory report NIR 2020 (Federal Office for the Environment (FOEN), 2020, S. 256).
In addition, the loss of refrigerant must be a material input as well, as the system is operated with 100 % refrigerant and accordingly the same amount of refrigerant is returned to the system.

2.3.3.5 Heat at diffusion absorption heat pump, 15kW, natural gas and biomethane

For the inventories (heat processes) of the 15 kW diffusion absorption heat pump, which is operated with natural gas or biogas, the material inputs of the old inventory of a 4 kW diffusion absorption heat pump were used. It is assumed that the material inputs do not differ significantly per MJ of useful heat.

The emissions for the heat at diffusion absorption heat pump were adjusted based on the new findings for the gas heating systems (see Table 6). This means that the amount of emissions per MJ of useful heat is the same as for gas heating systems. Only the gas input was adjusted, which instead of 1 MJ gas corresponds to 0.758 MJ gas according to the material input.

The emissions for biomethane or natural gas differ only in the case of CO and CO_2, which are entered once as fossil and once as biogenic.

2.3.4 Disposal

Brine-water and air-water heat pumps were assumed to be disposed of as industrial devices to WEEE treatment. Additionally, refrigerant fluid (the inventories of 50 % trifluoromethane and 50 % difluoroethane were used as approximation) is disposed of as hazardous waste to hazardous waste incineration. The amount of refrigerant fluid that is disposed of corresponds to 85% of the initial input minus the emissions into air (assumption of a 15% loss).

The disposal of a borehole heat exchanger 300 m was added containing transportation and wastewater treatment class 2 of heat carrier liquid. The amount of heat carrier that is disposed of corresponds to the input value considering a solution of containing 40% ethylene glycol for disposal.

The disposal of the delivery and return well for ground water heat pump includes municipal incineration of polyvinylchloride tubes. The remaining fractures of metals, gravel and clay is recycled and therefore not inventoried.

2.3.5 Summary of life cycle inventory data

In this chapter the life cycle inventories for the newly modelled and updated processes are presented. All data are provided as unit process raw data in the EcoSpold v1 format (unit process in SimaPro). The electronic data is including full EcoSpold v1 documentation.

For each investigated process, two types of tables (X-Process and X-Exchange) are provided in this report.

Name	heat pump, air-water, 15kW	heat pump, air-water, 50kW	heat pump, air-water, 7kW
Location	RER	RER	RER
InfrastructureProcess	1	1	1
Unit	unit	unit	unit
IncludedProcesses	Infrastructure of the air-water heat pump including all material inputs (pipes, air heat exchanger, coolant) and also the energy use for the construction of the heat pump components.	Infrastructure of the air-water heat pump including all material inputs (pipes, air heat exchanger, coolant) and also the energy use for the construction of the heat pump components.	Infrastructure of the air-water heat pump including all material inputs (pipes, air heat exchanger, coolant) and also the energy use for the construction of the heat pump components.
Amount	1	1	1
LocalName	Wärmepumpe, 15kW, Luft-Wasser	Wärmepumpe, 50kW, Luft-Wasser	Wärmepumpe, 7kW, Luft-Wasser
Synonyms	Wärmepumpe mit Wärmetauscher Luft/ Wasser 15kW	Wärmepumpe mit Wärmetauscher Luft/ Wasser 50kW	Wärmepumpe mit Wärmetauscher Luft/ Wasser 7kW
GeneralComment	Inventory for the production of an air-water heat pump, 15kW with a life time of 20 years.	Inventory for the production of an air-water heat pump, 50kW with a life time of 20 years.	Inventory for the production of an air-water heat pump, 7kW with a life time of 20 years.
InfrastructureIncluded	1	1	1
Category	heat pumps	heat pumps	heat pumps
SubCategory	heating systems	heating systems	heating systems
LocalCategory	Wärmepumpen	Wärmepumpen	Wärmepumpen
LocalSubCategory	Heizungssysteme	Heizungssysteme	Heizungssysteme
Formula			
StatisticalClassification			
CASNumber			
StartDate	2016	2016	2019
EndDate	2020	2020	2020
DataValidForEntirePeriod	1	1	1
OtherPeriodText			
Text	Data apply to the supply in Switzerland.	Data apply to the supply in Switzerland.	Data apply to the supply in Switzerland.
Text	Industry data.	Industry data.	average technology available on market
Percent			
ProductionVolume			
SamplingProcedure	Data provided by manufacturer	Data provided by manufacturer	Data provided by manufacturer
Extrapolations			

Figure 18: Metadata of air water heat pump production

Name	heat pump, brine-water, 15kW	heat pump, brine-water, 50kW	heat pump, brine-water, 7kW
Location	RER	RER	RER
InfrastructureProcess	1	1	1
Unit	unit	unit	unit
IncludedProcesses	All material inputs for the heat pump and coolant, share of Infrastructure for the production of the heat pump and also the energy use for producing the heat pump. The Infrastructure for a borehole heat exchanger needs to be added if it is part of the system.	All material inputs for the heat pump and coolant, share of Infrastructure for the production of the heat pump and also the energy use for producing the heat pump. The Infrastructure for a borehole heat exchanger needs to be added if it is part of the system.	All material inputs for the heat pump and coolant, share of Infrastructure for the production of the heat pump and also the energy use for producing the heat pump. The Infrastructure for a borehole heat exchanger needs to be added if it is part of the system.
LocalName	Wärmepumpe, 15kW, Sole-Wasser	Wärmepumpe, 50kW, Sole-Wasser	Wärmepumpe, 7kW, Sole-Wasser
Synonyms	Wärmepumpe mit Wärmetauscher Sole/ Wasser 15kW	Wärmepumpe mit Wärmetauscher Sole/ Wasser 50kW	Wärmepumpe mit Wärmetauscher Sole/ Wasser 7kW
GeneralComment	Inventory for the production of a brine-water heat pump, 15kW with a life time of 20 years.	Inventory for the production of a brine-water heat pump, 50kW with a life time of 20 years.	Inventory for the production of a brine-water heat pump, 7kW with a life time of 20 years.
InfrastructureIncluded	1	1	1
Category	heat pumps	heat pumps	heat pumps
SubCategory	heating systems	heating systems	heating systems
LocalCategory	Wärmepumpen	Wärmepumpen	Wärmepumpen
LocalSubCategory	Heizungssysteme	Heizungssysteme	Heizungssysteme
Formula			
StatisticalClassification			
CASNumber			
StartDate	2016	2016	2019
EndDate	2020	2020	2020
DataValidForEntirePeriod	1	1	1
OtherPeriodText			
Text	Data apply to the supply in Switzerland.	Data apply to the supply in Switzerland.	Data apply to the supply in Switzerland.
Text	Industry data.	Industry data.	average technology available on the market
Percent			
ProductionVolume			
SamplingProcedure	Data provided by manufacturer	Data provided by manufacturer	Data provided by manufacturer
Extrapolations			

Figure 19: Metadata of brine water heat pump production

Name	Borehole heat exchanger, 300m
Location	CH
InfrastructureProcess	1
Unit	unit
IncludedProcesses	Infrastructure of the geothermal probe, including all material inputs (pipes and backfill material, coolant) and also the energy use for building the borehole with machines. Disposal of intertwaste.
LocalName	Erdsonde für Wärmetauscher, 300m
Synonyms	Erdsonde inkl. Bohrung, Dupplex-Erdsonde
GeneralComment	Inventory for the production of a 300m deep borehole heat exchanger with a life time of at least 50 years.
InfrastructureIncluded	1
Category	heat pumps
SubCategory	heating systems
LocalCategory	Wärmepumpen
LocalSubCategory	Heizungssysteme
Formula	
StatisticalClassification	
CASNumber	
StartDate	2009
EndDate	2020
DataValidForEntirePeriod	1
OtherPeriodText	
Text	Data apply to the supply in Switzerland.
Text	Industry data.
Percent	
ProductionVolume	
SamplingProcedure	Data provided by manufacturer
Extrapolations	

Figure 20: Metadata of borehole heat exchanger production

Name	delivery and return well for groundwater heat pump, 9m, CH
Location	CH
InfrastructureProcess	1
Unit	unit
IncludedProcesses	Infrastructure of the delivery and return well which is connected to the groundwater, including all material inputs (pipes and inert materials) and also the energy use for building the wells with machines.
LocalName	Förder- und Schluckbrunnen für Grundwasser Wärmepumpe
Synonyms	Förder- und Schluckbrunenn für Grundwasser Wärmepumpe
GeneralComment	Inventory for the production of a delivery well 9m deep and a return well 7m deep for a groundwater heat pump with a lifetime of 20 years.
InfrastructureIncluded	1
Category	heat pumps
SubCategory	heating systems
LocalCategory	Wärmepumpen
LocalSubCategory	Heizungssysteme
Formula	
StatisticalClassification	
CASNumber	
StartDate	2009
EndDate	2020
DataValidForEntirePeriod	1
OtherPeriodText	
Text	Data apply to the supply in Switzerland.
Text	Industry data.
Percent	
ProductionVolume	
SamplingProcedure	Data provided by manufacturer
Extrapolations	

Figure 21: Metadata of delivery and return well production

ReferenceFunction	Name	ice storage tank with solar tube collector
Geography	Location	CH
ReferenceFunction	InfrastructureProcess	1
ReferenceFunction	Unit	unit
	IncludedProcesses	Infrastructure of the ice storage tank, including all material inputs (pipes concrete) plus the solar tube collector which is needed for the ice storage heating system. Also the energy use for building the storage tank with machines. For the whole heating system, a brine-water heat pump must be added to this process. Disposal of the solar tube collector at end of life are already considered in this process.
	Amount	1
	LocalName	Eisspeicher inkl. Solar Röhrenkollektor
	Synonyms	Eisspeicher inkl. Solar Röhrenkollektor
	GeneralComment	Inventory for the production of an ice storage tank with solar tube collector with a life time of 20 years.
	InfrastructureIncluded	1
	Category	heat pumps
	SubCategory	heating systems
	LocalCategory	Wärmepumpen
	LocalSubCategory	Heizungssysteme
	Formula	
	StatisticalClassification	
	CASNumber	
TimePeriod	StartDate	2012
	EndDate	2020
	DataValidForEntirePeriod	1
	OtherPeriodText	
Geography	Text	Data apply to the supply in Switzerland.
Technology	Text	Industry data.
Representativeness	Percent	
	ProductionVolume	
	SamplingProcedure	Data provided by manufacturer
	Extrapolations	

Figure 22: Metadata of ice storage tank production

ReferenceFunction	401	Name	heat, at heat pump, air-water, 15kW, CH electricity, in old building	heat, at heat pump, air-water, 15kW, CH electricity, in new building	heat, at heat pump, air-water, 50kW, CH electricity, in old building	heat, at heat pump, air-water, 50kW, CH electricity, in new building	heat, at heat pump, air-water, 7kW, CH electricity, in new building
Geography	662	Location	CH	CH	CH	CH	CH
ReferenceFunction	493	InfrastructureProcess	0	0	0	0	0
ReferenceFunction	403	Unit	MJ	MJ	MJ	MJ	MJ
	402	IncludedProcesses	Included are the share of the production of the air-water heatpump with a lifetime of 20years scaled for 1MJ. The use of Swiss electricity mix (CH) is calculated by the SPF of 2.7 for an old building, single house. Also the loss of coolant (2% in a year) is included. There are NO end of life processes included. Only the deposit of waste during the construction or usephase are included.	Included are the share of the production of the air-water heatpump with a lifetime of 20years scaled for 1MJ. The use of Swiss electricity mix (CH) is calculated by the SPF of 4.4 for a new building, single house. Also the loss of coolant (2% in a year) is included. There are NO end of life processes included. Only the deposit of waste during the construction or usephase are included.	Included are the share of the production of the air-water heatpump with a lifetime of 20years scaled for 1MJ. The use of Swiss electricity mix (CH) is calculated by the SPF of 3.0 for an old building, apartment house. Also the loss of coolant (2% in a year) is included. There are NO end of life processes included. Only the deposit of waste during the construction or usephase are included.	Included are the share of the production of the air-water heatpump with a lifetime of 20years scaled for 1MJ. The use of Swiss electricity mix (CH) is calculated by the SPF of 4.6 for a new building, apartment house. Also the loss of coolant (2% in a year) is included. There are NO end of life processes included. Only the deposit of waste during the construction or usephase are included.	Included are the share of the production of the air-water heatpump with a lifetime of 20 years scaled for 1MJ. The use of Swiss electricity mix (CH) is calculated by the SPF of 4.4 for a new building, single house. Also the loss of coolant (2% in a year) is included. The deposit of waste during the construction or usephase are included.
	490	LocalName	Nutzwärme, Wärmepumpe Luft-Wasser, 15kW, CH Strommix, in einem älteren Gebäude	Nutzwärme, Wärmepumpe Wasser-Luft-Wasser, 15kW, CH Strommix, in neuem Gebäude	Nutzwärme, Wärmepumpe Luft-Wasser, 50W, CH Strommix, in einem älteren Gebäude	Nutzwärme, Wärmepumpe Luft-Wasser, 50kW, CH Strommix, in einem neuen Gebäude	Nutzwärme, Wärmepumpe Luft-Wasser, 7kW, CH Strommix, in neuem Gebäude
	491	Synonyms	0	0	0	0	0
	492	GeneralComment	Heat from a air-water heat pump, 15kW with Swiss electricity mix (CH). Lifetime of the heating system is 20 years. SPF=2.7. Loss of coolant is 2% (of the total amount in the system) per year.	Heat from a air-water heat pump, 15kW with Swiss electricity mix (CH). Lifetime of the heating system is 20 years. SPF=4.4. Loss of coolant is 2% (of the total amount in the system) per year.	Heat from a air-water heat pump, 50kW with Swiss electricity mix (CH). Lifetime of the heating system is 20 years. SPF=3.0. Loss of coolant is 2% (of the total amount in the system) per year.	Heat from a air-water heat pump, 50kW with Swiss electricity mix (CH). Lifetime of the heating system is 20 years. SPF=4.6. Loss of coolant is 2% (of the total amount in the system) per year.	Heat from a air-water heat pump, 7kW with CH electricity mix. Lifetime of the heating system is 20 years. SPF=4.4. Loss of coolant is 2% (of the total amount in the system) per year.
	494	InfrastructureIncluded	1	1	1	1	1
	495	Category	heat pumps	heat pumps	heat pumps	heat pumps	heat pumps
	496	SubCategory	heating systems	heating systems	heating systems	heating systems	heating systems
	497	LocalCategory	Wärmepumpen	Wärmepumpen	Wärmepumpen	Wärmepumpen	Wärmepumpen
	498	LocalSubCategory	Heizungssysteme	Heizungssysteme	Heizungssysteme	Heizungssysteme	Heizungssysteme
	499	Formula					
	501	StatisticalClassification					
	502	CASNumber					
TimePeriod	601	StartDate	2019	2019	2019	2019	2019
	602	EndDate	2020	2020	2020	2020	2020
	603	DataValidForEntirePeriod	1	1	1	1	1
	611	OtherPeriodText	Time of publications.	Time of publications.	Time of publications.	Time of publications.	Time of publications.
Geography	663	Text	Data apply to the supply in Switzerland.	Data apply to the supply in Switzerland.	Data apply to the supply in Switzerland.	Data apply to the supply in Switzerland.	Data apply to the supply in Switzerland.
Technology	692	Text					
Representativeness	722	Percent					
	724	ProductionVolume					
	725	SamplingProcedure	heat efficieny based on literature	heat efficieny based on literature	heat efficieny based on literature	heat efficieny based on literature	based on literature
	726	Extrapolations	none	none	none	none	none

Figure 23: Metadata of heat, at air water heat pump with CH electricity mix

ReferenceFunction	401	Name	heat, at heat pump, air-water, 15kW, certified electricity, in old building	heat, at heat pump, air-water, 15kW, certified electricity, in new building	heat, at heat pump, air-water, 50kW, certified electricity, in old building	heat, at heat pump, air-water, 50kW, certified electricity, in new building	heat, at heat pump, air-water, 7kW, certified electricity, in new building
Geography	662	Location	CH	CH	CH	CH	CH
ReferenceFunction	493	InfrastructureProcess	0	0	0	0	0
ReferenceFunction	403	Unit	MJ	MJ	MJ	MJ	MJ
	402	IncludedProcesses	Included are the share of the production of the air-water heatpump with a lifetime of 20years scaled for 1MJ. The use of certified electricity mix (CH) is calculated by the SPF of 2.7 for an old building, single house. Also the loss of coolant (2% in a year) is included. There are NO end of life processes included. Only the deposit of waste during the construction or usephase are included.	Included are the share of the production of the air-water heatpump with a lifetime of 20years scaled for 1MJ. The use of certified electricity mix (CH) is calculated by the SPF of 4.4 for a new building, single house. Also the loss of coolant (2% in a year) is included. There are NO end of life processes included. Only the deposit of waste during the construction or usephase are included.	Included are the share of the production of the air-water heatpump with a lifetime of 20years scaled for 1MJ. The use of certified electricity mix (CH) is calculated by the SPF of 3.0 for an old building, apartment house. Also the loss of coolant (2% in a year) is included. There are NO end of life processes included. Only the deposit of waste during the construction or usephase are included.	Included are the share of the production of the air-water heatpump with a lifetime of 20years scaled for 1MJ. The use of certified electricity mix (CH) is calculated by the SPF of 4.6 for a new building, apartment house. Also the loss of coolant (2% in a year) is included. There are NO end of life processes included. Only the deposit of waste during the construction or usephase are included.	Included are the share of the production of the air-water heatpump with a lifetime of 20 years scaled for 1MJ. The use of certified electricity mix (CH) is calculated by the SPF of 4.4 for a new building, single house. Also the loss of coolant (2% in a year) is included. The deposit of waste during the construction or usephase are included.
	490	LocalName	Nutzwärme, Wärmepumpe Luft-Wasser, 15kW, zert. Strommix, in älterem Gebäude	Nutzwärme, Wärmepumpe Luft-Wasser, 15kW, zert. Strommix, in neuem Gebäude	Nutzwärme, Wärmepumpe Luft-Wasser, 50W, zert. Strommix, inälterem Gebäude	Nutzwärme, Wärmepumpe Luft-Wasser, 50kW, zert. Strommix, in neuem Gebäude	Nutzwärme, Wärmepumpe Luft-Wasser, 7kW, zert. Strommix, in neuem Gebäude
	491	Synonyms	0	0	0	0	0
	492	GeneralComment	Heat from a air-water heat pump, 15kW with certified electricity mix (CH). Lifetime of the heating system is 20 years. SPF=2.7. Loss of coolant is 2% (of the total amount in the system) per year.	Heat from a air-water heat pump, 15kW with certified electricity mix (CH). Lifetime of the heating system is 20 years. SPF=4.4. Loss of coolant is 2% (of the total amount in the system) per year.	Heat from a air-water heat pump, 50kW with certified electricity mix (CH). Lifetime of the heating system is 20 years. SPF=3.0. Loss of coolant is 2% (of the total amount in the system) per year.	Heat from a air-water heat pump, 50kW with certified electricity mix (CH). Lifetime of the heating system is 20 years. SPF=4.6. Loss of coolant is 2% (of the total amount in the system) per year.	Heat from a air-water heat pump, 7kW with certified electricity mix (CH). Lifetime of the heating system is 20 years. SPF=4.4. Loss of coolant is 2% (of the total amount in the system) per year.
	494	InfrastructureIncluded	1	1	1	1	1
	495	Category	heat pumps	heat pumps	heat pumps	heat pumps	heat pumps
	496	SubCategory	heating systems	heating systems	heating systems	heating systems	heating systems
	497	LocalCategory	Wärmepumpen	Wärmepumpen	Wärmepumpen	Wärmepumpen	Wärmepumpen
	498	LocalSubCategory	Heizungssysteme	Heizungssysteme	Heizungssysteme	Heizungssysteme	Heizungssysteme
	499	Formula					
	501	StatisticalClassification					
	502	CASNumber					
TimePeriod	601	StartDate	2019	2019	2019	2019	2019
TimePeriod	602	EndDate	2020	2020	2020	2020	2020
TimePeriod	603	DataValidForEntirePeriod	1	1	1	1	1
TimePeriod	611	OtherPeriodText	Time of publications.	Time of publications.	Time of publications.	Time of publications.	Time of publications.
Geography	663	Text	Data apply to the supply in Switzerland.	Data apply to the supply in Switzerland.	Data apply to the supply in Switzerland.	Data apply to the supply in Switzerland.	Data apply to the supply in Switzerland.
Technology	692	Text					
Representativeness	722	Percent					
Representativeness	724	ProductionVolume					
Representativeness	725	SamplingProcedure	heat efficieny based on literature	heat efficieny based on literature	heat efficieny based on literature	heat efficieny based on literature	based on literature
Representativeness	726	Extrapolations	none	none	none	none	none

Figure 24: Metadata of heat, at air-water heat pump with certified electricity mix

ReferenceFunction	401	Name	heat, at borehole heat pump, brine-water, 15kW, CH electricity, in old building	heat, at borehole heat pump, brine-water, 15kW, CH electricity, in new building	heat, at borehole heat pump, brine-water, 50kW, CH electricity, in old building	heat, at borehole heat pump, brine-water, 50kW, CH electricity, in new building	heat, at borehole heat pump, brine-water, 7kW, CH. elec., in new building
Geography	662	Location	CH	CH	CH	CH	CH
ReferenceFunction	493	InfrastructureProcess	0	0	0	0	0
ReferenceFunction	403	Unit	MJ	MJ	MJ	MJ	MJ
	402	IncludedProcesses	Included are the share of the production of the brine-water heatpump with a lifetime of 20years scaled for 1MJ when the heating system is running 2'100 hours a year. Also the borehole with the geothermal proble with a lifetime of at least 50years is part of this process. The use of electricity (CH electricity mix) is calculated by the SPF of 3.2 for an old building, single house. Also the loss of coolant (2% in a year) is included. There are NO end of life processes included. Only the deposit of waste during the construction or usephase are included.	Included are the share of the production of the brine-water heatpump with a lifetime of 20years scaled for 1MJ. Also the borehole with the geothermal proble with a lifetime of at least 50years is part of this process. The use of electricity (CH electricity mix) is calculated by the SPF of 5.3 for a new building, single house. Also the loss of coolant (2% in a year) is included. There are NO end of life processes included. Only the deposit of waste during the construction or usephase are included.	Included are the share of the production of the brine-water heatpump with a lifetime of 20years scaled for 1MJ. Also the borehole with the geothermal proble with a lifetime of at least 50years is part of this process. The use of electricity (CH electricity mix) is calculated by the SPF of 3.4 for an old building, apartment house. Also the loss of coolant (2% in a year) is included. There are NO end of life processes included. Only the deposit of waste during the construction or usephase are included.	Included are the share of the production of the brine-water heatpump with a lifetime of 20years scaled for 1MJ. Also the borehole with the geothermal proble with a lifetime of at least 50years is part of this process. The use of electricity (CH electricity mix) is calculated by the SPF of 5.5 for a new building, apartment house. Also the loss of coolant (2% in a year) is included. There are NO end of life processes included. Only the deposit of waste during the construction or usephase are included.	Included are the share of the production of the brine-water heatpump with a lifetime of 20 years scaled for 1MJ. Also the the borehole with a lifetime of 50 years is part of this process. The use of Swiss electricity mix is calculated by the SPF of 5.3 for a new building, single house. Also the loss of coolant (2% in a year) is included. The deposit of waste during the construction or usephase are included.
	490	LocalName	Nutzwärme, Wärmepumpe mit Erdsonde, 15kW, CH Strommix, in einem älteren Gebäude	Nutzwärme, Wärmepumpe mit Erdsonde, 15kW, CH Strommix, in einem neuen Gebäude	Nutzwärme, Wärmepumpe mit Erdsonde, 50W, CH Strommix, in einem älteren Gebäude	Nutzwärme, Wärmepumpe mit Erdsonde, 50kW, CH Strommix, in einem neuen Gebäude	Nutzwärme, Wärmepumpe mit Erdsonde, 7kW, CH Strommix, in neuem Gebäude
	491	Synonyms	0	0	0	0	0
	492	GeneralComment	Heat from a brine-water heat pump, 15kW with heat source form borehole, 150m deep and Swiss electricity mix (CH). Lifetime of the heat pump is 20 years, the borehole 50years. SPF=3.2. Loss of coolant is 2% (of the total amount in the system) per year.	Heat from a brine-water heat pump, 15kW with heat source form borehole, 150m deep and Swiss electricity mix (CH). Lifetime of the heat pump is 20 years, the borehole 50years. SPF=5.3. Loss of coolant is 2% (of the total amount in the system) per year.	Heat from a brine-water heat pump, 50kW with heat source form borehole, 150m deep and Swiss electricity mix (CH). Lifetime of the heat pump is 20 years, the borehole 50years. SPF=3.4. Loss of coolant is 2% (of the total amount in the system) per year.	Heat from a brine-water heat pump, 50kW with heat source form borehole, 150m deep and Swiss electricity mix (CH). Lifetime of the heat pump is 20 years, the borehole 50years. SPF=5.5. Loss of coolant is 2% (of the total amount in the system) per year.	Heat from a brine-water heat pump, 7kW with heat source form borehole, 150m deep and Swiss electricity mix (CH). Lifetime of the heating system is 20 years. SPF=5.3. Loss of coolant is 2% (of the total amount in the system) per year.
	494	InfrastructureIncluded	1	1	1	1	1
	495	Category	heat pumps	heat pumps	heat pumps	heat pumps	heat pumps
	496	SubCategory	heating systems	heating systems	heating systems	heating systems	heating systems
	497	LocalCategory	Wärmepumpen	Wärmepumpen	Wärmepumpen	Wärmepumpen	Wärmepumpen
	498	LocalSubCategory	Heizungssysteme	Heizungssysteme	Heizungssysteme	Heizungssysteme	Heizungssysteme
	499	Formula					
	501	StatisticalClassification					
	502	CASNumber					
TimePeriod	601	StartDate	2019	2019	2019	2019	2019
	602	EndDate	2020	2020	2020	2020	2020
	603	DataValidForEntirePeriod	1	1	1	1	1
	611	OtherPeriodText	Time of publications.	Time of publications.	Time of publications.	Time of publications.	Time of publications.
Geography	663	Text	Data apply to the supply in Switzerland.	Data apply to the supply in Switzerland.	Data apply to the supply in Switzerland.	Data apply to the supply in Switzerland.	Data apply to the supply in Switzerland.
Technology	692	Text					
Representativeness	722	Percent					
	724	ProductionVolume					
	725	SamplingProcedure	heat efficieny based on literature	heat efficieny based on literature	heat efficieny based on literature	heat efficieny based on literature	based on literature
	726	Extrapolations	none	none	none	none	none

Figure 25: Metadata of heat, at brine-water heat pump with CH electricity mix

ReferenceFunction	Name	heat, at borehole heat pump, brine-water, 15kW, cert. electr., in old building	heat, at borehole heat pump, brine-water, 15kW, cert. electr., in new building	heat, at borehole heat pump, brine-water, 50kW, cert. electr., in old building	heat, at borehole heat pump, brine-water, 50kW, cert. electr., in new building	heat, at borehole heat pump, brine-water, 7kW, cert. elec., in new building
Geography	Location	CH	CH	CH	CH	CH
ReferenceFunction	InfrastructureProcess	0	0	0	0	0
ReferenceFunction	Unit	MJ	MJ	MJ	MJ	MJ
	IncludedProcesses	Included are the share of the production of the brine-water heatpump with a lifetime of 20years scaled for 1MJ when the heating system is running 2'100 hours a year. Also the borehole with the geothermal proble with a lifetime of at least 50years is part of this process. The use of electricity from certified source is calculated by the SPF of 3.2 for an old building, single house. Also the loss of coolant (2% in a year) is included. There are NO end of life processes included. Only the deposit of waste during the construction or usephase are included.	Included are the share of the production of the brine-water heatpump with a lifetime of 20years scaled for 1MJ. Also the borehole with the geothermal proble with a lifetime of at least 50years is part of this process. The use of electricity from certified source is calculated by the SPF of 5.3 for a new building, single house. Also the loss of coolant (2% in a year) is included. There are NO end of life processes included. Only the deposit of waste during the construction or usephase are included.	Included are the share of the production of the brine-water heatpump with a lifetime of 20years scaled for 1MJ. Also the borehole with the geothermal proble with a lifetime of at least 50years is part of this process. The use of electricity from certified source is calculated by the SPF of 3.4 for an old building, apartment house. Also the loss of coolant (2% in a year) is included. There are NO end of life processes included. Only the deposit of waste during the construction or usephase are included.	Included are the share of the production of the brine-water heatpump with a lifetime of 20years scaled for 1MJ. Also the borehole with the geothermal proble with a lifetime of at least 50years is part of this process. The use of electricity from certified source is calculated by the SPF of 5.5 for a new building, apartment house. Also the loss of coolant (2% in a year) is included. There are NO end of life processes included. Only the deposit of waste during the construction or usephase are included.	Included are the share of the production of the brine-water heatpump with a lifetime of 20 years scaled for 1MJ. Also the the borehole with a lifetime of 50 years is part of this process. The use of Swiss certified electricity mix is calculated by the SPF of 5.3 for a new building, single house. Also the loss of coolant (2% in a year) is included. There are NO end of life processes included. Only the deposit of waste during the construction or usephase are included.
	LocalName	Nutzwärme, Wärmepumpe mit Erdsonde, 15kW, zert. Strommix, in älterem Gebäude	Nutzwärme, Wärmepumpe mit Erdsonde, 15kW, zert. Strommix, in neuem Gebäude	Nutzwärme, Wärmepumpe mit Erdsonde, 50W, zert. Strommix, in älterem Gebäude	Nutzwärme, Wärmepumpe mit Erdsonde, 50kW, zert. Strommix, in neuem Gebäude	Nutzwärme, Wärmepumpe mit Erdsonde, 7kW, zert. Strommix, in neuem Gebäude
	Synonyms	0	0	0	0	0
	GeneralComment	Heat from a brine-water heat pump, 15kW with heat source form borehole, 150m deep and cerified electricity mix (CH). Lifetime of the heat pump is 20 years, the borehole 50years. SPF=3.2. Loss of coolant is 2% (of the total amount in the system) per year.	Heat from a brine-water heat pump, 15kW with heat source form borehole, 150m deep and cerified electricity mix (CH). Lifetime of the heat pump is 20 years, the borehole 50years. SPF=5.3. Loss of coolant is 2% (of the total amount in the system) per year.	Heat from a brine-water heat pump, 50kW with heat source form borehole, 150m deep and cerified electricity mix (CH). Lifetime of the heat pump is 20 years, the borehole 50years. SPF=3.4. Loss of coolant is 2% (of the total amount in the system) per year.	Heat from a brine-water heat pump, 50kW with heat source form borehole, 150m deep and cerified electricity mix (CH). Lifetime of the heat pump is 20 years, the borehole 50years. SPF=5.5. Loss of coolant is 2% (of the total amount in the system) per year.	Heat from a brine-water heat pump, 7kW with heat source form borehole, 150m deep and Swiss certified electricity mix (CH). Lifetime of the heating system is 20 years. SPF=5.3. Loss of coolant is 2% (of the total amount in the system) per year.
	InfrastructureIncluded	1	1	1	1	1
	Category	heat pumps	heat pumps	heat pumps	heat pumps	heat pumps
	SubCategory	heating systems	heating systems	heating systems	heating systems	heating systems
	LocalCategory	Wärmepumpen	Wärmepumpen	Wärmepumpen	Wärmepumpen	Wärmepumpen
	LocalSubCategory	Heizungssysteme	Heizungssysteme	Heizungssysteme	Heizungssysteme	Heizungssysteme
	Formula					
	StatisticalClassification					
	CASNumber					
TimePeriod	StartDate	2019	2019	2019	2019	2019
	EndDate	2020	2020	2020	2020	2020
	DataValidForEntirePeriod	1	1	1	1	1
	OtherPeriodText	Time of publications.	Time of publications.	Time of publications.	Time of publications.	Time of publications.
Geography	Text	Data apply to the supply in Switzerland.	Data apply to the supply in Switzerland.	Data apply to the supply in Switzerland.	Data apply to the supply in Switzerland.	Data apply to the supply in Switzerland.
Technology	Text					
Representativeness	Percent					
	ProductionVolume					
	SamplingProcedure	heat efficieny based on literature	heat efficieny based on literature	heat efficieny based on literature	heat efficieny based on literature	based on literature
	Extrapolations	none	none	none	none	none

Figure 26: Metadata of heat, at brine-water heat pump with certified electricity mix

ReferenceFunction	Name	heat, at groundwater heat pump, brine-water, 15kW, CH electr., in old building	heat, at groundwater heat pump, brine-water, 15kW, CH electr., in new building	heat, at groundwater heat pump, brine-water, 50kW, CH electr., in old building	heat, at groundwater heat pump, brine-water, 50kW, CH electr., in new building	heat, at groundwater heat pump, brine-water, 7kW, CH elec., in new building
Geography	Location	CH	CH	CH	CH	CH
ReferenceFunction	InfrastructureProcess	0	0	0	0	0
ReferenceFunction	Unit	MJ	MJ	MJ	MJ	MJ
	IncludedProcesses	Included are the share of the production of the brine-water heatpump with a lifetime of 20years scaled for 1MJ. Also the the groundwater delivery and return with a lifetime of 20 years is part of this process. The use of Swiss electricity mix (CH) is calculated by the SPF of 3.2 for an old building, single house. Also the loss of coolant (2% in a year) is included. There are NO end of life processes included. Only the deposit of waste during the construction or usephase are included.	Included are the share of the production of the brine-water heatpump with a lifetime of 20years scaled for 1MJ. Also the the groundwater delivery and return with a lifetime of 20 years is part of this process. The use of Swiss electricity mix (CH) is calculated by the SPF of 5.3 for a new building, single house. Also the loss of coolant (2% in a year) is included. There are NO end of life processes included. Only the deposit of waste during the construction or usephase are included.	Included are the share of the production of the brine-water heatpump with a lifetime of 20years scaled for 1MJ. Also the the groundwater delivery and return with a lifetime of 20 years is part of this process. The use of Swiss electricity mix (CH) is calculated by the SPF of 3.4 for an old building, apartment house. Also the loss of coolant (2% in a year) is included. There are NO end of life processes included. Only the deposit of waste during the construction or usephase are included.	Included are the share of the production of the brine-water heatpump with a lifetime of 20years scaled for 1MJ. Also the the groundwater delivery and return with a lifetime of 20 years is part of this process. The use of Swiss electricity mix (CH) is calculated by the SPF of 5.5 for a new building, apartment house. Also the loss of coolant (2% in a year) is included. There are NO end of life processes included. Only the deposit of waste during the construction or usephase are included.	Included are the share of the production of the brine-water heatpump with a lifetime of 20 years scaled for 1MJ. Also the the groundwater delivery and return well with a lifetime of 20 years is part of this process. The use of Swiss electricity mix is calculated by the SPF of 5.3 for a new building, single house. Also the loss of coolant (2% in a year) is included. The deposit of waste during the construction or usephase are included.
	LocalName	Nutzwärme, Wärmepumpe mit Grundwasser, 15kW, CH Strommix, in älterem Gebäude	Nutzwärme, Wärmepumpe mit Grundwasser, 15kW, CH Strommix, in neuem Gebäude	Nutzwärme, Wärmepumpe mit Grundwasser, 50W, CH Strommix, in älterem Gebäude	Nutzwärme, Wärmepumpe mit Grundwasser, 50kW, CH Strommix, in neuem Gebäude	Nutzwärme, Wärmepumpe mit Grundwasser, 7W, CH Strommix, in neuem Gebäude
	Synonyms	0	0	0	0	0
	GeneralComment	Heat from a brine-water heat pump, 15kW with heat source form groundwater, 9m deep and Swiss electricity mix (CH). Lifetime of the heating system is 20 years. SPF=3.2. Loss of coolant is 2% (of the total amount in the system) per year.	Heat from a brine-water heat pump, 15kW with heat source form groundwater, 9m deep and Swiss electricity mix (CH). Lifetime of the heating system is 20 years. SPF=5.3. Loss of coolant is 2% (of the total amount in the system) per year.	Heat from a brine-water heat pump, 15kW with heat source form groundwater, 9m deep and Swiss electricity mix (CH). Lifetime of the heating system is 20 years. SPF=3.4. Loss of coolant is 2% (of the total amount in the system) per year.	Heat from a brine-water heat pump, 15kW with heat source form groundwater, 9m deep and Swiss electricity mix (CH). Lifetime of the heating system is 20 years. SPF=5.5. Loss of coolant is 2% (of the total amount in the system) per year.	Heat from a brine-water heat pump, 7kW with heat source form groundwater delivery and return well, 9m deep and Swiss electricity mix (CH). Lifetime of the heating system is 20 years. SPF=5.3. Loss of coolant is 2% (of the total amount in the system) per year.
	InfrastructureIncluded	1	1	1	1	1
	Category	heat pumps	heat pumps	heat pumps	heat pumps	heat pumps
	SubCategory	heating systems	heating systems	heating systems	heating systems	heating systems
	LocalCategory	Wärmepumpen	Wärmepumpen	Wärmepumpen	Wärmepumpen	Wärmepumpen
	LocalSubCategory	Heizungssysteme	Heizungssysteme	Heizungssysteme	Heizungssysteme	Heizungssysteme
	Formula					
	StatisticalClassification					
	CASNumber					
TimePeriod	StartDate	2019	2019	2019	2019	2019
	EndDate	2020	2020	2020	2020	2020
	DataValidForEntirePeriod	1	1	1	1	1
	OtherPeriodText	Time of publications.	Time of publications.	Time of publications.	Time of publications.	Time of publications.
Geography	Text	Data apply to the supply in Switzerland.	Data apply to the supply in Switzerland.	Data apply to the supply in Switzerland.	Data apply to the supply in Switzerland.	Data apply to the supply in Switzerland.
Technology	Text					
Representativeness	Percent					
	ProductionVolume					
	SamplingProcedure	heat efficieny based on literature	heat efficieny based on literature	heat efficieny based on literature	heat efficieny based on literature	based on literature
	Extrapolations	none	none	none	none	none

Figure 27: Metadata of heat, at groundwater heat pump with CH electricity mix

ReferenceFunction	Name	heat, at groundwater heat pump, brine-water, 15kW, cert. elec., in old building	heat, at groundwater heat pump, brine-water, 15kW, cert. elec., in new building	heat, at groundwater heat pump, brine-water, 50kW, cert. elec., in old building	heat, at groundwater heat pump, brine-water, 50kW, cert. elec., in new building	heat, at groundwater heat pump, brine-water, 7kW, cert. elec., in new building
Geography	Location	CH	CH	CH	CH	CH
ReferenceFunction	InfrastructureProcess	0	0	0	0	0
ReferenceFunction	Unit	MJ	MJ	MJ	MJ	MJ
	IncludedProcesses	Included are the share of the production of the brine-water heatpump with a lifetime of 20years scaled for 1MJ. Also the the groundwater delivery and return with a lifetime of 20 years is part of this process. The use of certified electricity (CH) is calculated by the SPF of 3.2 for an old building, single house. Also the loss of coolant (2% in a year) is included. There are NO end of life processes included. Only the deposit of waste during the construction or usephase are included.	Included are the share of the production of the brine-water heatpump with a lifetime of 20years scaled for 1MJ. Also the the groundwater delivery and return with a lifetime of 20 years is part of this process. The use of certified electricity (CH) is calculated by the SPF of 5.3 for a new building, single house. Also the loss of coolant (2% in a year) is included. There are NO end of life processes included. Only the deposit of waste during the construction or usephase are included.	Included are the share of the production of the brine-water heatpump with a lifetime of 20years scaled for 1MJ. Also the the groundwater delivery and return with a lifetime of 20 years is part of this process. The use of certified electricity (CH) is calculated by the SPF of 3.4 for an old building, apartment house. Also the loss of coolant (2% in a year) is included. There are NO end of life processes included. Only the deposit of waste during the construction or usephase are included.	Included are the share of the production of the brine-water heatpump with a lifetime of 20years scaled for 1MJ. Also the the groundwater delivery and return with a lifetime of 20 years is part of this process. The use of certified electricity (CH) is calculated by the SPF of 5.5 for a new building, apartment house. Also the loss of coolant (2% in a year) is included. There are NO end of life processes included. Only the deposit of waste during the construction or usephase are included.	Included are the share of the production of the brine-water heatpump with a lifetime of 20 years scaled for 1MJ. Also the the groundwater delivery and return well with a lifetime of 20 years is part of this process. The use of Swiss certified electricity mix is calculated by the SPF of 5.3 for a new building, single house. Also the loss of coolant (2% in a year) is included. There are NO end of life processes included. Only the deposit of waste during the construction or usephase are included.
	LocalName	Nutzwärme, Wärmepumpe mit Grundwasser, 15kW, zert. Strommix, in älterem Gebäude	Nutzwärme, Wärmepumpe mit Grundwasser, 15kW, zert. Strommix, in neuem Gebäude	Nutzwärme, Wärmepumpe mit Grundwasser, 50W, zert. Strommix, in älterem Gebäude	Nutzwärme, Wärmepumpe mit Grundwasser, 50kW, zert. Strommix, in neuem Gebäude	Nutzwärme, Wärmepumpe mit Grundwasser, 7W, zert. Strommix, in neuem Gebäude
	Synonyms	0	0	0	0	0
	GeneralComment	Heat from a brine-water heat pump, 15kW with heat source form groundwater, 9m deep and certified electricity mix (CH). Lifetime of the heating system is 20 years. SPF=3.2. Loss of coolant is 2% (of the total amount in the system) per year.	Heat from a brine-water heat pump, 15kW with heat source form groundwater, 9m deep and certified electricity mix (CH). Lifetime of the heating system is 20 years. SPF=5.3. Loss of coolant is 2% (of the total amount in the system) per year.	Heat from a brine-water heat pump, 50kW with heat source form groundwater, 9m deep and certified electricity mix (CH). Lifetime of the heating system is 20 years. SPF=3.4. Loss of coolant is 2% (of the total amount in the system) per year.	Heat from a brine-water heat pump, 50kW with heat source form groundwater, 9m deep and certified electricity mix (CH). Lifetime of the heating system is 20 years. SPF=5.5. Loss of coolant is 2% (of the total amount in the system) per year.	Heat from a brine-water heat pump, 7kW with heat source form groundwater delivery and return well, 9m deep and Swiss certified electricity mix (CH). Lifetime of the heating system is 20 years. SPF=5.3. Loss of coolant is 2% (of the total amount in the system) per year.
	InfrastructureIncluded	1	1	1	1	1
	Category	heat pumps	heat pumps	heat pumps	heat pumps	heat pumps
	SubCategory	heating systems	heating systems	heating systems	heating systems	heating systems
	LocalCategory	Wärmepumpen	Wärmepumpen	Wärmepumpen	Wärmepumpen	Wärmepumpen
	LocalSubCategory	Heizungssysteme	Heizungssysteme	Heizungssysteme	Heizungssysteme	Heizungssysteme
	Formula					
	StatisticalClassification					
	CASNumber					
TimePeriod	StartDate	2019	2019	2019	2019	2019
	EndDate	2020	2020	2020	2020	2020
	DataValidForEntirePeriod	1	1	1	1	1
	OtherPeriodText	Time of publications.	Time of publications.	Time of publications.	Time of publications.	Time of publications.
Geography	Text	Data apply to the supply in Switzerland.	Data apply to the supply in Switzerland.	Data apply to the supply in Switzerland.	Data apply to the supply in Switzerland.	Data apply to the supply in Switzerland.
Technology	Text					
Representativeness	Percent					
	ProductionVolume					
	SamplingProcedure	heat efficieny based on literature	heat efficieny based on literature	heat efficieny based on literature	heat efficieny based on literature	based on literature
	Extrapolations	none	none	none	none	none

Figure 28: Metadata of heat, at groundwater heat pump with certified electricity mix

ReferenceFunction	Name	heat, at groundwater heat pump, brine-water, 15kW, cert. elec., in old building	heat, at groundwater heat pump, brine-water, 15kW, cert. elec., in new building	heat, at groundwater heat pump, brine-water, 50kW, cert. elec., in old building	heat, at groundwater heat pump, brine-water, 50kW, cert. elec., in new building	heat, at groundwater heat pump, brine-water, 7kW, cert. elec., in new building
Geography	Location	CH	CH	CH	CH	CH
ReferenceFunction	InfrastructureProcess	0	0	0	0	0
ReferenceFunction	Unit	MJ	MJ	MJ	MJ	MJ
	IncludedProcesses	Included are the share of the production of the brine-water heatpump with a lifetime of 20years scaled for 1MJ. Also the the groundwater delivery and return with a lifetime of 20 years is part of this process. The use of certified electricity (CH) is calculated by the SPF of 3.2 for an old building, single house. Also the loss of coolant (2% in a year) is included. There are NO end of life processes included. Only the deposit of waste during the construction or usephase are included.	Included are the share of the production of the brine-water heatpump with a lifetime of 20years scaled for 1MJ. Also the the groundwater delivery and return with a lifetime of 20 years is part of this process. The use of certified electricity (CH) is calculated by the SPF of 5.3 for a new building, single house. Also the loss of coolant (2% in a year) is included. There are NO end of life processes included. Only the deposit of waste during the construction or usephase are included.	Included are the share of the production of the brine-water heatpump with a lifetime of 20years scaled for 1MJ. Also the the groundwater delivery and return with a lifetime of 20 years is part of this process. The use of certified electricity (CH) is calculated by the SPF of 3.4 for an old building, apartment house. Also the loss of coolant (2% in a year) is included. There are NO end of life processes included. Only the deposit of waste during the construction or usephase are included.	Included are the share of the production of the brine-water heatpump with a lifetime of 20years scaled for 1MJ. Also the the groundwater delivery and return with a lifetime of 20 years is part of this process. The use of certified electricity (CH) is calculated by the SPF of 5.5 for a new building, apartment house. Also the loss of coolant (2% in a year) is included. There are NO end of life processes included. Only the deposit of waste during the construction or usephase are included.	Included are the share of the production of the brine-water heatpump with a lifetime of 20 years scaled for 1MJ. Also the the groundwater delivery and return well with a lifetime of 20 years is part of this process. The use of Swiss certified electricity mix is calculated by the SPF of 5.3 for a new building, single house. Also the loss of coolant (2% in a year) is included. There are NO end of life processes included. Only the deposit of waste during the construction or usephase are included.
	LocalName	Nutzwärme, Wärmepumpe mit Grundwasser, 15kW, zert. Strommix, in älterem Gebäude	Nutzwärme, Wärmepumpe mit Grundwasser, 15kW, zert. Strommix, in neuem Gebäude	Nutzwärme, Wärmepumpe mit Grundwasser, 50W, zert. Strommix, in älterem Gebäude	Nutzwärme, Wärmepumpe mit Grundwasser, 50kW, zert. Strommix, in neuem Gebäude	Nutzwärme, Wärmepumpe mit Grundwasser, 7W, zert. Strommix, in neuem Gebäude
	Synonyms	0	0	0	0	0
	GeneralComment	Heat from a brine-water heat pump, 15kW with heat source form groundwater, 9m deep and certified electricity mix (CH). Lifetime of the heating system is 20 years. SPF=3.2. Loss of coolant is 2% (of the total amount in the system) per year.	Heat from a brine-water heat pump, 15kW with heat source form groundwater, 9m deep and certified electricity mix (CH). Lifetime of the heating system is 20 years. SPF=5.3. Loss of coolant is 2% (of the total amount in the system) per year.	Heat from a brine-water heat pump, 50kW with heat source form groundwater, 9m deep and certified electricity mix (CH). Lifetime of the heating system is 20 years. SPF=3.4. Loss of coolant is 2% (of the total amount in the system) per year.	Heat from a brine-water heat pump, 50kW with heat source form groundwater, 9m deep and certified electricity mix (CH). Lifetime of the heating system is 20 years. SPF=5.5. Loss of coolant is 2% (of the total amount in the system) per year.	Heat from a brine-water heat pump, 7kW with heat source form groundwater delivery and return well, 9m deep and Swiss certified electricity mix (CH). Lifetime of the heating system is 20 years. SPF=5.3. Loss of coolant is 2% (of the total amount in the system) per year.
	InfrastructureIncluded	1	1	1	1	1
	Category	heat pumps	heat pumps	heat pumps	heat pumps	heat pumps
	SubCategory	heating systems	heating systems	heating systems	heating systems	heating systems
	LocalCategory	Wärmepumpen	Wärmepumpen	Wärmepumpen	Wärmepumpen	Wärmepumpen
	LocalSubCategory	Heizungssysteme	Heizungssysteme	Heizungssysteme	Heizungssysteme	Heizungssysteme
	Formula					
	StatisticalClassification					
	CASNumber					
TimePeriod	StartDate	2019	2019	2019	2019	2019
	EndDate	2020	2020	2020	2020	2020
	DataValidForEntirePeriod	1	1	1	1	1
	OtherPeriodText	Time of publications.	Time of publications.	Time of publications.	Time of publications.	Time of publications.
Geography	Text	Data apply to the supply in Switzerland.	Data apply to the supply in Switzerland.	Data apply to the supply in Switzerland.	Data apply to the supply in Switzerland.	Data apply to the supply in Switzerland.
Technology	Text					
Representativeness	Percent					
	ProductionVolume					
	SamplingProcedure	heat efficieny based on literature	heat efficieny based on literature	heat efficieny based on literature	heat efficieny based on literature	based on literature
	Extrapolations	none	none	none	none	none

Figure 29: Metadata of heat, at groundwater heat pump with certified electricity mix

ReferenceFunction	401	Name	heat, at borehole heat pump, brine-water, 50kW, for district heating, CH electricity	heat, at groundwater heat pump, brine-water, 50kW, for district heating, CH electr.
Geography	662	Location	CH	CH
ReferenceFunction	493	InfrastructureProcess	0	0
ReferenceFunction	403	Unit	MJ	MJ
	402	IncludedProcesses	Included are the share of the production of the brine-water heatpump with a lifetime of 20years scaled for 1MJ. Also the borehole with the geothermal proble with a lifetime of at least 50years is part of this process. The use of electricity (CH electricity mix) is calculated by the SPF of 3.1 for district heating (60° flow temperature). Also the loss of coolant (2% in a year) is included. There are NO end of life processes included. Only the deposit of waste during the construction or usephase are included.	Included are the share of the production of the brine-water heatpump with a lifetime of 20years scaled for 1MJ. Also the the groundwater delivery and return with a lifetime of 20 years is part of this process. The use of Swiss electricity mix (CH) is calculated by the SPF of 3.1 for producing district heat (60° flow temperature). Also the loss of coolant (2% in a year) is included. There are NO end of life processes included. Only the deposit of waste during the construction or usephase are included.
	490	LocalName	Nutzwärme, Wärmepumpe mit Erdsonde, 50kW, CH Strommix, für Fernwärme	Nutzwärme, Wärmepumpe mit Grundwasser, 50kW, CH Strommix, für Fernwärme
	491	Synonyms	0	0
	492	GeneralComment	Heat from a brine-water heat pump, 50kW with heat source form borehole, 150m deep and Swiss electricity mix (CH). Lifetime of the heat pump is 20 years, the borehole 50years. SPF=3.1. Loss of coolant is 2% (of the total amount in the system) per year.	Heat from a brine-water heat pump, 50kW with heat source form ground water and Swiss electricity mix (CH). Lifetime of the heating system is 20 years. SPF=3.1. Loss of coolant is 2% (of the total amount in the system) per year.
	494	InfrastructureIncluded	1	1
	495	Category	heat pumps	heat pumps
	496	SubCategory	heating systems	heating systems
	497	LocalCategory	Wärmepumpen	Wärmepumpen
	498	LocalSubCategory	Heizungssysteme	Heizungssysteme
	499	Formula		
	501	StatisticalClassification		
	502	CASNumber		
TimePeriod	601	StartDate	2019	2019
	602	EndDate	2020	2020
	603	DataValidForEntirePeriod	1	1
	611	OtherPeriodText	Time of publications.	Time of publications.
Geography	663	Text	Data apply to the supply in Switzerland.	Data apply to the supply in Switzerland.
Technology	692	Text		
Representativeness	722	Percent		
	724	ProductionVolume		
	725	SamplingProcedure	heat efficieny based on literature	heat efficieny based on literature
	726	Extrapolations	none	none

Figure 30: Metadata of heat, at borehole and groundwater heat pump, for district heating

ReferenceFunction	Name	heat, at ice storage heat pump, brine-water, 15kW, CH electr., in old building	heat, at ice storage heat pump, brine-water, 15kW, CH electr., in new building	heat, at ice storage heat pump, brine-water, 50kW, CH electr., in old building	heat, at ice storage heat pump, brine-water, 50kW, CH electr., in new building	heat, at ice strorage heat pump, brine-water, 7kW, CH elec., in new building
Geography	Location	CH	CH	CH	CH	CH
ReferenceFunction	InfrastructureProcess	0	0	0	0	0
ReferenceFunction	Unit	MJ	MJ	MJ	MJ	MJ
	IncludedProcesses	Included are the share of the production of the brine-water heatpump with a lifetime of 20years scaled for 1MJ. Also the ice storage tank and the solar tube collectors as part of the whole system with a lifetime of 25 years is part of this process. The use of electricity (Swiss electriciy mix) is calculated by the SPF = 3.2 for an old building, single house. Also the loss of coolant (2% in a year) is included.	Included are the share of the production of the brine-water heatpump with a lifetime of 20years scaled for 1MJ. Also the ice storage tank and the solar tube collectors as part of the whole system with a lifetime of 25 years is part of this process. The use of electricity (Swiss electriciy mix) is calculated by the SPF = 5.3 for a new building, single house. Also the loss of coolant (2% in a year) is included.	Included are the share of the production of the brine-water heatpump with a lifetime of 20years scaled for 1MJ. Also the ice storage tank and the solar tube collectors as part of the whole system with a lifetime of 25 years is part of this process. The use of electricity (Swiss electriciy mix) is calculated by the SPF = 3.4 for an old building, apartment house. Also the loss of coolant (2% in a year) is included.	Included are the share of the production of the brine-water heatpump with a lifetime of 20years scaled for 1MJ. Also the ice storage tank and the solar tube collectors as part of the whole system with a lifetime of 25 years is part of this process. The use of electricity (Swiss electricity mix) is calculated by the SPF = 5.5 for a new building, apartment house. Also the loss of coolant (2% in a year) is included.	Included are the share of the production of the brine-water heatpump with a lifetime of 20 years scaled for 1MJ. Also the the ice storage tank with a lifetime of 25 years is part of this process. The use of Swiss electricity mix is calculated by the SPF of 5.3 for a new building, single house. Also the loss of coolant (2% in a year) is included. The deposit of waste during the construction or usephase are included.
	LocalName	Nutzwärme, Wärmepumpe mit Eisspeicher, 15kW, CH Strommix, in älterem Gebäude	Nutzwärme, Wärmepumpe mit Eisspeicher, 15kW, CH Strommix, in neuem Gebäude	Nutzwärme, Wärmepumpe mit Eisspeicher, 50W, CH Strommix, in älterem Gebäude	Nutzwärme, Wärmepumpe mit Eisspeicher, 50kW, CH Strommix, in neuem Gebäude	Nutzwärme, Wärmepumpe mit Eisspeicher, 7kW, CH Strommix, in neuem Gebäude
	Synonyms	0	0	0	0	0
	GeneralComment	Heat from a brine-water heat pump, 15kW with heat source form ice storage and solar tube collector plus energy input from Swiss electricity mix (CH). Lifetime of the heat pump is 20 years, ice storage lifetime is 25 years. SPF=3.2. Loss of coolant is 2% (of the total amount in the system) per year.	Heat from a brine-water heat pump, 15kW with heat source form ice storage and solar tube collector plus energy input from Swiss electricity mix (CH). Lifetime of the heating system is 20 years, ice storage lifetime is 25 years. SPF=5.3. Loss of coolant is 2% (of the total amount in the system) per year.	Heat from a brine-water heat pump, 50kW with heat source form ice storage and solar tube collector plus energy input from Swiss electricity mix (CH). Lifetime of the heating system is 20 years, ice storage lifetime is 25 years. SPF=3.4. Loss of coolant is 2% (of the total amount in the system) per year.	Heat from a brine-water heat pump, 50kW with heat source form ice storage and solar tube collector plus energy input from Swiss electricity mix (CH). Lifetime of the heating system is 20 years, ice storage lifetime is 25 years. SPF=5.5. Loss of coolant is 2% (of the total amount in the system) per year.	Heat from a brine-water heat pump, 7kW with heat source form ice storage tank and Swiss electricity mix (CH). Lifetime of the heating system is 20 years. SPF=5.3. Loss of coolant is 2% (of the total amount in the system) per year.
	InfrastructureIncluded	1	1	1	1	1
	Category	heat pumps	heat pumps	heat pumps	heat pumps	heat pumps
	SubCategory	heating systems	heating systems	heating systems	heating systems	heating systems
	LocalCategory	Wärmepumpen	Wärmepumpen	Wärmepumpen	Wärmepumpen	Wärmepumpen
	LocalSubCategory	Heizungssysteme	Heizungssysteme	Heizungssysteme	Heizungssysteme	Heizungssysteme
	Formula					
	StatisticalClassification					
	CASNumber					
TimePeriod	StartDate	2019	2019	2019	2019	2019
	EndDate	2020	2020	2020	2020	2020
	DataValidForEntirePeriod	1	1	1	1	1
	OtherPeriodText	Time of publications.	Time of publications.	Time of publications.	Time of publications.	Time of publications.
Geography	Text	Data apply to the supply in Switzerland.	Data apply to the supply in Switzerland.	Data apply to the supply in Switzerland.	Data apply to the supply in Switzerland.	Data apply to the supply in Switzerland.
Technology	Text					
Representativeness	Percent					
	ProductionVolume					
	SamplingProcedure	heat efficieny based on literature	heat efficieny based on literature	heat efficieny based on literature	heat efficieny based on literature	based on literature
	Extrapolations	none	none	none	none	none

Figure 31: Metadata of heat, at ice storage heat pump with CH electricity mix

ReferenceFunction	Name	heat, at ice storage heat pump, brine-water, 15kW, cert. elec., in old building	heat, at ice storage heat pump, brine-water, 15kW, cert. elec., in new building	heat, at ice storage heat pump, brine-water, 50kW, cert. elec., in old building	heat, at ice storage heat pump, brine-water, 50kW, cert. elec., in new building	heat, at ice strorage heat pump, brine-water, 7kW, cert. elec., in new building
Geography	Location	CH	CH	CH	CH	CH
ReferenceFunction	InfrastructureProcess	0	0	0	0	0
ReferenceFunction	Unit	MJ	MJ	MJ	MJ	MJ
	IncludedProcesses	Included are the share of the production of the brine-water heatpump with a lifetime of 20years scaled for 1MJ. Also the ice storage tank and the solar tube collectors as part of the whole system with a lifetime of 25 years is part of this process. The use of electricity from certified source is calculated by the SPF = 3.2 for an old building, single house. Also the loss of coolant (2% in a year) is included.	Included are the share of the production of the brine-water heatpump with a lifetime of 20years scaled for 1MJ. Also the ice storage tank and the solar tube collectors as part of the whole system with a lifetime of 25 years is part of this process. The use of electricity from certified source is calculated by the SPF = 5.3 for a new building, single house. Also the loss of coolant (2% in a year) is included.	Included are the share of the production of the brine-water heatpump with a lifetime of 20years scaled for 1MJ. Also the ice storage tank and the solar tube collectors as part of the whole system with a lifetime of 25 years is part of this process. The use of electricity from certified source is calculated by the SPF = 3.4 for an old building, apartment house. Also the loss of coolant (2% in a year) is included.	Included are the share of the production of the brine-water heatpump with a lifetime of 20years scaled for 1MJ. Also the ice storage tank and the solar tube collectors as part of the whole system with a lifetime of 25 years is part of this process. The use of electricity from certified source is calculated by the SPF = 5.5 for a new building, apartment house. Also the loss of coolant (2% in a year) is included.	Included are the share of the production of the brine-water heatpump with a lifetime of 20 years scaled for 1MJ. Also the the ice storage tank with a lifetime of 25 years is part of this process. The use of Swiss certified electricity mix is calculated by the SPF of 5.3 for a new building, single house. Also the loss of coolant (2% in a year) is included. There are NO end of life processes included. Only the deposit of waste during the construction or usephase are included.
	LocalName	Nutzwärme, Wärmepumpe mit Eisspeicher, 15kW, zert. Strommix, in älterem Gebäude	Nutzwärme, Wärmepumpe mit Eisspeicher, 15kW, zert. Strommix, in neuem Gebäude	Nutzwärme, Wärmepumpe mit Eisspeicher, 50W, zert. Strommix, in älterem Gebäude	Nutzwärme, Wärmepumpe mit Eisspeicher, 50kW, zert. Strommix, in neuem Gebäude	Nutzwärme, Wärmepumpe mit Eisspeicher, 7kW, zert. Strommix, in neuem Gebäude
	Synonyms	0	0	0	0	0
	GeneralComment	Heat from a brine-water heat pump, 15kW with heat source form ice storage and solar tube collector plus energy input from certified electricity mix (CH). Lifetime of the heat pump is 20 years, ice storage lifetime is 25 years. SPF=3.2. Loss of coolant is 2% (of the total amount in the system) per year.	Heat from a brine-water heat pump, 15kW with heat source form ice storage and solar tube collector plus energy input from certified electricity mix (CH). Lifetime of the heating system is 20 years, ice storage lifetime is 25 years. SPF=5.3. Loss of coolant is 2% (of the total amount in the system) per year.	Heat from a brine-water heat pump, 50kW with heat source form ice storage and solar tube collector plus energy input from certified electricity mix (CH). Lifetime of the heating system is 20 years, ice storage lifetime is 25 years. SPF=3.4. Loss of coolant is 2% (of the total amount in the system) per year.	Heat from a brine-water heat pump, 50kW with heat source form ice storage and solar tube collector plus energy input from certified electricity mix (CH). Lifetime of the heating system is 20 years, ice storage lifetime is 25 years. SPF=5.5. Loss of coolant is 2% (of the total amount in the system) per year.	Heat from a brine-water heat pump, 7kW with heat source form ice storage tank and Swiss certified electricity mix (CH). Lifetime of the heating system is 20 years. SPF=5.3. Loss of coolant is 2% (of the total amount in the system) per year.
	InfrastructureIncluded	1	1	1	1	1
	Category	heat pumps	heat pumps	heat pumps	heat pumps	heat pumps
	SubCategory	heating systems	heating systems	heating systems	heating systems	heating systems
	LocalCategory	Wärmepumpen	Wärmepumpen	Wärmepumpen	Wärmepumpen	Wärmepumpen
	LocalSubCategory	Heizungssysteme	Heizungssysteme	Heizungssysteme	Heizungssysteme	Heizungssysteme
	Formula					
	StatisticalClassification					
	CASNumber					
TimePeriod	StartDate	2019	2019	2019	2019	2019
	EndDate	2020	2020	2020	2020	2020
	DataValidForEntirePeriod	1	1	1	1	1
	OtherPeriodText	Time of publications.	Time of publications.	Time of publications.	Time of publications.	Time of publications.
Geography	Text	Data apply to the supply in Switzerland.	Data apply to the supply in Switzerland.	Data apply to the supply in Switzerland.	Data apply to the supply in Switzerland.	Data apply to the supply in Switzerland.
Technology	Text					
Representativeness	Percent					
	ProductionVolume					
	SamplingProcedure	heat efficieny based on literature	heat efficieny based on literature	heat efficieny based on literature	heat efficieny based on literature	based on literature
	Extrapolations	none	none	none	none	none

Figure 32: Metadata of heat, at ice storage heat pump with certified electricity mix

ReferenceFunction	Name	heat, natural gas, at diffusion absorption heat pump 15kW
Geography	Location	CH
ReferenceFunction	InfrastructureProcess	0
ReferenceFunction	Unit	MJ
	IncludedProcesses	Included are the share of the production of the diffusion absorption heat pump with a lifetime of 20years scaled for 1MJ. Also the share of the borehole for 1MJ is part of this process. The use of natural gas is calculated for this kind of heat pump. There is no loss of coolant in this process. There ae no end of life processes included.
	LocalName	Nutzwärme, Erdgas, Diffusion-Absorption Wärmepumpe, 15kW
	Synonyms	0
	GeneralComment	Heat from diffusion absorption heat pump 15kW with heat source from borehole and energy input from natural gas. The process is based on a 4kW diffusion absorption heat pump, assuming there is no significant difference of the input material for the heat output at 15kW per MJ. The captured uncertainties covers the possible difference.
	InfrastructureIncluded	1
	Category	heat pumps
	SubCategory	heating systems
	LocalCategory	Wärmepumpen
	LocalSubCategory	Heizungssysteme
	Formula	1
	StatisticalClassification	
	CASNumber	
TimePeriod	StartDate	2007
	EndDate	2020
	DataValidForEntirePeriod	1
	OtherPeriodText	Time of publications.
Geography	Text	Data apply to the supply in Switzerland.
Technology	Text	
Representativeness	Percent	
	ProductionVolume	
	SamplingProcedure	heat efficieny based on literature
	Extrapolations	none

Figure 33: Metadata of heat, at natural gas diffusion heat pump

ReferenceFunction	Name	heat, biomethane, at diffusion absorption heat pump 15kW
Geography	Location	CH
ReferenceFunction	InfrastructureProcess	0
ReferenceFunction	Unit	MJ
	IncludedProcesses	Included are the share of the production of the diffusion absorption heat pump with a lifetime of 20years scaled for 1MJ. Also the share of the borehole for 1MJ is part of this process. The use of biomethane is calculated for this kind of heat pump. There is no loss of coolant in this process. There ae no end of life processes included.
	LocalName	Nutzwärme, Biomethan, Diffusion-Absorption Wärmepumpe, 15kW
	Synonyms	0
	GeneralComment	Heat from diffusion absorption heat pump 15kW with heat source from borehole and energy input from biogas. The process is based on a 4kW diffusion absorption heat pump, assuming there is no significant difference of the input material for the heat output at 15kW per MJ. The captured uncertainties covers the possible difference.
	InfrastructureIncluded	1
	Category	heat pumps
	SubCategory	heating systems
	LocalCategory	Wärmepumpen
	LocalSubCategory	Heizungssysteme
	Formula	1
	StatisticalClassification	
	CASNumber	
TimePeriod	StartDate	2007
	EndDate	2020
	DataValidForEntirePeriod	1
	OtherPeriodText	Time of publications.
Geography	Text	Data apply to the supply in Switzerland.
Technology	Text	
Representativeness	Percent	
	ProductionVolume	
	SamplingProcedure	heat efficieny based on literature
	Extrapolations	none

Figure 34: Metadata of heat, at biomethane diffusion heat pump

Type	Field name, IndexNumber	777-258
ReferenceFunction	Name	disposal, heat pump, air-water, 7kW
Geography	Location	CH
ReferenceFunction	InfrastructureProcess	1
ReferenceFunction	Unit	unit
	IncludedProcesses	Disposal of the air-water heat pump (256 kg). Transport to WEEE dismantling facilities, machines for handling in sorting plant, electricity demand for sorting plant, final disposal of waste material. Cut-off to recycling for metals.
	Amount	1
	LocalName	Entsorgung, Wärmepumpe, Luft-Wasser, 7kW
	Synonyms	
	GeneralComment	Inventory for the disposal of an air-water heat pump, 7kW with a life time of 20 years.
	InfrastructureIncluded	1
	Category	heat pumps
	SubCategory	disposal
	LocalCategory	Wärmepumpen
	LocalSubCategory	Entsorgung
	Formula	
	StatisticalClassification	
	CASNumber	
TimePeriod	StartDate	2018
	EndDate	2020
	DataValidForEntirePeriod	1
	OtherPeriodText	
Geography	Text	Data apply to the supply in Switzerland.
Technology	Text	average technology available on market
Representativeness	Percent	
	ProductionVolume	
	SamplingProcedure	Data provided by manufacturer
	Extrapolations	
	UncertaintyAdjustments	none

Figure 35: Metadata of air water heat pump disposal

ReferenceFunction	Name	disposal, heat pump, brine-water, 7kW
Geography	Location	CH
ReferenceFunction	InfrastructureProcess	1
ReferenceFunction	Unit	unit
	IncludedProcesses	Disposal of the heat pump (158 kg). Transport to WEEE dismantling facilities, machines for handling in sorting plant, electricity demand for sorting plant, final disposal of waste material. Cut-off to recycling for metals.
	LocalName	Entsorgung, Wärmepumpe, Sole-Wasser, 7kW
	Synonyms	
	GeneralComment	Inventory for the disposal of a brine-water heat pump, 7kW with a life time of 20 years.
	InfrastructureIncluded	1
	Category	heat pumps
	SubCategory	disposal
	LocalCategory	Wärmepumpen
	LocalSubCategory	Entsorgung
	Formula	
	StatisticalClassification	
	CASNumber	
TimePeriod	StartDate	2018
	EndDate	2020
	DataValidForEntirePeriod	1
	OtherPeriodText	
Geography	Text	Data apply to the supply in Switzerland.
Technology	Text	average technology available on the market
Representativeness	Percent	
	ProductionVolume	
	SamplingProcedure	Data provided by manufacturer
	Extrapolations	
	UncertaintyAdjustments	none

Figure 36: Metadata of brine water heat pump disposal

ReferenceFunction	Name	disposal, borehole heat exchanger, 300m
Geography	Location	CH
ReferenceFunction	InfrastructureProcess	1
ReferenceFunction	Unit	unit
DataSetInformation	Type	1
	Version	1.0
	energyValues	0
	LanguageCode	en
	LocalLanguageCode	de
DataEntryBy	Person	101
	QualityNetwork	1
ReferenceFunction	DataSetRelatesToProduct	1
	IncludedProcesses	disposal of borehole heat exchnager, 300m
	Amount	1
	LocalName	Entsorgung, Wärmepumpe, Erdsonde 300m
	Synonyms	
	GeneralComment	Inventory for the disposal of a 300m deep borehole heat exchanger with a life time of at least 50 years.
	InfrastructureIncluded	1
	Category	heat pumps
	SubCategory	disposal
	LocalCategory	Wärmepumpen
	LocalSubCategory	Entsorgung
	Formula	
	StatisticalClassification	
	CASNumber	
TimePeriod	StartDate	2018
	EndDate	2020
	DataValidForEntirePeriod	1
	OtherPeriodText	
Geography	Text	Data apply to the supply in Switzerland.
Technology	Text	Industry data.
Representativeness	Percent	
	ProductionVolume	
	SamplingProcedure	Data provided by manufacturer
	Extrapolations	
	UncertaintyAdjustments	none

Figure 37: Metadata of disposal of borehole heat exchanger

ReferenceFunction	Name	disposal, delivery and return well for groundwater heat pump, 9m, CH
Geography	Location	CH
ReferenceFunction	InfrastructureProcess	1
ReferenceFunction	Unit	unit
DataSetInformation	Type	1
	Version	1.0
	energyValues	0
	LanguageCode	en
	LocalLanguageCode	de
DataEntryBy	Person	101
	QualityNetwork	1
ReferenceFunction	DataSetRelatesToProduct	1
	IncludedProcesses	Disposal of plastic parts of Infrastructure of the delivery and return well which is connected to the groundwater.
	Amount	1
	LocalName	Entsorgung, Förder- und Schluckbrunnen für Grundwasser Wärmepumpe
	Synonyms	0
	GeneralComment	Inventory for the disposal of a delivery well 9m deep and a return well 7m deep for a groundwater heat pump with a lifetime of 20 years.
	InfrastructureIncluded	1
	Category	heat pumps
	SubCategory	disposal
	LocalCategory	Wärmepumpen
	LocalSubCategory	Entsorgung
	Formula	
	StatisticalClassification	
	CASNumber	
TimePeriod	StartDate	2009
	EndDate	2020
	DataValidForEntirePeriod	1
	OtherPeriodText	
Geography	Text	Data apply to the supply in Switzerland.
Technology	Text	Industry data.
Representativeness	Percent	
	ProductionVolume	
	SamplingProcedure	Data provided by manufacturer
	Extrapolations	
	UncertaintyAdjustments	none

Figure 38: Metadata of disposal of delivery and return well for groundwater heat pump

	Name	Location	Infrastructure Process	Unit	heat pump, air-water, 15kW	heat pump, air-water, 50kW	Uncertainty Type	Standard Deviation 95%	General Comment
	Location				RER	RER			
	Infrastructure Process				1	1			
	Unit				unit	unit			
product	heat pump, air-water, 15kW	RER	1	unit	1	0			
product	heat pump, air-water, 50kW	RER	1	unit	0	1	0		
resource, in water	Water, unspecified natural origin, CH	-	-	m3	1.01E+0	2.90E+0	1	1.40	(4,5,3,1,1,5,BU:1.05); ;
technosphere	electricity, medium voltage, production ENTSO, at grid	ENTSO	0	kWh	5.90E+2	1.70E+3	1	1.55	(3,3,3,3,4,3,BU:1.05); ;
	heat, biomethane, at industrial furnace 1MW	CH	0	MJ	7.456E+2	2.0484E+3	1	1.55	(3,3,3,3,4,3,BU:1.05); ;
	heat, mixed chips from forest, at furnace 1000kW	CH	0	MJ	6.044E+2	1.7399E+3	1	1.55	(3,3,3,3,4,3,BU:1.05); ;
	natural gas, burned in industrial furnace >100kW	RER	0	MJ	1.5862E+3	4.5655E+3	1	1.22	(2,1,1,1,1,5,BU:1.05); ;
	light fuel oil, burned in industrial furnace 1MW, non-modulating	RER	0	MJ	5.00E+1	1.4400E+2	1	1.22	(2,3,1,1,1,5,BU:1.05); ;
resource, land	Occupation, industrial area, vegetation	-	-	m2a	8.74E+0	2.52E+1	1	1.57	(2,3,2,2,1,5,BU:1.5); ;
	Occupation, industrial area, built up	-	-	m2a	2.41E+0	6.94E+0	1	1.57	(2,3,2,2,1,5,BU:1.5); ;
technosphere	tube insulation, elastomere, at plant	DE	0	kg	1.39E+1	2.92E+1	1	1.40	(4,5,3,1,1,5,BU:1.05); ;
	rock wool, at plant	CH	0	kg	5.00E+0	5.00E+0	1	1.31	(2,3,2,2,3,5,BU:1.05); ;
	trifluoromethane, at plant	GLO	0	kg	2.25E+0	1.00E+1	1	1.63	(4,3,1,2,4,5,BU:1.05); ;
	1,1-difluoroethane, HFC-152a, at plant	US	0	kg	2.25E+0	1.00E+1	1	1.63	(4,3,1,2,4,5,BU:1.05); ;
	copper, at regional storage	RER	0	kg	6.02E+1	1.97E+2	1	1.40	(4,5,3,1,1,5,BU:1.05); ;
	polyvinylchloride, bulk polymerised, at plant	RER	0	kg	1.40E+0	2.90E+0	1	1.40	(4,5,3,1,1,5,BU:1.05); ;
	aluminium, primary, at plant	RER	0	kg	3.00E+1	1.32E+2	1	1.40	(4,5,3,1,1,5,BU:1.05); ;
	steel, low-alloyed, at plant	RER	0	kg	1.60E+2	4.10E+2	1	1.40	(4,5,3,1,1,5,BU:1.05); ;
	transport, freight, lorry 16-32 metric ton, fleet average	CH	0	tkm	1.36E+1	3.90E+1	1	2.34	(4,4,2,3,4,5,BU:2); ;
	transport, freight, rail	RER	0	tkm	1.63E+2	4.68E+2	1	2.34	(4,4,2,3,4,5,BU:2); ;
	lubricating oil, at plant	RER	0	kg	2.20E+0	4.70E+0	1	1.55	(3,3,3,3,4,3,BU:1.05); ;
	electronic component, unspecified, at plant	GLO	0	kg	2.00E+0	5.00E+0	1	1.40	(4,5,3,1,1,5,BU:1.05); ;
	disposal, plastics, mixture, 15.3% water, to municipal incineration	CH	0	kg	1.53E+1	3.22E+1	1	1.40	(4,5,3,1,1,5,BU:1.05); ;
air, high population density	Heat, waste	-	-	MJ	2.12E+3	6.11E+3	1	1.40	(4,5,3,1,1,5,BU:1.05); ;
	Methane, difluoro-, HFC-32	-	-	kg	4.95E-1	2.20E+0	1	1.56	(1,1,1,3,1,5,BU:1.5); ;
	Ethane, pentafluoro-, HFC-125	-	-	kg	4.95E-1	2.20E+0	1	1.56	(1,1,1,3,1,5,BU:1.5); ;

	Name	Location	Infrastructure Process	Unit	heat pump, air-water, 7kW
	Location				RER
	Infrastructure Process				1
	Unit				unit
product	heat pump, air-water, 7kW	RER	1	unit	1
resource, in water	Water, unspecified natural origin, CH	-	-	m3	9.50E-1
technosphere	electricity, medium voltage, production ENTSO, at grid	ENTSO	0	kWh	5.57E+2
	heat, biomethane, at industrial furnace 1MW	CH	0	MJ	7.04E+2
	heat, mixed chips from forest, at furnace 1000kW	CH	0	MJ	5.710E+2
	natural gas, burned in industrial furnace >100kW	RER	0	MJ	1.498E+3
	light fuel oil, burned in industrial furnace 1MW, non-modulating	RER	0	MJ	4.73E+1
resource, land	Occupation, industrial area, vegetation	-	-	m2a	8.26E+0
	Occupation, industrial area, built up	-	-	m2a	2.28E+0
technosphere	tube insulation, elastomere, at plant	DE	0	kg	1.21E+1
	rock wool, at plant	CH	0	kg	4.00E+0
	trifluoromethane, at plant	GLO	0	kg	1.75E+0
	1,1-difluoroethane, HFC-152a, at plant	US	0	kg	1.75E+0
	copper, at regional storage	RER	0	kg	5.92E+1
	polyvinylchloride, bulk polymerised, at plant	RER	0	kg	1.20E+0
	aluminium, primary, at plant	RER	0	kg	3.23E+1
	steel, low-alloyed, at plant	RER	0	kg	1.47E+2
	transport, freight, lorry 16-32 metric ton, fleet average	CH	0	tkm	1.28E+1
	transport, freight, rail	RER	0	tkm	1.54E+2
	lubricating oil, at plant	RER	0	kg	2.20E+0
	electronic component, unspecified, at plant	GLO	0	kg	1.50E+0
	disposal, plastics, mixture, 15.3% water, to municipal incineration	CH	0	kg	1.33E+1
air, high population density	Heat, waste	-	-	MJ	2.01E+3
	Methane, difluoro-, HFC-32	-	-	kg	3.85E-1
	Ethane, pentafluoro-, HFC-125	-	-	kg	3.85E-1

Figure 39: Unit process raw data of air water heat pump production

	Name	Location	Infrastructure Process	Unit	heat pump, brine-water, 15kW	heat pump, brine-water, 50kW	Uncertainty Type	Standard Deviation 95%	General Comment
	Location				RER	RER			
	Infrastructure Process				1	1			
	Unit				unit	unit			
product	heat pump, brine-water, 15kW	RER	1	unit	1	0	0		
product	heat pump, brine-water, 50kW	RER	1	unit	0	1	0		
resource, in water	Water, unspecified natural origin, CH	-	-	m3	6.78E-1	1.43E+0	1	1.40	(4,5,3,1,1,5,BU:1.05); ;
technosphere	electricity, medium voltage, production	ENTSO	0	kWh	3.96E+2	8.34E+2	1	1.55	(3,3,3,3,4,3,BU:1.05); ;
	heat, biomethane, at industrial furnace 1MW	CH	0	MJ	5.00E+2	1.05E+3	1	1.55	(3,3,3,3,4,3,BU:1.05); ;
	heat, mixed chips from forest, at furnace 1000kW	CH	0	MJ	4.07E+2	8.53E+2	1	1.55	(3,3,3,3,4,3,BU:1.05); ;
	natural gas, burned in industrial furnace >100kW	RER	0	MJ	1.07E+3	2.24E+3	1	1.22	(2,1,1,1,1,5,BU:1.05); ;
	light fuel oil, burned in industrial furnace 1MW, non-modulating	RER	0	MJ	3.35E+1	7.09E+1	1	1.22	(2,3,1,1,1,5,BU:1.05); ;
resource, land	Occupation, industrial area, vegetation	-	-	m2a	5.87E+0	1.24E+1	1	1.57	(2,3,2,2,1,5,BU:1.5); ;
	Occupation, industrial area, built up	-	-	m2a	1.62E+0	3.41E+0	1	1.57	(2,3,2,2,1,5,BU:1.5); ;
technosphere	tube insulation, elastomere, at plant	DE	0	kg	1.39E+1	2.92E+1	1	1.40	(4,5,3,1,1,5,BU:1.05); ;
	trifluoromethane, at plant	GLO	0	kg	1.40E+0	4.80E+0	1	2.29	(5,3,1,2,5,5,BU:1.05); ;
	1,1-difluoroethane, HFC-152a, at plant	US	0	kg	1.40E+0	4.80E+0	1	2.29	(5,3,1,2,5,5,BU:1.05); ;
	copper, at regional storage	RER	0	kg	3.10E+1	6.40E+1	1	1.40	(4,5,3,1,1,5,BU:1.05); ;
	polyvinylchloride, bulk polymerised, at plant	RER	0	kg	1.40E+0	2.90E+0	1	1.40	(4,5,3,1,1,5,BU:1.05); ;
	steel, low-alloyed, at plant	RER	0	kg	1.32E+2	2.78E+2	1	1.40	(4,5,3,1,1,5,BU:1.05); ;
	transport, freight, lorry 16-32 metric ton, fleet average	CH	0	tkm	9.10E+0	1.92E+1	1	2.34	(4,4,2,3,4,5,BU:2); ;
	transport, freight, rail	RER	0	tkm	1.09E+2	2.30E+2	1	2.34	(4,4,2,3,4,5,BU:2); ;
	lubricating oil, at plant	RER	0	kg	2.20E+0	4.70E+0	1	1.55	(3,3,3,3,4,3,BU:1.05); ;
	electronic component, unspecified, at plant	GLO	0	kg	2.00E+0	5.00E+0	1	1.40	(4,5,3,1,1,5,BU:1.05); ;
	disposal, plastics, mixture, 15.3% water, to municipal incineration	CH	0	kg	1.53E+1	3.22E+1	1	1.40	(4,5,3,1,1,5,BU:1.05); ;
air, high population density	Heat, waste	-	-	MJ	1.43E+3	3.00E+3	1	1.40	(4,5,3,1,1,5,BU:1.05); ;
	Methane, difluoro-, HFC-32	-	-	kg	3.08E-1	1.06E+0	1	1.56	(1,1,1,3,1,5,BU:1.5); ;
	Ethane, pentafluoro-, HFC-125	-	-	kg	3.08E-1	1.06E+0	1	1.56	(1,1,1,3,1,5,BU:1.5); ;

	Name	Location	Infrastructure Process	Unit	heat pump, brine-water, 7kW	Uncertainty Type	Standard Deviation 95%	General Comment
	Location				RER			
	Infrastructure Process				1			
	Unit				unit			
product	heat pump, brine-water, 7kW	RER	1	unit	1	0		
resource, in water	Water, unspecified natural origin, CH	-	-	m3	5.88E-1	1	1.40	(4,5,3,1,1,5,BU:1.05); ;
technosphere	electricity, medium voltage, production	ENTSO	0	kWh	3.44E+2	1	1.55	(3,3,3,3,4,3,BU:1.05); ;
	heat, biomethane, at industrial furnace 1MW	CH	0	MJ	4.35E+2	1	1.55	(3,3,3,3,4,3,BU:1.05); ;
	heat, mixed chips from forest, at furnace 1000kW	CH	0	MJ	3.52E+2	1	1.55	(3,3,3,3,4,3,BU:1.05); ;
	natural gas, burned in industrial furnace >100kW	RER	0	MJ	9.25E+2	1	1.22	(2,1,1,1,1,5,BU:1.05); ;
	light fuel oil, burned in industrial furnace 1MW, non-modulating	RER	0	MJ	2.92E+1	1	1.22	(2,3,1,1,1,5,BU:1.05); ;
resource, land	Occupation, industrial area, vegetation	-	-	m2a	5.10E+0	1	1.57	(2,3,2,2,1,5,BU:1.5); ;
	Occupation, industrial area, built up	-	-	m2a	1.41E+0	1	1.57	(2,3,2,2,1,5,BU:1.5); ;
technosphere	tube insulation, elastomere, at plant	DE	0	kg	1.21E+1	1	1.40	(4,5,3,1,1,5,BU:1.05); ;
	trifluoromethane, at plant	GLO	0	kg	1.00E+0	1	2.29	(5,3,1,2,5,5,BU:1.05); ;
	1,1-difluoroethane, HFC-152a, at plant	US	0	kg	1.00E+0	1	2.29	(5,3,1,2,5,5,BU:1.05); ;
	copper, at regional storage	RER	0	kg	2.70E+1	1	1.40	(4,5,3,1,1,5,BU:1.05); ;
	polyvinylchloride, bulk polymerised, at plant	RER	0	kg	1.20E+0	1	1.40	(4,5,3,1,1,5,BU:1.05); ;
	steel, low-alloyed, at plant	RER	0	kg	1.15E+2	1	1.40	(4,5,3,1,1,5,BU:1.05); ;
	transport, freight, lorry 16-32 metric ton, fleet average	CH	0	tkm	7.90E+0	1	2.34	(4,4,2,3,4,5,BU:2); ;
	transport, freight, rail	RER	0	tkm	9.48E+1	1	2.34	(4,4,2,3,4,5,BU:2); ;
	lubricating oil, at plant	RER	0	kg	1.90E+0	1	1.55	(3,3,3,3,4,3,BU:1.05); ;
	electronic component, unspecified, at plant	GLO	0	kg	1.50E+0	1	1.40	(4,5,3,1,1,5,BU:1.05); ;
	disposal, plastics, mixture, 15.3% water, to municipal incineration	CH	0	kg	1.33E+1	1	1.40	(4,5,3,1,1,5,BU:1.05); ;
air, high population density	Heat, waste	-	-	MJ	1.24E+3	1	1.40	(4,5,3,1,1,5,BU:1.05); ;
	Methane, difluoro-, HFC-32	-	-	kg	2.20E-1	1	1.56	(1,1,1,3,1,5,BU:1.5); ;
	Ethane, pentafluoro-, HFC-125	-	-	kg	2.20E-1	1	1.56	(1,1,1,3,1,5,BU:1.5); ;

Figure 40: Unit process raw data of brine water heat pump production

	Name	Location	Infrastructure Process	Unit	Borehole heat exchanger, 300m	Uncertainty Type	Standard Deviation 95%	General Comment
	Location				CH			
	Infrastructure Process				1			
	Unit				unit			
product	Borehole heat exchanger, 300m	CH	1	unit	1	0		
technosphere	bentonite, at processing	DE	0	kg	1.15E+3	1	1.22	(2,2,1,3,3,3,BU:1.05); ;
	polyethylene, HDPE, granulate, at plant	RER	0	kg	2.58E+2	1	1.22	(2,2,1,3,3,3,BU:1.05); ;
	extrusion, plastic pipes	RER	0	kg	2.58E+2	1	1.22	(2,2,1,3,3,3,BU:1.05); ;
	cement, unspecified, at plant	CH	0	kg	5.19E+2	1	1.22	(2,2,1,3,3,3,BU:1.05); ;
	tap water, at user	CH	0	kg	1.73E+3	1	1.65	(4,2,3,5,4,5,BU:1.05); ;
	ethylene glycol, at plant	RER	0	kg	2.79E+2	1	1.22	(2,2,1,3,3,3,BU:1.05); ;
	tap water, at user	CH	0	kg	7.54E+2	1	1.22	(2,2,1,3,3,3,BU:1.05); ;
	diesel, burned in building machine, average	CH	0	MJ	3.96E+4	1	2.06	(2,2,1,3,3,3,BU:2); ;
	transport, freight, rail, electricity with shunting	CH	0	tkm	3.86E+2	1	2.34	(4,4,2,3,4,5,BU:2); ;
	transport, freight, lorry 16-32 metric ton, fleet average	CH	0	tkm	6.00E+1	1	2.34	(4,4,2,3,4,5,BU:2); ;
	disposal, inert waste, 5% water, to inert material landfill	CH	0	kg	1.36E+4	1	1.22	(2,2,1,3,3,3,BU:1.05); ;

Figure 41: Unit process raw data of borehole heat exchanger production

	Name	Location	Infrastructure Process	Unit	delivery and return well for groundwater heat pump, 9m, CH	Uncertainty Type	Standard Deviation 95%	General Comment
	Location				CH			
	Infrastructure Process				1			
	Unit				unit			
product	delivery and return well for groundwater heat pump, 9m, CH	CH	1	unit	1	0		
technosphere	polyvinylchloride, at regional storage	RER	0	kg	6.79E+0	1	1.89	(5,5,3,3,4,5,BU:1.05); ;
	extrusion, plastic pipes	RER	0	kg	6.79E+0	1	1.89	(5,5,3,3,4,5,BU:1.05); ;
	clay plaster, at plant	CH	0	kg	5.08E+1	1	1.35	(3,3,3,2,3,5,BU:1.05); ;
	gravel, round, at mine	CH	0	kg	2.29E+2	1	1.35	(3,3,3,2,3,5,BU:1.05); ;
	polyvinylchloride, at regional storage	RER	0	kg	2.85E+1	1	1.35	(3,3,3,2,3,5,BU:1.05); ;
	extrusion, plastic pipes	RER	0	kg	2.85E+1	1	1.35	(3,3,3,2,3,5,BU:1.05); ;
	diesel, burned in building machine, average	CH	0	MJ	1.05E+3	1	2.34	(5,3,3,2,3,5,BU:2); ;
	aluminium, primary, at plant	RER	0	kg	3.00E-1	1	1.64	(5,3,3,2,3,5,BU:1.05); ;
	aluminium product manufacturing, average metal working	RER	0	kg	3.00E-1	1	1.64	(5,3,3,2,3,5,BU:1.05); ;
	steel, low-alloyed, at plant	RER	0	kg	1.89E+0	1	1.35	(3,3,3,2,3,5,BU:1.05); ;
	steel product manufacturing, average metal working	RER	0	kg	1.89E+0	1	1.35	(3,3,3,2,3,5,BU:1.05); ;
	clay plaster, at plant	CH	0	kg	7.01E+1	1	1.35	(3,3,3,2,3,5,BU:1.05); ;
	gravel, round, at mine	CH	0	kg	2.89E+2	1	1.35	(3,3,3,2,3,5,BU:1.05); ;
	polyvinylchloride, at regional storage	RER	0	kg	1.07E+1	1	1.35	(3,3,3,2,3,5,BU:1.05); ;
	extrusion, plastic pipes	RER	0	kg	1.07E+1	1	1.35	(3,3,3,2,3,5,BU:1.05); ;
	diesel, burned in building machine, average	CH	0	MJ	8.18E+2	1	2.34	(5,3,3,2,3,5,BU:2); ;
	transport, freight, rail, diesel, without particle filter	CH	0	tkm	7.42E+1	1	2.34	(4,4,2,3,4,5,BU:2); ;
	transport, freight, lorry 16-32 metric ton, fleet average	CH	0	tkm	1.52E+1	1	2.34	(4,4,2,3,4,5,BU:2); ;
	disposal, inert waste, 5% water, to inert material landfill	CH	0	kg	5.19E+2	1	1.64	(5,3,3,2,3,5,BU:1.05); ;
	disposal, municipal solid waste, 22.9% water, to municipal incineration	CH	0	kg	4.52E+2	1	1.64	(5,3,3,2,3,5,BU:1.05); ;

Figure 42: Unit process raw data of delivery and return well production

	Name	Location	Infrastructure Process	Unit	ice storage tank with solar tube collector	Uncertainty Type	Standard Deviation 95%	General Comment
	Location				CH			
	Infrastructure Process				1			
	Unit				unit			
product	ice storage tank with solar tube collector	CH	1	unit	1	0		
technosphere	concrete, exacting, at plant	CH	0	m3	3.28E+0	1	1.25	(2,3,3,1,1,5,BU:1.05); ;
	excavation, hydraulic digger, with particle filter	CH	0	m3	1.20E+1	1	2.07	(2,3,3,1,1,5,BU:2); ;
	polyethylene, HDPE, granulate, at plant	RER	0	kg	3.00E+1	1	1.25	(2,3,3,1,1,5,BU:1.05); ;
	extrusion, plastic pipes	RER	0	kg	3.00E+1	1	1.25	(2,3,3,1,1,5,BU:1.05); ;
	evacuated tube collector, at plant	GB	1	m2	1.20E+1	1	3.11	(2,3,3,1,3,5,BU:3); ;
	polyethylene, HDPE, granulate, at plant	RER	0	kg	5.25E+0	1	1.62	(2,5,5,1,1,5,BU:1.05); ;
	extrusion, plastic pipes	RER	0	kg	5.25E+0	1	1.62	(2,5,5,1,1,5,BU:1.05); ;
	tap water, at user	CH	0	kg	1.00E+4	1	1.93	(4,5,5,1,4,5,BU:1.05); ;
	transport, freight, rail	RER	0	tkm	8.07E+2	1	2.11	(4,3,3,2,1,5,BU:2); ;
	transport, freight, lorry 16-32 metric ton, fleet average	CH	0	tkm	1.62E+2	1	2.11	(4,3,3,1,1,5,BU:2); ;

Figure 43: Unit process raw data of ice storage tank production

	401	Input Group	Output Group	Name	Location	Category	Subcategory	Infrastructure Process	Unit	heat, at heat pump, air-water, 15kW, CH electricity, in old building	heat, at heat pump, air-water, 15kW, CH electricity, in new building	heat, at heat pump, air-water, 50kW, CH electricity, in old building	heat, at heat pump, air-water, 50kW, CH electricity, in new building	Uncertainty Type	Standard Deviation 95%	General Comment
	662			Location						CH	CH	CH	CH			
	493			Infrastructure Process						0	0	0	0			
	403			Unit						MJ	MJ	MJ	MJ			
product		-	0	heat, at heat pump, air-water, 15kW, CH electricity, in old building	CH	-	-	0	MJ	1	0	0	0			
		-	0	heat, at heat pump, air-water, 15kW, CH electricity, in new building	CH	-	-	0	MJ	0	1	0	0			
		-	0	heat, at heat pump, air-water, 50kW, CH electricity, in old building	CH	-	-	0	MJ	0	0	1	0			
		-	0	heat, at heat pump, air-water, 50kW, CH electricity, in new building	CH	-	-	0	MJ	0	0	0	1	0		
resource, in ground		4	-	Energy, geothermal, converted	-	resource	in ground	-	MJ	6.30E-1	7.73E-1	6.67E-1	7.83E-1	1	1.22	(2,1,1,1,1,5,BU:1.05); ;
technosphere		5	-	electricity, low voltage, at grid	CH	-	-	0	kWh	1.03E-1	6.31E-2	9.26E-2	6.04E-2	1	1.22	(2,1,1,1,1,5,BU:1.05); ;
		5	-	1,1-difluoroethane, HFC-152a, at plant	US	-	-	0	kg	3.97E-7	3.97E-7	5.29E-7	5.29E-7	1	2.29	(5,3,1,2,5,5,BU:1.05); ;
		5	-	trifluoromethane, at plant	GLO	-	-	0	kg	3.97E-7	3.97E-7	5.29E-7	5.29E-7	1	2.29	(5,3,1,2,5,5,BU:1.05); ;
		5	-	heat pump, air-water, 15kW	RER	-	-	1	unit	4.41E-7	4.41E-7	0	0	1	3.05	(2,1,1,1,1,5,BU:3); ;
		5	-	heat pump, air-water, 50kW	RER	-	-	1	unit	0	0	1.32E-7	1.32E-7	1	3.05	(2,1,1,1,1,5,BU:3); ;
air, high population densitv		4	-	Heat, waste	-	air	high population densit	-	MJ	3.70E-1	2.27E-1	3.33E-1	2.17E-1	1	1.22	(2,1,1,1,1,5,BU:1.05); ;
		4	-	Methane, difluoro-, HFC-32	-	air	high population densit	-	kg	3.97E-7	3.97E-7	5.29E-7	5.29E-7	1	1.56	(1,1,1,1,1,5,BU:1.5); ;
		4	-	Ethane, pentafluoro-, HFC-125	-	air	high population densit	-	kg	3.97E-7	3.97E-7	5.29E-7	5.29E-7	1	1.56	(1,1,1,1,1,5,BU:1.5); ;

Figure 44: Unit process raw data of heat, at air water heat pump with CH electricity mix

	401	Input Group	Output Group	Name	Location	Infrastructure Process	Unit	heat, at heat pump, air-water, 15kW, certified electricity, in old building	heat, at heat pump, air-water, 15kW, certified electricity, in new building	heat, at heat pump, air-water, 50kW, certified electricity, in old building	heat, at heat pump, air-water, 50kW, certified electricity, in new building	Uncertainty Type	Standard Deviation 95%	General Comment
	662			Location				CH	CH	CH	CH			
	493			Infrastructure Process				0	0	0	0			
	403			Unit				MJ	MJ	MJ	MJ			
product		-	0	heat, at heat pump, air-water, 15kW, certified electricity, in old building	CH	0	MJ	1	0	0	0			
		-	0	heat, at heat pump, air-water, 15kW, certified electricity, in new building	CH	0	MJ	0	1	0	0			
		-	0	heat, at heat pump, air-water, 50kW, certified electricity, in old building	CH	0	MJ	0	0	1	0			
		-	0	heat, at heat pump, air-water, 50kW, certified electricity, in new building	CH	0	MJ	0	0	0	1	0		
resource, in ground		4	-	Energy, geothermal, converted	-	-	MJ	6.30E-1	7.73E-1	6.67E-1	7.83E-1	1	1.22	(2,1,1,1,1,5,BU:1.05); ;
technosphere		5	-	electricity, low voltage, certified electricity, at grid	CH	0	kWh	1.03E-1	6.31E-2	9.26E-2	6.04E-2	1	1.22	(2,1,1,1,1,5,BU:1.05); ;
		5	-	1,1-difluoroethane, HFC-152a, at plant	US	0	kg	3.97E-7	3.97E-7	5.29E-7	5.29E-7	1	2.29	(5,3,1,2,5,5,BU:1.05); ;
		5	-	trifluoromethane, at plant	GLO	0	kg	3.97E-7	3.97E-7	5.29E-7	5.29E-7	1	2.29	(5,3,1,2,5,5,BU:1.05); ;
		5	-	heat pump, air-water, 15kW	RER	1	unit	4.41E-7	4.41E-7	0	0	1	3.05	(2,1,1,1,1,5,BU:3); ;
		5	-	heat pump, air-water, 50kW	RER	1	unit	0	0	1.32E-7	1.32E-7	1	3.05	(2,1,1,1,1,5,BU:3); ;
air, high population densitv		4	-	Heat, waste	-	-	MJ	3.70E-1	2.27E-1	3.33E-1	2.17E-1	1	1.22	(2,1,1,1,1,5,BU:1.05); ;
		4	-	Methane, difluoro-, HFC-32	-	-	kg	3.97E-7	3.97E-7	5.29E-7	5.29E-7	1	1.56	(1,1,1,1,1,5,BU:1.5); ;
		4	-	Ethane, pentafluoro-, HFC-125	-	-	kg	3.97E-7	3.97E-7	5.29E-7	5.29E-7	1	1.56	(1,1,1,1,1,5,BU:1.5); ;

Figure 45: Unit process raw data of heat, at air water heat pump with certified electricity mix

	Name	Location	Infrastructure Process	Unit	heat, at borehole heat pump, brine-water, 15kW, CH electricity, in old building	heat, at borehole heat pump, brine-water, 15kW, CH electricity, in new building	heat, at borehole heat pump, brine-water, 50kW, CH electricity, in old building	heat, at borehole heat pump, brine-water, 50kW, CH electricity, in new building	Uncertainty Type	Standard Deviation 95%	General Comment
	Location				CH	CH	CH	CH			
	Infrastructure Process				0	0	0	0			
	Unit				MJ	MJ	MJ	MJ			
product	heat, at borehole heat pump, brine-water, 15kW, CH electricity, in old building	CH	0	MJ	1	0	0	0			
	heat, at borehole heat pump, brine-water, 15kW, CH electricity, in new building	CH	0	MJ	0	1	0	0			
	heat, at borehole heat pump, brine-water, 50kW, CH electricity, in old building	CH	0	MJ	0	0	1	0			
	heat, at borehole heat pump, brine-water, 50kW, CH electricity, in new building	CH	0	MJ	0	0	0	1	0		
resource, in ground	Energy, geothermal, converted	-	-	MJ	6.88E-1	8.11E-1	7.06E-1	8.18E-1	1	1.22	(2,1,1,1,1,5,BU:1.05); ;
technosphere	electricity, low voltage, at grid	CH	0	kWh	8.68E-2	5.24E-2	8.17E-2	5.05E-2	1	1.22	(2,1,1,1,1,5,BU:1.05); ;
	1,1-difluoroethane, HFC-152a, at plant	US	0	kg	2.47E-7	2.47E-7	2.54E-7	2.54E-7	1	2.29	(5,3,1,2,5,5,BU:1.05); ;
	trifluoromethane, at plant	GLO	0	kg	2.47E-7	2.47E-7	2.54E-7	2.54E-7	1	2.29	(5,3,1,2,5,5,BU:1.05); ;
	heat pump, brine-water, 15kW	RER	1	unit	4.41E-7	4.41E-7	0	0	1	1.22	(2,1,1,1,1,5,BU:1.05); ;
	heat pump, brine-water, 50kW	RER	1	unit	0	0	1.32E-7	1.32E-7	1	1.22	(2,1,1,1,1,5,BU:1.05); ;
	Borehole heat exchanger, 300m	CH	1	unit	1.76E-7	1.76E-7	1.76E-7	1.76E-7	1	1.22	(2,1,1,1,1,5,BU:1.05); ;
air, high population density	Heat, waste	-	-	MJ	3.13E-1	1.89E-1	2.94E-1	1.82E-1	1	1.22	(2,1,1,1,1,5,BU:1.05); ;
	Methane, difluoro-, HFC-32	-	-	kg	2.47E-7	2.47E-7	2.54E-7	2.54E-7	1	1.56	(1,1,1,1,1,5,BU:1.5); ;
	Ethane, pentafluoro-, HFC-125	-	-	kg	2.47E-7	2.47E-7	2.54E-7	2.54E-7	1	1.56	(1,1,1,1,1,5,BU:1.5); ;

Figure 46: Unit process raw data of heat, at brine-water heat pump with CH electricity mix

	Name	Location	Infrastructure Process	Unit	heat, at borehole heat pump, brine-water, 15kW, cert. electr., in old building	heat, at borehole heat pump, brine-water, 15kW, cert. electr., in new building	heat, at borehole heat pump, brine-water, 50kW, cert. electr., in old building	heat, at borehole heat pump, brine-water, 50kW, cert. electr., in new building	Uncertainty Type	Standard Deviation 95%	General Comment
	Location				CH	CH	CH	CH			
	Infrastructure Process				0	0	0	0			
	Unit				MJ	MJ	MJ	MJ			
product	heat, at borehole heat pump, brine-water, 15kW, cert. electr., in old building	CH	0	MJ	1	0	0	0			
	heat, at borehole heat pump, brine-water, 15kW, cert. electr., in new building	CH	0	MJ	0	1	0	0			
	heat, at borehole heat pump, brine-water, 50kW, cert. electr., in old building	CH	0	MJ	0	0	1	0			
	heat, at borehole heat pump, brine-water, 50kW, cert. electr., in new building	CH	0	MJ	0	0	0	1	0		
resource, in ground	Energy, geothermal, converted	-	-	MJ	6.88E-1	8.11E-1	7.06E-1	8.18E-1	1	1.22	(2,1,1,1,1,5,BU:1.05); ;
technosphere	electricity, low voltage, certified electricity, at grid	CH	0	kWh	8.68E-2	5.24E-2	8.17E-2	5.05E-2	1	1.22	(2,1,1,1,1,5,BU:1.05); ;
	1,1-difluoroethane, HFC-152a, at plant	US	0	kg	2.47E-7	2.47E-7	2.54E-7	2.54E-7	1	2.29	(5,3,1,2,5,5,BU:1.05); ;
	trifluoromethane, at plant	GLO	0	kg	2.47E-7	2.47E-7	2.54E-7	2.54E-7	1	2.29	(5,3,1,2,5,5,BU:1.05); ;
	heat pump, brine-water, 15kW	RER	1	unit	4.41E-7	4.41E-7	0	0	1	1.22	(2,1,1,1,1,5,BU:1.05); ;
	heat pump, brine-water, 50kW	RER	1	unit	0	0	1.32E-7	1.32E-7	1	1.22	(2,1,1,1,1,5,BU:1.05); ;
	Borehole heat exchanger, 300m	CH	1	unit	1.76E-7	1.76E-7	1.76E-7	1.76E-7	1	1.22	(2,1,1,1,1,5,BU:1.05); ;
air, high population density	Heat, waste	-	-	MJ	3.13E-1	1.89E-1	2.94E-1	1.82E-1	1	1.22	(2,1,1,1,1,5,BU:1.05); ;
	Methane, difluoro-, HFC-32	-	-	kg	2.47E-7	2.47E-7	2.54E-7	2.54E-7	1	1.56	(1,1,1,1,1,5,BU:1.5); ;
	Ethane, pentafluoro-, HFC-125	-	-	kg	2.47E-7	2.47E-7	2.54E-7	2.54E-7	1	1.56	(1,1,1,1,1,5,BU:1.5); ;

Figure 47: Unit process raw data of heat, at brine-water heat pump with certified electricity mix

	Name	Location	Infrastructure Process	Unit	heat, at groundwater heat pump, brine-water, 15kW, CH electr., in old building	heat, at groundwater heat pump, brine-water, 15kW, CH electr., in new building	heat, at groundwater heat pump, brine-water, 50kW, CH electr., in old building	heat, at groundwater heat pump, brine-water, 50kW, CH electr., in new building	Uncertainty Type	Standard Deviation 95%	General Comment
	Location				CH	CH	CH	CH			
	Infrastructure Process				0	0	0	0			
	Unit				MJ	MJ	MJ	MJ			
product	heat, at groundwater heat pump, brine-water, 15kW, CH electr., in old building	CH	0	MJ	1	0	0	0			
	heat, at groundwater heat pump, brine-water, 15kW, CH electr., in new building	CH	0	MJ	0	1	0	0			
	heat, at groundwater heat pump, brine-water, 50kW, CH electr., in old building	CH	0	MJ	0	0	1	0			
	heat, at groundwater heat pump, brine-water, 50kW, CH electr., in new building	CH	0	MJ	0	0	0	1	0		
resource, in water	Energy, environmental, water	-	-	MJ	7.44E-1	8.11E-1	7.56E-1	8.18E-1	1	1.22	(2,1,1,1,1,5,BU:1.05); ;
technosphere	electricity, low voltage, at grid	CH	0	kWh	8.68E-2	5.24E-2	8.17E-2	5.05E-2	1	1.22	(2,1,1,1,1,5,BU:1.05); ;
	1,1-difluoroethane, HFC-152a, at plant	US	0	kg	2.47E-7	2.47E-7	2.54E-7	2.54E-7	1	2.29	(5,3,1,2,5,5,BU:1.05); ;
	trifluoromethane, at plant	GLO	0	kg	2.47E-7	2.47E-7	2.54E-7	2.54E-7	1	2.29	(5,3,1,2,5,5,BU:1.05); ;
	heat pump, brine-water, 15kW	RER	1	unit	4.41E-7	4.41E-7	0	0	1	1.22	(2,1,1,1,1,5,BU:1.05); ;
	heat pump, brine-water, 50kW	RER	1	unit	0	0	1.32E-7	1.32E-7	1	1.22	(2,1,1,1,1,5,BU:1.05); ;
	delivery and return well for groundwater heat pump, 9m, CH	CH	1	unit	4.41E-7	4.41E-7	1.32E-7	1.32E-7	1	1.22	(2,1,1,1,1,5,BU:1.05); ;
air, high population density	Heat, waste	-	-	MJ	3.13E-1	1.89E-1	2.94E-1	1.82E-1	1	1.22	(2,1,1,1,1,5,BU:1.05); ;
	Methane, difluoro-, HFC-32	-	-	kg	2.47E-7	2.47E-7	2.54E-7	2.54E-7	1	1.56	(1,1,1,1,1,5,BU:1.5); ;
	Ethane, pentafluoro-, HFC-125	-	-	kg	2.47E-7	2.47E-7	2.54E-7	2.54E-7	1	1.56	(1,1,1,1,1,5,BU:1.5); ;

Figure 48: Unit process raw data of heat, at groundwater heat pump with CH electricity mix

	Name	Location	Infrastructure Process	Unit	heat, at borehole heat pump, brine-water, 50kW, for district heating, CH electricity	Uncertainty Type	Standard Deviation 95%	General Comment
	Location				CH			
	Infrastructure Process				0			
	Unit				MJ			
	heat, at borehole heat pump, brine-water, 50kW, for district heating, CH electricity	CH	0	MJ	1	0		
resource, in ground	Energy, geothermal, converted	-	-	MJ	6.77E-1	1	1.22	(2,1,1,1,1,5,BU:1.05); ;
technosphere	electricity, low voltage, at grid	CH	0	kWh	8.96E-2	1	1.22	(2,1,1,1,1,5,BU:1.05); ;
	1,1-difluoroethane, HFC-152a, at plant	US	0	kg	2.54E-7	1	2.29	(5,3,1,2,5,5,BU:1.05); ;
	trifluoromethane, at plant	GLO	0	kg	2.54E-7	1	2.29	(5,3,1,2,5,5,BU:1.05); ;
	heat pump, brine-water, 15kW	RER	1	unit	0	1	3.05	(2,1,1,1,1,5,BU:3); ;
	heat pump, brine-water, 50kW	RER	1	unit	1.32E-7	1	3.05	(2,1,1,1,1,5,BU:3); ;
	Borehole heat exchanger, 300m	CH	1	unit	1.76E-7	1	3.05	(2,1,1,1,1,5,BU:3); ;
air, high population density	Heat, waste	-	-	MJ	3.23E-1	1	1.22	(2,1,1,1,1,5,BU:1.05); ;
	Methane, difluoro-, HFC-32	-	-	kg	2.54E-7	1	1.56	(1,1,1,1,1,5,BU:1.5); ;
	Ethane, pentafluoro-, HFC-125	-	-	kg	2.54E-7	1	1.56	(1,1,1,1,1,5,BU:1.5); ;

Figure 49: Unit process raw data of heat, at borehole heat pump, for district heating, with CH electricity mix

	Name	Location	Infrastructure Process	Unit	heat, at groundwater heat pump, brine-water, 50kW, for district heating, CH electr.	Uncertainty Type	Standard Deviation 95%	General Comment
	Location				CH			
	Infrastructure Process				0			
	Unit				MJ			
	heat, at groundwater heat pump, brine-water, 50kW, for district heating, CH electr.	CH	0	MJ	1	0		
resource, in ground	Energy, geothermal, converted	-	-	MJ	1.04E-1	1	1.22	(2,1,1,1,1,5,BU:1.05); ;
technosphere	electricity, low voltage, at grid	CH	0	kWh	8.96E-2	1	1.22	(2,1,1,1,1,5,BU:1.05); ;
	1,1-difluoroethane, HFC-152a, at plant	US	0	kg	2.54E-7	1	2.29	(5,3,1,2,5,5,BU:1.05); ;
	trifluoromethane, at plant	GLO	0	kg	2.54E-7	1	2.29	(5,3,1,2,5,5,BU:1.05); ;
	heat pump, brine-water, 15kW	RER	1	unit	0	1	3.05	(2,1,1,1,1,5,BU:3); ;
	heat pump, brine-water, 50kW	RER	1	unit	1.32E-7	1	3.05	(2,1,1,1,1,5,BU:3); ;
	delivery and return well for groundwater heat pump, 9m, CH	CH	1	unit	1.32E-7	1	3.05	(2,1,1,1,1,5,BU:3); ;
air, high population densitv	Heat, waste	-	-	MJ	3.23E-1	1	1.22	(2,1,1,1,1,5,BU:1.05); ;
	Methane, difluoro-, HFC-32	-	-	kg	2.54E-7	1	1.56	(1,1,1,1,1,5,BU:1.5); ;
	Ethane, pentafluoro-, HFC-125	-	-	kg	2.54E-7	1	1.56	(1,1,1,1,1,5,BU:1.5); ;

Figure 50: Unit process raw data of heat, at groundwater heat pump, for district heating, with CH electricity mix

	Name	Location	Infrastructure Process	Unit	heat, at groundwater heat pump, brine-water, 15kW, cert. elec., in old building	heat, at groundwater heat pump, brine-water, 15kW, cert. elec., in new building	heat, at groundwater heat pump, brine-water, 50kW, cert. elec., in old building	heat, at groundwater heat pump, brine-water, 50kW, cert. elec., in new building	Uncertainty Type	Standard Deviation 95%	General Comment
	Location				CH	CH	CH	CH			
	Infrastructure Process				0	0	0	0			
	Unit				MJ	MJ	MJ	MJ			
product	heat, at groundwater heat pump, brine-water, 15kW, cert. elec., in old building	CH	0	MJ	1	0	0	0			
	heat, at groundwater heat pump, brine-water, 15kW, cert. elec., in new building	CH	0	MJ	0	1	0	0			
	heat, at groundwater heat pump, brine-water, 50kW, cert. elec., in old building	CH	0	MJ	0	0	1	0			
	heat, at groundwater heat pump, brine-water, 50kW, cert. elec., in new building	CH	0	MJ	0	0	0	1	0		
resource, in water	Energy, environmental, water	-	-	MJ	7.44E-1	8.11E-1	7.56E-1	8.18E-1	1	1.22	(2,1,1,1,1,5,BU:1.05); ;
technosphere	electricity, low voltage, certified electricity, at grid	CH	0	kWh	8.68E-2	5.24E-2	8.17E-2	5.05E-2	1	1.22	(2,1,1,1,1,5,BU:1.05); ;
	1,1-difluoroethane, HFC-152a, at plant	US	0	kg	2.47E-7	2.47E-7	2.54E-7	2.54E-7	1	2.29	(5,3,1,2,5,5,BU:1.05); ;
	trifluoromethane, at plant	GLO	0	kg	2.47E-7	2.47E-7	2.54E-7	2.54E-7	1	2.29	(5,3,1,2,5,5,BU:1.05); ;
	heat pump, brine-water, 15kW	RER	1	unit	4.41E-7	4.41E-7	0	0	1	1.22	(2,1,1,1,1,5,BU:1.05); ;
	heat pump, brine-water, 50kW	RER	1	unit	0	0	1.32E-7	1.32E-7	1	1.22	(2,1,1,1,1,5,BU:1.05); ;
	delivery and return well for groundwater heat pump, 9m, CH	CH	1	unit	4.41E-7	4.41E-7	1.32E-7	1.32E-7	1	1.22	(2,1,1,1,1,5,BU:1.05); ;
air, high population densitv	Heat, waste	-	-	MJ	3.13E-1	1.89E-1	2.94E-1	1.82E-1	1	1.22	(2,1,1,1,1,5,BU:1.05); ;
	Methane, difluoro-, HFC-32	-	-	kg	2.47E-7	2.47E-7	2.54E-7	2.54E-7	1	1.56	(1,1,1,1,1,5,BU:1.5); ;
	Ethane, pentafluoro-, HFC-125	-	-	kg	2.47E-7	2.47E-7	2.54E-7	2.54E-7	1	1.56	(1,1,1,1,1,5,BU:1.5); ;

Figure 51: Unit process raw data of heat, at groundwater heat pump with certified electricity mix

		Input Group	Output Group	Name	Location	Category	Subcategory	Infrastructure Process	Unit	heat, at ice storage heat pump, brine-water, 15kW, CH electr., in old building	heat, at ice storage heat pump, brine-water, 15kW, CH electr., in new building	heat, at ice storage heat pump, brine-water, 50kW, CH electr., in old building	heat, at ice storage heat pump, brine-water, 50kW, CH electr., in new building	Uncertainty Type	Standard Deviation 95%	General Comment
	401															
	662			Location						CH	CH	CH	CH			
	493			Infrastructure Process						0	0	0	0			
	403			Unit						MJ	MJ	MJ	MJ			
product		-	0	heat, at ice storage heat pump, brine-water, 15kW, CH electr., in old building	CH	-	-	0	MJ	1	0	0	0			
		-	0	heat, at ice storage heat pump, brine-water, 15kW, CH electr., in new building	CH	-	-	0	MJ	0	1	0	0			
		-	0	heat, at ice storage heat pump, brine-water, 50kW, CH electr., in old building	CH	-	-	0	MJ	0	0	1	0			
		-	0	heat, at ice storage heat pump, brine-water, 50kW, CH electr., in new building	CH	-	-	0	MJ	0	0	0	1	0		
resource, in air		4	-	Energy, solar, converted	-	resource	in air	-	MJ	6.88E-1	8.11E-1	7.06E-1	8.18E-1	1	1.22	(2,1,1,1,1,5,BU:1.05); ;
technosphere		5	-	electricity, low voltage, at grid	CH	-	-	0	kWh	8.68E-2	5.24E-2	8.17E-2	5.05E-2	1	1.22	(2,1,1,1,1,5,BU:1.05); ;
		5	-	1,1-difluoroethane, HFC-152a, at plant	US	-	-	0	kg	2.47E-7	2.47E-7	2.54E-7	2.54E-7	1	2.29	(5,3,1,2,5,5,BU:1.05); ;
		5	-	trifluoromethane, at plant	GLO	-	-	0	kg	2.47E-7	2.47E-7	2.54E-7	2.54E-7	1	2.29	(5,3,1,2,5,5,BU:1.05); ;
		5	-	heat pump, brine-water, 15kW	RER	-	-	1	unit	4.41E-7	4.41E-7	0	0	1	3.05	(2,1,1,1,1,5,BU:3); ;
		5	-	heat pump, brine-water, 50kW	RER	-	-	1	unit	0	0	1.32E-7	1.32E-7	1	3.05	(2,1,1,1,1,5,BU:3); ;
		5	-	ice storage tank with solar tube collector	CH	-	-	1	unit	3.53E-7	3.53E-7	1.06E-7	1.06E-7	1	3.05	(2,1,1,1,1,5,BU:3); ;
air, high population densitv		4	-	Heat, waste	-	air	high population density	-	MJ	3.13E-1	1.89E-1	2.94E-1	1.82E-1	1	1.22	(2,1,1,1,1,5,BU:1.05); ;
		4	-	Methane, difluoro-, HFC-32	-	air	high population density	-	kg	2.47E-7	2.47E-7	2.54E-7	2.54E-7	1	1.56	(1,1,1,1,1,5,BU:1.5); ;
		4	-	Ethane, pentafluoro-, HFC-125	-	air	high population density	-	kg	2.47E-7	2.47E-7	2.54E-7	2.54E-7	1	1.56	(1,1,1,1,1,5,BU:1.5); ;

Figure 52: Unit process raw data of heat, at ice storage heat pump with CH electricity mix

		Input Group	Output Group	Name	Location	Category	Subcategory	Infrastructure Process	Unit	heat, at ice storage heat pump, brine-water, 15kW, cert. elec., in old building	heat, at ice storage heat pump, brine-water, 15kW, cert. elec., in new building	heat, at ice storage heat pump, brine-water, 50kW, cert. elec., in old building	heat, at ice storage heat pump, brine-water, 50kW, cert. elec., in new building	Uncertainty Type	Standard Deviation 95%	General Comment
	401															
	662			Location						CH	CH	CH	CH			
	493			Infrastructure Process						0	0	0	0			
	403			Unit						MJ	MJ	MJ	MJ			
product		-	0	heat, at ice storage heat pump, brine-water, 15kW, cert. elec., in old building	CH	-	-	0	MJ	1	0	0	0			
		-	0	heat, at ice storage heat pump, brine-water, 15kW, cert. elec., in new building	CH	-	-	0	MJ	0	1	0	0			
		-	0	heat, at ice storage heat pump, brine-water, 50kW, cert. elec., in old building	CH	-	-	0	MJ	0	0	1	0			
		-	0	heat, at ice storage heat pump, brine-water, 50kW, cert. elec., in new building	CH	-	-	0	MJ	0	0	0	1	0		
resource, in air		4	-	Energy, solar, converted	-	resource	in air	-	MJ	6.88E-1	8.11E-1	7.06E-1	8.18E-1	1	1.22	(2,1,1,1,1,5,BU:1.05); ;
technosphere		5	-	electricity, low voltage, certified electricity, at grid	CH	-	-	0	kWh	8.68E-2	5.24E-2	8.17E-2	5.05E-2	1	1.22	(2,1,1,1,1,5,BU:1.05); ;
		5	-	1,1-difluoroethane, HFC-152a, at plant	US	-	-	0	kg	2.47E-7	2.47E-7	2.54E-7	2.54E-7	1	2.29	(5,3,1,2,5,5,BU:1.05); ;
		5	-	trifluoromethane, at plant	GLO	-	-	0	kg	2.47E-7	2.47E-7	2.54E-7	2.54E-7	1	2.29	(5,3,1,2,5,5,BU:1.05); ;
		5	-	heat pump, brine-water, 15kW	RER	-	-	1	unit	4.41E-7	4.41E-7	0	0	1	3.05	(2,1,1,1,1,5,BU:3); ;
		5	-	heat pump, brine-water, 50kW	RER	-	-	1	unit	0	0	1.32E-7	1.32E-7	1	3.05	(2,1,1,1,1,5,BU:3); ;
		5	-	ice storage tank with solar tube collector	CH	-	-	1	unit	3.53E-7	3.53E-7	1.06E-7	1.06E-7	1	3.05	(2,1,1,1,1,5,BU:3); ;
air, high population density		4	-	Heat, waste	-	air	high population density	-	MJ	3.13E-1	1.89E-1	2.94E-1	1.82E-1	1	1.22	(2,1,1,1,1,5,BU:1.05); ;
		4	-	Methane, difluoro-, HFC-32	-	air	high population density	-	kg	2.47E-7	2.47E-7	2.54E-7	2.54E-7	1	1.56	(1,1,1,1,1,5,BU:1.5); ;
		4	-	Ethane, pentafluoro-, HFC-125	-	air	high population density	-	kg	2.47E-7	2.47E-7	2.54E-7	2.54E-7	1	1.56	(1,1,1,1,1,5,BU:1.5); ;

Figure 53: Unit process raw data of heat, at ice storage heat pump with certified electricity mix

	Name	Location	Infrastructure Process	Unit	heat, at borehole heat pump, brine-water, 7kW, CH. elec., in new building	heat, at groundwater heat pump, brine-water, 7kW, CH elec., in new building	heat, at ice strorage heat pump, brine-water, 7kW, CH elec., in new building	Uncertainty Type	Standard Deviation 95%	General Comment
	Location				CH	CH	CH			
	Infrastructure Process				0	0	0			
	Unit				MJ	MJ	MJ			
product	heat, at borehole heat pump, brine-water, 7kW, CH. elec., in new building	CH	0	MJ	1	0	0			
	heat, at groundwater heat pump, brine-water, 7kW, CH elec., in new building	CH	0	MJ	0	1	0			
	heat, at ice strorage heat pump, brine-water, 7kW, CH elec., in new building	CH	0	MJ	0	0	1	0		
resource, in air	Energy, solar, converted	-	-	MJ			8.11E-1	1	1.22	(2,1,1,1,1,5,BU:1.05); ;
resource, in ground	Energy, geothermal, converted	-	-	MJ	8.11E-1	8.11E-1		1	1.22	(2,1,1,1,1,5,BU:1.05); ;
resource, in water	Energy, environmental, water	-	-	MJ	0	0	0	1	1.22	(2,1,1,1,1,5,BU:1.05); ;
technosphere	electricity, low voltage, at grid	CH	0	kWh	5.24E-2	5.24E-2	5.24E-2	1	1.22	(2,1,1,1,1,5,BU:1.05); ;
	1,1-difluoroethane, HFC-152a, at plant	US	0	kg	3.78E-7	3.78E-7	3.78E-7	1	2.29	(5,3,1,2,5,5,BU:1.05); ;
	trifluoromethane, at plant	GLO	0	kg	3.78E-7	3.78E-7	3.78E-7	1	2.29	(5,3,1,2,5,5,BU:1.05); ;
	heat pump, brine-water, 7kW	RER	1	unit	9.45E-7	9.45E-7	9.45E-7	1	3.05	(2,1,1,1,1,5,BU:3); ;
	Borehole heat exchanger, 300m	CH	1	unit	1.76E-7	0	0	1	3.05	(2,1,1,1,1,5,BU:3); ;
	delivery and return well for groundwater heat pump, 9m, CH	CH	1	unit	0	9.45E-7	0	1	3.05	(2,1,1,1,1,5,BU:3); ;
	ice storage tank with solar tube collector	CH	1	unit	0	0	3.53E-7	1	3.05	(2,1,1,1,1,5,BU:3); ;
air, high population densitv	Heat, waste	-	-	MJ	1.89E-1	1.89E-1	1.89E-1	1	1.22	(2,1,1,1,1,5,BU:1.05); ;
	Methane, difluoro-, HFC-32	-	-	kg	3.78E-7	3.78E-7	3.78E-7	1	1.56	(1,1,1,1,1,5,BU:1.5); ;
	Ethane, pentafluoro-, HFC-125	-	-	kg	3.78E-7	3.78E-7	3.78E-7	1	1.56	(1,1,1,1,1,5,BU:1.5); ;

Figure 54: Unit process raw data of heat, at heat pump 7kW with CH electricity mix

	Name	Location	Infrastructure Process	Unit	heat, at borehole heat pump, brine-water, 7kW, cert. elec., in new building	heat, at groundwater heat pump, brine-water, 7kW, cert. elec., in new building	heat, at ice strorage heat pump, brine-water, 7kW, cert. elec., in new building	Uncertainty Type	Standard Deviation 95%	General Comment
	Location				CH	CH	CH			
	Infrastructure Process				0	0	0			
	Unit				MJ	MJ	MJ			
product	heat, at borehole heat pump, brine-water, 7kW, cert. elec., in new building	CH	0	MJ	1	0	0			
	heat, at groundwater heat pump, brine-water, 7kW, cert. elec., in new building	CH	0	MJ	0	1	0			
	heat, at ice strorage heat pump, brine-water, 7kW, cert. elec., in new building	CH	0	MJ	0	0	1	0		
resource, in air	Energy, solar, converted	-	-	MJ			8.11E-1	1	1.22	(2,1,1,1,1,5,BU:1.05); ;
resource, in ground	Energy, geothermal, converted	-	-	MJ	8.11E-1	8.11E-1	0	1	1.22	(2,1,1,1,1,5,BU:1.05); ;
resource, in water	Energy, environmental, water	-	-	MJ	0	0	0	1	1.22	(2,1,1,1,1,5,BU:1.05); ;
technosphere	electricity, low voltage, certified electricity, at grid	CH	0	kWh	5.24E-2	5.24E-2	5.24E-2	1	1.22	(2,1,1,1,1,5,BU:1.05); ;
	1,1-difluoroethane, HFC-152a, at plant	US	0	kg	3.78E-7	3.78E-7	3.78E-7	1	2.29	(5,3,1,2,5,5,BU:1.05); ;
	trifluoromethane, at plant	GLO	0	kg	3.78E-7	3.78E-7	3.78E-7	1	2.29	(5,3,1,2,5,5,BU:1.05); ;
	heat pump, brine-water, 7kW	RER	1	unit	4.41E-7	4.41E-7	4.41E-7	1	3.05	(2,1,1,1,1,5,BU:3); ;
	Borehole heat exchanger, 300m	CH	1	unit	1.76E-7	0	0	1	3.05	(2,1,1,1,1,5,BU:3); ;
	delivery and return well for groundwater heat pump, 9m, CH	CH	1	unit	0	9.45E-7	0	1	3.05	(2,1,1,1,1,5,BU:3); ;
	ice storage tank with solar tube collector	CH	1	unit	0	0	3.53E-7	1	3.05	(2,1,1,1,1,5,BU:3); ;
air, high population density	Heat, waste	-	-	MJ	1.89E-1	1.89E-1	1.89E-1	1	1.22	(2,1,1,1,1,5,BU:1.05); ;
	Methane, difluoro-, HFC-32	-	-	kg	3.78E-7	3.78E-7	3.78E-7	1	1.56	(1,1,1,1,1,5,BU:1.5); ;
	Ethane, pentafluoro-, HFC-125	-	-	kg	3.78E-7	3.78E-7	3.78E-7	1	1.56	(1,1,1,1,1,5,BU:1.5); ;

Figure 55: Unit process raw data of heat, at heat pump 7kW with certified electricity mix

	Name	Location	Infrastructure Process	Unit	heat, natural gas, at diffusion absorption heat pump 15kW	Uncertainty Type	Standard Deviation 95%	General Comment
	Location				CH			
	Infrastructure Process				0			
	Unit				MJ			
product	heat, natural gas, at diffusion absorption heat pump 15kW	CH	0	MJ	1	0		
resource, in ground	Energy, geothermal, converted	-	-	MJ	2.42E-1	1	1.26	(3,4,2,2,1,5,BU:1.05); ;
technosphere	natural gas, low pressure, at consumer	CH	0	MJ	7.58E-1	1	1.26	(3,4,2,2,1,5,BU:1.05); ;
	electricity, low voltage, at grid	CH	0	kWh	5.56E-3	1	1.68	(4,5,2,2,4,5,BU:1.05); ;
	diffusion absorption heat pump 4kW, future	CH	1	unit	6.01E-7	1	3.10	(4,4,2,2,1,5,BU:3); ;
	Borehole heat exchanger, 300m	CH	1	unit	1.76E-7	1	1.32	(4,4,2,2,1,5,BU:1.05); ;
air, high population density	Heat, waste	-	-	MJ	8.18E-1	1	1.26	(3,4,2,2,1,5,BU:1.05); ;
	Acetaldehyde	-	-	kg	7.58E-10	1	1.88	(4,3,2,2,4,5,BU:1.5); ;
	Benzo(a)pyrene	-	-	kg	4.24E-13	1	3.32	(4,3,2,2,4,5,BU:3); ;
	Benzene	-	-	kg	3.03E-7	1	3.32	(4,3,2,2,4,5,BU:3); ;
	Butane	-	-	kg	5.30E-7	1	1.88	(4,3,2,2,4,5,BU:1.5); ;
	Methane, fossil	-	-	kg	4.55E-6	1	1.88	(4,3,2,2,4,5,BU:1.5); ;
	Carbon monoxide, fossil	-	-	kg	1.06E-5	1	5.37	(4,3,2,2,4,5,BU:5); ;
	Carbon dioxide, fossil	-	-	kg	4.24E-2	1	1.63	(4,3,2,2,4,5,BU:1.05); ;
	Acetic acid	-	-	kg	1.14E-7	1	1.88	(4,3,2,2,4,5,BU:1.5); ;
	Formaldehyde	-	-	kg	7.58E-8	1	1.88	(4,3,2,2,4,5,BU:1.5); ;
	Ammonia	-	-	kg	7.58E-10	1	1.68	(4,3,2,2,4,5,BU:1.2); ;
	Mercury	-	-	kg	7.58E-11	1	5.37	(4,3,2,2,4,5,BU:5); ;
	Cadmium	-	-	kg	1.89E-13	1	5.37	(4,3,2,2,4,5,BU:5); ;
	Lead	-	-	kg	1.14E-12	1	5.37	(4,3,2,2,4,5,BU:5); ;
	Dinitrogen monoxide	-	-	kg	2.90E-8	1	1.88	(4,3,2,2,4,5,BU:1.5); ;
	Nitrogen oxides	-	-	kg	3.79E-6	1	1.88	(4,3,2,2,4,5,BU:1.5); ;
	PAH, polycyclic aromatic hydrocarbons	-	-	kg	7.58E-9	1	3.32	(4,3,2,2,4,5,BU:3); ;
	Particulates, < 2.5 um	-	-	kg	7.58E-8	1	3.32	(4,3,2,2,4,5,BU:3); ;
	Pentane	-	-	kg	9.09E-7	1	1.88	(4,3,2,2,4,5,BU:1.5); ;
	Propane	-	-	kg	1.52E-7	1	1.88	(4,3,2,2,4,5,BU:1.5); ;
	Propionic acid	-	-	kg	1.52E-8	1	1.88	(4,3,2,2,4,5,BU:1.5); ;
	Sulfur dioxide	-	-	kg	3.79E-7	1	1.63	(4,3,2,2,4,5,BU:1.05); ;
	Dioxins, measured as 2,3,7,8-tetrachlorodibenzo-p-dioxin	-	-	kg	2.27E-17	1	3.32	(4,3,2,2,4,5,BU:3); ;
	Toluene	-	-	kg	1.52E-7	1	1.88	(4,3,2,2,4,5,BU:1.5); ;
water, river	Nitrate	-	-	kg	9.85E-8	1	1.88	(4,3,2,2,4,5,BU:1.5); ;
	Nitrite	-	-	kg	2.27E-9	1	1.88	(4,3,2,2,4,5,BU:1.5); ;
	Sulfate	-	-	kg	3.79E-8	1	1.88	(4,3,2,2,4,5,BU:1.5); ;
	Sulfite	-	-	kg	3.79E-8	1	1.88	(4,3,2,2,4,5,BU:1.5); ;

Figure 56: Unit process raw data of heat, at natural gas diffusion heat pump

	Name	Location	Infrastructure Process	Unit	heat, biomethane, at diffusion absorption heat pump 15kW	Uncertainty Type	Standard Deviation 95%	General Comment
	Location				CH			
	Infrastructure Process				0			
	Unit				MJ			
product	heat, biomethane, at diffusion absorption heat pump 15kW	CH	0	MJ	1	0		
resource, in ground	Energy, geothermal, converted	-	-	MJ	2.42E-1	1	1.26	(3,4,2,2,1,5,BU:1.05); ;
technosphere	methane, 96 vol-%, from biogas, low pressure, at consumer	CH	0	MJ	7.58E-1	1	1.25	(2,4,2,2,1,5,BU:1.05); ;
	electricity, low voltage, at grid	CH	0	kWh	5.56E-3	1	1.68	(4,5,2,2,4,5,BU:1.05); ;
	diffusion absorption heat pump 4kW, future	CH	1	unit	6.01E-7	1	3.10	(4,4,2,2,1,5,BU:3); ;
	Borehole heat exchanger, 300m	CH	1	unit	1.76E-7	1	1.32	(4,4,2,2,1,5,BU:1.05); ;
air, high population	Heat, waste	-	-	MJ	8.18E-1	1	1.26	(3,4,2,2,1,5,BU:1.05); ;
	Acetaldehyde	-	-	kg	7.58E-10	1	1.88	(4,3,2,2,4,5,BU:1.5); ;
	Benzo(a)pyrene	-	-	kg	4.24E-13	1	3.32	(4,3,2,2,4,5,BU:3); ;
	Benzene	-	-	kg	3.03E-7	1	3.32	(4,3,2,2,4,5,BU:3); ;
	Butane	-	-	kg	5.30E-7	1	1.88	(4,3,2,2,4,5,BU:1.5); ;
	Methane, fossil	-	-	kg	4.55E-6	1	1.88	(4,3,2,2,4,5,BU:1.5); ;
	Carbon dioxide, biogenic	-	-	kg	1.06E-5	1	1.63	(4,3,2,2,4,5,BU:1.05); ;
	Carbon monoxide, biogenic	-	-	kg	4.24E-2	1	5.37	(4,3,2,2,4,5,BU:5); ;
	Acetic acid	-	-	kg	1.14E-7	1	1.88	(4,3,2,2,4,5,BU:1.5); ;
	Formaldehyde	-	-	kg	7.58E-8	1	1.88	(4,3,2,2,4,5,BU:1.5); ;
	Ammonia	-	-	kg	7.58E-10	1	1.68	(4,3,2,2,4,5,BU:1.2); ;
	Mercury	-	-	kg	7.58E-11	1	5.37	(4,3,2,2,4,5,BU:5); ;
	Cadmium	-	-	kg	1.89E-13	1	5.37	(4,3,2,2,4,5,BU:5); ;
	Lead	-	-	kg	1.14E-12	1	5.37	(4,3,2,2,4,5,BU:5); ;
	Dinitrogen monoxide	-	-	kg	2.90E-8	1	1.88	(4,3,2,2,4,5,BU:1.5); ;
	Nitrogen oxides	-	-	kg	3.79E-6	1	1.88	(4,3,2,2,4,5,BU:1.5); ;
	PAH, polycyclic aromatic hydrocarbons	-	-	kg	7.58E-9	1	3.32	(4,3,2,2,4,5,BU:3); ;
	Particulates, < 2.5 um	-	-	kg	7.58E-8	1	3.32	(4,3,2,2,4,5,BU:3); ;
	Pentane	-	-	kg	9.09E-7	1	1.88	(4,3,2,2,4,5,BU:1.5); ;
	Propane	-	-	kg	1.52E-7	1	1.88	(4,3,2,2,4,5,BU:1.5); ;
	Propionic acid	-	-	kg	1.52E-8	1	1.88	(4,3,2,2,4,5,BU:1.5); ;
	Sulfur dioxide	-	-	kg	3.79E-7	1	1.63	(4,3,2,2,4,5,BU:1.05); ;
	Dioxins, measured as 2,3,7,8-tetrachlorodibenzo-p-dioxin	-	-	kg	2.27E-17	1	3.32	(4,3,2,2,4,5,BU:3); ;
	Toluene	-	-	kg	1.52E-7	1	1.88	(4,3,2,2,4,5,BU:1.5); ;
water, river	Nitrate	-	-	kg	9.85E-8	1	1.88	(4,3,2,2,4,5,BU:1.5); ;
	Nitrite	-	-	kg	2.27E-9	1	1.88	(4,3,2,2,4,5,BU:1.5); ;
	Sulfate	-	-	kg	3.79E-8	1	1.88	(4,3,2,2,4,5,BU:1.5); ;
	Sulfite	-	-	kg	3.79E-8	1	1.88	(4,3,2,2,4,5,BU:1.5); ;

Figure 57: Unit process raw data of heat, at biomethane diffusion heat pump

		Input Group	Output Group	Name	Location	Infrastructure Process	Unit	disposal, heat pump, air-water, 7kW	Uncertainty Type	Standard Deviation 95%	General Comment
	401										
	662			Location				CH			
	493			Infrastructure Process				1			
	403			Unit				unit			
product		-	1	disposal, heat pump, air-water, 7kW	CH	1	unit	1	0		
technosphere		5	-	disposal, industrial devices, to WEEE treatment	CH	0	kg	2.56E+2			
		5	-	disposal, hazardous waste, 25% water, to hazardous waste incineration	CH	0	kg	2.32E+0			
air, high population density		4	-	Methane, difluoro-, HFC-32	-	-	kg	1.93E-1	1	1.56	(1,1,1,3,1,5,BU:1.5); ;
		4	-	Ethane, pentafluoro-, HFC-125	-	-	kg	1.93E-1	1	1.56	(1,1,1,3,1,5,BU:1.5); ;

Figure 58: Unit process raw data disposal of air-water heat pump

	401	Input Group	Output Group	Name	Location	Infrastructure Process	Unit	disposal, heat pump, brine-water, 7kW	Uncertainty Type	Standard Deviation 95%	General Comment
	662			Location				CH			
	493			Infrastructure Process				1			
	403			Unit				unit			
product		-	0	disposal, heat pump, brine-water, 7kW	CH	1	unit	1	0		
technosphere		5	-	disposal, industrial devices, to WEEE treatment	CH	0	kg	1.58E+02			
		5	-	disposal, hazardous waste, 25% water, to hazardous waste incineration	CH	0	kg	1.33E+0			
air, high population density		4	-	Methane, difluoro-, HFC-32	-	-	kg	1.10E-1	1	1.56	(1,1,1,3,1,5,BU:1.5); ;
		4	-	Ethane, pentafluoro-, HFC-125	-	-	kg	1.10E-1	1	1.56	(1,1,1,3,1,5,BU:1.5); ;

Figure 59: Unit process raw data disposal of brine-water heat pump

	401	Input Group	Output Group	Name	Location	Category	Subcategory	Infrastructure Process	Unit	disposal, borehole heat exchanger, 300m	Uncertainty Type	Standard Deviation 95%	General Comment
	662			Location						CH			
	493			Infrastructure Process						1			
	403			Unit						unit			
product		-	1	disposal, borehole heat exchanger, 300m	CH	-	-	1	unit				
technosphere		5	-	transport, freight, lorry 16-32 metric ton, fleet average	CH	-	-	0	tkm	91.70	1	2.34	(4,4,2,3,4,5,BU:2); ;
		5	-	treatment, heat carrier liquid, 40% C3H8O2, to wastewater treatment, class 2	CH	-	-	0	m3	8.37E-1	1	0.00	(4,4,2,3,4,5,BU:2); ;

Figure 60: Unit process raw data disposal of borehole heat exchanger

	401	Input Group	Output Group	Name	Location	Infrastructure Process	Unit	disposal, delivery and return well for groundwater heat pump, 9m, CH	Uncertainty Type	Standard Deviation 95%	General Comment
	662			Location				CH			
	493			Infrastructure Process				1			
	403			Unit				unit			
product		-	0	disposal, delivery and return well for groundwater heat pump, 9m, CH	CH	1	unit				
technosphere		5	-	disposal, polyvinylchloride, 0.2% water, to municipal incineration	CH	0	kg	4.60E+1	1	1.64	(5,3,3,2,3,5,BU:1.05); ;

Figure 61: Unit process raw data disposal of delivery and return well for groundwater heat pump

2.3.6 Data quality

The data quality is generally very good. Energy efficiency as well as the infrastructure components and refrigerant losses were updated. Other inputs and outputs which have not been updated during this study are normally of very low relevance for the calculated environmental impacts.

2.3.7 Life cycle impact assessment

At the infrastructure level, the results of the new inventories tend to be higher than those of the former inventories mainly due to more accurate production data, although the inventories are not directly comparable in terms of performance and weight.
On the level of the delivered heat the results depend heavily on the seasonal performance factor (efficiency) of the heat pump. Since the flow temperature in new buildings is typically lower, the efficiency is also higher and thus the environmental impact lower than in old buildings. But also the used electricity mix has a decisive influence on the result. For example, the use of certified electricity results in a significant reduction of the environmental impact. As the former inventories represented the seasonal performance factor of the average of new and old buildings, the results are hardly comparable.

Table 15: LCIA results of heat pump inventories

Inventory name/unit	Ecological Scarcity 2013	IPCC 2013, GWP 100a	former inventory (UVEK 2018) that most closely matches the update	Ecological Scarcity 2013	IPCC 2013, GWP 100a	UBP ratio	kg CO2eq ratio
	UBP	kg CO2eq		UBP	kg CO2eq	%	%
Borehole heat exchanger, 300m/p/CH/I U	6.80E+06	6.25E+03	Borehole heat exchanger 150 m/CH/I U	3.47E+06	3.04E+03	196%	206%
delivery and return well for groundwater heat pump, 9m, CH/p/CH/I U	5.59E+05	5.58E+02	n.a.				
ice storage tank with solar tube collector/p/CH/I U	3.93E+06	2.12E+03	n.a.				
heat pump, air-water, 7kW/p/RER/I U	6.42E+06	3.06E+03	n.a.				
heat pump, air-water, 15kW/p/RER/I U	7.19E+06	3.67E+03	n.a.				
heat pump, air-water, 50kW/p/RER/I U	2.32E+07	1.37E+04	n.a.				
heat pump, brine-water, 7kW/p/RER/I U	3.82E+06	1.85E+03	Heat pump, brine-water, 10kW/CH/I U	2.56E+06	1.58E+03	149%	117%
heat pump, brine-water, 15kW/p/RER/I U	4.74E+06	2.41E+03					
heat pump, brine-water, 50kW/p/RER/I U	1.15E+07	6.88E+03	Heat pump 30kW/RER/I U	7.69E+06	4.73E+03	149%	145%
heat, at borehole heat pump, brine-water, 7kW, cert. elec., in new building/MJ/CH U	8.19E+00	4.22E-03	n.a.				
heat, at borehole heat pump, brine-water, 7kW, CH. elec., in new building/MJ/CH U	2.41E+01	1.09E-02	n.a.				
heat, at borehole heat pump, brine-water, 15kW, cert. electr., in new building/MJ/CH U	7.14E+00	3.96E-03	n.a.				
heat, at borehole heat pump, brine-water, 15kW, cert. electr., in old building/MJ/CH U	9.81E+00	4.49E-03	n.a.				
heat, at borehole heat pump, brine-water, 15kW, CH electricity, in new building/MJ/CH U	2.23E+01	9.71E-03	n.a.				
heat, at borehole heat pump, brine-water, 15kW, CH electricity, in old building/MJ/CH U	3.30E+01	1.40E-02	Heat, borehole heat exchanger, at brine-	3.07E+01	1.83E-02	93%	131%

water heat pump 10kW/CH U

Inventory name/unit	Ecological Scarcity 2013	IPCC 2013, GWP 100a	former inventory (UVEK 2018) that most closely matches the update	Ecological Scarcity 2013	IPCC 2013, GWP 100a	UBP ratio	kg CO2eq ratio
	UBP	kg CO2eq		UBP	kg CO2eq	%	%
heat, at borehole heat pump, brine-water, 50kW, cert. electr., in new building/MJ/CH U	7.69E+00	3.79E-03	n.a.				
heat, at borehole heat pump, brine-water, 50kW, cert. electr., in old building/MJ/CH U	9.03E+00	4.27E-03	n.a.				
heat, at borehole heat pump, brine-water, 50kW, CH electricity, in new building/MJ/CH U	2.12E+01	9.34E-03	n.a.				
heat, at borehole heat pump, brine-water, 50kW, CH electricity, in old building/MJ/CH U	3.08E+01	1.32E-02	n.a.				
heat, at groundwater heat pump, brine-water, 7kW, cert. elec., in new building/MJ/CH U	6.24E+00	3.52E-03	n.a.				
heat, at groundwater heat pump, brine-water, 7kW, CH elec., in new building/MJ/CH U	2.42E+01	1.32E-02	n.a.				
heat, at groundwater heat pump, brine-water, 15kW, cert. elec., in new building/MJ/CH U	6.10E+00	2.98E-03	n.a.				
heat, at groundwater heat pump, brine-water, 15kW, cert. elec., in old building/MJ/CH U	7.59E+00	3.45E-03	n.a.				
heat, at groundwater heat pump, brine-water, 15kW, CH electr., in new building/MJ/CH U	2.21E+01	1.18E-02	n.a.				
heat, at groundwater heat pump, brine-water, 15kW, CH electr., in old building/MJ/CH U	3.41E+01	1.80E-02	n.a.				
heat, at groundwater heat pump, brine-water, 50kW, cert. elec., in new building/MJ/CH U	5.29E+00	2.66E-03	n.a.				
heat, at groundwater heat pump, brine-water, 50kW, cert. elec., in old building/MJ/CH U	6.64E+00	3.08E-03	n.a.				
heat, at groundwater heat pump, brine-water, 50kW, CH electr., in new building/MJ/CH U	2.07E+01	1.11E-02	n.a.				
heat, at groundwater heat pump, brine-water, 50kW, CH electr., in old building/MJ/CH U	3.16E+01	1.68E-02	n.a.				
heat, at heat pump, air-water, 7kW, certified electricity, in new building/MJ/CH U	1.02E+01	6.31E-03	n.a.				
heat, at heat pump, air-water, 7kW, CH electricity, in new building/MJ/CH U	2.95E+01	1.69E-02	n.a.				
heat, at heat pump, air-water, 15kW, certified electricity, in new building/MJ/CH U	6.82E+00	4.01E-03	n.a.				

Inventory name/unit	Ecological Scarcity 2013	IPCC 2013, GWP 100a	former inventory (UVEK 2018) that most closely matches the update	Ecological Scarcity 2013	IPCC 2013, GWP 100a	UBP ratio	kg CO2eq ratio
	UBP	kg CO2eq		UBP	kg CO2eq	%	%
heat, at heat pump, air-water, 15kW, certified electricity, in old building/MJ/CH U	8.63E+00	4.56E-03	n.a.				
heat, at heat pump, air-water, 15kW, CH electricity, in new building/MJ/CH U	2.61E+01	1.46E-02	n.a.				
heat, at heat pump, air-water, 15kW, CH electricity, in old building/MJ/CH U	4.01E+01	2.18E-02	n.a.				
heat, at heat pump, air-water, 50kW, certified electricity, in new building/MJ/CH U	6.86E+00	4.68E-03	n.a.				
heat, at heat pump, air-water, 50kW, certified electricity, in old building/MJ/CH U	8.33E+00	5.12E-03	n.a.				
heat, at heat pump, air-water, 50kW, CH electricity, in new building/MJ/CH U	2.53E+01	1.48E-02	n.a.				
heat, at heat pump, air-water, 50kW, CH electricity, in old building/MJ/CH U	3.66E+01	2.06E-02	Heat, at air-water heat pump 10kW/CH U	4.10E+01	2.53E-02	112%	123%
heat, at ice strorage heat pump, brine-water, 7kW, cert. elec., in new building/MJ/CH U	6.20E+00	3.74E-03	n.a.				
heat, at ice strorage heat pump, brine-water, 7kW, CH elec., in new building/MJ/CH U	2.41E+01	1.35E-02	n.a.				
heat, at ice storage heat pump, brine-water, 15kW, cert. elec., in new building/MJ/CH U	6.35E+00	3.48E-03	n.a.				
heat, at ice storage heat pump, brine-water, 15kW, cert. elec., in old building/MJ/CH U	7.91E+00	3.95E-03	n.a.				
heat, at ice storage heat pump, brine-water, 15kW, CH electr., in new building/MJ/CH U	2.24E+01	1.23E-02	n.a.				
heat, at ice storage heat pump, brine-water, 15kW, CH electr., in old building/MJ/CH U	3.44E+01	1.85E-02	n.a.				
heat, at ice storage heat pump, brine-water, 50kW, cert. elec., in new building/MJ/CH U	4.73E+00	2.81E-03	n.a.				
heat, at ice storage heat pump, brine-water, 50kW, cert. elec., in old building/MJ/CH U	6.15E+00	3.24E-03	n.a.				
heat, at ice storage heat pump, brine-water, 50kW, CH electr., in new building/MJ/CH U	2.02E+01	1.13E-02	n.a.				
heat, at ice storage heat pump, brine-water, 50kW, CH electr., in old building/MJ/CH U	3.11E+01	1.69E-02	n.a.				

2.3.8 Outlook

The LCIA of the different heat pump systems are very sensitive to the electricity mix and the SPF. Therefore, it is recommended to create inventories for heat pump systems with other electricity mixes that are of interest and with further SPF factors that are valid for other building types such as GEAK A, C, D for example or to provide more options for different levels of output temperatures which have a direct influence on the efficiency of the heating devices.

2.4 Solar collector PVT systems

A PVT system consists of a photovoltaic system (PV) and a solar thermal collector (T). These two parts are combined into one component. The PV modules are cooled by the solar collectors, which enables them to achieve a higher efficiency by about 5 % (Zenhäusern, SPF Institut für Solartechnik, 2020).
An entire PVT system has on the one hand the output of electrical energy and on the other hand the output of useful heat for hot water and/or for a residential and commercial heating (heat pump) from the solar thermal energy.
Because of the project assignment, the focus in this system is also put on the heat output. However, as the electricity output from the PV modules cannot be neglected, because the PVT system requires both components, the electrical energy created by the PV is also considered in the following analysis.

The following inventories were created:

Infrastructure

16.7kWp, 100m2 PV system for PVT system installed on slanted roof/CH

- solar system for PVT only for hot water storage/CH
- solar system for PVT only for earth probe regeneration/CH

Energy

- heat at 100m² solar collector in PVT system for hot water storage/CH
- heat at 100m² solar collector in PVT system for earth probe regeneration/CH
- electricity from PV system, 16.7kWp/CH

2.4.1 Infrastructure

Two system setups that are common in Switzerland were analyzed in the study. In both setups, the PV-system is made of single-Si panels. For the thermal part of the system, one setup uses borehole regeneration, the other setup a heat storage tank. In both situations, the total surface area is 100 m2, which is considered an economically viable option. Only the liquid collector will be examined. The air collector and concentrate collector will be left out, since almost only liquid collectors are used in Switzerland.

2.4.1.1 PV-part

The PV part is the same for both setups. First, the basic photovoltaic panels, single-Si, were used from the UVEK database, which were adjusted by removing "tempering of flat glass" process, as this is not necessary when a collector is on top. This was done for the photovoltaic panels, single-Si inventories for all sites where they are produced (RER, APA, CN) in the UVEK database. These adjusted inventories were included in the UVEK inventory "Photovoltaic panel, single-Si, at regional storage/m2/RER", which also already exists and includes all the processes that have been carried out before (RER, APA, CN). This inventory, in turn, was implemented in the newly built inventory for a 100 m² PV module system built on a slanted roof. The basis of this inventory was the 3 kWp pitched roof system, single-Si, panel, mounted, process.

It is assumed that 6 m² per kWp PV modules are used. This results in a 100 m² PV system with the peak power of 16,667 kWp. With this assumption, the material inputs for a 16,667 kWp PV system could be upscaled from the 3 kWp PV system via the peak power. The compilation for the inventory of the PV part for the PVT system is shown in Table 16)

Transports are also included in the process and were also simply upscaled via the output based on the assumption that the plant will also become linearly heavier in line with the surface. In addition, there is a loss from the electricity input in form of "heat waste". This heat loss is equal to the power input, converted into MJ. (Jungbluth, 2003). The study uses input data from Jungbluth (2003) but adjusts all inputs by a factor of 1.08 to account for the efficiency gains in the last two decades.

Table 16: Material, resource and energy inputs for the production of the PV part in a 100 m2 PVT system			
Material for PV	**Unit**	**Amount**	**Source**
Electricity, low voltage, at grid CH	kWh / pcs	1.28	(Jungbluth, 2003)
Inverter, 2500W	pcs / pcs	13.33	(Jungbluth, 2003)
Electric installation, PV plant	pcs / pcs	5.56	(Jungbluth, 2003)
Slanted-roof construction, mounted	m^2 / pcs	110.38	(Jungbluth, 2003)
Photovoltaic panel, single-Si, regional storage (newly built process)	m^2 / pcs	113.69	(Jungbluth, 2003)

2.4.1.2 T-Part: Setup 1 with borehole regeneration

Besides the PV part, the first setup includes the solar collector, the pipe system, a heat pump and a geothermal probe, where the solar thermal energy produced in summer is used to regenerate the heat in the ground which is used in winter to heat up the house and / or warm water through the heat pump. The thermal probe itself is not part of this inventory as it is already part of the inventory of the heat pump which is operated with an earth probe. For the complete system in a house the heat pump must be added.

As a basis for this system, the already existing inventory "flat plate collector, aluminium copper absorber" was adapted for the present system. Here, too, a little less material is required due to the interaction with the PV modules. Specifically, the rock wool and solar glass (low-iron) in the basic inventory could be omitted. With this adjusted inventory for the T-part, the whole system could be set up for setup 1, as shown in Table 17. The original inventory for the solar collector was made for the size of 30 m^2, which was linearly scaled to 100m^2 for the new inventory of the PVT system. Only the water and ethylene glycol input were adjusted based on the information provided by Dr. Zenhäusern from the Institute for Solar Technology. According to this, the water content in the system is 62 % and the ethylene glycol content 38 %.

Table 17: Material, resource and energy inputs for the production of the T- part in a 100 m2 PVT system, setup 1 with earth probe regeneration			
Material for T, scenario1	**Unit**	**Amount**	**Source**
Water, completely softened	kg / pcs	186.34	(Zenhäusern, SPF Institut für Solartechnik, 2020), (Jungbluth, 2007)
Ethylene glycol	kg / pcs	114.21	(Zenhäusern, SPF Institut für Solartechnik, 2020), (Jungbluth, 2007)
Tube insulation, elastomere	kg / pcs	42.93	(Jungbluth, 2007)
Packaging film, LDPE	kg / pcs	4.05	(Jungbluth, 2007)
Chromium steel 18/8	kg / pcs	55.25	(Jungbluth, 2007)
Aluminium, production mix, wrought alloy	kg / pcs	69.93	(Jungbluth, 2007)
Pump 40W	pcs / pcs	6.47	(Jungbluth, 2007)
Expansion vessel 80l	pcs / pcs	5.83	(Jungbluth, 2007)
Flat plate collector for PVT, aluminium absorber	m^2	99.9	(Jungbluth, 2007)
Power coating, aluminium sheet	m^2	3.50	(Jungbluth, 2007)

The regeneration of the soil is higher or lower depending on the case study or the concept of the whole system, respectively. According to literature research and three different case studies, the regeneration of the soil using a PVT system can be between 45 % and 120 %.

2.4.1.3 T-Part: Setup 2 with heat storage tank

The second scenario includes also the solar collector, pipe system, heat pump and a heat storage tank instead of a geothermal probe. This tank stores the hot water until it gets used.
The procedure for compiling the inventory was exactly the same as in setup 1, the only difference being that the hot water storage tank is added. The inventory is therefore compiled as shown:

Table 18: Material, resource and energy inputs for the production of the T- part in a 100 m2 PVT system, setup 2 with heat storage

Material for T, scenario2	Unit	Amount	Source
Water, completely softened	kg / pcs	186.34	(Zenhäusern, SPF Institut für Solartechnik, 2020), (Jungbluth, 2007)
Ethylene glycol	kg / pcs	114.21	(Zenhäusern, SPF Institut für Solartechnik, 2020), (Jungbluth, 2007)
Tube insulation, elastomere	kg / pcs	42.93	(Jungbluth, 2007)
Packaging film, LDPE	kg / pcs	4.05	(Jungbluth, 2007)
Chromium steel 18/8	kg / pcs	55.25	(Jungbluth, 2007)
Aluminium, production mix, wrought alloy	kg / pcs	69.93	(Jungbluth, 2007)
Pump 40W	pcs / pcs	6.47	(Jungbluth, 2007)
Heat storage, 2000l	pcs / pcs	2.50	(Jungbluth, 2007)
Expansion vessel 80l	pcs / pcs	5.83	(Jungbluth, 2007)
Flat plate collector for PVT, aluminium absorber	m^2	99.9	(Jungbluth, 2007)
Power coating, aluminium sheet	m^2	3.50	(Jungbluth, 2007)

2.4.2 Reference unit

For the thermal energy coming from the PVT systems, 1 MJ of thermal energy output is calculated. For the electricity 1 kWh of energy output is calculated. All outputs are generated in a PVT system with a 100 m^2 surface.

2.4.3 Use Phase

As already mentioned, there are two outputs in this system. One is the electric current and the other is the heating heat.

2.4.3.1 Electricity from PVT

For the electric current of the PV modules a solar energy input of 3.85MJ per kWh is required. This is calculated according to Albedo, which takes the thermal energy into account (Jungbluth, 2003).

For the washing of the modules, 20 l per year per m^2 is assumed (Jungbluth, 2003). Per kWh, with an assumed annual output of 819 kWh/kWp*a the usage of 0.15l_{water}/kWh is calculated.

For the number of modules required for 1 kWh output, 819 kWh/kWp*a and an expected lifetime of 30 years is also assumed. This rather long lifetime can be expected without any loss of power, because the 819 kWh/kWp*a already include the expected loss of power of a single-Si PV module during its lifespan (Jungbluth, 2003). The whole is divided by 1.08, because the most efficient 75 % of the PV modules show a 8 % higher efficiency(Jungbluth, 2003). The whole is divided by 1.05 again, because the PV modules have a 5 % higher efficiency due to the cooling of the solar collector (Zenhäusern, SPF Institut für Solartechnik, 2020).

$$\left(\frac{1}{819\,\frac{kWh}{kWp*a}*16.667kWp*30a}/1.08\right)/1.05 = 2.15E\text{-}6 \text{ pcs}$$

The heat loss is assumed to be the difference between the solar input and the energy used, i.e. the 25 % (Frischknecht u. a., 2007). At the end of the inventory, the same amount of water that is used for washing the panels is put into a waste water treatment plant.

2.4.3.2 Heat from PVT

For the heat output from the solar collectors two inventories were made. One for each of the two scenarios already described. The two heat processes differ only in which infrastructure process is used and the energy that is fed back into the earth (setup 1) or not (setup 2). For more details see Table 19 below.

Table 19: Inputs for both setups of the heat from PVT inventories

Inputs for heat 1 MJ	Unit	Amount setup 1, borehole regeneration	Amount, setup 2, heat storage tank	Source
Energy, solar, converted	MJ / MJ	1.13	1.13	(Jungbluth, 2007)
Energy, geothermal, converted in ground	MJ / MJ	0	-1.00	Estimation based on literature
Electricity, PV in PVT system, 16.667kWp	kWh / MJ	2.14E-4	2.14E-4	(Jungbluth, 2007, table 5.1)
Solar system for PVT only, 100m2, Al-Cu flat plate collector with borehole	pcs / MJ	3.17E-7	0	Estimation through potential function, numbers based on (Jungbluth, 2007)
Solar system for PVT only, 100m2, Al-Cu flat plate collector with heat storage	pcs / MJ	0	3.17E-7	Estimation through potential function, numbers based on (Jungbluth, 2007)
Transport freight, light commercial vehicle	tkm / MJ	5.52E-5	5.52E-5	(Jungbluth, 2007)
Heat waste	MJ / MJ	1.13	1.13	(Jungbluth, 2007)

2.4.3.3 Energy efficiency

The thermal energy gain in a PVT system does not show a higher efficiency in itself. However, the cooling of the PV modules by the solar collectors increases the efficiency of the PV modules by about 5 % (Zenhäusern, SPF Institut für Solartechnik, 2020). Since the heat pump and other components require electrical energy, the efficiency of the whole system increases if the self-produced electrical energy is used. In addition, setup 1 with the earth probe regeneration also has a greater benefit as a system, since the heat from the earth can be used for a longer period of time. However, the quantitative increase in benefits cannot be stated in general terms and is very much dependent on the design and the individual use of an entire PVT system.

2.4.4 Summary of life cycle inventory data

In this chapter the life cycle inventories for the newly modelled and updated processes are presented. All data are provided as unit process raw data in the EcoSpold v1 format (unit process in SimaPro). The electronic data is including full EcoSpold v1 documentation.
For each investigated process, two types of tables (X-Process and X-Exchange) are provided in this report.

Type	ID	Field name, IndexNumber	777-075
ReferenceFunction	401	Name	16.667kWp, 100m2, PV system for PVT, installed on slanted roof, single-Si
Geography	662	Location	CH
ReferenceFunction	493	InfrastructureProcess	1
ReferenceFunction	403	Unit	unit
	402	IncludedProcesses	All components for the installation of a 16.667kWp photovoltaic plant, for a PVT-system (PV modules without flat glass!) energy use for the mounting, transport of materials and persons to the construction place. Disposal of components after end of life.
	490	LocalName	16.667kWp, 100m2, PV-Anlage für PVT, auf Schrägdach installiert, monokristallin
	491	Synonyms	Solaranlage nur für PVT-Systeme auf Schrägdach montiert, PV-module for PVT systems only mounted on slanted roof, cadmium telluride, thin film, monocristalline, silicone, WITHOUT FLAT GLASS
	492	GeneralComment	Photovoltaic installation with a capacity of 16.667kWp for a PVT system only and a life time of 30 years installed in CH.
	494	InfrastructureIncluded	1
	495	Category	PVT
	496	SubCategory	heating systems
	497	LocalCategory	Solarenergie, thermisch, elektrisch
	498	LocalSubCategory	Heizungssysteme
	499	Formula	
	501	StatisticalClassification	
	502	CASNumber	
TimePeriod	601	StartDate	2015
	602	EndDate	2020
	603	DataValidForEntirePeriod	1
	611	OtherPeriodText	
Geography	663	Text	Installation in CH
Technology	692	Text	Modern production plant.
Representativeness	722	Percent	
	724	ProductionVolume	
	725	SamplingProcedure	Data provided by manufacturer and literature data on worldwide module production.
	726	Extrapolations	

Figure 62: Meta data of process 16.7kWp, 100m2 PV system for PVT system installed on slanted roof

	Name	Location	Infrastructure Process	Unit	16.7kWp, 100m2, PV system for PVT, installed on slanted roof, single-Si	Uncertainty Type	Standard Deviation 95%	General Comment
	Location				CH			
	Infrastructure Process				1			
	Unit				unit			
product	16.7kWp, 100m2, PV system for PVT, installed on slanted roof, single-Si	CH	1	unit	1	0		
technosphere	electricity, low voltage, at grid	CH	0	kWh	1.28E+0	1	1.05	(,,,,,,BU:1.05); ;
	inverter, 2500W, at plant	RER	1	unit	1.33E+1	1	3.12	(3,4,4,1,1,5,BU:3); ;
	electric installation, photovoltaic plant, at plant	CH	1	unit	5.56E+0	1	3.06	(2,4,2,1,1,5,BU:3); ;
	slanted-roof construction, mounted, on roof	RER	1	m2	1.10E+2	1	3.06	(3,1,2,1,1,5,BU:3); ;
	photovoltaic panel for PVT, single-Si, without flat glass, at regional storage	RER	1	m2	1.14E+2	1	3.07	(3,4,1,1,1,5,BU:3); ;
	transport, freight, light commercial vehicle	CH	0	tkm	4.56E+2	1	2.09	(3,4,3,1,1,5,BU:2); ;
	transport, freight, lorry, fleet average	RER	0	tkm	2.03E+3	1	2.09	(3,4,3,1,1,5,BU:2); ;
air, high population density	Heat, waste	-	-	MJ	4.60E+0	1	1.28	(3,4,3,1,1,5,BU:1.05); ;

Figure 63: Unit process raw data of process 16.667kWp, 100m2 PV system for PVT system installed on slanted roof

Type	ID	Field name, IndexNumber	777-077	777-078
ReferenceFunction	401	Name	solar system for PVT ONLY, 100m2 Al-Cu flat plate collector, on slanted roof, hot water heat storage	solar system for PVT ONLY, 100m2 Al-Cu flat plate collector, on slanted roof, with borehole regeneration
Geography	662	Location	CH	CH
ReferenceFunction	493	InfrastructureProcess	1	1
ReferenceFunction	403	Unit	unit	unit
	402	IncludedProcesses	Production and disposal of a complete solar thermal system in combination with PV-System for a PVT system ONLY (including heat storage tank). Including different components, heat exchange fluid, warm water pipes, transports of parts to CH, and delivery with a van.	Production and disposal of a complete solar thermal system in combination with PV-System for a PVT system ONLY (including part (share calculated by lifetime=50y) of borehole for regeneration). Including different components, heat exchange fluid, warm water pipes, transports of parts to CH, and delivery with a van.
	490	LocalName	Solarthermie system nur für PVT-Systeme, 100m2, Al-Cu Solarkollektor auf Schrägrach mit Heisswassertank	Solarthermie system nur für PVT-Systeme, 100m2, Al-Cu Solarkollektor auf Schrägrach mit Erdsondenregenerierung
	491	Synonyms	100m2 Solarkollektor / Plattenabsorber (Al-Cu) nur für PVT-Systeme auf Schrägdach montiert inkl. Heisswassertank , 100m2 flat plate collector (Al-Cu) for PVT systems only mounted on slanted roof, heat storage hot water tank included	100m2 Solarkollektor / Plattenabsorber (Al-Cu) nur für PVT-Systeme auf Schrägdach montiert inkl. Erdsondenanteil für Regenerierung , 100m2 flat plate collector (Al-Cu) for PVT systems only mounted on slanted roof, borehole for regeneration included
	492	GeneralComment	Complete solar thermal system on slanted roof, mounted, only in combination with PV-System for a PVT system (including heat storage tank). One collector has an aparture area of 2.335 m2 and an empty weight of 42 kg. The dataset refers to 100 m2 aparture area, which is equal to 109 m2 collector area. The flat plate collector has a selective nickel pigmented aluminium oxide coating on an aluminium absorber.	Complete solar thermal system on slanted roof, mounted, only in combination with PV-System for a PVT system (including part of borehole (share calculated by lifetime=50y)for regeneration). One collector has an aparture area of 2.335 m2 and an empty weight of 42 kg. The dataset refers to 100 m2 aparture area, which is equal to 109 m2 collector area. The flat plate collector has a selective nickel pigmented aluminium oxide coating on an aluminium absorber.
	494	InfrastructureIncluded	1	1
	495	Category	PVT	PVT
	496	SubCategory	heating systems	heating systems
	497	LocalCategory	Solarenergie, thermisch, elektrisch	Solarenergie, thermisch, elektrisch
	498	LocalSubCategory	Heizungssysteme	Heizungssysteme
	499	Formula		
	501	StatisticalClassification		
	502	CASNumber		
TimePeriod	601	StartDate	2015	2015
	602	EndDate	2020	2020
	603	DataValidForEntirePeriod	1	1
	611	OtherPeriodText		
Geography	663	Text	Solar collector system operated in CH	Solar collector system operated in CH
Technology	692	Text	Solar thermal part of a PVT system combined with hot water heat storage.	Solar thermal part of a PVT system combined with borehole for heat regeneration.
Representativeness	722	Percent		
	724	ProductionVolume		
	725	SamplingProcedure	Data provided by manufacturer, environmental reports, direct contacts with factory representatives and publication of plant data.	Data provided by manufacturer, environmental reports, direct contacts with factory representatives and publication of plant data.
	726	Extrapolations		

Figure 64: Meta data of process solar system for PVT only, with hot water storage and earth probe regeneration

	Name	Location	Infrastructure Process	Unit	solar system for PVT ONLY, 100m2 Al-Cu flat plate collector, on slanted roof, hot water heat storage	solar system for PVT ONLY, 100m2 Al-Cu flat plate collector, on slanted roof, with borehole regeneration	Uncertainty Type	Standard Deviation 95%	General Comment
	Location				CH	CH			
	Infrastructure Process				1	1			
	Unit				unit	unit			
product	solar system for PVT ONLY, 100m2 Al-Cu flat plate collector, on slanted roof, hot water heat storage	CH	1	unit	1	0			
	solar system for PVT ONLY, 100m2 Al-Cu flat plate collector, on slanted roof, with borehole regeneration	CH	1	unit	0	1	0		
technosphere	water, completely softened, at plant	RER	0	kg	1.86E+2	1.86E+2	1	1.34	(3,5,3,1,1,5,BU:1.05); ;
	ethylene glycol, at plant	RER	0	kg	1.14E+2	1.14E+2	1	1.34	(3,5,3,1,1,5,BU:1.05); ;
	tube insulation, elastomere, at plant	DE	0	kg	4.29E+1	4.29E+1	1	1.34	(3,5,3,1,1,5,BU:1.05); ;
	packaging film, LDPE, at plant	RER	0	kg	4.05E+0	4.05E+0	1	1.34	(3,5,3,1,1,5,BU:1.05); ;
	chromium steel 18/8, at plant	RER	0	kg	5.53E+1	5.53E+1	1	1.34	(3,5,3,1,1,5,BU:1.05); ;
	aluminium, production mix, wrought alloy, at plant	RER	0	kg	6.99E+1	6.99E+1	1	1.34	(3,5,3,1,1,5,BU:1.05); ;
	pump 40W, at plant	CH	1	unit	6.47E+0	6.47E+0	1	3.12	(3,5,3,1,1,5,BU:3); ;
	heat storage 2000l, at plant	CH	1	unit	2.50E+0	0	1	3.12	(3,5,3,1,1,5,BU:3); ;
#BEZUG!	expansion vessel 80l, at plant	CH	1	unit	5.83E+0	5.83E+0	1	3.12	(3,5,3,1,1,5,BU:3); ;
	flat plate collector for PVT, aluminium copper absorber, at plant	CH	1	m2	9.99E+1	9.99E+1	1	3.12	(3,5,3,1,1,5,BU:3); ;
	drawing of pipes, steel	RER	0	kg	5.53E+1	5.53E+1	1	1.41	(3,5,3,1,3,5,BU:1.05); ;
	sheet rolling, aluminium	RER	0	kg	6.99E+1	6.99E+1	1	1.34	(3,5,3,1,1,5,BU:1.05); ;
	powder coating, aluminium sheet	RER	0	m2	3.50E+0	3.50E+0	1	1.34	(3,5,3,1,1,5,BU:1.05); ;
	transport, freight, light commercial vehicle	CH	0	tkm	2.20E+3	2.20E+3	1	2.12	(3,5,3,1,1,5,BU:2); ;
	transport, freight, lorry 16-32 metric ton, fleet average	CH	0	tkm	2.36E+1	2.36E+1	1	3.04	(4,5,5,5,5,5,BU:2); ;
	transport, freight, rail	RER	0	tkm	2.84E+2	2.84E+2	1	3.04	(4,5,5,5,5,5,BU:2); ;
	treatment, heat carrier liquid, 40% C3H8O2, to wastewater treatment, class 2	CH	0	m3	3.01E-1	8.40E-2	1	1.34	(3,5,3,1,1,5,BU:1.05); ;
	disposal, plastics, mixture, 15.3% water, to municipal incineration	CH	0	kg	4.70E+1	4.70E+1	1	1.34	(3,5,3,1,1,5,BU:1.05); ;

Figure 65: Unit process raw data of process solar system for PVT only, with hot water storage and earth probe regeneration

ReferenceFunction	Name	heat, at 100m2 solar collector in PVT system, Al-Cu, slanted roof, borehole for heat regeneration	heat, at 100m2 solar collector in PVT system, Al-Cu, slanted roof, hot water heat storage
Geography	Location	CH	CH
ReferenceFunction	InfrastructureProcess	0	0
ReferenceFunction	Unit	MJ	MJ
	IncludedProcesses	Infrastructure of the solar system of a PVT system including maintenance and electricity use for operation. PV infrastructure is not included but allocated to the electricity production of a PVT system.	Infrastructure of the solar system of a PVT system including maintenance and electricity use for operation. PV infrastructure is not included but allocated to the electricity production of a PVT system.
	LocalName	Nutzwärme, ab 100m2 Solarthermieanlage in PVT-System, Al-Cu, auf Schrägdach, mit Erdsonden regeneration	Nutzwärme, ab 100m2 Solarthermieanlage in PVT-System, Al-Cu, auf Schrägdach, mit Warmwasserspeicher
	Synonyms	Wärme aus Solarkollektor NUR in PVT-System, 100m2, auf Schrägdach montiert mit Erdsonden regeneration, heat from solar collector ONLY in PVT-System, 100m2, mounted on slanted-roof with borehole regeneration	Wärme aus Solarkollektor NUR in PVT-System, 100m2, auf Schrägdach montiert mit Warmwasser Wärmespeicher, heat from solar collector ONLY in PVT-System, 100m2, mounted on slanted-roof with hot water heat storage
	GeneralComment	Use of the heat of a PVT system for borehole heat regeneration, which leads to a better performance of the heat pump system (about 2.5% less electricity demand for the heat pump per 1 degree of regeneration) The simulation is made for solar collector systems in Switzerland. The annual irradiation amounts to 1249 kWh/m2. 50% solar fraction, 30° inclination, 22° southeast orientation.	Use of a solar system with PV modules (electricity use for the solar collector from PV) for the same size better known as PVT system including hot water heat storage. Excluding further necessary auxiliary heating. The simulation is made for solar collector systems in Switzerland. The annual irradiation amounts to 1249 kWh/m2. 50% solar fraction, 30° inclination, 22° southeast orientation.
	InfrastructureIncluded	1	1
	Category	PVT	PVT
	SubCategory	heating systems	heating systems
	LocalCategory	Solarenergie, thermisch, elektrisch	Solarenergie, thermisch, elektrisch
	LocalSubCategory	Heizungssysteme	Heizungssysteme
	Formula		
	StatisticalClassification		
	CASNumber		
TimePeriod	StartDate	2015	2015
	EndDate	2020	2020
	DataValidForEntirePeriod	1	1
	OtherPeriodText		
Geography	Text	operated in Switzerland	operated in Switzerland
Technology	Text	PVT combination system with borehole heat regeneration	PVT combination system with borehole heat regeneration
Representativeness	Percent		
	ProductionVolume		
	SamplingProcedure	Data provided by manufacturer and literature data on worldwide module production.	Data provided by manufacturer and literature data on worldwide module production.
	Extrapolations		
	UncertaintyAdjustments	none	none

Figure 66: Meta data of process heat at 100m^2 solar collector in PVT system

	Name	Location	Infrastructure Process	Unit	heat, at 100m2 solar collector in PVT system, Al-Cu, slanted roof, borehole for heat regeneration	heat, at 100m2 solar collector in PVT system, Al-Cu, slanted roof, hot water heat storage	Uncertainty Type	Standard Deviation 95%	General Comment
	Location				CH	CH			
	Infrastructure Process				0	0			
	Unit				MJ	MJ			
product	heat, at 100m2 solar collector in PVT system, Al-Cu, slanted roof, borehole for heat regeneration	CH	0	MJ	1	0			
product	heat, at 100m2 solar collector in PVT system, Al-Cu, slanted roof, hot water heat storage	CH	0	MJ	0	1	0		
resource, in air	Energy, solar, converted	-	-	MJ	1.13E+0	1.13E+0	1	1.05	(,,,,,,BU:1.05); ;
resource, in ground	Energy, geothermal, converted	-	-	MJ	-1.00E+0	0	1	1.31	(2,5,1,1,1,5,BU:1.05); ;
technosphere	electricity, PV in PVT-System, 16.7kWp, single-Si, slanted-roof	CH	0	kWh	2.14E-4	2.14E-4	1	1.31	(2,5,1,1,1,5,BU:1.05); ;
	solar system for PVT ONLY, 100m2 Al-Cu flat plate collector, on slanted roof, with borehole regeneration	CH	1	unit	3.17E-7	0	1	3.09	(2,5,1,1,1,5,BU:3); ;
	solar system for PVT ONLY, 100m2 Al-Cu flat plate collector, on slanted roof, hot water heat storage	CH	1	unit	0	3.17E-7	1	3.09	(2,5,1,1,1,5,BU:3); ;
	transport, freight, light commercial vehicle	CH	0	tkm	5.52E-5	5.52E-5	1	2.10	(2,5,1,1,1,5,BU:2); ;
air, high population density	Heat, waste	-	-	MJ	1.13E+0	1.13E+0	1	1.31	(2,5,1,1,1,5,BU:1.05); ;

Figure 67: Unit process raw data of process heat at 100m^2 solar collector in PVT system

Type	ID	Field name, IndexNumber	777-079
ReferenceFunction	401	Name	electricity, PV in PVT-System, 16.7kWp, single-Si, slanted-roof
Geography	662	Location	CH
ReferenceFunction	493	InfrastructureProcess	0
ReferenceFunction	403	Unit	kWh
	402	IncludedProcesses	Infrastructure for 16.667kWp PV-plant in a PVT system. Water use for cleaning. Amount of solar energy transformed to electricity. Waste heat emission due to losses of electricity in the system. The thermal components are not included but allocated to the heat production of the PVT system.
	490	LocalName	Strom, Photovoltaik in PVT-System, 16.7kWp, 100m2, monokristallin, auf Schrägdach
	491	Synonyms	
	492	GeneralComment	This inventory is valid for the electricity production of a PVT system only. The electricity efficiency in a PVT system is about 5% better as a comparable PV panel. Dataset can be used for comparison of energy technologies in Switzerland, but not for assessment of average production patterns. Yield data must be corrected for the installations used in other countries.
	494	InfrastructureIncluded	1
	495	Category	PVT
	496	SubCategory	heating systems
	497	LocalCategory	Solarenergie, thermisch, elektrisch
	498	LocalSubCategory	Heizungssysteme
	499	Formula	
	501	StatisticalClassification	
	502	CASNumber	
TimePeriod	601	StartDate	2015
	602	EndDate	2020
	603	DataValidForEntirePeriod	1
	611	OtherPeriodText	
Geography	663	Text	Use in CH.
Technology	692	Text	Modern production plant.
Representativeness	722	Percent	
	724	ProductionVolume	
	725	SamplingProcedure	Data provided by manufacturer and literature data on worldwide module production.
	726	Extrapolations	

Figure 68: Meta data of process electricity from PV system, 16.7kWp

	Name	Location	Infrastructure Process	Unit	electricity, PV in PVT-System, 16.7kWp, single-Si, slanted-roof	Uncertainty Type	Standard Deviation 95%	General Comment
	Location				CH			
	Infrastructure Process				0			
	Unit				kWh			
product	electricity, PV in PVT-System, 16.7kWp, single-Si, slanted-roof	CH	0	kWh	1	0		
resource, in air	Energy, solar, converted	-	-	MJ	3.85E+0	1	1.05	(,,,,,,BU:1.05); ;
technosphere	tap water, at user	CH	0	kg	1.47E-1	1	1.09	(2,2,1,1,1,3,BU:1.05); ;
	16.7kWp, 100m2, PV system for PVT, installed on slanted roof, single-	CH	1	unit	2.15E-6	1	3.01	(2,2,1,1,1,3,BU:3); ;
air, high population density	Heat, waste	-	-	MJ	2.50E+3	1	2.34	(1,5,5,5,5,5,BU:1.05); ;
technosphere	treatment, sewage, from residence, to wastewater treatment, class 2	CH	0	m3	1.47E-4	1	1.09	(2,2,1,1,1,3,BU:1.05); ;

Figure 69: Unit process raw data of process electricity from PV system, 16.667kWp

2.4.5 Data quality

In general, the data quality of the adapted inputs is good.
Other inputs and outputs which have not been updated during this study are normally of very low relevance for the calculated environmental impacts. For future updates it would be reasonable to make more inventories to represent a larger variety of PVT systems on the market.

2.4.6 Life cycle impact assessment

At the infrastructure level, the size is not comparable to existing inventories. Therefore, no direct comparison was made.
On the level of the delivered electricity, the PVT systems perform around 5 % better than the comparable PV system due to 5 % higher efficiency due to the dissipation of the heat.
Regarding the delivered heat, the PVT systems perform similar to comparable collector systems.

Table 20: LCIA results of PVT inventories

Inventory name/unit	**Ecological Scarcity 2013**	**IPCC 2013, GWP 100a**	**former inventory (UVEK 2018) that most closely matches the update**	**Ecological Scarcity 2013**	**IPCC 2013, GWP 100a**	**UBP ratio**	**kg CO2eq ratio**
	UBP	kg CO2eq		UBP	kg CO2eq	%	%
16.667kWp, 100m2, PV system for PVT, installed on slanted roof, single-Si/p/CH/I U	6.14E+07	4.63E+04	n.a.				
solar system for PVT ONLY, 100m2 Al-Cu flat plate collector, on slanted roof, hot water heat storage/p/CH/I U	2.91E+07	1.33E+04	n.a.				
solar system for PVT ONLY, 100m2 Al-Cu flat plate collector, on slanted roof, with borehole regeneration/p/CH/I U	2.47E+07	1.12E+04	n.a.				
heat, at 100m2 solar collector in PVT system, Al-Cu, slanted roof, borehole for heat regeneration/MJ/CH U	8.00E+00	3.66E-03	n.a.				
heat, at 100m2 solar collector in PVT system, Al-Cu, slanted roof, hot water heat storage/MJ/CH U	1.05E+01	4.34E-03	heat, at 30 m2 Cu collector, multiple dwelling, slanted roof, for hot water/CH U	1.13E+01	4.18E-03	93%	104%
electricity, PV in PVT-System, 16.7kWp, single-Si, slanted-roof/kWh/CH U	1.36E+02	9.95E-02	electricity, PV, at 3kWp slanted-roof, single-Si, panel, mounted/kWh/CH U	1.43E+02	1.06E-01	95%	94%

2.4.7 Outlook

The LCIA of the PVT systems shows only very small differences compared to existing datasets. Therefore, we do not recommend to proceed into this direction.

2.5 District heating systems

A district heating system consists of the pipe system for transporting the heat and a system where the heat is generated. The heat can be produced in different ways. This means that different heating systems with different energy sources can be used.

The following inventories were created:

Infrastructure

- Transport, district heat, average/CH

Energy – heat

- District heat, at consumer, Swiss average/CH
- District heat, at consumer, wood chips cogeneration 1MW/CH, allocation exergy
- District heat, at consumer, wood chips cogeneration 1MW/CH, economic allocation
- District heat, at consumer, wood chips in industrial furnace 1MW/CH
- District heat, at consumer, natural gas cogeneration 1MW/CH, allocation exergy
- District heat, at consumer, natural gas cogeneration 1MW/CH, economic allocation
- District heat, at consumer, natural gas in industrial furnace 1MW/CH
- District heat, at consumer, diesel cogeneration 1MW/CH, allocation exergy
- District heat, at consumer, diesel cogeneration 1MW/CH, economic allocation
- District heat, at consumer, diesel in industrial furnace 1MW/CH
- District heat, at consumer, biomethane cogeneration 1MW/CH, allocation exergy
- District heat, at consumer, biomethane cogeneration 1MW/CH, economic allocation
- District heat, at consumer, biomethane in industrial furnace 1MW/CH
- District heat, at consumer, heat from waste incineration/CH, burden free
- District heat, at consumer, heat from heat pump/CH
- District heat, at consumer, from ground water heat pump, allocation exergy
- District heat, at consumer, from ground water heat pump, economic allocation
- District heat, at consumer, ground water heat pump 50kW/CH
- District heat, at consumer, heat from nuclear power plant/CH, allocation exergy
- District heat, at consumer, heat from nuclear power plant, economic allocation
- Heat, at nuclear power plant/CH, allocation exergy
- Heat, at nuclear power plant/CH, economic allocation

The heat made available via district heating amounts to at least 7'670 GWh in 2018 (VFS, 2019) which corresponds to about eight percent of Switzerland's heating requirements. The production mix of the average district heat mix in Switzerland is given in Table 21. Based on information of heat and power production of each of the VFS members, we assumed that 50 % of the natural gas and wood heat is produced in CHP and 50 % is produced in heating plants without power generation. District heat form non-members is mainly produced in wood heating plants (VFS, 2019). Heat form municipal waste incineration is assumed to be burden free. The same is true for heat waste from nuclear power generation, which is approximated with the inventory heat from municipal waste incineration. The renewable fraction is mainly based on heat from borehole heat pumps.

Table 21: Swiss average district heat production mix

	swiss average district heat production mix	comment
light fuel oil	2.4%	100% industrial furnace
natural gas	22.6%	50% industrial furnace, 50% cogen
municipal waste incineration	32.2%	burden free
wood	14.6%	50% industrial furnace, 50% cogen
wood from non VFS members	15.7%	100% industrial furnace
renewables	5.6%	100% heat pumps
others	6.9%	heat waste from nuclear power plants, burden free

Besides the average Swiss district heat mix, several district heat inventories with only one energy source are provided in order to create individual district heat mixes.

2.5.1 Infrastructure

In the present case, processes have been developed for combined heat and power plants that use wood, natural gas and fuel oil. The inventories for the wood, natural gas and fuel oil CHP plants were also updated or newly created as part of this project. These new processes were implemented for the district heating inventories. These new processes are described under chapter 2.6 Cogeneration systems (p. 97).

For the heat distribution system, the infrastructure was calculated per transported heat (MJ) and not per unit or meters. As reference for this whole inventory the inventory from report *Umweltkennwerte und Primärenergiefaktoren von Energiesystemen* (Stolz & Frischknecht, 2017) was used. The corresponding inventory is presented in the following Table 22.

Table 22: Inventory for infrastructure for district heating delivery system per MJ

Process	Geography	Unit	Amount
electricity, medium voltage, at grid	CH	kWh	5.56E-03
reinforcing steel, at plant	RER	kg	6.00E-05
wire drawing, steel	RER	kg	6.00E-05
Polyurethane, rigit foam, at plant	RER	kg	2.00E-06
polyethylene, HDPE, granulate, at plant	RER	kg	8.00E-06
extrusion, plastic pipes	RER	kg	8.00E-06
glass wool mat, at platn	CH	kg	3.00E-06
concrete, normal, at plant	CH	m3	2.73E-07
excavation, skid-steer loader	RER	m3	2.00E-06
transport, freight, lorry 20-28t fleet average	CH	tkm	2.00E-05
transport, freight, rail	CH	tkm	4.00E-05
disposal, inert waste, 5% water, to inert material landfill	CH	kg	6.20E-04
disposal, polyurethane, 0.2% water, to municipal incineration	CH	kg	1.20E-06

2.5.2 Reference unit, energy demand and losses

For the thermal energy coming from the district heating systems, 1 MJ of thermal energy output is calculated.

An average thermal energy loss of 11 % in heat distribution was assumed for all district heating inventories. This is the average value of the two large district heating systems of IWB Basel and ERZ Zurich (personal communication with IWB and ERZ, 2020). An average heat loss of 11% is also considered realistic by the Swiss District Heating Association (VFS) (personal communication with VFS, 2021).

2.5.3 Emissions to air

The inventory for the heat delivery system considers 0.12 MJ heat waste per MJ heat (Stolz & Frischknecht, 2017). The emissions from the heat source like the CHP plants are described in chapter 2.6.5 Emissions to air (p. 102).

2.5.4 Additional heat inventories

Some of the heat inventories were not available yet in the UVEK database. In the following the new heat inventories are shorty described.

2.5.4.1 Heat from biomethane cogeneration and industrial furnace

Three inventories were created; one with allocation exergy, one with economic allocation and one with biomethane in industrial furnace.
As described above, thermal heat loss of 11% was assumed.

2.5.4.2 Heat from ground water and borehole heat pumps

One inventory was created for heat from ground water heat pump 50kW and one for heat from borehole heat pump. As described above, a thermal heat loss of 11%.

2.5.4.3 Heat from nuclear power plant

Heat from nuclear power plant was not yet available in the UVEK database.
Two inventories were created (one with allocation exergy and one with economic allocation) based on electricity from nuclear power plant, pressure water reactor, as only this type sells heat in Switzerland.

The produced heat from nuclear power plants in Switzerland according to VFS (2019) is about 578 MWh. In the same time, 25'373 MWh electricity were produced. Therefore of the total energy sold, 97.8% was electricity and 2.2% was heat.

The exergy factor for heat was assumed to be 0.170, similar to cogeneration plants.
For the economic factor the same prices for electricity and heat as for cogeneration natural gas was assumed.

This leads to the following allocation factors:
Allocation exergy: 0.4% for heat
Economic allocation: 0.9% for heat

In other words, only a very small amount of the inputs and emissions of nuclear energy production is allocated to heat, as this is rather a “waste” product.

2.5.5 Summary of life cycle inventory data

In this chapter the life cycle inventories for the newly modelled and updated processes are presented. All data are provided as unit process raw data in the EcoSpold v1 format (unit process in SimaPro). The electronic data is including full EcoSpold v1 documentation.
For each investigated process, two types of tables (X-Process and X-Exchange) are provided in this report.

ReferenceFunction	Name	transport, district heat, average
Geography	Location	CH
ReferenceFunction	InfrastructureProcess	0
ReferenceFunction	Unit	MJ
	IncludedProcesses	Included is the infrastructure of the deliverysystem for district heat and the energy input which is used for the transport of the heat, calculated on 1 MJ. The deposit of waste during the construction or usephase are included.
	LocalName	Transport, Fernwärme, durchschnitt
	Synonyms	0
	GeneralComment	This process is made for a district heat system. The heat input is not included and must be added for the specific district heat system.
	InfrastructureIncluded	1
	Category	transport systems
	SubCategory	district heat
	LocalCategory	Transportsysteme
	LocalSubCategory	Fernwärme
	Formula	
	StatisticalClassification	
	CASNumber	
TimePeriod	StartDate	2015
	EndDate	2020
	DataValidForEntirePeriod	1
	OtherPeriodText	Time of publications.
Geography	Text	Data apply to the supply in Switzerland.
Technology	Text	average technology
Representativeness	Percent	
	ProductionVolume	
	SamplingProcedure	based on literature
	Extrapolations	none

Figure 70: Meta data of process transport, district heat, average

	Name	Location	Infrastructure Process	Unit	transport, district heat, average	Uncertainty Type	Standard Deviation 95%	General Comment
	Location				CH			
	Infrastructure Process				0			
	Unit				MJ			
product	transport, district heat, average	CH	0	MJ	1	0		
technosphere	electricity, medium voltage, at grid	CH	0	kWh	5.56E-3	1	1.13	(2,1,2,1,1,4,BU:1.05); ;
	reinforcing steel, at plant	RER	0	kg	6.00E-5	1	1.13	(2,1,2,1,1,4,BU:1.05); ;
	wire drawing, steel	RER	0	kg	6.00E-5	1	1.13	(2,1,2,1,1,4,BU:1.05); ;
	polyurethane, rigid foam, at plant	RER	0	kg	2.00E-6	1	1.13	(2,1,2,1,1,4,BU:1.05); ;
	polyethylene, HDPE, granulate, at plant	RER	0	kg	8.00E-6	1	1.13	(2,1,2,1,1,4,BU:1.05); ;
	extrusion, plastic pipes	RER	0	kg	8.00E-6	1	1.13	(2,1,2,1,1,4,BU:1.05); ;
	glass wool mat, at plant	CH	0	kg	3.00E-6	1	1.13	(2,1,2,1,1,4,BU:1.05); ;
	concrete, normal, at plant	CH	0	m3	2.73E-7	1	1.13	(2,1,2,1,1,4,BU:1.05); ;
	excavation, skid-steer loader	RER	0	m3	2.00E-6	1	1.13	(2,1,2,1,1,4,BU:1.05); ;
	transport, freight, lorry 16-32 metric ton, fleet average	CH	0	tkm	2.00E-5	1	2.02	(2,1,2,1,1,4,BU:2); ;
	transport, freight, rail	RER	0	tkm	4.00E-5	1	2.02	(2,1,2,1,1,4,BU:2); ;
	disposal, inert waste, 5% water, to inert material landfill	CH	0	kg	6.20E-4	1	1.13	(2,1,2,1,1,4,BU:1.05); ;
	disposal, polyurethane, 0.2% water, to municipal incineration	CH	0	kg	1.20E-6	1	1.13	(2,1,2,1,1,4,BU:1.05); ;
air, unspecified	Heat, waste	-	-	MJ	2.00E-2	1	1.13	(2,1,2,1,1,4,BU:1.05); ;
	Heat, waste	-	-	MJ	1.00E-1	1	1.13	(2,1,2,1,1,4,BU:1.05); ;

Figure 71: Unit process raw data of delivery system for transport district heat production

ReferenceFunction	Name	district heat, at consumer, wood chips cogen 1MWth, allocation exergy	district heat, at consumer, wood chips cogen 1MWth, economic allocation	district heat, at consumer, wood chips in industrial furnace 1MW
Geography	Location	CH	CH	CH
ReferenceFunction	InfrastructureProcess	0	0	0
ReferenceFunction	Unit	MJ	MJ	MJ
	IncludedProcesses	Included is the infrastructure of the deliverysystem for district heat, the losses and the heat from wood at cogen 1MWth. The deposit of waste during the construction or usephase are included.	Included is the infrastructure of the deliverysystem for district heat, the losses and the heat from wood at cogen 1MWth. The deposit of waste during the construction or usephase are included.	Included is the infrastructure of the deliverysystem for district heat, the losses and the heat from wood at industrial furnace 1MWth. The deposit of waste during the construction or usephase are included.
	LocalName	Fernwärme, an Abnehmer, Holzheizkraftwerk 1MWth, Allokation Exergie	Fernwärme, an Abnehmer, Holzheizkraftwerk 1MWth, ökonomische Allokation	Fernwärme, an Abnehmer, Feuerung Holzschnitzel 1MW
	Synonyms	0	0	0
	GeneralComment	Inventory is valid for the district heat based on heat from wood chips in cogeneration plant only. Heat loss is 11% while heat transportation. For heat from cogeneration allocation exergy was used.	Inventory is valid for the district heat based on heat from wood chips in cogeneration plant only. Heat loss is 11% while heat transportation. For heat from cogeneration economic allocation was used.	Inventory is valid for the district heat based on heat from wood chips in heating plant only. Heat loss is 11% while heat transportation.
	InfrastructureIncluded	1	1	1
	Category	wood energy	wood energy	wood energy
	SubCategory	district heat	district heat	district heat
	LocalCategory	Holzenergie	Holzenergie	Holzenergie
	LocalSubCategory	Fernwärme	Fernwärme	Fernwärme
	Formula	1	1	1
	StatisticalClassification			
	CASNumber			
TimePeriod	StartDate	2018	2018	2018
	EndDate	2020	2020	2020
	DataValidForEntirePeriod	1	1	1
	OtherPeriodText	Time of publications.	Time of publications.	Time of publications.
Geography	Text	Data apply to the supply in Switzerland.	Data apply to the supply in Switzerland.	Data apply to the supply in Switzerland.
Technology	Text	average technology	average technology	average technology
Representativeness	Percent			
	ProductionVolume			
	SamplingProcedure	heat efficieny based on literature	heat efficieny based on literature	heat efficieny based on literature
	Extrapolations	none	none	none
	UncertaintyAdjustments	none	none	none

Figure 72: Metadata of district heat based on wood

	Name	Location	Infrastructure Process	Unit	district heat, at consumer, wood chips cogen 1MWth, allocation exergy	district heat, at consumer, wood chips cogen 1MWth, economic allocation	district heat, at consumer, wood chips in industrial furnace 1MW	Uncertainty Type	Standard Deviation 95%	General Comment
	Location				CH	CH	CH			
	Infrastructure Process				0	0	0			
	Unit				MJ	MJ	MJ			
product	district heat, at consumer, wood chips cogen 1MWth, allocation exergy	CH	0	MJ	1	0	0	0		
product	district heat, at consumer, wood chips cogen 1MWth, economic allocation	CH	0	MJ	0	1	0	0		
product	district heat, at consumer, wood chips in industrial furnace 1MW	CH	0	MJ	0	0	1	0		
technosphere	tansport, district heat, average	CH	0	MJ	1.00E+0	1.00E+0	1.00E+0	1	3.05	(2,2,2,1,1,5,BU:3); ;
	heat, at cogen 1MWth, wood chips, economic allocation	CH	0	MJ	0	1.11E+0	0	1	1.22	(2,2,2,1,1,5,BU:1.05); ;
	heat, at cogen 1MWth, wood chips, allocation exergy	CH	0	MJ	1.11E+0	0	0	1	1.22	(2,2,2,1,1,5,BU:1.05); ;
	heat, mixed chips from industry, at furnace 1000kW	CH	0	MJ	0	0	1.11E+0	1	1.22	(2,2,2,1,1,5,BU:1.05); ;

Figure 73: Unit process raw data of district heat based on wood

ReferenceFunction	Name	district heat, at consumer, natural gas cogen 1MWth, economic allocation	district heat, at consumer, natural gas cogen 1MWth, allocation exergy	district heat, at consumer, natural gas in industrial furnace 1MW
Geography	Location	CH	CH	CH
ReferenceFunction	InfrastructureProcess	0	0	0
ReferenceFunction	Unit	MJ	MJ	MJ
	IncludedProcesses	Included is the infrastructure of the deliverysystem for district heat, the losses and the heat from natural gas at cogen 1MWth. The deposit of waste during the construction or usephase are included.	Included is the infrastructure of the deliverysystem for district heat, the losses and the heat from natural gas at cogen 1MWth. The deposit of waste during the construction or usephase are included.	Included is the infrastructure of the deliverysystem for district heat, the losses and the heat from natural gas at industrial furnace 1MWth. The deposit of waste during the construction or usephase are included.
	LocalName	Fernwärme, an Abnehmer, Erdgas in BHKW 1MWth, ökonomische Allokation	Fernwärme, an Abnehmer, Erdgas in BHKW 1MWth, Allokation Exergie	Fernwärme, an Abnehmer, Feuerung Erdgas 1MW
	Synonyms	0	0	0
	GeneralComment	Inventory is valid for the district heat based on heat from natural gas in cogeneration plant only. Heat loss is 11% while heat transportation. For heat from cogeneration allocation exergy was used.	Inventory is valid for the district heat based on heat from natural gas in cogeneration plant only. Heat loss is 11% while heat transportation. For heat from cogeneration economic allocation was used.	Inventory is valid for the district heat based on heat from natural gas in heating plant only. Heat loss is 11% while heat transportation.
	InfrastructureIncluded	1	1	1
	Category	natural gas	natural gas	natural gas
	SubCategory	district heat	district heat	district heat
	LocalCategory	Erdgas	Erdgas	Erdgas
	LocalSubCategory	Fernwärme	Fernwärme	Fernwärme
	Formula	1	1	1
	StatisticalClassification			
	CASNumber			
TimePeriod	StartDate	2018	2018	2018
	EndDate	2020	2020	2020
	DataValidForEntirePeriod	1	1	1
	OtherPeriodText	Time of publications.	Time of publications.	Time of publications.
Geography	Text	Data apply to the supply in Switzerland.	Data apply to the supply in Switzerland.	Data apply to the supply in Switzerland.
Technology	Text	average technology	average technology	average technology
Representativeness	Percent			
	ProductionVolume			
	SamplingProcedure	heat efficieny based on literature	heat efficieny based on literature	heat efficieny based on literature
	Extrapolations	none	none	none
	UncertaintyAdjustments	none	none	none

Figure 74: Metadata of district heat based on natural gas

	Name	Location	Infrastructure Process	Unit	district heat, at consumer, natural gas cogen 1MWth, economic allocation	district heat, at consumer, natural gas cogen 1MWth, allocation exergy	district heat, at consumer, natural gas in industrial furnace 1MW	Uncertainty Type	Standard Deviation 95%	General Comment
	Location				CH	CH	CH			
	Infrastructure Process				0	0	0			
	Unit				MJ	MJ	MJ			
product	district heat, at consumer, natural gas cogen 1MWth, economic allocation	CH	0	MJ	1	0	0	0		
product	district heat, at consumer, natural gas cogen 1MWth, allocation exergy	CH	0	MJ	0	1	0	0		
product	district heat, at consumer, natural gas in industrial furnace 1MW	CH	0	MJ	0	0	1	0		
technosphere	tansport, district heat, average	CH	0	MJ	1.00E+0	1.00E+0	1.00E+0	1	3.05	(2,2,2,1,1,5,BU:3); ;
	heat, at cogen 1MWth, natural gas, economic allocation	CH	0	MJ	1.11E+0	0	0	1	1.22	(2,2,2,1,1,5,BU:1.05); ;
	heat, at cogen 1MWth, natural gas, allocation exergy	CH	0	MJ	0	1.11E+0	0	1	1.22	(2,2,2,1,1,5,BU:1.05); ;
	heat, natural gas, at industrial furnace 1MW	CH	0	MJ	0	0	1.11E+0	1	1.22	(2,2,2,1,1,5,BU:1.05); ;

Figure 75: Unit process raw data of district heat based on natural gas

ReferenceFunction	Name	district heat, at consumer, biomethane cogen 1MWth, economic allocation	district heat, at consumer, biomethane cogen 1MWth, allocation exergy	district heat, at consumer, biomethane in industrial furnace 1MW
Geography	Location	CH	CH	CH
ReferenceFunction	InfrastructureProcess	0	0	0
ReferenceFunction	Unit	MJ	MJ	MJ
	IncludedProcesses	Included is the infrastructure of the deliverysystem for district heat, the losses and the heat from biomethane at cogen 1MWth. The deposit of waste during the construction or usephase are included.	Included is the infrastructure of the deliverysystem for district heat, the losses and the heat from biomethane at cogen 1MWth. The deposit of waste during the construction or usephase are included.	Included is the infrastructure of the deliverysystem for district heat, the losses and the heat from bioomethane at industrial furnace 1MWth. The deposit of waste during the construction or usephase are included.
	LocalName	Fernwärme, an Abnehmer, Biomethan in BHKW 1MWth, ökonomische Allokation	Fernwärme, an Abnehmer, Biomethan in BHKW 1MWth, Allokation Exergie	Fernwärme, an Abnehmer, Feuerung Biomethan 1MW
	Synonyms	0	0	0
	GeneralComment	Inventory is valid for the district heat based on heat from biomethane in cogeneration plant only. Heat loss is 11% while heat transportation. For heat from cogeneration allocation exergy was used.	Inventory is valid for the district heat based on heat from biomethane in cogeneration plant only. Heat loss is 11% while heat transportation. For heat from cogeneration economic allocation was used.	Inventory is valid for the district heat based on heat from biomethane in heating plant only. Heat loss is 11% while heat transportation.
	InfrastructureIncluded	1	1	1
	Category	biomethane	biomethane	biomethane
	SubCategory	district heat	district heat	district heat
	LocalCategory	Biomethan	Biomethan	Biomethan
	LocalSubCategory	Fernwärme	Fernwärme	Fernwärme
	Formula	1	1	1
	StatisticalClassification			
	CASNumber			
TimePeriod	StartDate	2018	2018	2018
	EndDate	2020	2020	2020
	DataValidForEntirePeriod	1	1	1
	OtherPeriodText	Time of publications.	Time of publications.	Time of publications.
Geography	Text	Data apply to the supply in Switzerland.	Data apply to the supply in Switzerland.	Data apply to the supply in Switzerland.
Technology	Text	average technology	average technology	average technology
Representativeness	Percent			
	ProductionVolume			
	SamplingProcedure	heat efficieny based on literature	heat efficieny based on literature	heat efficieny based on literature
	Extrapolations	none	none	none
	UncertaintyAdjustments	none	none	none

Figure 1: Metadata of district heat based on biomethane

Index		401	Input Group	Output Group	Name	Location	Infrastructure Process	Unit	district heat, at consumer, biomethane cogen 1MWth, economic allocation	district heat, at consumer, biomethane cogen 1MWth, allocation exergy	district heat, at consumer, biomethane in industrial furnace 1MW
		662			Location				CH	CH	CH
		493			Infrastructure Process				0	0	0
		403			Unit				MJ	MJ	MJ
777-251	product		-	0	district heat, at consumer, biomethane cogen 1MWth, economic allocation	CH	0	MJ	1	0	0
777-252	product		-	0	district heat, at consumer, biomethane cogen 1MWth, allocation exergy	CH	0	MJ	0	1	0
777-253	product		-	0	district heat, at consumer, biomethane in industrial furnace 1MW	CH	0	MJ	0	0	1
777-164	technosphere		5	-	transport, district heat, average	CH	0	MJ	1.00E+0	1.00E+0	1.00E+0
777-129			5	-	heat, at cogen 1MWth, biomethane, economic allocation	CH	0	MJ	1.11E+0	0	0
777-131			5	-	heat, at cogen 1MWth, biomethane, allocation exergy	CH	0	MJ	0	1.11E+0	0
777-021			5	-	heat, biomethane, at industrial furnace 1MW	CH	0	MJ	0	0	1.11E+0

Figure 2: Unit process raw data of district heat based on based on biomethane

ReferenceFunction	Name	district heat, at consumer, diesel cogen 1MWth, economic allocation	district heat, at consumer, diesel cogen 1MWth, allocation exergy	district heat, at consumer, light fuel oil in industrial furnace 1MW
Geography	Location	CH	CH	CH
ReferenceFunction	InfrastructureProcess	0	0	0
ReferenceFunction	Unit	MJ	MJ	MJ
	IncludedProcesses	Included is the infrastructure of the deliverysystem for district heat, the losses and the heat from light fuel oil at cogen 1MWth. The deposit of waste during the construction or usephase are included.	Included is the infrastructure of the deliverysystem for district heat, the losses and the heat from light fuel oil at cogen 1MWth. The deposit of waste during the construction or usephase are included.	Included is the infrastructure of the deliverysystem for district heat, the losses and the heat from light fuel oil at industrial furnace 1MWth. The deposit of waste during the construction or usephase are included.
	LocalName	Fernwärme, an Abnehmer, Diesel BHKW 1MWth, ökonomische Allokation	Fernwärme, an Abnehmer, Diesel BHKW 1MWth, Allokation Exergie	Fernwärme, an Abnehmer, Feuerung Heizöl 1MW
	Synonyms	0	0	0
	GeneralComment	Inventory is valid for the district heat based on heat from light fuel oil in cogeneration plant only. Heat loss is 11% while heat transportation. For heat from cogeneration allocation exergy was used.	Inventory is valid for the district heat based on heat from light fuel oil in cogeneration plant only. Heat loss is 11% while heat transportation. For heat from cogeneration economic allocation was used.	Inventory is valid for the district heat based on heat from light fuel oil in heating plant only. Heat loss is 11% while heat transportation.
	InfrastructureIncluded	1	1	1
	Category	oil	oil	oil
	SubCategory	district heat	district heat	district heat
	LocalCategory	Erdöl	Erdöl	Erdöl
	LocalSubCategory	Fernwärme	Fernwärme	Fernwärme
	Formula	1	1	1
	StatisticalClassification			
	CASNumber			
TimePeriod	StartDate	2018	2018	2018
	EndDate	2020	2020	2020
	DataValidForEntirePeriod	1	1	1
	OtherPeriodText	Time of publications.	Time of publications.	Time of publications.
Geography	Text	Data apply to the supply in Switzerland.	Data apply to the supply in Switzerland.	Data apply to the supply in Switzerland.
Technology	Text	average technology	average technology	average technology
Representativeness	Percent			
	ProductionVolume			
	SamplingProcedure	heat efficieny based on literature	heat efficieny based on literature	heat efficieny based on literature
	Extrapolations	none	none	none
	UncertaintyAdjustments	none	none	none

Figure 76: Metadata of district heat based on light fuel oil

	Name	Location	Infrastructure Process	Unit	district heat, at consumer, diesel cogen 1MWth, economic allocation	district heat, at consumer, diesel cogen 1MWth, allocation exergy	district heat, at consumer, light fuel oil in industrial furnace 1MW	Uncertainty Type	Standard Deviation 95%	General Comment
	Location				CH	CH	CH			
	Infrastructure Process				0	0	0			
	Unit				MJ	MJ	MJ			
product	district heat, at consumer, diesel cogen 1MWth, economic allocation	CH	0	MJ	1	0	0	0		
product	district heat, at consumer, diesel cogen 1MWth, allocation exergy	CH	0	MJ	0	1	0	0		
product	district heat, at consumer, light fuel oil in industrial furnace 1MW	CH	0	MJ	0	0	1	0		
technosphere	transport, district heat, average	CH	0	MJ	1.00E+0	1.00E+0	1.00E+0	1	3.05	(2,2,2,1,1,5,BU:3); ;
	heat, at cogen 1MWth, diesel, economic allocation	CH	0	MJ	1.11E+0	0	0	1	1.22	(2,2,2,1,1,5,BU:1.05); ;
	heat, at cogen 1MWth, diesel, allocation exergy	CH	0	MJ	0	1.11E+0	0	1	1.22	(2,2,2,1,1,5,BU:1.05); ;
	heat, light fuel oil, at industrial furnace 1MW	CH	0	MJ	0	0	1.11E+0	1	1.22	(2,2,2,1,1,5,BU:1.05); ;

Figure 77: Unit process raw data of district heat based on light fuel oil

		district heat, at consumer, waste from municipal waste incineration	district heat, at consumer, borehole heat pump 50kW, economic allocation
ReferenceFunction	Name	district heat, at consumer, waste from municipal waste incineration	district heat, at consumer, borehole heat pump 50kW, economic allocation
Geography	Location	CH	CH
ReferenceFunction	InfrastructureProcess	0	0
ReferenceFunction	Unit	MJ	MJ
	IncludedProcesses	Included is the infrastructure of the deliverysystem for district heat, the losses and the heat from waste incineration. The deposit of waste during the construction or usephase are included.	Included is the infrastructure of the deliverysystem for district heat, the losses and the heat from borehole heat pump 50kW. The deposit of waste during the construction or usephase are included.
	LocalName	Fernwärme, an Abnehmer, Wärme ab KVA,	Fernwärme, an Abnehmer, Erdsonden Wärmepumpe 50kW
	Synonyms	0	0
	GeneralComment	Inventory is valid for the district heat based on heat waste incineration only. Heat loss is 11% while heat transportation. Heat from waste incineration ist considered to be burden-free.	Inventory is valid for the district heat based on heat from borehole heat pump only. Heat loss is 11% while heat transportation.
	InfrastructureIncluded	1	1
	Category	waste management	heat pumps
	SubCategory	district heat	district heat
	LocalCategory	Entsorgungssysteme	Wärmepumpen
	LocalSubCategory	Fernwärme	Fernwärme
	Formula		1
	StatisticalClassification		
	CASNumber		
TimePeriod	StartDate	2018	2018
	EndDate	2020	2020
	DataValidForEntirePeriod	1	1
	OtherPeriodText	Time of publications.	Time of publications.
Geography	Text	Data apply to the supply in Switzerland.	Data apply to the supply in Switzerland.
Technology	Text	Average technology	Average technology
Representativeness	Percent		
	ProductionVolume		
	SamplingProcedure	literature	literature
	Extrapolations	none	none

Figure 78: Metadata of district heat based on heat from municipal incineration and heat pumps

	Name	Location	Infrastructure Process	Unit	district heat, at consumer, waste from municipal waste incineration	district heat, at consumer, borehole heat pump 50kW, economic allocation	Uncertainty Type	Standard Deviation 95%	General Comment
	Location				CH	CH			
	Infrastructure Process				0	0			
	Unit				MJ	MJ			
product	district heat, at consumer, waste from municipal waste incineration	CH	0	MJ	1	0	0		
product	district heat, at consumer, borehole heat pump 50kW, economic allocation	CH	0	MJ	0	1	0		
technosphere	transport, district heat, average	CH	0	MJ	1.00E+0	1.00E+0	1	3.05	(2,2,2,1,1,5,BU:3); ;
	heat, at borehole heat pump, brine-water, 50kW, CH electricity, in new building	CH	0	MJ	0	1.11E+0	1	1.22	(2,2,2,1,1,5,BU:1.05); ;
	heat from waste, at municipal waste incineration plant	CH	0	MJ	1.11E+0	0	1	1.22	(2,2,2,1,1,5,BU:1.05); ;

Figure 79: Unit process raw data of district heat based on heat from municipal incineration and heat pumps

ReferenceFunction	Name	district heat, at consumer, ground water heat pump 50kW
Geography	Location	CH
ReferenceFunction	InfrastructureProcess	0
ReferenceFunction	Unit	MJ
	IncludedProcesses	Included is the infrastructure of the deliverysystem for district heat, the losses and the heat from ground water heat pump. The deposit of waste during the construction or usephase are included.
	LocalName	Fernwärme, an Abnehmer, Wärme ab Grundwasser Wärmepumpe 50kW
	Synonyms	0
	GeneralComment	Inventory is valid for the district heat based on heat from ground water heat pump only. Heat loss is 11% while heat transportation.
	InfrastructureIncluded	1
	Category	heat pumps
	SubCategory	district heat
	LocalCategory	Wärmepumpen
	LocalSubCategory	Fernwärme
	Formula	1
	StatisticalClassification	
	CASNumber	
TimePeriod	StartDate	2018
	EndDate	2020
	DataValidForEntirePeriod	1
	OtherPeriodText	Time of publications.
Geography	Text	Data apply to the supply in Switzerland.
Technology	Text	average technology
Representativeness	Percent	
	ProductionVolume	
	SamplingProcedure	heat efficieny based on literature
	Extrapolations	none
	UncertaintyAdjustments	none

Figure 3: Metadata of district heat based on ground water heat pumps

	Name	Location	Infrastructure Process	Unit	district heat, at consumer, ground water heat pump 50kW	Uncertainty Type	Standard Deviation 95%	General Comment
	Location				CH			
	Infrastructure Process				0			
	Unit				MJ			
product	district heat, at consumer, ground water heat pump 50kW	CH	0	MJ	1	0		
technosphere	transport, district heat, average	CH	0	MJ	1.00E+0	1	3.05	(2,2,2,1,1,5,BU:3); ;
	heat, at groundwater heat pump, brine-water, 50kW, for district heating, CH electr.	CH	0	MJ	1.11E+0	1	1.22	(2,2,2,1,1,5,BU:1.05); ;

Figure 4: Unit process raw data of district heat based on based on ground water heat pumps

Name	district heat, at consumer, borehole heat pump 50kW
Location	CH
InfrastructureProcess	0
Unit	MJ
IncludedProcesses	Included is the infrastructure of the deliverysystem for district heat, the losses and the heat from borehole heat pump 50kW. The deposit of waste during the construction or usephase are included.
LocalName	Fernwärme, an Abnehmer, Wärme ab Erdsonden Wärmepumpe 50kW
Synonyms	0
GeneralComment	Inventory is valid for the district heat based on heat from borehole heat pump only. Heat loss is 11% while heat transportation.
InfrastructureIncluded	1
Category	heat pumps
SubCategory	district heat
LocalCategory	Wärmepumpen
LocalSubCategory	Fernwärme
Formula	1
StatisticalClassification	
CASNumber	
StartDate	2018
EndDate	2020
DataValidForEntirePeriod	1
OtherPeriodText	Time of publications.
Text	Data apply to the supply in Switzerland.
Text	Average technology
Percent	
ProductionVolume	
SamplingProcedure	literature
Extrapolations	none
UncertaintyAdjustments	none

Figure 5: Metadata of district heat based on borehole heat pumps

	Name	Location	Infrastructure Process	Unit	district heat, at consumer, borehole heat pump 50kW	Uncertainty Type	Standard Deviation 95%	General Comment
	Location				CH			
	Infrastructure Process				0			
	Unit				MJ			
product	district heat, at consumer, borehole heat pump 50kW	CH	0	MJ	1	0		
technosphere	transport, district heat, average	CH	0	MJ	1.00E+0	1	3.05	(2,2,2,1,1,5,BU:3); ;
	heat, at borehole heat pump, brine-water, 50kW, for district heating, CH electricity	CH	0	MJ	1.11E+0	1	1.22	(2,2,2,1,1,5,BU:1.05); ;

Figure 6: Unit process raw data of district heat based on based on borehole heat pumps

ReferenceFunction	Name	district heat, at consumer, swiss average, allocation exergy
Geography	Location	CH
ReferenceFunction	InfrastructureProcess	0
ReferenceFunction	Unit	MJ
DataSetInformation	Type	1
	Version	1.0
	energyValues	0
	LanguageCode	en
	LocalLanguageCode	de
DataEntryBy	Person	101
	QualityNetwork	1
ReferenceFunction	DataSetRelatesToProduct	1
	IncludedProcesses	Included is the infrastructure of the deliverysystem for district heat, the losses and the different energy sources. The deposit of waste during the construction or usephase are included.
	Amount	1
	LocalName	Fernwärme, an Abnehmer, Schweizer Durchschnitt, Allokation Exergie
	Synonyms	
	GeneralComment	Inventory is valid for the average district heat mix in Switzerland (2.4% light fuel oil from heating plant, 11.3% natural gas from heating plant, 11.3% natural gas from cogen, 23.0% wood in heating plant, 7.3% wood in cogen, 5.6% heat pump, 32.2% heat from municipal incineration and 6.9 % heat from nuclear power plant) including 11% of heat loss while heat transportation. For heat from cogeneration allocation exergy was used.
	InfrastructureIncluded	1
	Category	others
	SubCategory	district heat
	LocalCategory	0
	LocalSubCategory	Fernwärme
	Formula	1
	StatisticalClassification	
	CASNumber	
TimePeriod	StartDate	2018
	EndDate	2020
	DataValidForEntirePeriod	1
	OtherPeriodText	Time of publications.
Geography	Text	Data apply to the supply in Switzerland.
Technology	Text	average technology
Representativeness	Percent	
	ProductionVolume	
	SamplingProcedure	based on literature
	Extrapolations	

Figure 80: Metadata of swiss average district heat

	Name	Location	Infrastructure Process	Unit	district heat, at consumer, swiss average, allocation exergy	Uncertainty Type	Standard Deviation 95%	General Comment
	Location				CH			
	Infrastructure Process				0			
	Unit				MJ			
product	district heat, at consumer, swiss average, allocation exergy	CH	0	MJ	1	0		
product	district heat, at consumer, swiss average, economic allocation	CH	0	MJ	0	0		
technosphere	transport, district heat, average	CH	0	MJ	1.00E+0	1	3.05	(2,2,2,1,1,5,BU:3); ;
	heat, light fuel oil, at industrial furnace 1MW	CH	0	MJ	2.66E-2	1	1.22	(2,1,2,1,1,5,BU:1.05); ;
	heat, at cogen 1MWth, natural gas, allocation exergy	CH	0	MJ	1.25E-1	1	1.30	(4,1,2,1,1,5,BU:1.05); ;
	heat, natural gas, at industrial furnace 1MW	CH	0	MJ	1.25E-1	1	1.30	(4,1,2,1,1,5,BU:1.05); ;
	heat, mixed chips from forest, at furnace 1000kW	CH	0	MJ	2.56E-1	1	1.30	(4,1,2,1,1,5,BU:1.05); ;
	heat, at cogen 1MWth, wood chips, allocation exergy	CH	0	MJ	8.14E-2	1	1.30	(4,1,2,1,1,5,BU:1.05); ;
	heat, at borehole heat pump, brine-water, 50kW, CH electricity, in new building	CH	0	MJ	6.20E-2	1	1.38	(4,2,2,1,3,5,BU:1.05); ;
	heat from waste, at municipal waste incineration plant	CH	0	MJ	3.57E-1	1	1.30	(4,1,2,1,1,5,BU:1.05); ;
	heat, at nuclear power plant, allocation exergy	CH	0	MJ	7.64E-2	1	1.62	(4,1,2,1,4,5,BU:1.05); ;

Figure 81: Unit process raw data of swiss average district heat

Type	Field name, IndexNumber	777-247	777-248
ReferenceFunction	Name	heat, at nuclear power plant, allocation exergy	heat, at nuclear power plant, economic allocation
Geography	Location	CH	CH
ReferenceFunction	InfrastructureProcess	0	0
ReferenceFunction	Unit	MJ	MJ
	IncludedProcesses	Included is the demnd of materials, energy, infrastructures and transports for the production of heat at a nuclear power plant The deposit of waste during the construction or usephase are included.	Included is the demnd of materials, energy, infrastructures and transports for the production of heat at a nuclear power plant The deposit of waste during the construction or usephase are included.
	LocalName	Wärme, ab Kernkraftwerk, Allokation Exergie	Wärme, ab Kernkraftwerk, ökonomische Allokation
	Synonyms	0	0
	GeneralComment	Inventory for 1 MJ heat from nuclear power plant. In 2019, of the total energy produced were 97.8% as electricity and 2.2% as heat. The exergy factor is 1 for ectricity and 0.170 for heat. This leads to the allocation factor of 0.996 for electricity an 0.004 for heat.	Inventory for 1 MJ heat from nuclear power plant. In 2019, of the total energy produced were 97.8% as electricity and 2.2% as heat. The economic factor is 0.72 for ectricity and 0.28 for heat. This leads to the allocation factor of 0.991 for electricity an 0.009 for heat.
	InfrastructureIncluded	1	1
	Category	nuclear power	nuclear power
	SubCategory	district heat	district heat
	LocalCategory	Kernenergie	Kernenergie
	LocalSubCategory	Fernwärme	Fernwärme
	Formula		
	StatisticalClassification		
	CASNumber		
TimePeriod	StartDate	2019	2019
	EndDate	2020	2020
	DataValidForEntirePeriod	1	1
	OtherPeriodText	Time of publications.	Time of publications.
Geography	Text	Data apply to the supply in Switzerland.	Data apply to the supply in Switzerland.
Technology	Text	average technology	average technology
Representativeness	Percent		
	ProductionVolume		
	SamplingProcedure	literature	literature
	Extrapolations	none	none
	UncertaintyAdjustments	none	none

Figure 82: Metadata of heat from nuclear power plant

	Name	Location	Infrastructure Process	Unit	heat, at nuclear power plant, allocation exergy	heat, at nuclear power plant, economic allocation	Uncertainty Type	Standard Deviation 95%	General Comment
	Location				CH	CH			
	Infrastructure Process				0	0			
	Unit				MJ	MJ			
product	heat, at nuclear power plant, allocation exergy	CH	0	MJ	1	0			
	heat, at nuclear power plant, economic allocation	CH	0	MJ	0	1	0		
resource, in water	Water, river	-	-	m3	6.16E-6	1.42E-5	1	1.22	(2,2,2,1,1,5,BU:1.05); ;
technosphere	water, decarbonised, at plant	RER	0	kg	2.87E-3	6.61E-3	1	1.22	(2,2,2,1,1,5,BU:1.05); ;
	diesel, burned in diesel-electric generating set	GLO	0	MJ	3.96E-7	9.12E-7	1	1.22	(2,2,2,1,1,5,BU:1.05); ;
	lubricating oil, at plant	RER	0	kg	1.73E-9	3.99E-9	1	1.22	(2,2,2,1,1,5,BU:1.05); ;
	acetylene, at regional storehouse	CH	0	kg	3.86E-11	8.87E-11	1	1.22	(2,2,2,1,1,5,BU:1.05); ;
	anionic resin, at plant	CH	0	kg	6.89E-11	1.59E-10	1	1.22	(2,2,2,1,1,5,BU:1.05); ;
	argon, liquid, at plant	RER	0	kg	2.80E-8	6.43E-8	1	1.22	(2,2,2,1,1,5,BU:1.05); ;
	boric acid, anhydrous, powder, at plant	RER	0	kg	6.89E-11	1.59E-10	1	1.22	(2,2,2,1,1,5,BU:1.05); ;
	carbon dioxide liquid, at plant	RER	0	kg	1.79E-10	4.12E-10	1	1.22	(2,2,2,1,1,5,BU:1.05); ;
	cationic resin, at plant	CH	0	kg	6.89E-11	1.59E-10	1	1.22	(2,2,2,1,1,5,BU:1.05); ;
	cement, unspecified, at plant	CH	0	kg	9.84E-10	2.27E-9	1	1.22	(2,2,2,1,1,5,BU:1.05); ;
	chemicals inorganic, at plant	GLO	0	kg	2.51E-9	5.77E-9	1	1.22	(2,2,2,1,1,5,BU:1.05); ;
	chemicals organic, at plant	GLO	0	kg	1.48E-9	3.40E-9	1	1.22	(2,2,2,1,1,5,BU:1.05); ;
	flat glass, coated, at plant	RER	0	kg	4.68E-9	1.08E-8	1	1.22	(2,2,2,1,1,5,BU:1.05); ;
	hydrogen, liquid, at plant	RER	0	kg	1.10E-8	2.54E-8	1	1.22	(2,2,2,1,1,5,BU:1.05); ;
	nitrogen, liquid, at plant	RER	0	kg	6.61E-8	1.52E-7	1	1.22	(2,2,2,1,1,5,BU:1.05); ;
	oxygen, liquid, at plant	RER	0	kg	1.79E-8	4.12E-8	1	1.22	(2,2,2,1,1,5,BU:1.05); ;
	paper, woodfree, coated, at integrated mill	RER	0	kg	6.89E-10	1.59E-9	1	1.22	(2,2,2,1,1,5,BU:1.05); ;
	cast iron, at plant	RER	0	kg	1.38E-10	3.18E-10	1	1.22	(2,2,2,1,1,5,BU:1.05); ;
	steel, low-alloyed, at plant	RER	0	kg	1.71E-9	3.94E-9	1	1.22	(2,2,2,1,1,5,BU:1.05); ;
	reinforcing steel, at plant	RER	0	kg	5.03E-10	1.16E-9	1	1.22	(2,2,2,1,1,5,BU:1.05); ;
	concrete, normal, at plant	CH	0	m3	1.04E-11	2.40E-11	1	1.22	(2,2,2,1,1,5,BU:1.05); ;
	transport, freight, lorry 16-32 metric ton, fleet average	CH	0	tkm	2.78E-8	6.41E-8	1	2.05	(2,2,2,1,1,5,BU:2); ;
	transport, freight, lorry, fleet average	RER	0	tkm	8.27E-9	1.90E-8	1	2.05	(2,2,2,1,1,5,BU:2); ;
	bitumen, at refinery	CH	0	kg	8.26E-10	1.90E-9	1	1.22	(2,2,2,1,1,5,BU:1.05); ;
	sodium hypochlorite, 15% in H2O, at plant	RER	0	kg	1.85E-8	4.26E-8	1	1.22	(2,2,2,1,1,5,BU:1.05); ;
	nuclear power plant, pressure water reactor 1000MW	CH	1	unit	2.76E-15	6.36E-15	1	3.05	(2,2,2,1,1,5,BU:3); ;
	U enriched 4.75%, in fuel element for LWR, at nuclear fuel fabrication plant	CH	0	kg	2.32E-9	5.35E-9	1	1.22	(2,2,2,1,1,5,BU:1.05); ;
	nuclear spent fuel, in reprocessing, at plant	RER	0	kg	1.05E-9	2.43E-9	1	1.22	(2,2,2,1,1,5,BU:1.05); ;
	nuclear spent fuel, in conditioning, at plant	CH	0	kg	1.59E-9	3.65E-9	1	1.22	(2,2,2,1,1,5,BU:1.05); ;
	radioactive waste, in interim storage, for final repository LLW	CH	0	m3	1.88E-12	4.34E-12	1	1.22	(2,2,2,1,1,5,BU:1.05); ;
	radioactive waste, in interim storage conditioning	CH	0	m3	4.63E-14	1.06E-13	1	1.22	(2,2,2,1,1,5,BU:1.05); ;
	radioactive waste, in final repository for nuclear waste LLW	CH	0	m3	3.04E-11	7.00E-11	1	1.22	(2,2,2,1,1,5,BU:1.05); ;
	disposal, hazardous waste, 25% water, to hazardous waste incineration	CH	0	kg	1.04E-9	2.39E-9	1	1.22	(2,2,2,1,1,5,BU:1.05); ;
	disposal, separator sludge, 90% water, to hazardous waste incineration	CH	0	kg	2.35E-9	5.40E-9	1	1.22	(2,2,2,1,1,5,BU:1.05); ;
	disposal, used mineral oil, 10% water, to hazardous waste incineration	CH	0	kg	1.75E-9	4.02E-9	1	1.22	(2,2,2,1,1,5,BU:1.05); ;
air, low population density	Aerosols, radioactive, unspecified	-	-	kBq	5.75E-12	1.32E-11	1	3.05	(2,2,2,1,1,5,BU:3); ;
	Antimony-124	-	-	kBq	5.09E-13	1.17E-12	1	3.05	(2,2,2,1,1,5,BU:3); ;
	Barium-140	-	-	kBq	2.51E-11	5.77E-11	1	3.05	(2,2,2,1,1,5,BU:3); ;
	Carbon-14	-	-	kBq	3.39E-13	7.81E-13	1	3.05	(2,2,2,1,1,5,BU:3); ;
	Cesium-137	-	-	kBq	8.18E-6	1.88E-5	1	3.05	(2,2,2,1,1,5,BU:3); ;
	Cobalt-57	-	-	kBq	7.80E-12	1.79E-11	1	3.05	(2,2,2,1,1,5,BU:3); ;
	Cobalt-58	-	-	kBq	1.76E-11	4.04E-11	1	3.05	(2,2,2,1,1,5,BU:3); ;
	Cobalt-60	-	-	kBq	8.11E-11	1.87E-10	1	3.05	(2,2,2,1,1,5,BU:3); ;
	Heat, waste	-	-	MJ	8.19E-3	1.89E-2	1	1.22	(2,2,2,1,1,5,BU:1.05); ;
	Iodine-131	-	-	kBq	3.62E-9	8.33E-9	1	3.05	(2,2,2,1,1,5,BU:3); ;
	Iodine-133	-	-	kBq	1.95E-9	4.49E-9	1	3.05	(2,2,2,1,1,5,BU:3); ;
	Krypton-85	-	-	kBq	1.06E-5	2.43E-5	1	3.05	(2,2,2,1,1,5,BU:3); ;
	Niobium-95	-	-	kBq	1.20E-13	2.76E-13	1	3.05	(2,2,2,1,1,5,BU:3); ;
	Noble gases, radioactive, unspecified	-	-	kBq	2.77E-4	6.38E-4	1	3.05	(2,2,2,1,1,5,BU:3); ;
	Radioactive species, other beta emitters	-	-	kBq	9.29E-11	2.14E-10	1	3.05	(2,2,2,1,1,5,BU:3); ;
	Silver-110	-	-	kBq	3.35E-12	7.72E-12	1	3.05	(2,2,2,1,1,5,BU:3); ;
	Xenon-133	-	-	kBq	6.47E-4	1.49E-3	1	3.05	(2,2,2,1,1,5,BU:3); ;
	Xenon-135	-	-	kBq	1.78E-4	4.09E-4	1	3.05	(2,2,2,1,1,5,BU:3); ;
	Zirconium-95	-	-	kBq	6.19E-11	1.42E-10	1	3.05	(2,2,2,1,1,5,BU:3); ;
water, river	Antimony-122	-	-	kBq	9.68E-10	2.23E-9	1	3.05	(2,2,2,1,1,5,BU:3); ;
	Antimony-124	-	-	kBq	4.42E-8	1.02E-7	1	3.05	(2,2,2,1,1,5,BU:3); ;
	Antimony-125	-	-	kBq	4.47E-8	1.03E-7	1	3.05	(2,2,2,1,1,5,BU:3); ;
	Cerium-141	-	-	kBq	1.88E-10	4.34E-10	1	3.05	(2,2,2,1,1,5,BU:3); ;
	Cerium-144	-	-	kBq	5.16E-10	1.19E-9	1	3.05	(2,2,2,1,1,5,BU:3); ;
	Cesium-134	-	-	kBq	4.04E-9	9.29E-9	1	3.05	(2,2,2,1,1,5,BU:3); ;
	Cesium-136	-	-	kBq	3.01E-10	6.93E-10	1	3.05	(2,2,2,1,1,5,BU:3); ;
	Cesium-137	-	-	kBq	1.07E-7	2.47E-7	1	3.05	(2,2,2,1,1,5,BU:3); ;
	Chromium-51	-	-	kBq	8.10E-9	1.86E-8	1	3.05	(2,2,2,1,1,5,BU:3); ;
	Cobalt-57	-	-	kBq	9.55E-9	2.20E-8	1	3.05	(2,2,2,1,1,5,BU:3); ;
	Cobalt-58	-	-	kBq	1.22E-6	2.81E-6	1	3.05	(2,2,2,1,1,5,BU:3); ;
	Cobalt-60	-	-	kBq	4.23E-7	9.74E-7	1	3.05	(2,2,2,1,1,5,BU:3); ;
	Hydrogen-3, Tritium	-	-	kBq	1.99E-3	4.58E-3	1	3.05	(2,2,2,1,1,5,BU:3); ;
	Iodine-131	-	-	kBq	8.79E-9	2.02E-8	1	3.05	(2,2,2,1,1,5,BU:3); ;
	Iodine-133	-	-	kBq	4.46E-10	1.03E-9	1	3.05	(2,2,2,1,1,5,BU:3); ;
	Iron-59	-	-	kBq	4.50E-10	1.04E-9	1	3.05	(2,2,2,1,1,5,BU:3); ;
	Lanthanum-140	-	-	kBq	5.30E-10	1.22E-9	1	3.05	(2,2,2,1,1,5,BU:3); ;
	Manganese-54	-	-	kBq	1.40E-8	3.23E-8	1	3.05	(2,2,2,1,1,5,BU:3); ;
	Molybdenum-99	-	-	kBq	6.43E-12	1.48E-11	1	3.05	(2,2,2,1,1,5,BU:3); ;
	Niobium-95	-	-	kBq	3.29E-9	7.57E-9	1	3.05	(2,2,2,1,1,5,BU:3); ;
	Radioactive species, alpha emitters	-	-	kBq	3.23E-11	7.44E-11	1	3.05	(2,2,2,1,1,5,BU:3); ;
	Ruthenium-103	-	-	kBq	3.05E-10	7.03E-10	1	3.05	(2,2,2,1,1,5,BU:3); ;
	Silver-110	-	-	kBq	4.74E-9	1.09E-8	1	3.05	(2,2,2,1,1,5,BU:3); ;
	Sodium-24	-	-	kBq	1.07E-8	2.46E-8	1	3.05	(2,2,2,1,1,5,BU:3); ;
	Strontium-89	-	-	kBq	3.91E-9	9.00E-9	1	3.05	(2,2,2,1,1,5,BU:3); ;
	Strontium-90	-	-	kBq	1.39E-9	3.20E-9	1	3.05	(2,2,2,1,1,5,BU:3); ;
	Technetium-99m	-	-	kBq	3.01E-9	6.93E-9	1	3.05	(2,2,2,1,1,5,BU:3); ;
	Tellurium-123m	-	-	kBq	1.68E-9	3.87E-9	1	3.05	(2,2,2,1,1,5,BU:3); ;
	Tellurium-132	-	-	kBq	9.02E-11	2.08E-10	1	3.05	(2,2,2,1,1,5,BU:3); ;
	Zinc-65	-	-	kBq	2.82E-10	6.48E-10	1	3.05	(2,2,2,1,1,5,BU:3); ;
	Zirconium-95	-	-	kBq	1.61E-9	3.70E-9	1	3.05	(2,2,2,1,1,5,BU:3); ;

Figure 83: Unit process raw data of heat from nuclear power plant

ReferenceFunction	Name	district heat, at consumer, heat from nuclear power plant, allocation exergy	district heat, at consumer; heat from nuclear power plant, economic allocation
Geography	Location	CH	CH
ReferenceFunction	InfrastructureProcess	0	0
ReferenceFunction	Unit	MJ	MJ
	IncludedProcesses	Included is the infrastructure of the deliverysystem for district heat, the losses and the heat from nuclear power plant. The deposit of waste during the construction or usephase are included.	Included is the infrastructure of the deliverysystem for district heat, the losses and the heat from nuclear power plant. The deposit of waste during the construction or usephase are included.
	LocalName	Fernwärme, an Abnehmer, Wärme, ab Kernkraftwerl, Allokation Exergie	Fernwärme, an Abnehmer, Wärme, ab Kernkraftwerk, ökonomische Allokation
	Synonyms	0	0
	GeneralComment	Inventory is valid for the district heat based on heat from nuclear power plant. Heat loss is 11% while heat transportation. For heat from nucelar power plant allocation exergy was used.	Inventory is valid for the district heat based on heat from nuclear power plant. Heat loss is 11% while heat transportation. For heat from nucelar power plant economic allocation was used.
	InfrastructureIncluded	1	1
	Category	nuclear power	nuclear power
	SubCategory	district heat	district heat
	LocalCategory	Kernenergie	Kernenergie
	LocalSubCategory	Fernwärme	Fernwärme
	Formula		
	StatisticalClassification		
	CASNumber		
TimePeriod	StartDate	2019	2019
	EndDate	2020	2020
	DataValidForEntirePeriod	1	1
	OtherPeriodText	Time of publications.	Time of publications.
Geography	Text	Data apply to the supply in Switzerland.	Data apply to the supply in Switzerland.
Technology	Text	average technology	average technology
Representativeness	Percent		
	ProductionVolume		
	SamplingProcedure	heat efficieny based on literature	heat efficieny based on literature
	Extrapolations	none	none

Figure 84: Metadata of district heat based on heat from nuclear power plant

	Name	Location	Infrastructure Process	Unit	district heat, at consumer, heat from nuclear power plant, allocation exergy	district heat, at consumer; heat from nuclear power plant, economic allocation	Uncertainty Type	Standard Deviation 95%	General Comment
	Location				CH	CH			
	Infrastructure Process				0	0			
	Unit				MJ	MJ			
product	district heat, at consumer, heat from nuclear power plant, allocation exergy	CH	0	MJ	1	0			
	district heat, at consumer; heat from nuclear power plant, economic allocation	CH	0	MJ	0	1	0		
technosphere	transport, district heat, average	CH	0	MJ	1.00E+0	1.00E+0	1	3.05	(2,2,2,1,1,5,BU:3); ;
	heat, at nuclear power plant, allocation exergy	CH	0	MJ	1.11E+0	0	1	1.22	(2,2,2,1,1,5,BU:1.05); ;
	heat, at nuclear power plant, economic allocation	CH	0	MJ	0	1.11E+0	1	1.22	(2,2,2,1,1,5,BU:1.05); ;

Figure 85: Unit process raw data of district heat based on heat from nuclear power plant

2.5.6 Data quality

The data quality is generally very good. The thermal energy losses are valid for bigger district heating systems and may vary for smaller ones.
Other inputs and outputs which have not been updated during this study are normally of very low relevance for the calculated environmental impacts.

2.5.7 Life cycle impact assessment

Until now there were no district heating system inventories available.
District heating from municipal waste incineration shows the lowest impact as this heat generation is defined to be burden-free and only the transport of the heat (infrastructure) adds to the impact. Also very low are the impacts of heat from nuclear power plant because most of the impact (more than 99%) is allocated to the nuclear electricity and the heat is almost burden-free. For all other heat sources, heat from cogenerations shows lower impacts than heat from heat furnaces only.

Table 23: LCIA results of district heat inventories

Inventory name/unit	Ecological Scarcity 2013	IPCC 2013, GWP 100a	former inventory (UVEK 2018) that most closely matches the update	Ecological Scarcity 2013	IPCC 2013, GWP 100a	UBP ratio	kg CO2eq ratio
	UBP	kg CO2eq		UBP	kg CO2eq	%	%
district heat, at consumer, biomethane cogen 1MWth, allocation exergy/MJ/CH U	1.26E+01	1.71E-02	n.a.				
district heat, at consumer, biomethane cogen 1MWth, economic allocation/MJ/CH U	2.22E+01	3.15E-02	n.a.				
district heat, at consumer, biomethane in industrial furnace 1MW/MJ/CH U	3.11E+01	4.64E-02	n.a.				
district heat, at consumer, borehole heat pump 50kW, /MJ/CH U	4.20E+01	2.37E-02	n.a.				
district heat, at consumer, diesel cogen 1MWth, allocation exergy/MJ/CH U	3.45E+01	3.53E-02	n.a.				
district heat, at consumer, diesel cogen 1MWth, economic allocation/MJ/CH U	7.62E+01	7.92E-02	n.a.				
district heat, at consumer, ground water heat pump 50kW, /MJ/CH U	3.95E+01	2.14E-02	n.a.				
district heat, at consumer, heat from nuclear power plant, allocation exergy/CH U	2.48E+00	1.19E-03	n.a.				
district heat, at consumer, light fuel oil in industrial furnace 1MW/MJ/CH U	8.69E+01	1.06E-01	n.a.				
district heat, at consumer, natural gas cogen 1MWth, allocation exergy/MJ/CH U	1.88E+01	2.90E-02	n.a.				
district heat, at consumer, natural gas cogen 1MWth, economic allocation/MJ/CH U	3.39E+01	5.40E-02	n.a.				
district heat, at consumer, natural gas in industrial furnace 1MW/MJ/CH U	4.96E+01	8.18E-02	n.a.				
district heat, at consumer, swiss average, allocation exergy/MJ/CH U	2.59E+01	1.85E-02	n.a.				

Inventory name/unit	Ecological Scarcity 2013	IPCC 2013, GWP 100a	former inventory (UVEK 2018) that most closely matches the update	Ecological Scarcity 2013	IPCC 2013, GWP 100a	UBP ratio	kg CO2eq ratio
	UBP	kg CO2eq		UBP	kg CO2eq	%	%
district heat, at consumer, swiss average, economic allocation/CH U	3.40E+01	2.54E-02	n.a.				
district heat, at consumer, waste from municipal waste incineration/CH U	2.05E+00	1.17E-03	n.a.				
district heat, at consumer, wood chips cogen 1MWth, allocation exergy/MJ/CH U	2.70E+01	6.10E-03	n.a.				
district heat, at consumer, wood chips cogen 1MWth, economic allocation/MJ/CH U	3.61E+01	7.89E-03	n.a.				
district heat, at consumer, wood chips in industrial furnace 1MW/MJ/CH U	5.08E+01	7.20E-03	n.a.				
district heat, at consumer; heat from nuclear power plant, economic allocation/CH U	3.02E+00	1.21E-03	n.a.				
transport, district heat, average/MJ/CH U	2.05E+00	1.17E-03	n.a.				

2.5.8 Outlook

The LCIA of the different district heating systems show large differences for the datasets. The impact depends very much on the district heating composition. Therefore, we recommend to provide inventories for the larger known district heating systems in Switzerland. Furthermore, additional district heating sources such as heat form various heat pump systems could be added.

2.6 Cogeneration systems

Combined heat and power generation is the term used to describe processes in which the heat produced during electricity generation is used as process heat or heat for building heat. In these plants, combustion engines or gas turbines operate a generator. The main energy sources used are natural gas, light fuel heating oil, heavy fuel oil, wood, sewage gas, biogas or liquid gas. The electricity is consumed by the operator or fed into the public grid.

Different technologies and different performance classes are considered. The performance classes considered here range from 15kWth ($5kW_{el}$ resp.) to 5 MW_{th} ($5MW_{el}$ resp).
The systems under consideration are models which were offered on the market around the year 2015-2020.

The following inventories were created/updated:

Energy – per MJ burned

- Natural gas, burned in cogen 15kWth/CH
- Natural gas, burned in cogen 50kWth/CH
- Natural gas, burned in cogen 300kWth/CH
- Natural gas, burned in cogen 1MWth/CH
- Biomethane, burned in cogen 15kWth/CH
- Biomethane, burned in cogen 50kWth/CH
- Biomethane, burned in cogen 300kWth/CH
- Biomethane, burned in cogen 1MWth/CH
- Diesel, burned in cogen 15kWth/CH
- Diesel, burned in cogen 50kWth/CH
- Diesel, burned in cogen 300kWth/CH
- Diesel, burned in cogen 1MWth/CH
- Pellets, burned in cogen 50kWth/CH
- Pellets, burned in cogen 300kWth/CH
- Wood chips, burned in cogen 300kWth/CH
- Wood chips, burned in cogen 1MWth/CH

Energy – heat and electricity

- Heat, at cogen 15kWth, natural gas, allocation exergy
- Heat, at cogen 15kWth, natural gas, economic allocation
- Electricity, at cogen 15kWth, natural gas, allocation exergy
- Electricity, at cogen 15kWth, natural gas, economic allocation
- The same heat and electricity inventories were also created for all other inventories listed under Energy – per MJ burned

2.6.1 Infrastructure

For the infrastructure of the various CHP plants, no updated data was found. No useful data could be collected with the budget limitations of this project. Therefore the infrastructure processes were taken over from Hecks (2004) for the natural gas and diesel CHP plants. For the wood CHP plants, data were taken over from Bauer (2007).

2.6.2 Inputs for operation of cogen units

The following three tables list the considered inputs for the operation of the different cogeneration units as described in Hecks (2004) and Bauer (2007).

Table 24: Inputs for operation of natural gas cogeneration units per MJ Energy input

Category	Natural gas, burned in cogeneration plant				
	15kWth	**50kWth**	**300kWth**	**1MW**	**Source**
Natural gas in MJ	1	1	1	1	Heck 2004
Lubrication oil in kg	3.00E-05	3E-05	3E-05	3E-05	Heck 2004
Mini CHP, common components	1.39E-07	0	0	0	Heck 2004
Cogen unit 50kWe CHP, common components		1.67E-08	0	0	Heck 2004
Cogen unit 200kWe CHP, common components			4.5801E-09	0	Heck 2004
Cogen unit 1MWe CHP, common components			0	1.06E-09	Heck 2004
Mini CHP, components for electricity	4.96E-07	0	0	0	Heck 2004
Cogen unit 50kWe CHP, components for electricity	0.00E+00	4.6389E-08	0	0	Heck 2004
Cogen unit 200kWe CHP, components for electricity	0.00E+00	0	1.1743E-08	0	Heck 2004
Cogen unit 1MWe CHP, components for electricity	0.00E+00	0	0	2.3043E-09	Heck 2004
Mini CHP, components for heat	1.93E-07	0	0	0	Heck 2004
Cogen unit 50kWe CHP, components for heat	0.00E+00	2.6094E-08	0	0	Heck 2004
Cogen unit 200kWe CHP, components for heat	0.00E+00	0	7.5082E-09	0	Heck 2004
Cogen unit 1MWe CHP, components for heat	0.00E+00	0	0	1.963E-09	Heck 2004

Table 25: Inputs for operation of the diesel cogeneration units per MJ Energy input

Category	Diesel, burned in cogeneration plant				
	15kWth	**50kWth**	**300kWth**	**1MW**	**Source**
Diesel in kg	0.02340027	0.02340027	0.02340027	0.02340027	Heck 2004
Lubrication oil in kg	3.00E-05	3E-05	3E-05	3E-05	Heck 2004
Urea, as kg N	0.0008	0.0008	0.0008	0.0008	Heck 2004
Cogen unit 200kWe CHP, common components	5.42E-09	5.42E-09	5.42E-09	5.42E-09	Heck 2004

Cogen unit 200kWe CHP, components for electricity	6.38E-09	6.38E-09	6.38E-09	6.38E-09	Heck 2004
Cogen unit 200kWe CHP, components for heat	1.04E-08	1.04E-08	1.04E-08	1.04E-08	Heck 2004

Table 26: Inputs for operation of the wood cogeneration units per MJ Energy input

	Wood, burned in cogeneration plant				
Category	**15kWth**	**50kWth**	**300kWth**	**1MW**	**Source**
Wood chips/pellets in kg	7.25E-2	7.25E-2	8.55E-02	8.55E-02	(Bauer, 2007)
Lubrication oil in kg	4.65E-06	4.65E-06	4.65E-06	4.65E-06	(Bauer, 2007)
Ammonia, liquid, in kg N	1.17E-08	1.17E-08	1.17E-08	1.17E-08	(Bauer, 2007)
Chemicals organic, at plant/GLO U	8.15E-06	8.15E-06	8.15E-06	8.15E-06	(Bauer, 2007)
Chlorine, liquid, production mix, at plant/RER U	4.65E-07	4.65E-07	4.65E-07	4.65E-07	(Bauer, 2007)
Sodium chloride, powder, at plant/RER U	5.82E-06	5.82E-06	5.82E-06	5.82E-06	(Bauer, 2007)
Water, decarbonized, at plant/RER U	1.12E-03	1.12E-03	1.12E-03	1.12E-03	(Bauer, 2007)
transport, freight, lorry 16-32, in tkm	5.88E-03	5.88E-03	5.88E-03	5.88E-03	(Bauer, 2007)
Cogen unit ORC 1400kWth, wood burning, common components for heat+electricity/CH/I U	1.82E-09	1.82E-09	1.82E-09	1.82E-09	(Bauer, 2007)*
Cogen unit ORC 1400kWth, wood burning, building/CH/I U	4.54E-10	4.54E-10	4.54E-10	4.54E-10	(Bauer, 2007)*
Cogen unit ORC 1400kWth, wood burning, components for electricity only/CH/I U	4.54E-08	4.54E-08	4.54E-08	4.54E-08	(Bauer, 2007)*

*There was only the 1.4MWth wooden cogeneration unit available as infrastructure. It was assumed, that the needed infrastructure per MJ energy burned in a wooden cogeneration unit remains constant independently of the energetic performance

2.6.3 Energy efficiency

Table 27 shows the electrical and thermal utilisation rates of cogen units for different size categories. Data for the natural gas and light fuel cogeneration plants were taken from (ASUE, 2018), that maintains a database with the technical data for many current cogeneration plants. For wood cogeneration plants 50kWth and 300kWth technical data sheets for wood cogeneration plants were used (TDS wood cogen, 2020). For the 1MWth wood cogeneration plant data for a wood gasification plant type was used based on Paschotta R. (2023) For the diesel cogeneration plant 300kWth no thermal efficiency factor could be found. Following the efficiency curve in correlation to the size of the gas and wood cogeneration plants, this factor was assumed to be 47%.

Table 27: average energy efficiencies of the different cogeneration plants

Category	nel	nth	ntot	Source
Cogeneration plant, 15kWth, natural gas	26%	67%	93%	(ASUE, 2018)
Cogeneration plant, 50Wth, natural gas	29%	62%	92%	(ASUE, 2018)
Cogeneration plant, 300Wth, natural gas	38%	49%	87%	(ASUE, 2018)
Cogeneration plant, 1MWth, natural gas	41%	47%	88%	(ASUE, 2018)
Cogeneration plant, 15kWth, diesel	30%	60%	91%	(ASUE, 2018)
Cogeneration plant, 50kWth, diesel	34%	53%	87%	(ASUE, 2018)
Cogeneration plant, 300kWth, diesel	39%	47%	86%	(ASUE, 2018) nth based on own assumption
Cogeneration plant, 1MWth, diesel	44%	42%	86%	(ASUE, 2018)
Cogeneration plant, 50kWth, wood pellets	26%	65%	91%	(TDS wood cogen, 2020)
Cogeneration plant, 300kWth, wood pellets	30%	54%	84%	(TDS wood cogen, 2020)
Cogeneration plant, 300kWth, wood chips	30%	54%	84%	(TDS wood cogen, 2020)
Cogeneration plant, 1MWth, wood chips	35%	45%	80%	Paschotta, R. (2023)

2.6.4 Allocation factors

In the case of combined heat and power generation, expenditure and emissions must be divided between the two products heat and electricity. The allocation of expenditures and environmental impacts to products and by-products is done in three stages. First, the clearly allocable expenditures (e.g. heat distribution in the case of combined heat and power generation) are directly assigned. At the same time, the clearly quantifiable shares are also passed on to the individual products. The remaining expenses and environmental impacts of a process are then to be allocated to the products on the basis of physical, chemical or biological causalities (not parameters).

The following allocation variants come into consideration here:

- by energy content: The allocation of inputs and emissions by energy content of the products can be used in the analysis of energy chains. However, there is no direct connection between energy content and environmental pollution. Furthermore, the demand situation is not considered here either.
- according to exergy content: In energy systems which convert energy sources into energy of different values (e.g. combined heat and power generation), the exergy share of the final energy sources can be used as a key for the allocation. In this way, the higher-value energy form (electricity) per kWh is assigned a higher environmental impact than the waste heat used. This reflects the fact that one kWh of electricity can provide two to three times the amount of useful heat from ambient heat at ambient temperature. Increased use of waste heat reduces the electricity supply, which consequently leads to a reduction in the

environmental impact assigned to the electricity. The demand situation is not taken into account here either.

- according to product prices: The product prices serve as an indicator of demand. This allocation method considers the driving forces why something is produced
- no allocation: the environmental impact is allocated entirely to the main product. This approach can be taken if the by-products can also be declared as waste or by-products. Otherwise, this method should only be used if the data situation is poor.
- Convention: The allocation can be made according to conventions. This procedure can be used, for example, in the absence of market economy conditions instead of allocation according to product prices.

In this study, only inventories regarding economic allocation and allocation to exergy content were created.

The following assumptions are made for the exergy allocation:
For the upper temperature, the thermodynamic mean temperature of the flow temperature TV and return temperature TR is used. The thermodynamic mean temperature can then be calculated approximately as follows (Baehr 2000, Ménard et al. 1999):

$$T_m = (T_V - T_R)/2$$

For calculation purposes, the temperatures are to be used in Kelvin (degrees Kelvin = degrees Celsius + 273.15). As lower temperature or ambient temperature Tu: 20 °C (= usable temperature) is assumed. This results in the exergy factor for heat

$$w_{ex,th} = (T_m - T_u)/T_m$$

whereby the temperatures are to be taken again in degrees Kelvin for the calculation. The exergy factor gate for electricity is

$$w_{ex,el} = 1$$

Assumptions for temperature values based on technical datasheets (Hecks, 2004; TDS gas and oil cogen, 2020):

- CHP 15kWth units: heating water temperatures = 60/75 °C
- CHP 50kWth heating water temperatures = 70/85 °C
- CHP 300kWth: heating water temperatures = 70/85 °C.
- CHP 1MWth: heating water temperatures = 70/90 °C

The exergetic efficiency (or exergetic utilisation factor) is calculated from the electrical and thermal efficiencies (or utilisation factors) by weighting them with the exergetic factors:

$$\text{Exergetic efficiency} = w_{ex,el}\eta_{el} + w_{ex,th}\eta_{th}$$

For economic allocation, prices for electricity and heat were determined based on average prices for 2019 and 2020 (HEV, 2020). For district heating the average price of natural gas was used as a proxy.

Table 28: average price for electricity and heat sources for Switzerland

Category	electricity	Natural gas	Light fuel oil	Wood (pellets)
CHF/MWh	244	96	86	74

Table 29: Relevant parameters for allocation exergy and economic allocation

	Natural gas				**Diesel**				Wood		
	15kWth	50kWth	300kWth	1MWth	15kWth	50kWth	300kWth	1MWth	50kWth	300kWth	1MWth
Efficiency											
Electricity	25.9%	29.4%	37.5%	40.5%	30.2%	34.1%	38.6%	44.3%	26.4%	30.0%	35.0%
Heat	66.7%	62.3%	49.0%	47.3%	60.5%	52.7%	47.0%	41.6%	64.6%	54.3%	45.0%
Total	92.6%	91.6%	86.6%	87.8%	90.7%	86.8%	85.6%	85.9%	91.0%	84.3%	80.0%
max. flow temperature	75	85	90	90	75	85	85	90	85	85	90
ma.x return temperature	60	70	70	70	60	70	70	70	70	70	70
Thermodynamic average	67.5	77.5	80	80	67.5	77.5	77.5	80	77.5	77.5	80
Ambient temperature	20	20	20	20	21	22	23	24	26	26	26
Exergy factor											
Electricity	1	1	1	1	1	1	1	1	1	1	1
Heat	0.139	0.164	0.170	0.170	0.139	0.164	0.164	0.170	0.164	0.164	0.170
Price CHF/MWH											
Electricity	244	244	244	244	244	244	244	244	244	244	244
Heat	96	96	96	96	88	88	88	88	74	74	74
Price normalised											
Electricity	0.72	0.72	0.72	0.72	0.74	0.74	0.74	0.74	0.77	0.77	0.77
Heat	0.28	0.28	0.28	0.28	0.26	0.26	0.26	0.26	0.23	0.23	0.23
Allocation factor											
Exergy: electricity	0.736	0.742	0.818	0.835	0.782	0.798	0.833	0.862	0.714	0.771	0.821
Exergy: heat	0.264	0.258	0.182	0.165	0.218	0.202	0.167	0.138	0.286	0.229	0.179
economic: electricity	0.497	0.545	0.661	0.686	0.582	0.643	0.696	0.748	0.575	0.647	0.720
economic: heat	0.503	0.455	0.339	0.314	0.418	0.357	0.304	0.252	0.425	0.353	0.280

2.6.5 Emissions to air

In the case of cogeneration units, the achievable efficiency depends on the emission limits that must be adhered to. If the engine is adjusted so that NOx emissions are reduced, the efficiency also decreases. This is a trade-off between emissions and efficiency. Therefore, the companies usually give the performance values for the respective emission limits. Therefore for NOx and CO emissions the emission limits of the LRV (Luftreinhalteverordnung) was used for the gas and diesel cogeneration units and data from (Federal Office for the Environment (FOEN), 2020) was used for the wood cogeneration units. For all other emissions it was assumed that they are similar to the emissions of the respective natural gas and oil heating systems.

Table 30: emissions in kg per MJ natural gas burned in the different cogeneration units

	15kWth	50kWth	300kWth	1MWth	source
Acetaldehyde	1.00E-09	1.00E-09	1.00E-09	1.00E-09	Faist Emmenegger et al. 2007
Acetic acid	1.50E-07	1.50E-07	1.50E-07	1.50E-07	Faist Emmenegger et al. 2007
Ammonia	1.00E-09	1.00E-09	1.00E-09	1.00E-09	Faist Emmenegger et al. 2007
Benzene	4.00E-07	4.00E-07	4.00E-07	4.00E-07	Faist Emmenegger et al. 2007
Benzo(a)pyrene	5.60E-13	5.60E-13	5.60E-13	5.60E-13	FOEN 2020
Butane	7.00E-07	7.00E-07	7.00E-07	7.00E-07	Faist Emmenegger et al. 2007
Cadmium	2.50E-13	2.50E-13	2.50E-13	2.50E-13	FOEN 2020
Carbon dioxide, fossil	5.60E-02	5.60E-02	5.60E-02	5.60E-02	FOEN 2020
Carbon monoxide, fossil	1.04E-04	1.04E-04	9.60E-05	9.60E-05	TDS gas and oil cogen 2020
Dinitrogen monoxide	3.83E-08	3.83E-08	3.83E-08	3.83E-08	FOEN 2020
Dioxin, 2,3,7,8 Tetrachlorodibenzo-p-	3.00E-17	3.00E-17	3.00E-17	3.00E-17	Faist Emmenegger et al. 2007
Formaldehyde	1.00E-07	1.00E-07	1.00E-07	1.00E-07	Faist Emmenegger et al. 2007
Heat, waste	1.08E+00	1.07E+00	1.08E+00	9.80E-01	TDS gas and oil cogen 2020
Lead	1.50E-12	1.50E-12	1.50E-12	1.50E-12	FOEN 2020
Mercury	1.00E-10	1.00E-10	1.00E-10	1.00E-10	FOEN 2020
Methane, fossil	8.00E-05	8.00E-05	8.00E-05	8.00E-05	Hecks 2004
Nitrogen oxides	4.00E-05	4.00E-05	4.80E-05	3.20E-05	TDS gas and oil cogen 2020
PAH, polycyclic aromatic hydrocarbons	1.00E-08	1.00E-08	1.00E-08	1.00E-08	Faist Emmenegger et al. 2007
Particulates, < 2.5 um	1.00E-07	1.00E-07	1.00E-07	1.00E-07	FOEN 2020
Pentane	1.20E-06	1.20E-06	1.20E-06	1.20E-06	Faist Emmenegger et al. 2007
Propane	2.00E-07	2.00E-07	2.00E-07	2.00E-07	Faist Emmenegger et al. 2007
Propionic acid	2.00E-08	2.00E-08	2.00E-08	2.00E-08	Faist Emmenegger et al. 2007
Sulfur dioxide	5.00E-07	5.00E-07	5.00E-07	5.00E-07	FOEN 2020
Toluene	2.00E-07	2.00E-07	2.00E-07	2.00E-07	Faist Emmenegger et al. 2007

Table 31: emissions in kg per MJ diesel burned in the different cogeneration units

	15kWth	50kWth	300kWth	1MWth	source
Acetaldehyde	1.40E-07	1.40E-07	1.40E-07	4.67E-08	Jungluth 2018
Acetic acid	1.40E-07	1.40E-07	1.40E-07	4.67E-08	Jungluth 2018
acetone	3.50E-07	3.50E-07	3.50E-07	1.17E-07	Jungluth 2018
acroelin	1.15E-08	1.15E-08	1.15E-08	1.15E-08	Jungluth 2018
Aldehydes, unspecified	3.50E-07	3.50E-07	3.50E-07	1.17E-07	Jungluth 2018
Ammonia	9.60E-05	9.60E-05	9.60E-05	9.60E-05	Assumption: LRV
benzaldehyde	6.00E-09	6.00E-09	6.00E-09	6.00E-09	Jungluth 2018
Benzene	6.40E-06	6.40E-06	6.40E-06	6.40E-06	Jungluth 2018
Benzoapyren	2.50E-11	2.50E-11	2.50E-11	2.50E-11	Jungluth 2018
Butane	1.05E-06	1.05E-06	1.05E-06	3.50E-07	Jungluth 2018
Cadmium	5.10E-10	5.10E-10	5.10E-10	5.10E-10	Jungluth 2018
Carbon dioxide, fossil	7.37E-02	7.37E-02	7.37E-02	7.37E-02	FOEN 2020
Carbon monoxide, fossil	2.08E-04	2.08E-04	9.60E-05	9.60E-05	Assumption: LRV
copper	4.00E-10	4.00E-10	4.00E-10	6.99E-10	Jungluth 2018
Dinitrogen monoxide	3.83E-08	3.83E-08	3.83E-08	3.83E-08	FOEN 2020
Dioxin, 2,3,7,8 ...	5.70E-17	5.70E-17	5.70E-17	4.50E-16	Jungluth 2018
Ethane	1.40E-07	1.40E-07	1.40E-07	4.46E-08	Jungluth 2018
Ethanol	7.00E-08	7.00E-08	7.00E-08	2.33E-08	Jungluth 2018
ethyne	1.00E-08	1.00E-08	1.00E-08	1.00E-08	Jungluth 2018
Etyhlene diamine	3.50E-07	3.50E-07	3.50E-07	1.17E-07	Jungluth 2018
Fomraldehyde	6.40E-05	6.40E-05	6.40E-05	6.40E-05	Assumption: LRV
Heat, waste	1.08E+00	1.08E+00	1.08E+00	1.08E+00	Jungluth 2018
hydrocarbons, aliphatic, alkanes, unspecified	1.75E-06	1.75E-06	1.75E-06	5.83E-07	Jungluth 2018
Hydrocarbons, aromatic	1.19E-07	1.19E-07	1.19E-07	3.97E-08	Jungluth 2018
hydrogen chloride	9.40E-08	9.40E-08	9.40E-08	9.40E-08	Jungluth 2018
hydrogen fluoride	4.50E-09	4.50E-09	4.50E-09	9.00E-09	Jungluth 2018
Lead	1.17E-07	1.17E-07	1.17E-07	1.17E-07	Jungluth 2018
mercury	4.66E-10	4.66E-10	4.66E-10	4.66E-10	Jungluth 2018
Methane, fossil	1.19999E-05	1.19999E-05	1.20E-05	1.19999E-05	Hecks 2004
Nickel	1.17E-07	1.17E-07	1.17E-07	1.17E-07	Jungluth 2018
nitrate	8.10E-11	8.10E-11	8.10E-11	8.10E-11	Jungluth 2018
Nitrogen oxides	1.28E-04	1.28E-04	8.00E-05	8.00E-05	Assumption: LRV
PAH	4.60E-10	4.60E-10	4.60E-10	5.80E-10	Jungluth 2018
Particulates, < 2.5 um	1.60E-06	1.60E-06	1.60E-06	1.60E-06	FOEN 2020
Pentane	7.00E-07	7.00E-07	7.00E-07	2.33E-07	Jungluth 2018

	15kWth	50kWth	300kWth	1MWth	source
Platinum	1.28E-04	1.28E-04	1.08E+00	8.00E-05	Hecks 2004
potassium	7.90E-10	7.90E-10	7.90E-10	7.90E-10	Jungluth 2018
propanal	6.00E-09	6.00E-09	6.00E-09	6.00E-09	Jungluth 2018
Propane	2.10E-07	2.10E-07	2.10E-07	7.00E-08	Jungluth 2018
propene	2.00E-08	2.00E-08	2.00E-08	2.00E-08	Jungluth 2018
Propionic acid	1.40E-07	1.40E-07	1.40E-07	4.67E-08	Jungluth 2018
Propylene oxide	1.40E-07	1.40E-07	1.40E-07	4.67E-08	Jungluth 2018
Sulfur dioxide	5.00E-07	5.00E-07	5.00E-07	5.00E-07	FOEN 2020
Toluene	9.87E-08	9.87E-08	9.87E-08	3.29E-08	Jungluth 2018
Zinc	5.00E-10	5.00E-10	5.00E-10	1.56E-10	Jungluth 2018

Table 32: emissions in kg per MJ wood burned in the different cogeneration units

	50kw pellets	300kw pellets	300kw chips	1MW chips	source
Acetaldehyde	6.10E-08	6.10E-08	6.10E-08	6.10E-08	Bauer 2007
Ammonia	5.00E-06	5.00E-06	5.00E-06	5.00E-06	FOEN 2020
Arsenic	1.00E-09	1.00E-09	1.00E-09	1.00E-09	Bauer 2007
Benzene	9.10E-07	9.10E-07	9.10E-07	9.10E-07	Bauer 2007
Benzene, ethyl-	3.00E-08	3.00E-08	3.00E-08	3.00E-08	Bauer 2007
Benzene, hexachloro-	1.00E-12	1.00E-12	1.00E-12	1.00E-12	FOEN 2020
Benzo(a)pyrene	9.10E-10	9.10E-10	9.10E-10	9.10E-10	FOEN 2020
Bromine	6.00E-08	6.00E-08	6.00E-08	6.00E-08	Bauer 2007
Cadmium	1.30E-08	1.30E-08	1.30E-08	1.30E-08	FOEN 2020
Calcium	5.85E-06	5.85E-06	5.85E-06	5.85E-06	Bauer 2007
Carbon dioxide, biogenic	9.20E-02	9.20E-02	9.20E-02	9.20E-02	Bauer 2007
Carbon monoxide, biogenic	9.00E-05	9.00E-05	9.00E-05	9.00E-05	FOEN 2020
Chlorine	1.80E-07	1.80E-07	1.80E-07	1.80E-07	Bauer 2007
Chromium	3.96E-09	3.96E-09	3.96E-09	3.96E-09	Bauer 2007
Chromium VI	4.00E-11	4.00E-11	4.00E-11	4.00E-11	Bauer 2007
Copper	2.20E-08	2.20E-08	2.20E-08	2.20E-08	Bauer 2007
Dinitrogen monoxide	2.50E-06	2.50E-06	2.50E-06	2.30E-06	Bauer 2007
Dioxin, 2,3,7,8 Tetrachlorodibenzo-p-	4.50E-14	4.50E-14	4.50E-14	4.50E-14	FOEN 2020
Fluorine	5.00E-08	5.00E-08	5.00E-08	5.00E-08	Bauer 2007
Formaldehyde	6.40E-06	6.40E-06	6.40E-06	6.40E-06	Bauer 2007
Heat, waste	1.08E+00	1.08E+00	1.08E+00	1.08E+00	Bauer 2007
Hydrocarbons, aliphatic, alkanes, unspecified	9.10E-07	9.10E-07	9.10E-07	9.10E-07	Bauer 2007

	50kw pellets	300kw pellets	300kw chips	1MW chips	source
Hydrocarbons, aliphatic, unsaturated	3.10E-06	3.10E-06	3.10E-06	3.10E-06	FOEN 2020
Lead	2.70E-08	2.70E-08	2.70E-08	2.70E-08	FOEN 2020
Magnesium	3.60E-07	3.60E-07	3.60E-07	3.60E-07	Bauer 2007
Manganese	1.70E-07	1.70E-07	1.70E-07	1.70E-07	Bauer 2007
Mercury	6.00E-10	6.00E-10	6.00E-10	6.00E-10	FOEN 2020
Methane, biogenic	2.72E-06	2.00E-06	6.34E-06	4.00E-06	Bauer 2007
m-Xylene	1.20E-07	1.20E-07	1.20E-07	1.20E-07	Bauer 2007
Nickel	6.00E-09	6.00E-09	6.00E-09	6.00E-09	Bauer 2007
Nitrogen oxides	1.16E-04	1.16E-04	1.16E-04	1.16E-04	FOEN 2020
NMVOC, non-methane volatile organic compounds, unspecified origin	2.00E-06	2.00E-06	2.00E-06	2.00E-06	FOEN 2020
PAH, polycyclic aromatic hydrocarbons	1.11E-08	1.11E-08	1.11E-08	1.11E-08	Bauer 2007
Particulates, < 2.5 um	1.00E-05	1.00E-05	1.00E-05	1.00E-05	FOEN 2020
Phenol, pentachloro-	8.10E-12	8.10E-12	8.10E-12	8.10E-12	Bauer 2007
Phosphorus	3.00E-07	3.00E-07	3.00E-07	3.00E-07	Bauer 2007
Potassium	2.34E-05	2.34E-05	2.34E-05	2.34E-05	Bauer 2007
Sodium	1.30E-06	1.30E-06	1.30E-06	1.30E-06	Bauer 2007
Sulfur dioxide	1.00E-05	1.00E-05	1.00E-05	1.00E-05	FOEN 2020
Toluene	3.00E-07	3.00E-07	3.00E-07	3.00E-07	Bauer 2007
Zinc	3.00E-07	3.00E-07	3.00E-07	3.00E-07	Bauer 2007

2.6.6 Waste to treatment

While gas and diesel CHP do not produce any significant residues, wood heating systems generate ashes which must be disposed of. The ashes are 1% of the dry wood mass. Since 2008, ashes from wood heating systems are not listed as agricultural fertilisers anymore (SR 916.171). The disposal of wood ashes in the forest is prohibited (ChemRRV). Therefore this disposal route was not considered anymore. It is assumed that 50 % of this is landfilled and 50 % is burned in the MSW incinerator. For the 50kWth pellets CHP it is assumed that 100 % of the ashes is burned in the MWS.

Table 33: disposal in kg per MJ wood burned in the different cogeneration units

	50kw pellets	300kw pellets	300kw chips	1MW chips	source
Wood ash, to incineration	0.000272	0.000133	0.00012	0.00028	Bauer 2007 and own assumptions
Wood ash, to landfill	0	0.000133	0.00012	0.00014	Bauer 2007 and own assumptions

2.6.7 Summary of life cycle inventory data

In this chapter the life cycle inventories for the newly modelled and updated processes are presented. All data are provided as unit process raw data in the EcoSpold v1 format (unit process in SimaPro). The electronic data is including full EcoSpold v1 documentation.
For each investigated process, two types of tables (X-Process and X-Exchange) are provided in this report.

ReferenceFunction	Name	natural gas, burned in cogen 15kWth	natural gas, burned in cogen 50kWth	natural gas, burned in cogen 300kWth	natural gas, burned in cogen 1MWth
Geography	Location	CH	CH	CH	CH
ReferenceFunction	InfrastructureProcess	0	0	0	0
ReferenceFunction	Unit	MJ	MJ	MJ	MJ
	IncludedProcesses	The module includes fuel input from (CH) network, infrastructure (cogeneration plant), emissions to air and water, and electricity needed for operation.	The module includes fuel input from (CH) network, infrastructure (cogeneration plant), emissions to air and water, and electricity needed for operation.	The module includes fuel input from (CH) network, infrastructure (cogeneration plant), emissions to air and water, and electricity needed for operation.	The module includes fuel input from (CH) network, infrastructure (cogeneration plant), emissions to air and water, and electricity needed for operation.
	LocalName	Erdgas, in BHkWth 15kWth	Erdgas, in BHkWth 50kWth	Erdgas, in BHkWth 300kWth	Erdgas, in BHkWth 1MWth
	Synonyms	0	0	0	0
	GeneralComment	Inventory for 1 MJ natural gas (Hu), burned in a cogeneration plant with a capacity of 15 kWth. This inventory reflects the unallocated process of burning natural gas in a cogen unit with all necessary inputs and emissions. Efficiency of the cogen unit as well allocation is not yet considered	Inventory for 1 MJ natural gas (Hu), burned in a cogeneration plant with a capacity of 50 kWth. This inventory reflects the unallocated process of burning natural gas in a cogen unit with all necessary inputs and emissions. Efficiency of the cogen unit as well allocation is not yet considered	Inventory for 1 MJ natural gas (Hu), burned in a cogeneration plant with a capacity of 300 kWth. This inventory reflects the unallocated process of burning natural gas in a cogen unit with all necessary inputs and emissions. Efficiency of the cogen unit as well allocation is not yet considered	Inventory for 1 MJ natural gas (Hu), burned in a cogeneration plant with a capacity of 1 MWth. This inventory reflects the unallocated process of burning natural gas in a cogen unit with all necessary inputs and emissions. Efficiency of the cogen unit as well allocation is not yet considered
	InfrastructureIncluded	1	1	1	1
	Category	natural gas	natural gas	natural gas	natural gas
	SubCategory	cogeneration	cogeneration	cogeneration	cogeneration
	LocalCategory	Erdgas	Erdgas	Erdgas	Erdgas
	LocalSubCategory	Wärmekraftkopplung (WKK)	Wärmekraftkopplung (WKK)	Wärmekraftkopplung (WKK)	Wärmekraftkopplung (WKK)
	Formula				
	StatisticalClassification				
	CASNumber				
TimePeriod	StartDate	2015	2015	2015	2015
	EndDate	2020	2020	2020	2020
	DataValidForEntirePeriod	1	1	1	1
	OtherPeriodText	Time of publications.	Time of publications.	Time of publications.	Time of publications.
Geography	Text	Data apply to the combustion in Switzerland.	Data apply to the combustion in Switzerland.	Data apply to the combustion in Switzerland.	Data apply to the combustion in Switzerland.
Technology	Text	Average technology available on the market	Average technology available on the market	Average technology available on the market	Average technology available on the market
Representativeness	Percent				
	ProductionVolume				
	SamplingProcedure	based on literature	based on literature	based on literature	based on literature
	Extrapolations	Some emissions are extrapolated from natural gas, burned in boiler 15kW	Some emissions are extrapolated from natural gas, burned in boiler 50kW	Some emissions are extrapolated from natural gas, burned in boiler 300kW	Some emissions are extrapolated from natural gas, burned in industrial furnace 1MW

Figure 86: Metadata of natural gas, burned in cogen

	Name	Location	Infrastructure Process	Unit	natural gas, burned in cogen 15kWth	natural gas, burned in cogen 50kWth	natural gas, burned in cogen 300kWth	natural gas, burned in cogen 1MWth	Uncertainty Type	Standard Deviation 95%	General Comment
	Location				CH	CH	CH	CH			
	Infrastructure Process				0	0	0	0			
	Unit				MJ	MJ	MJ	MJ			
product	natural gas, burned in cogen 15kWth	CH	0	MJ	1	0	0	0			
	natural gas, burned in cogen 50kWth	CH	0	MJ	0	1	0	0			
	natural gas, burned in cogen 300kWth	CH	0	MJ	0	0	1	0			
	natural gas, burned in cogen 1MWth	CH	0	MJ	0	0	0	1	0		
technosphere	natural gas, low pressure, at	CH	0	MJ	1.00E+0	1.00E+0	1.00E+0	1.00E+0	1	1.22	(1,3,2,1,1,5,BU:1.05); ;
	Mini CHP plant, common components	CH	1	unit	1.39E-7	0	0	0	1	3.05	(1,3,2,1,1,5,BU:3); ;
	cogen unit 50kWe, common components	RER	1	unit		1.67E-8	0	0	1	3.05	(1,3,2,1,1,5,BU:3); ;
	cogen unit 200kWe, common components	RER	1	unit			4.58E-9	0	1	3.05	(1,3,2,1,1,5,BU:3); ;
	cogen unit 1MWe, common components	RER	1	unit			0	1.06E-9	1	3.05	(1,3,2,1,1,5,BU:3); ;
	lubricating oil, at plant	RER	0	kg	3.00E-5	3.00E-5	3.00E-5	3.00E-5	1	1.22	(1,3,2,1,1,5,BU:1.05); ;
	Mini CHP plant, components for	CH	1	unit	4.96E-7	0	0	0	1	3.05	(1,3,2,1,1,5,BU:3); ;
	cogen unit 50kWe, components for	RER	1	unit	0	4.64E-8	0	0	1	3.05	(1,3,2,1,1,5,BU:3); ;
	cogen unit 200kWe, components for electricity only	RER	1	unit	0	0	1.17E-8	0	1	3.05	(1,3,2,1,1,5,BU:3); ;
	cogen unit 1MWe, components for electricity only	RER	1	unit	0	0	0	2.30E-9	1	3.05	(1,3,2,1,1,5,BU:3); ;
	Mini CHP plant, components for heat only	CH	1	unit	1.93E-7	0	0	0	1	3.05	(1,3,2,1,1,5,BU:3); ;
	cogen unit 50kWe, components for heat only	RER	1	unit	0	2.61E-8	0	0	1	3.05	(1,3,2,1,1,5,BU:3); ;
	cogen unit 200kWe, components for heat only	RER	1	unit	0	0	7.51E-9	0	1	3.05	(1,3,2,1,1,5,BU:3); ;
	cogen unit 1MWe, components for heat only	RER	1	unit	0	0.0000E+00	0	1.96E-9	1	3.05	(1,3,2,1,1,5,BU:3); ;
air, high population densitv	Acetaldehyde	-	-	kg	1.00E-9	1.00E-9	1.00E-9	1.00E-9	1	1.83	(2,3,5,1,1,5,BU:1.5); ;
	Acetic acid	-	-	kg	1.50E-7	1.50E-7	1.50E-7	1.50E-7	1	1.83	(2,3,5,1,1,5,BU:1.5); ;
	Ammonia	-	-	kg	1.00E-9	1.00E-9	1.00E-9	1.00E-9	1	1.62	(2,3,5,1,1,5,BU:1.2); ;
	Benzene	-	-	kg	4.00E-7	4.00E-7	4.00E-7	4.00E-7	1	3.28	(2,3,5,1,1,5,BU:3); ;
	Benzo(a)pyrene	-	-	kg	5.60E-13	5.60E-13	5.60E-13	5.60E-13	1	3.28	(2,3,5,1,1,5,BU:3); ;
	Butane	-	-	kg	7.00E-7	7.00E-7	7.00E-7	7.00E-7	1	1.58	(2,3,3,1,1,5,BU:1.5); ;
	Cadmium	-	-	kg	2.50E-13	2.50E-13	2.50E-13	2.50E-13	1	5.32	(2,3,5,1,1,5,BU:5); ;
	Carbon dioxide, fossil	-	-	kg	5.60E-2	5.60E-2	5.60E-2	5.60E-2	1	1.22	(2,1,1,1,1,5,BU:1.05); ;
	Carbon monoxide, fossil	-	-	kg	2.08E-4	2.08E-4	9.60E-5	9.60E-5	1	5.07	(2,3,3,1,1,5,BU:5); ;
	Dinitrogen monoxide	-	-	kg	3.83E-8	3.83E-8	3.83E-8	3.83E-8	1	1.83	(2,3,5,1,1,5,BU:1.5); ;
	Dioxins, measured as 2,3,7,8-tetrachlorodibenzo-p-dioxin	-	-	kg	3.00E-17	3.00E-17	3.00E-17	3.00E-17	1	3.06	(2,3,3,1,1,5,BU:3); ;
	Formaldehyde	-	-	kg	1.00E-7	1.00E-7	1.00E-7	1.00E-7	1	1.83	(2,3,5,1,1,5,BU:1.5); ;
	Heat, waste	-	-	MJ	1.08E+0	1.07E+0	1.08E+0	9.80E-1	1	1.25	(2,3,3,1,1,5,BU:1.05); ;
	Lead	-	-	kg	1.50E-12	1.50E-12	1.50E-12	1.50E-12	1	5.32	(2,3,5,1,1,5,BU:5); ;
	Mercury	-	-	kg	1.00E-10	1.00E-10	1.00E-10	1.00E-10	1	5.32	(2,3,5,1,1,5,BU:5); ;
	Methane, fossil	-	-	kg	8.00E-5	8.00E-5	8.00E-5	8.00E-5	1	1.58	(2,3,3,1,1,5,BU:1.5); ;
	Nitrogen oxides	-	-	kg	8.00E-5	8.00E-5	4.80E-5	3.20E-5	1	1.83	(2,3,5,1,1,5,BU:1.5); ;
	PAH, polycyclic aromatic hydrocarbons	-	-	kg	1.00E-8	1.00E-8	1.00E-8	1.00E-8	1	3.28	(2,3,5,1,1,5,BU:3); ;
	Particulates, < 2.5 um	-	-	kg	1.00E-7	1.00E-7	1.00E-7	1.00E-7	1	3.06	(2,3,3,1,1,5,BU:3); ;
	Pentane	-	-	kg	1.20E-6	1.20E-6	1.20E-6	1.20E-6	1	1.83	(2,3,5,1,1,5,BU:1.5); ;
	Propane	-	-	kg	2.00E-7	2.00E-7	2.00E-7	2.00E-7	1	1.83	(2,3,5,1,1,5,BU:1.5); ;
	Propionic acid	-	-	kg	2.00E-8	2.00E-8	2.00E-8	2.00E-8	1	1.83	(2,3,5,1,1,5,BU:1.5); ;
	Sulfur dioxide	-	-	kg	5.00E-7	5.00E-7	5.00E-7	5.00E-7	1	1.25	(2,3,3,1,1,5,BU:1.05); ;
	Toluene	-	-	kg	2.00E-7	2.00E-7	2.00E-7	2.00E-7	1	1.83	(2,3,5,1,1,5,BU:1.5); ;
water, river	Nitrate	-	-	kg	1.30E-7	1.30E-7	1.30E-7		1	1.83	(2,3,5,1,1,5,BU:1.5); ;
	Nitrite	-	-	kg	3.00E-9	3.00E-9	3.00E-9		1	1.83	(2,3,5,1,1,5,BU:1.5); ;
	Sulfate	-	-	kg	5.00E-8	5.00E-8	5.00E-8		1	1.83	(2,3,5,1,1,5,BU:1.5); ;
	Sulfite	-	-	kg	5.00E-8	5.00E-8	5.00E-8		1	1.83	(2,3,5,1,1,5,BU:1.5); ;

Figure 87: Unit process raw data of natural gas, burned in cogen

ReferenceFunction	Name	biomethane, burned in cogen 15kWth	biomethane, burned in cogen 50kWth	biomethane, burned in cogen 300kWth	biomethane, burned in cogen 1MWth
Geography	Location	CH	CH	CH	CH
ReferenceFunction	InfrastructureProcess	0	0	0	0
ReferenceFunction	Unit	MJ	MJ	MJ	MJ
DataSetInformation	Type	1	1	1	1
	Version	1.0	1.0	1.0	1.0
	energyValues	0	0	0	0
	LanguageCode	en	en	en	en
	LocalLanguageCode	de	de	de	de
DataEntryBy	Person	101	101	101	101
	QualityNetwork	1	1	1	1
ReferenceFunction	DataSetRelatesToProduct	1	1	1	1
	IncludedProcesses	The module includes fuel input from (CH) network, infrastructure (cogeneration plant), emissions to air and water, and electricity needed for operation.	The module includes fuel input from (CH) network, infrastructure (cogeneration plant), emissions to air and water, and electricity needed for operation.	The module includes fuel input from (CH) network, infrastructure (cogeneration plant), emissions to air and water, and electricity needed for operation.	The module includes fuel input from (CH) network, infrastructure (cogeneration plant), emissions to air and water, and electricity needed for operation.
	Amount	1	1	1	1
	LocalName	Biomethan, in BHkWth 15kWth	Biomethan, in BHkWth 50kWth	Biomethan, in BHkWth 300kWth	Biomethan, in BHkWth 1MWth
	Synonyms	0	0	0	0
	GeneralComment	Inventory for 1 MJ biomethane, burned in a cogeneration plant with a capacity of 15 kWth. This inventory reflects the unallocated process of burning biomethane in a cogen unit with all necessary inputs and emissions. Efficiency of the cogen unit as well allocation is not yet considered	Inventory for 1 MJ biomethane, burned in a cogeneration plant with a capacity of 50 kWth. This inventory reflects the unallocated process of burning biomethane in a cogen unit with all necessary inputs and emissions. Efficiency of the cogen unit as well allocation is not yet considered	Inventory for 1 MJ biomethane, burned in a cogeneration plant with a capacity of 300 kWth. This inventory reflects the unallocated process of burning biomethane in a cogen unit with all necessary inputs and emissions. Efficiency of the cogen unit as well allocation is not yet considered	Inventory for 1 MJ biomethane, burned in a cogeneration plant with a capacity of 1 MWth. This inventory reflects the unallocated process of burning biomethane in a cogen unit with all necessary inputs and emissions. Efficiency of the cogen unit as well allocation is not yet considered
	InfrastructureIncluded	1	1	1	1
	Category	biomethane	biomethane	biomethane	biomethane
	SubCategory	cogeneration	cogeneration	cogeneration	cogeneration
	LocalCategory		Biomethan	Biomethan	Biomethan
	LocalSubCategory	Wärmekraftkopplung (WKK)	Wärmekraftkopplung (WKK)	Wärmekraftkopplung (WKK)	Wärmekraftkopplung (WKK)
	Formula				
	StatisticalClassification				
	CASNumber				
TimePeriod	StartDate	2015	2015	2015	2015
	EndDate	2020	2020	2020	2020
	DataValidForEntirePeriod	1	1	1	1
	OtherPeriodText	Time of publications.	Time of publications.	Time of publications.	Time of publications.
Geography	Text	Data apply to the combustion in Switzerland.	Data apply to the combustion in Switzerland.	Data apply to the combustion in Switzerland.	Data apply to the combustion in Switzerland.
Technology	Text	Average technology available on the market	Average technology available on the market	Average technology available on the market	Average technology available on the market
Representativeness	Percent				
	ProductionVolume				
	SamplingProcedure	based on literature	based on literature	based on literature	based on literature
	Extrapolations	extrapolated from natural gas, burned in cogen 15kWth	extrapolated from natural gas, burned in cogen 50kWth	extrapolated from natural gas, burned in cogen 300kWth	extrapolated from natural gas, burned in cogen 1MWth

Figure 88: Metadata of biomethane, burned in cogen

	Name	Location	Infrastructure Process	Unit	biomethane, burned in cogen 15kWth	biomethane, burned in cogen 50kWth	biomethane, burned in cogen 300kWth	biomethane, burned in cogen 1MWth	Uncertainty Type	Standard Deviation 95%	General Comment
	Location				CH	CH	CH	CH			
	Infrastructure Process				0	0	0	0			
	Unit				MJ	MJ	MJ	MJ			
product	biomethane, burned in cogen 15kWth	CH	0	MJ	1	0	0	0			
	biomethane, burned in cogen 50kWth	CH	0	MJ	0	1	0	0			
	biomethane, burned in cogen 300kWth	CH	0	MJ	0	0	1	0			
	biomethane, burned in cogen 1MWth	CH	0	MJ	0	0	0	1	0		
technosphere	methane, 96 vol-%, from biogas, low	CH	0	MJ	1.00E+0	1.00E+0	1.00E+0	1.00E+0	1	1.22	(1,3,2,1,1,5,BU:1.05); ;
	Mini CHP plant, common components	CH	1	unit	1.39E-7	0	0	0	1	3.05	(1,3,2,1,1,5,BU:3); ;
	cogen unit 50kWe, common components	RER	1	unit		1.67E-8	0	0	1	3.05	(1,3,2,1,1,5,BU:3); ;
	cogen unit 200kWe, common components	RER	1	unit			4.58E-9	0	1	3.05	(1,3,2,1,1,5,BU:3); ;
	cogen unit 1MWe, common components	RER	1	unit			0	1.06E-9	1	3.05	(1,3,2,1,1,5,BU:3); ;
	lubricating oil, at plant	RER	0	kg	3.00E-5	3.00E-5	3.00E-5	3.00E-5	1	1.22	(1,3,2,1,1,5,BU:1.05); ;
	Mini CHP plant, components for	CH	1	unit	4.96E-7	0	0	0	1	3.05	(1,3,2,1,1,5,BU:3); ;
	cogen unit 50kWe, components for	RER	1	unit	0	4.64E-8	0	0	1	3.05	(1,3,2,1,1,5,BU:3); ;
	cogen unit 200kWe, components for electricity only	RER	1	unit	0	0	1.17E-8	0	1	3.05	(1,3,2,1,1,5,BU:3); ;
	cogen unit 1MWe, components for electricity only	RER	1	unit	0	0	0	2.30E-9	1	3.05	(1,3,2,1,1,5,BU:3); ;
	Mini CHP plant, components for heat only	CH	1	unit	1.93E-7	0	0	0	1	3.05	(1,3,2,1,1,5,BU:3); ;
	cogen unit 50kWe, components for heat only	RER	1	unit	0	2.61E-8	0	0	1	3.05	(1,3,2,1,1,5,BU:3); ;
	cogen unit 200kWe, components for heat only	RER	1	unit	0	0	7.51E-9	0	1	3.05	(1,3,2,1,1,5,BU:3); ;
	cogen unit 1MWe, components for heat only	RER	1	unit	0	0.0000E+00	0	1.96E-9	1	3.05	(1,3,2,1,1,5,BU:3); ;
air, high population density	Acetaldehyde	-	-	kg	1.00E-9	1.00E-9	1.00E-9	1.00E-9	1	1.83	(2,3,5,1,1,5,BU:1.5); ;
	Acetic acid	-	-	kg	1.50E-7	1.50E-7	1.50E-7	1.50E-7	1	1.83	(2,3,5,1,1,5,BU:1.5); ;
	Ammonia	-	-	kg	1.00E-9	1.00E-9	1.00E-9	1.00E-9	1	1.62	(2,3,5,1,1,5,BU:1.2); ;
	Benzene	-	-	kg	4.00E-7	4.00E-7	4.00E-7	4.00E-7	1	3.28	(2,3,5,1,1,5,BU:3); ;
	Benzo(a)pyrene	-	-	kg	5.60E-13	5.60E-13	5.60E-13	5.60E-13	1	3.28	(2,3,5,1,1,5,BU:3); ;
	Butane	-	-	kg	7.00E-7	7.00E-7	7.00E-7	7.00E-7	1	1.58	(2,3,3,1,1,5,BU:1.5); ;
	Cadmium	-	-	kg	2.50E-13	2.50E-13	2.50E-13	2.50E-13	1	5.32	(2,3,5,1,1,5,BU:5); ;
	Carbon dioxide, biogenic	-	-	kg	5.60E-2	5.60E-2	5.60E-2	5.60E-2	1	1.22	(2,1,1,1,1,5,BU:1.05); ;
	Carbon monoxide, biogenic	-	-	kg	2.08E-4	2.08E-4	9.60E-5	9.60E-5	1	5.07	(2,3,3,1,1,5,BU:5); ;
	Dinitrogen monoxide	-	-	kg	3.83E-8	3.83E-8	3.83E-8	3.83E-8	1	1.83	(2,3,5,1,1,5,BU:1.5); ;
	Dioxins, measured as 2,3,7,8-tetrachlorodibenzo-p-dioxin	-	-	kg	3.00E-17	3.00E-17	3.00E-17	3.00E-17	1	3.06	(2,3,3,1,1,5,BU:3); ;
	Formaldehyde	-	-	kg	1.00E-7	1.00E-7	1.00E-7	1.00E-7	1	1.83	(2,3,5,1,1,5,BU:1.5); ;
	Heat, waste	-	-	MJ	1.08E+0	1.07E+0	1.08E+0	9.80E-1	1	1.25	(2,3,3,1,1,5,BU:1.05); ;
	Lead	-	-	kg	1.50E-12	1.50E-12	1.50E-12	1.50E-12	1	5.32	(2,3,5,1,1,5,BU:5); ;
	Mercury	-	-	kg	1.00E-10	1.00E-10	1.00E-10	1.00E-10	1	5.32	(2,3,5,1,1,5,BU:5); ;
	Methane, biogenic	-	-	kg	8.00E-5	8.00E-5	8.00E-5	8.00E-5	1	1.58	(2,3,3,1,1,5,BU:1.5); ;
	Nitrogen oxides	-	-	kg	8.00E-5	8.00E-5	4.80E-5	3.20E-5	1	1.83	(2,3,5,1,1,5,BU:1.5); ;
	PAH, polycyclic aromatic hydrocarbons	-	-	kg	1.00E-8	1.00E-8	1.00E-8	1.00E-8	1	3.28	(2,3,5,1,1,5,BU:3); ;
	Particulates, < 2.5 um	-	-	kg	1.00E-7	1.00E-7	1.00E-7	1.00E-7	1	3.06	(2,3,3,1,1,5,BU:3); ;
	Pentane	-	-	kg	1.20E-6	1.20E-6	1.20E-6	1.20E-6	1	1.83	(2,3,5,1,1,5,BU:1.5); ;
	Propane	-	-	kg	2.00E-7	2.00E-7	2.00E-7	2.00E-7	1	1.83	(2,3,5,1,1,5,BU:1.5); ;
	Propionic acid	-	-	kg	2.00E-8	2.00E-8	2.00E-8	2.00E-8	1	1.83	(2,3,5,1,1,5,BU:1.5); ;
	Sulfur dioxide	-	-	kg	5.00E-7	5.00E-7	5.00E-7	5.00E-7	1	1.25	(2,3,3,1,1,5,BU:1.05); ;
	Toluene	-	-	kg	2.00E-7	2.00E-7	2.00E-7	2.00E-7	1	1.83	(2,3,5,1,1,5,BU:1.5); ;
water, river	Nitrate	-	-	kg	1.30E-7	1.30E-7	1.30E-7		1	1.83	(2,3,5,1,1,5,BU:1.5); ;
	Nitrite	-	-	kg	3.00E-9	3.00E-9	3.00E-9		1	1.83	(2,3,5,1,1,5,BU:1.5); ;
	Sulfate	-	-	kg	5.00E-8	5.00E-8	5.00E-8		1	1.83	(2,3,5,1,1,5,BU:1.5); ;
	Sulfite	-	-	kg	5.00E-8	5.00E-8	5.00E-8		1	1.83	(2,3,5,1,1,5,BU:1.5); ;

Figure 89: Unit process raw data of biomethane, burned in cogen

ReferenceFunction	Name	diesel, burned in cogen 15kWth	diesel, burned in cogen 50kWth	diesel, burned in cogen 300kWth	diesel, burned in cogen 1MWth
Geography	Location	CH	CH	CH	CH
ReferenceFunction	InfrastructureProcess	0	0	0	0
ReferenceFunction	Unit	MJ	MJ	MJ	MJ
	IncludedProcesses	The module includes fuel input from (CH) network, infrastructure (cogeneration plant), emissions to air and water, and electricity needed for operation.	The module includes fuel input from (CH) network, infrastructure (cogeneration plant), emissions to air and water, and electricity needed for operation.	The module includes fuel input from (CH) network, infrastructure (cogeneration plant), emissions to air and water, and electricity needed for operation.	The module includes fuel input from (CH) network, infrastructure (cogeneration plant), emissions to air and water, and electricity needed for operation.
	Amount	1	1	1	1
	LocalName	Diesel, in BHkWth 15kWth	Diesel, in BHkWth 50kWth	Diesel, in BHkWth 300kWth	Diesel, in BHkWth 1MWth
	Synonyms	0	0	0	0
	GeneralComment	Inventory for 1 MJ diesel, burned in a cogeneration plant with a capacity of 15 kWth. This inventory reflects the unallocated process of burning natural gas in a cogen unit with all necessary inputs and emissions. Efficiency of the cogen unit as well allocation is not yet considered	Inventory for 1 MJ diesel, burned in a cogeneration plant with a capacity of 50 kWth. This inventory reflects the unallocated process of burning diesel in a cogen unit with all necessary inputs and emissions. Efficiency of the cogen unit as well allocation is not yet considered	Inventory for 1 MJ diesel, burned in a cogeneration plant with a capacity of 300 kWth. This inventory reflects the unallocated process of burning diesel in a cogen unit with all necessary inputs and emissions. Efficiency of the cogen unit as well allocation is not yet considered	Inventory for 1 MJ diesel, burned in a cogeneration plant with a capacity of 1 MWth. This inventory reflects the unallocated process of burning diesel in a cogen unit with all necessary inputs and emissions. Efficiency of the cogen unit as well allocation is not yet considered
	InfrastructureIncluded	1	1	1	1
	Category	oil	oil	oil	oil
	SubCategory	cogeneration	cogeneration	cogeneration	cogeneration
	LocalCategory	Erdöl	Erdöl	Erdöl	Erdöl
	LocalSubCategory	Wärmekraftkopplung (WKK)	Wärmekraftkopplung (WKK)	Wärmekraftkopplung (WKK)	Wärmekraftkopplung (WKK)
	Formula				
	StatisticalClassification				
	CASNumber				
TimePeriod	StartDate	2015	2015	2015	2015
	EndDate	2020	2020	2020	2020
	DataValidForEntirePeriod	1	1	1	1
	OtherPeriodText	Time of publications.	Time of publications.	Time of publications.	Time of publications.
Geography	Text	Data apply to the combustion in Switzerland.	Data apply to the combustion in Switzerland.	Data apply to the combustion in Switzerland.	Data apply to the combustion in Switzerland.
Technology	Text	Average technology available on the market	Average technology available on the market	Average technology available on the market	Average technology available on the market
Representativeness	Percent				
	ProductionVolume				
	SamplingProcedure	based on literature	based on literature	based on literature	based on literature
	Extrapolations	Infrastructure extrapolated from 200kWel cogen unit. Some emissions are extrapolated from light fuel oil, burned in boiler <100KW	Infrastructure extrapolated from 200kWel cogen unit. Some emissions are extrapolated from light fuel oil, burned in boiler <100KW	Infrastructure extrapolated from 200kWel cogen unit. Some emissions are extrapolated from light fuel oil, burned in boiler >100KW	Infrastructure extrapolated from 200kWel cogen unit. Some emissions are extrapolated from light fuel oil, burned in boiler >100KW

Figure 90: Metadata of diesel, burned in cogen

	Name	Location	Infrastructure Process	Unit	diesel, burned in cogen 15kWth	diesel, burned in cogen 50kWth	diesel, burned in cogen 300kWth	diesel, burned in cogen 1MWth	Uncertainty Type	Standard Deviation 95%	General Comment
	Location				CH	CH	CH	CH			
	Infrastructure Process				0	0	0	0			
	Unit				MJ	MJ	MJ	MJ			
product	diesel, burned in cogen 15kWth	CH	0	MJ	1	0	0	0			
	diesel, burned in cogen 50kWth	CH	0	MJ	0	1	0	0			
	diesel, burned in cogen 300kWth	CH	0	MJ	0	0	1	0			
	diesel, burned in cogen 1MWth	CH	0	MJ	0	0	0	1	0		
technosphere	diesel, at regional storage	CH	0	kg	2.34E-2	2.34E-2	2.34E-2	2.34E-2	1	1.22	(1,3,2,1,1,5,BU:1.05); ;
technosphere	cogen unit 200kWe diesel SCR, common components for	RER	1	unit	5.42E-9	5.42E-9	5.42E-9	5.42E-9	1	3.05	(1,3,2,1,1,5,BU:3); ;
	lubricating oil, at plant	RER	0	kg	6.70E-5	6.70E-5	6.70E-5	6.70E-5	1	1.22	(1,3,2,1,1,5,BU:1.05); ;
	urea, as N, at regional storehouse	RER	0	kg	8.00E-4	8.00E-4	8.00E-4	8.00E-4	1	1.22	(1,3,2,1,1,5,BU:1.05); ;
	Mini CHP plant, components for electricity only	CH	1	unit	4.96E-7				1	3.05	(1,3,2,1,1,5,BU:3); ;
	cogen unit 50kWe, components for electricity only	RER	1	unit		4.64E-8			1	3.05	(1,3,2,1,1,5,BU:3); ;
	cogen unit 200kWe diesel SCR, components for electricity only	RER	1	unit			6.38E-9		1	3.05	(1,3,2,1,1,5,BU:3); ;
	cogen unit 1MWe, components for electricity only	RER	1	unit			0	2.30E-9	1	3.05	(1,3,2,1,1,5,BU:3); ;
	Mini CHP plant, components for heat only	CH	1	unit	1.93E-7				1	3.05	(1,3,2,1,1,5,BU:3); ;
	cogen unit 50kWe, components for heat only	RER	1	unit		2.61E-8			1	3.05	(1,3,2,1,1,5,BU:3); ;
	cogen unit 200kWe diesel SCR, components for heat only	RER	1	unit			1.04E-8		1	3.05	(1,3,2,1,1,5,BU:3); ;
	cogen unit 1MWe, components for heat only	RER	1	unit				1.96E-9	1	3.05	(1,3,2,1,1,5,BU:3); ;
air, high population density	Acetaldehyde	-	-	kg	1.40E-7	1.40E-7	1.40E-7	4.67E-8	1	1.83	(2,3,5,1,1,5,BU:1.5); ;
	Acetic acid	-	-	kg	1.40E-7	1.40E-7	1.40E-7	4.67E-8	1	1.83	(2,3,5,1,1,5,BU:1.5); ;
	Acetone	-	-	kg	3.50E-7	3.50E-7	3.50E-7	1.17E-7	1	1.83	(2,3,5,1,1,5,BU:1.5); ;
	Acrolein	-	-	kg	1.15E-8	1.15E-8	1.15E-8	1.15E-8	1	1.83	(2,3,5,1,1,5,BU:1.5); ;
	Aldehydes, unspecified	-	-	kg	3.50E-7	3.50E-7	3.50E-7	1.17E-7	1	1.83	(2,3,5,1,1,5,BU:1.5); ;
	Ammonia	-	-	kg	9.60E-5	9.60E-5	9.60E-5	9.60E-5	1	1.62	(2,3,5,1,1,5,BU:1.2); ;
	Benzaldehyde	-	-	kg	6.00E-9	6.00E-9	6.00E-9	6.00E-9	1	1.83	(2,3,5,1,1,5,BU:1.5); ;
	Benzene	-	-	kg	6.40E-6	6.40E-6	6.40E-6	6.40E-6	1	3.28	(2,3,5,1,1,5,BU:3); ;
	Benzo(a)pyrene	-	-	kg	2.50E-11	2.50E-11	2.50E-11	2.50E-11	1	3.28	(2,3,5,1,1,5,BU:3); ;
	Butane	-	-	kg	1.05E-6	1.05E-6	1.05E-6	3.50E-7	1	1.58	(2,3,3,1,1,5,BU:1.5); ;
	Cadmium	-	-	kg	5.10E-10	5.10E-10	5.10E-10	5.10E-10	1	5.32	(2,3,5,1,1,5,BU:5); ;
	Carbon dioxide, fossil	-	-	kg	7.37E-2	7.37E-2	7.37E-2	7.37E-2	1	1.22	(2,1,1,1,1,5,BU:1.05); ;
	Carbon monoxide, fossil	-	-	kg	2.08E-4	2.08E-4	9.60E-5	9.60E-5	1	5.07	(2,3,3,1,1,5,BU:5); ;
	Copper	-	-	kg	4.00E-10	4.00E-10	4.00E-10	6.99E-10	1	5.32	(2,3,5,1,1,5,BU:5); ;
	Dinitrogen monoxide	-	-	kg	3.83E-8	3.83E-8	3.83E-8	3.83E-8	1	1.83	(2,3,5,1,1,5,BU:1.5); ;
	Dioxins, measured as 2,3,7,8-tetrachlorodibenzo-p-dioxin	-	-	kg	5.70E-17	5.70E-17	5.70E-17	4.50E-16	1	3.06	(2,3,3,1,1,5,BU:3); ;
	Ethane	-	-	kg	1.40E-7	1.40E-7	1.40E-7	4.46E-8	1	1.83	(2,3,5,1,1,5,BU:1.5); ;
	Ethanol	-	-	kg	7.00E-8	7.00E-8	7.00E-8	2.33E-8	1	1.83	(2,3,5,1,1,5,BU:1.5); ;
	Ethyne	-	-	kg	1.00E-8	1.00E-8	1.00E-8	1.00E-8	1	1.83	(2,3,5,1,1,5,BU:1.5); ;
	Ethylene diamine	-	-	kg	3.50E-7	3.50E-7	3.50E-7	1.17E-7	1	1.83	(2,3,5,1,1,5,BU:1.5); ;
	Formaldehyde	-	-	kg	6.40E-5	6.40E-5	6.40E-5	6.40E-5	1	1.83	(2,3,5,1,1,5,BU:1.5); ;
	Heat, waste	-	-	MJ	1.08E+0	1.08E+0	1.08E+0	1.08E+0	1	1.25	(2,3,3,1,1,5,BU:1.05); ;
	Hydrocarbons, aliphatic, alkanes, unspecified	-	-	kg	1.75E-6	1.75E-6	1.75E-6	5.83E-7	1	1.83	(2,3,5,1,1,5,BU:1.5); ;
	Hydrocarbons, aromatic	-	-	kg	1.19E-7	1.19E-7	1.19E-7	3.97E-8	1	1.83	(2,3,5,1,1,5,BU:1.5); ;
	Hydrogen chloride	-	-	kg	9.40E-8	9.40E-8	9.40E-8	9.40E-8	1	1.83	(2,3,5,1,1,5,BU:1.5); ;
	Hydrogen fluoride	-	-	kg	4.50E-9	4.50E-9	4.50E-9	9.00E-9	1	1.83	(2,3,5,1,1,5,BU:1.5); ;
	Lead	-	-	kg	1.17E-7	1.17E-7	1.17E-7	1.17E-7	1	5.32	(2,3,5,1,1,5,BU:5); ;
	Mercury	-	-	kg	4.66E-10	4.66E-10	4.66E-10	4.66E-10	1	5.32	(2,3,5,1,1,5,BU:5); ;
	Methane, fossil	-	-	kg	1.20E-5	1.20E-5	1.20E-5	1.20E-5	1	1.58	(2,3,3,1,1,5,BU:1.5); ;
	Nickel	-	-	kg	1.17E-7	1.17E-7	1.17E-7	1.17E-7	1	5.07	(2,3,3,1,1,5,BU:5); ;
	Nitrate	-	-	kg	8.10E-11	8.10E-11	8.10E-11	8.10E-11	1	1.58	(2,3,3,1,1,5,BU:1.5); ;
	Nitrogen oxides	-	-	kg	1.28E-4	1.28E-4	8.00E-5	8.00E-5	1	1.83	(2,3,5,1,1,5,BU:1.5); ;
	PAH, polycyclic aromatic hydrocarbons	-	-	kg	4.60E-10	4.60E-10	4.60E-10	5.80E-10	1	3.28	(2,3,5,1,1,5,BU:3); ;
	Particulates, < 2.5 um	-	-	kg	1.60E-6	1.60E-6	1.60E-6	1.60E-6	1	3.06	(2,3,3,1,1,5,BU:3); ;
	Pentane	-	-	kg	7.00E-7	7.00E-7	7.00E-7	2.33E-7	1	1.83	(2,3,5,1,1,5,BU:1.5); ;
	Platinum	-	-	kg	1.28E-4	1.28E-4	1.08E+0	8.00E-5	1	5.32	(2,3,5,1,1,5,BU:5); ;
	Potassium	-	-	kg	7.90E-10	7.90E-10	7.90E-10	7.90E-10	1	5.32	(2,3,5,1,1,5,BU:5); ;
	Propanal	-	-	kg	6.00E-9	6.00E-9	6.00E-9	6.00E-9	1	1.83	(2,3,5,1,1,5,BU:1.5); ;
	Propane	-	-	kg	2.10E-7	2.10E-7	2.10E-7	7.00E-8	1	1.83	(2,3,5,1,1,5,BU:1.5); ;
	Propene	-	-	kg	2.00E-8	2.00E-8	2.00E-8	2.00E-8	1	1.83	(2,3,5,1,1,5,BU:1.5); ;
	Propionic acid	-	-	kg	1.40E-7	1.40E-7	1.40E-7	4.67E-8	1	1.83	(2,3,5,1,1,5,BU:1.5); ;
	Propylene oxide	-	-	kg	1.40E-7	1.40E-7	1.40E-7	4.67E-8	1	1.83	(2,3,5,1,1,5,BU:1.5); ;
	Sulfur dioxide	-	-	kg	5.00E-7	5.00E-7	5.00E-7	5.00E-7	1	1.25	(2,3,3,1,1,5,BU:1.05); ;
	Toluene	-	-	kg	9.87E-8	9.87E-8	9.87E-8	3.29E-8	1	1.83	(2,3,5,1,1,5,BU:1.5); ;
	Zinc	-	-	kg	5.00E-10	5.00E-10	5.00E-10	1.56E-10	1	5.32	(2,3,5,1,1,5,BU:5); ;

Figure 91: Unit process raw data of diesel, burned in cogen

ReferenceFunction	Name	pellets, burned in cogen 50kWth	pellets, burned in cogen 300kWth	wood chips, burned in cogen 300kWth	wood chips, burned in cogen 1MWth
Geography	Location	CH	CH	CH	CH
ReferenceFunction	InfrastructureProcess	0	0	0	0
ReferenceFunction	Unit	MJ	MJ	MJ	MJ
DataSetInformation	Type	1	1	1	1
	Version	1.0	1.0	1.0	1.0
	energyValues	0	0	0	0
	LanguageCode	en	en	en	en
	LocalLanguageCode	de	de	de	de
DataEntryBy	Person	101	101	101	101
	QualityNetwork	1	1	1	1
ReferenceFunction	DataSetRelatesToProduct	1	1	1	1
	IncludedProcesses	The module includes fuel input from (CH) network, infrastructure (cogeneration plant), emissions to air and water, and electricity needed for operation.	The module includes fuel input from (CH) network, infrastructure (cogeneration plant), emissions to air and water, and electricity needed for operation.	The module includes fuel input from (CH) network, infrastructure (cogeneration plant), emissions to air and water, and electricity needed for operation.	The module includes fuel input from (CH) network, infrastructure (cogeneration plant), emissions to air and water, and electricity needed for operation.
	Amount	1	1	1	1
	LocalName	Pellets, in BHkWth 50kWth	Pellets, in BHkWth 300kWth	Holzschnitzel, in BHkWth 300kWth	Holzschnitzel, in BHkWth 1MWth
	Synonyms	0	0	0	0
	GeneralComment	Inventory for 1 MJ pellets, burned in a cogeneration plant with a capacity of 50 kWth. This inventory reflects the unallocated process of burning natural gas in a cogen unit with all necessary inputs and emissions. Efficiency of the cogen unit as well allocation is not yet considered	Inventory for 1 MJ pellets, burned in a cogeneration plant with a capacity of 30 kWth. This inventory reflects the unallocated process of burning natural gas in a cogen unit with all necessary inputs and emissions. Efficiency of the cogen unit as well allocation is not yet considered	Inventory for 1 MJ wood chips, burned in a cogeneration plant with a capacity of 300 kWth. This inventory reflects the unallocated process of burning natural gas in a cogen unit with all necessary inputs and emissions. Efficiency of the cogen unit as well allocation is not yet considered	Inventory for 1 MJ wood chips, burned in a cogeneration plant with a capacity of 1 MWth. This inventory reflects the unallocated process of burning natural gas in a cogen unit with all necessary inputs and emissions. Efficiency of the cogen unit as well allocation is not yet considered
	InfrastructureIncluded	1	1	1	1
	Category	wood energy	wood energy	wood energy	wood energy
	SubCategory	cogeneration	cogeneration	cogeneration	cogeneration
	LocalCategory	Erdöl	Erdöl	Erdöl	Erdöl
	LocalSubCategory	Wärmekraftkopplung (WKK)	Wärmekraftkopplung (WKK)	Wärmekraftkopplung (WKK)	Wärmekraftkopplung (WKK)
	Formula				
	StatisticalClassification				
	CASNumber				
TimePeriod	StartDate	2015	2015	2015	2015
	EndDate	2020	2020	2020	2020
	DataValidForEntirePeriod	1	1	1	1
	OtherPeriodText	Time of publications.	Time of publications.	Time of publications.	Time of publications.
Geography	Text	Data apply to the supply in Switzerland.	Data apply to the supply in Switzerland.	Data apply to the supply in Switzerland.	Data apply to the supply in Switzerland.
Technology	Text	Average technology available on the market	Average technology available on the market	Average technology available on the market	Average technology available on the market
Representativeness	Percent				
	ProductionVolume				
	SamplingProcedure	literature	literature	literature	literature
	Extrapolations	Infrastructure extrapolated from 1.4MWth cogen unit. Some emission data extrapolated from pellets, burned in furnace 50kW	Infrastructure extrapolated from 1.4MWth cogen unit. Some emission data extrapolated from pellets, burned in furnace 300kW	Infrastructure extrapolated from 1.4MWth cogen unit. Some emission data extrapolated from wood chips, burned in furnace 300kW	Infrastructure extrapolated from 1.4MWth cogen unit. Some emission data extrapolated from wood chips, burned in furnace 1MW

Figure 92: Metadata of wood, burned in cogen

	Name	Location	Infrastructure Process	Unit	pellets, burned in cogen 50kWth	pellets, burned in cogen 300kWth	wood chips, burned in cogen 300kWth	wood chips, burned in cogen 1MWth	Uncertainty Type	Standard Deviation 95%	General Comment
	Location				CH	CH	CH	CH			
	Infrastructure Process				0	0	0	0			
	Unit				MJ	MJ	MJ	MJ			
product	pellets, burned in cogen 50kWth	CH	0	MJ	1	0	0	0			
product	pellets, burned in cogen 300kWth	CH	0	MJ	0	1	0	0			
	wood chips, burned in cogen 300kWth	CH	0	MJ	0	0	1	0			
	wood chips, burned in cogen 1MWth	CH	0	MJ	0	0	0	1	0		
technosphere	lubricating oil, at plant	RER	0	kg	4.65E-6	4.65E-6	4.65E-6	4.65E-6	1	1.33	(3,3,2,1,3,5,BU:1.05); ;
	ammonia, liquid, at regional storehouse	CH	0	kg	1.17E-8	1.17E-8	1.17E-8	1.17E-8	1	1.64	(3,5,5,1,1,5,BU:1.05); ;
	chemicals organic, at plant	GLO	0	kg	8.15E-6	8.15E-6	8.15E-6	8.15E-6	1	1.33	(3,3,2,1,3,5,BU:1.05); ;
	chlorine, liquid, production mix, at plant	RER	0	kg	4.65E-7	4.65E-7	4.65E-7	4.65E-7	1	1.33	(3,3,2,1,3,5,BU:1.05); ;
	sodium chloride, powder, at plant	RER	0	kg	5.82E-6	5.82E-6	5.82E-6	5.82E-6	1	1.33	(3,3,2,1,3,5,BU:1.05); ;
	water, decarbonised, at plant	RER	0	kg	1.12E-3	1.12E-3	1.12E-3	1.12E-3	1	1.64	(3,5,5,1,1,5,BU:1.05); ;
	wood chips, production mix, wet, measured as dry mass, at forest road & at sawmill	RER	0	kg			5.35E-2	5.35E-2	1	1.64	(3,5,5,1,1,5,BU:1.05); ;
	wood pellet, measured as dry mass, at plant	RER	0	kg	5.35E-2	5.35E-2			1	1.64	(3,5,5,1,1,5,BU:1.05); ;
	transport, freight, lorry 16-32 metric ton, fleet average	CH	0	tkm	5.88E-3	5.88E-3	5.88E-3	5.88E-3	1	2.34	(3,5,5,1,1,5,BU:2); ;
	cogen unit ORC 1400kWth, wood burning, common components for heat+electricity	CH	1	unit	1.82E-9	1.82E-9	1.82E-9	1.82E-9	1	3.33	(3,5,5,1,1,5,BU:3); ;
	cogen unit 6400kWth, wood burning, building	CH	1	unit	4.54E-10	4.54E-10	4.54E-10	4.54E-10	1	3.33	(3,5,5,1,1,5,BU:3); ;
	cogen unit ORC 1400kWth, wood burning, components for electricity only	CH	1	unit	4.54E-8	4.54E-8	4.54E-8	4.54E-8	1	3.33	(3,5,5,1,1,5,BU:3); ;
	disposal, used mineral oil, 10% water, to hazardous waste incineration	CH	0	kg	4.65E-6	4.65E-6	4.65E-6	4.65E-6	1	1.64	(3,5,5,1,1,5,BU:1.05); ;
	disposal, municipal solid waste, 22.9% water, to municipal incineration	CH	0	kg	4.65E-6	4.65E-6	4.65E-6	4.65E-6	1	1.64	(3,5,5,1,1,5,BU:1.05); ;
	treatment, sewage, to wastewater treatment, class 2	CH	0	m3	1.12E-6	1.12E-6	1.12E-6	1.12E-6	1	1.64	(3,5,5,1,1,5,BU:1.05); ;
	disposal, wood ash mixture, pure, 0% water, to municipal incineration	CH	0	kg	6.49E-4	1.62E-4	1.62E-4	1.62E-4	1	1.64	(3,5,5,1,1,5,BU:1.05); ;
	disposal, wood ash mixture, pure, 0% water, to sanitary landfill	CH	0	kg		4.87E-4	4.87E-4	4.87E-4	1	1.64	(3,5,5,1,1,5,BU:1.05); ;
air, high population density	Acetaldehyde	-	-	kg	6.10E-08	6.10E-08	6.10E-8	6.10E-8	1	1.89	(3,5,5,1,1,5,BU:1.5); ;
	Ammonia	-	-	kg	5.00E-06	5.00E-06	5.00E-6	5.00E-6	1	1.30	(1,1,2,1,1,5,BU:1.2); ;
	Arsenic	-	-	kg	1.00E-09	1.00E-09	1.00E-9	1.00E-9	1	5.38	(3,5,5,1,1,5,BU:5); ;
	Benzene	-	-	kg	9.10E-07	9.10E-07	9.10E-7	9.10E-7	1	3.33	(3,5,5,1,1,5,BU:3); ;
	Benzene, ethyl-	-	-	kg	3.00E-08	3.00E-08	3.00E-8	3.00E-8	1	3.33	(3,5,5,1,1,5,BU:3); ;
	Benzene, hexachloro-	-	-	kg	1.00E-12	1.00E-12	1.00E-12	1.00E-12	1	3.05	(1,1,2,1,1,5,BU:3); ;
	Benzo(a)pyrene	-	-	kg	9.10E-10	9.10E-10	9.10E-10	9.10E-10	1	3.05	(1,1,2,1,1,5,BU:3); ;
	Bromine	-	-	kg	6.00E-08	6.00E-08	6.00E-8	6.00E-8	1	5.38	(3,5,5,1,1,5,BU:5); ;
	Cadmium	-	-	kg	1.30E-08	1.30E-08	1.30E-8	1.30E-8	1	5.05	(1,1,2,1,1,5,BU:5); ;
	Calcium	-	-	kg	5.85E-06	5.85E-06	5.85E-6	5.85E-6	1	5.38	(3,5,5,1,1,5,BU:5); ;
	Carbon dioxide, biogenic	-	-	kg	9.20E-02	9.20E-02	9.20E-2	9.20E-2	1	1.21	(1,1,2,1,1,5,BU:1.05); ;
	Carbon monoxide, biogenic	-	-	kg	9.00E-05	9.00E-05	9.00E-5	9.00E-5	1	5.05	(1,1,2,1,1,5,BU:5); ;
	Chlorine	-	-	kg	1.80E-07	1.80E-07	1.80E-7	1.80E-7	1	1.89	(3,5,5,1,1,5,BU:1.5); ;
	Chromium	-	-	kg	3.96E-09	3.96E-09	3.96E-9	3.96E-9	1	5.38	(3,5,5,1,1,5,BU:5); ;
	Chromium VI	-	-	kg	4.00E-11	4.00E-11	4.00E-11	4.00E-11	1	5.38	(3,5,5,1,1,5,BU:5); ;
	Copper	-	-	kg	2.20E-08	2.20E-08	2.20E-8	2.20E-8	1	5.38	(3,5,5,1,1,5,BU:5); ;
	Dinitrogen monoxide	-	-	kg	2.50E-06	2.50E-06	2.50E-6	2.30E-6	1	1.89	(3,5,5,1,1,5,BU:1.5); ;
	Dioxins, measured as 2,3,7,8-tetrachlorodibenzo-p-dioxin	-	-	kg	4.50E-14	4.50E-14	4.50E-14	4.50E-14	1	3.05	(1,1,2,1,1,5,BU:3); ;
	Fluorine	-	-	kg	5.00E-08	5.00E-08	5.00E-8	5.00E-8	1	1.89	(3,5,5,1,1,5,BU:1.5); ;
	Formaldehyde	-	-	kg	6.40E-06	6.40E-06	6.40E-6	6.40E-6	1	1.89	(3,5,5,1,1,5,BU:1.5); ;
	Heat, waste	-	-	MJ	1.08E+00	1.08E+00	1.08E+0	1.08E+0	1	1.64	(3,5,5,1,1,5,BU:1.05); ;
	Hydrocarbons, aliphatic, alkanes, unspecified	-	-	kg	9.10E-07	9.10E-07	9.10E-7	9.10E-7	1	1.89	(3,5,5,1,1,5,BU:1.5); ;
	Hydrocarbons, aliphatic, unsaturated	-	-	kg	3.10E-06	3.10E-06	3.10E-6	3.10E-6	1	1.89	(3,5,5,1,1,5,BU:1.5); ;
	Lead	-	-	kg	2.70E-08	2.70E-08	2.70E-8	2.70E-8	1	5.05	(1,1,2,1,1,5,BU:5); ;
	Magnesium	-	-	kg	3.60E-07	3.60E-07	3.60E-7	3.60E-7	1	5.38	(3,5,5,1,1,5,BU:5); ;
	Manganese	-	-	kg	1.70E-07	1.70E-07	1.70E-7	1.70E-7	1	5.38	(3,5,5,1,1,5,BU:5); ;
	Mercury	-	-	kg	6.00E-10	6.00E-10	6.00E-10	6.00E-10	1	5.05	(1,1,2,1,1,5,BU:5); ;
	Methane, biogenic	-	-	kg	2.72E-06	2.00E-06	6.34E-6	4.00E-6	1	1.56	(1,1,2,1,1,5,BU:1.5); ;
	m-Xylene	-	-	kg	1.20E-07	1.20E-07	1.20E-7	1.20E-7	1	1.89	(3,5,5,1,1,5,BU:1.5); ;
	Nickel	-	-	kg	6.00E-09	6.00E-09	6.00E-9	6.00E-9	1	5.38	(3,5,5,1,1,5,BU:5); ;
	Nitrogen oxides	-	-	kg	1.16E-04	1.16E-04	1.16E-4	1.16E-4	1	1.56	(1,1,2,1,1,5,BU:1.5); ;
	NMVOC, non-methane volatile organic compounds, unspecified origin	-	-	kg	2.00E-06	2.00E-06	2.00E-6	2.00E-6	1	1.56	(1,1,2,1,1,5,BU:1.5); ;
	PAH, polycyclic aromatic hydrocarbons	-	-	kg	1.11E-08	1.11E-08	1.11E-8	1.11E-8	1	3.33	(3,5,5,1,1,5,BU:3); ;
	Particulates, < 2.5 um	-	-	kg	1.00E-05	1.00E-05	1.00E-5	1.00E-5	1	3.05	(1,1,2,1,1,5,BU:3); ;
	Particulates, > 2.5 um, and < 10um	-	-	kg	0.00E+00	0.00E+00	0.00E+00	0.00E+00	1	2.05	(1,1,2,1,1,5,BU:2); ;
	Phenol, pentachloro-	-	-	kg	8.10E-12	8.10E-12	8.10E-12	8.10E-12	1	1.89	(3,5,5,1,1,5,BU:1.5); ;
	Phosphorus	-	-	kg	3.00E-07	3.00E-07	3.00E-7	3.00E-7	1	1.89	(3,5,5,1,1,5,BU:1.5); ;
	Potassium	-	-	kg	2.34E-05	2.34E-05	2.34E-5	2.34E-5	1	5.38	(3,5,5,1,1,5,BU:5); ;
	Sodium	-	-	kg	1.30E-06	1.30E-06	1.30E-6	1.30E-6	1	5.38	(3,5,5,1,1,5,BU:5); ;
	Sulfur dioxide	-	-	kg	1.00E-05	1.00E-05	1.00E-5	1.00E-5	1	1.21	(1,1,2,1,1,5,BU:1.05); ;
	Toluene	-	-	kg	3.00E-07	3.00E-07	3.00E-7	3.00E-7	1	1.89	(3,5,5,1,1,5,BU:1.5); ;
	Zinc	-	-	kg	3.00E-07	3.00E-07	3.00E-7	3.00E-7	1	5.38	(3,5,5,1,1,5,BU:5); ;

Figure 93: Unit process raw data of wood, burned in cogen

the “heat and electricity at cogen” inventories (about 32 additional figures) are not separately listed as the only additional information is the allocation factor which is already listed in Table 29.

2.6.8 Data quality

The data quality is generally good. Emission factors for the main air pollutants and the efficiency were updated with recent data for this study. No newer data were found for the infrastructure.
Other inputs and outputs which have not been updated during this study are normally of very low relevance for the calculated environmental impacts.

2.6.9 Life cycle impact assessment

At the level of MJ input the updated natural gas inventories show similar results to the former inventories. The reason is that there is the same amount of natural gas as input and the same amount of CO_2 emissions. Regarding the diesel inventories, the ecological scarcity results show somewhat higher impacts due to additional emissions that were missing in the former inventory.
Regarding wood chips inventories, the ecological scarcity results show somewhat higher impacts due to higher particulate matter, cadmium and dioxin emissions compared to the former inventory. On the other hand, the CO_2 emissions are lower due to lower N2O emissions.
There were no biomethane or wood pellet cogen inventories so far.
A comparison between the different energy sources shows that cogen units fueled with biomethane show lowest impacts, followed by wood and natural gas. Cogen units with diesel show the highest impacts.

Table 34: LCIA results of co-generation inventories

Inventory name/unit	**Ecological Scarcity 2013**	**IPCC 2013, GWP 100a**	**former inventory (UVEK 2018) that most closely matches the update**	**Ecological Scarcity 2013**	**IPCC 2013, GWP 100a**	**UBP ratio**	**kg CO2eq ratio**
	UBP	kg CO2eq		UBP	kg CO2eq	%	%
biomethane, burned in cogen 15kWth/MJ/CH U	3.13E+01	4.25E-02	n.a.				
biomethane, burned in cogen 1MWth/MJ/CH U	2.73E+01	4.11E-02	n.a.				
biomethane, burned in cogen 300kWth/MJ/CH U	2.82E+01	4.13E-02	n.a.				
biomethane, burned in cogen 50kWth/MJ/CH U	2.97E+01	4.16E-02	n.a.				
diesel, burned in cogen 15kWth/MJ/CH U	9.21E+01	9.45E-02	n.a.				
diesel, burned in cogen 1MWth/MJ/CH U	8.79E+01	9.30E-02	n.a.				
diesel, burned in cogen 300kWth/MJ/CH U	8.85E+01	9.30E-02	Diesel, burned in cogen 200kWe diesel SCR/CH U	7.49E+01	9.45E-02	118%	98%
diesel, burned in cogen 50kWth/MJ/CH U	9.05E+01	9.33E-02	n.a.				
natural gas, burned in cogen 15kWth/MJ/CH U	4.73E+01	7.31E-02	n.a.				
natural gas, burned in cogen 1MWth/MJ/CH U	4.31E+01	7.16E-02	Natural gas, burned in cogen 1MWe lean burn/CH U	4.49E+01	7.30E-02	96%	98%
natural gas, burned in cogen 300kWth/MJ/CH U	4.40E+01	7.18E-02	natural gas, burned in cogen 200kWe lean burn/MJ/CH U	4.51E+01	7.31E-02	98%	98%
natural gas, burned in cogen 50kWth/MJ/CH U	4.56E+01	7.33E-02	Natural gas, burned in cogen 50kWe lean burn/CH U	4.54E+01	7.30E-02	101%	100%
pellets, burned in cogen 300kWth/MJ/MJ/CH U	3.75E+01	1.24E-02					
pellets, burned in cogen 50kWth/MJ/MJ/CH U	3.74E+01	1.24E-02					

wood chips, burned in cogen 1MWth/MJ/CH U	3.95E+01	7.16E-03	Wood chips, burned in cogen ORC 1400kWth/CH U	3.38E+01	9.02E-03	117%	79%
wood chips, burned in cogen 300kWth/MJ/CH U	3.97E+01	7.28E-03					

2.6.10 Outlook

The LCIA of the different cogeneration heating systems shows large differences for the datasets between the different fuel types. More differences can be encountered for the datasets in relation to the heat provided. We recommend to provide more options for different levels of output temperatures which have a direct influence on the efficiency of the cogeneration heating devices.

In addition, it is very decisive whether a co-generation plant is rather heat or electricity driven. This changes the respective yield of electricity and heat which leads to different allocations. It would therefore be ideal if the thermal and electrical efficiency could be entered in parameterised form. Alternatively, additional inventories could be created for electricity and heat cogeneration.

Furthermore, we recommend to provide also European datasets for the cogeneration heating systems.

2.7 Wood heating systems

This chapter contains information on furnaces that are operated with wood. The data from the previous report (Bauer, 2007) is updated for the reference year 2020.

There are different burner systems varying in the type of wood burned and in the size of the installation. The wood fuel types described in this report include wood chips, wood logs and wood pellets. For each wood fuel type we provide inventories for infrastructure (furnaces), for energy per MJ burned and for heat supply.

The assessed furnaces are distinguished by their power of heat supply in kW. Information on performance should be understood as order of magnitude (+/- 10%). We provide inventory data for three classes of wood furnaces commonly used for residential heating and for one class of industrial furnace.

The following inventories were created or updated:

Infrastructure
- Furnace, wood chips, 50kW/CH
- Furnace, wood chips, 300kW/CH
- Furnace, wood chips, 1000kW/CH
- Furnace, wood chips, 5000kW/CH
- Furnace, logs, 6kW/CH
- Furnace, logs, 15kW/CH
- Furnace, logs, 50kW/CH
- Furnace, pellets, 15kW/CH
- Furnace, pellets, 50kW/CH
- Furnace, pellets, 300kW/CH

Energy – per MJ burned
- Wood chips, burned in furnace 50kW/CH – for hardwood, softwood, mixed from forest and from industry
- Wood chips, burned in furnace 300kW/CH – for hardwood, softwood, mixed from forest and from industry
- Wood chips, burned in furnace 1000kW/CH – for hardwood, softwood, mixed from forest and from industry
- Wood chips, burned in furnace 5000kW/CH – for hardwood, softwood, mixed from forest and from industry
- Logs, burned in furnace 6kW/CH – for hardwood, softwood, mixed
- Logs, burned in furnace 15kW/CH– for hardwood, softwood, mixed
- Logs, burned in furnace 50kW/CH– for hardwood, softwood, mixed
- Pellets, burned in furnace 15kW/CH
- Pellets, burned in furnace 50kW/CH
- Pellets, burned in furnace 300kW/CH

Energy – heat
- Heat, logs, burned in furnace 6kW/CH - for hardwood, softwood, mixed
- The same heat inventories were also created for all other inventories listed under *Energy – per MJ burned*

2.7.1 Infrastructure

2.7.1.1 Pellet furnace

To generate the new inventories for pellet furnaces in this report, the existing inventories from Bauer (2007) were used and adapted to the currently used heating systems. The scaling was done using the average weights of modern pellet stoves. For scaling the furnaces, the materials for the silos for pellet storage and the chimney were taken out of the old inventories and scaled separately. The silo and chimney are therefore not included in the total weight of the stove. The inputs for the silo and the chimney are listed as an input in the furnace inventory.

Pellets are stored in a concrete silo. The storage capacity generally covers the annual need in fuel for each power class (Bauer, 2007).

At the end of life of the furnace the concrete, polyethylene and mineral oil (lubricating oil) are disposed of in a municipal solid waste incineration plant. All the other materials are recycled and charged to the next user according to the cut-off approach.

Table 35 lists all the materials and energy inputs used for building the infrastructure of pellet furnaces in three different power classes.

Table 35: Average weight of pellet furnaces and material, energy and resources demand per piece of pellet furnace production

	15kw pellet furnace	50kw pellet furnace	300kw pellet furnace	Unit	source
Average weight of furnace	325.20	705.00	2'377.00	kg	Average of datasheets: (Brunner GmbH, 2020b, 2020a; ETA Heiztechnik GmbH, 2017; fröling, Heizkessel- und Behälterbau GesmbH, o. J.; Hargassner GmbH, 2020; Herz, o. J.; Viessmann Werke GmbH & Co. KG, 2019a, 2019b)
Transformation, from unknown	2.94	17.08	57.60	m^2	(Bauer, 2007) and calculation with the average weight from datasheets
Transformation, to industrial area	2.94	17.08	57.60	m^2	(Bauer, 2007) and calculation with the average weight from datasheets
Occupation, industrial area	44.03	256.26	864.01	m^2a	(Bauer, 2007) and calculation with the average weight from datasheets
Water, unspecified natural origin	1.24	2.68	9.04	m^3	(Viessmann Werke GmbH & Co. KG, 2017)
Electricity, medium voltage	571.68	1'239.34	4'178.59	kWh	(Viessmann Werke GmbH & Co. KG, 2017)
Natural gas, burned in industrial furnace 1MW	3'095.07	6'709.80	22'622.98	MJ	(Viessmann Werke GmbH & Co. KG, 2017)
Chimney	2.1	3.8	7.05	m	(Bauer, 2007), (Jungbluth, 2004) and calculation with the average weight from datasheets
Concrete, normal	5.49	12.74	76.43	m^3	(Bauer, 2007) and calculation with the average weight from datasheets
Aluminium, primary	0.09	0.19	0.64	kg	(Bauer, 2007) and calculation with the average weight from datasheets
Cast iron	6.40	13.29	44.80	kg	(Bauer, 2007) and calculation with the average weight from datasheets
Ceramic tiles	48.03	113.89	384.01	kg	(Bauer, 2007) and calculation with the average weight from datasheets
Copper	2.99	6.17	20.80	kg	(Bauer, 2007) and calculation with the average weight from datasheets
Lubricating oil	0.21	0.66	2.24	kg	(Bauer, 2007) and calculation with the average weight from datasheets

Polyethylene, HDPE, granulate	0.64	1.33	4.48	kg	(Bauer, 2007) and calculation with the average weight from datasheets
Steel, low-alloyed	266.83	569.47	1'920.03	kg	(Bauer, 2007) and calculation with the average weight from datasheets
	15kw pellet furnace	**50kw pellet furnace**	**300kw pellet furnace**	**Unit**	**source**
Sheet rolling, steel	1.33	3.80	9.60	kg	(Bauer, 2007) and calculation with the average weight from datasheets
Drawing of pipes, steel	1.33	3.80	9.60	kg	(Bauer, 2007) and calculation with the average weight from datasheets
Heat waste	2'060	4'460	15'040	MJ	(Bauer, 2007) and calculation with the average weight from datasheets
Disposal concrete, 5% water to inert material landfill	13'075.00	30'316	181'896	kg	(Bauer, 2007) and calculation with the average weight from datasheets
Disposal polyethylene, 0.4% water to municipal incineration	0.64	1.33	4.48	kg	(Bauer, 2007) and calculation with the average weight from datasheets
Disposal used mineral oil, 10% water, to hazardous waste incineration	0.21	0.66	2.24	kg	(Bauer, 2007) and calculation with the average weight from datasheets

2.7.1.2 Wood chips furnace

The inventories for the wood chips furnace infrastructure were also drawn up on the basis of the old inventories (Bauer, 2007). Here too, data sheets of state-of-the-art wood chip furnaces were selected to determine the average weight of these furnaces to be used for the calculations. The detailed composition of the materials, energy and resource demands for the production of these furnaces are listed in Table 36.

A further subdivision for the three wood types softwood, mixed wood and hardwood was made for the heaters of the different power classes. The only difference in infrastructure is that the storage space is larger or smaller depending on the wood type. Table 36 lists the infrastructure for the stoves, which is the same for all wood types. Table 37 shows the material inputs for the storage rooms by wood types and capacity. The only differences in the infrastructure for the different types of wood are the space needed for the entire heating system, the material inputs of concrete and the processes involved. Wood chips must be stored in a silo. This is usually embedded in the ground, made of concrete and has a wall thickness of 20 cm. Depending on the size of the plant, the chips are delivered in different numbers.

It is assumed that the storage tank of the 50 kW furnace can cover the fuel requirements for a whole year. In the case of the 300 kW furnace, the content is sufficient for one third of the annual requirement, and in the case of the 1000 kW furnace for one tenth. The silos are each two metres deep (Bauer, 2007).

Table 36: Average weight of wood chips furnaces and material, energy and resources demand per piece of wood chips furnace production

	50kW wood chips furnace	300kW wood chips furnace	1MW wood chips furnace	5MW wood chips furnace	Unit	Source
Average weight of furnace	806.75	2'500.00	16'775.00	80'000.00	kg	Average of datasheets: (AEW Energie AG, 2020; fröling, Heizkessel- und Behälterbau GesmbH, 2015, S. 4; Hargassner GmbH, 2020; Schmid AG energy solutions, 2019a, 2019b; Thanei, Schmid AG - energy solutions, 2020; Tiba AG, 2020)
Water, unspecified natural origin	3.07	9.51	63.80	304.28	m^3	(Viessmann Werke GmbH & Co. KG, 2017)
Electricity, medium voltage ENTSO	1’418.21	4’394.81	29’489.18	140’633.96	kWh	(Viessmann Werke GmbH & Co. KG, 2017)
Natural gas, burned in industrial furnace	7’678.20	23’793.62	159’655.21	761’395.92	MJ	(Viessmann Werke GmbH & Co. KG, 2017)
Chimney	3.80	7.05	9.08	16.67	m	(Bauer, 2007) and calculation with the average weight from datasheets
Aluminium, primary	0.25	0.59	4.83	25.05	kg	(Bauer, 2007) and calculation with the average weight from datasheets
Cast iron	17.68	41.75	327.11	1’753.29	kg	(Bauer, 2007) and calculation with the average weight from datasheets
Concrete, normal, at plant/CH U	0.06	0.35	2.40	6.31	m^3	(Bauer, 2007) and calculation with the average weight from datasheets
Copper	8.21	19.20	155.77	814.03	kg	(Bauer, 2007) and calculation with the average weight from datasheets
Lubricating oil	0.88	3.13	15.58	87.66	kg	(Bauer, 2007) and calculation with the average weight from datasheets
Polyethylene, HDPE, granulate	1.77	4.07	32.97	175.33	kg	(Bauer, 2007) and calculation with the average weight from datasheets
Rock wool	1.26	9.91	90.86	125.23	kg	(Bauer, 2007) and calculation with the average weight from datasheets
Steel, low-alloyed	776.69	2’421.34	16’147.88	77’019.41	kg	(Bauer, 2007) and calculation with the average weight from datasheets
Sheet rolling	4.42	12.32	71.39	438.32	kg	(Bauer, 2007) and calculation with the average weight from datasheets
Drawing of pipes	4.42	12.32	71.39	438.32	kg	(Bauer, 2007) and calculation with the average weight from datasheets
Heat, waste	5’105.54	15’821.32	106’161.06	506’282.26	MJ	(Bauer, 2007) and calculation with the average weight from datasheets
Disposal, polyethylene, 0.4% water, to municipal incineration/kg/CH U	1.77	4.07	32.97	175.33	kg	(Bauer, 2007) and calculation with the average weight from datasheets
Disposal, used mineral oil, 10% water, to hazardous waste incineration/CH U	0.88	3.13	15.58	87.66	kg	(Bauer, 2007) and calculation with the average weight from datasheets
Disposal, mineral wool, 0% water, to inert material landfill/CH U	1.26	9.91	90.86	125.23	kg	(Bauer, 2007) and calculation with the average weight from datasheets

Table 37: Average amount of concrete for wood chips storage room and disposal. Source: (Bauer, 2007) and calculation with the average weight from datasheets.

		Transformation, from unknown	Transformation, to industrial area	Occupation, industrial area	Concrete, normal, at plant/CH U	Disposal, concrete, 5% water, to inert material landfill/CH U
	Unit	m^2	m^2	m^2a	m^3	kg
Softwood	**50kW**	92.2	92.2	1'843.9	39.6	94'422.5
	300kW	133.6	133.6	2'671.8	64.1	154'185.8
	1MW	358.3	358.3	7'165.3	68.1	168'787.5
	5MW	9'142.1	9'142.1	182'842.8	98.0	250'028.3
Mixed wood	**50kW**	85.2	85.2	1'704.9	37.1	88'471.6
	300kW	124.2	124.2	2'484.0	59.9	143'470.9
	1MW	329.7	329.7	6'594.2	63.7	157'200.5
	5MW	8'453.4	8'453.4	169'067.0	91.5	232'762.8
Hardwood	**50kW**	68.2	68.2	1'363.9	30.9	73'785.6
	300kW	99.1	99.1	1'983.0	49.6	118'974.9
	1MW	264.8	264.8	5'296.1	52.7	131'088.5
	5MW	6'762.7	6'762.7	135'253.6	75.3	194'251.3

2.7.1.3 Wood logs furnace

As for pellets furnace and wood chips furnace infrastructure, the inventories for the wood logs furnace infrastructure were drawn up on the basis of the old inventories (Bauer, 2007). Here too, data sheets with state-of-the-art wood logs furnaces were selected to determine the average weight of these furnaces to use for the calculations.

For the heaters of the different power classes, a further subdivision was made for the three wood types softwood, mixed wood and hardwood. The only difference in the infrastructure is that the storage space is larger or smaller depending on the wood type. Table 38 lists the infrastructure for the stoves, which is the same for all wood types.

The wood logs are stored at a dry place and there is no need for a silo. Therefore, the inventory of the storage only includes the land use (Bauer, 2007). The material inputs for the storage rooms are shown separately by wood type and capacity in Table 39.

Table 38: Average weight of wood logs furnaces and material, energy and resources demand per piece of furnace production

	6 kW wood logs furnace	15 kW wood logs furnace	50 kW wood logs furnace	Unit	Source
Average weight of furnace	184.1	494.3	937.8	kg	Average of datasheets: (ATMOS, 2016; Fröling Heizkessel- und Behälterbau Ges.m.b.H., 2015; Hark GmbH & Co., 2014, 2017; Schmid AG energy solutions, 2017; Viessmann Werke GmbH & Co. KG, 2019a, 2019b; Wamsler, Haus- und Küchentechnik GmbH, 2011; Wamsler SE, 2013; Windhager Zentralheizung GmbH, 2020)
Water, unspecified natural origin	0.70	1.88	3.57	m^3	(Viessmann Werke GmbH & Co. KG, 2017)
Electricity, medium voltage ENTSO	323.63	868.85	1'648.64	kWh	(Viessmann Werke GmbH & Co. KG, 2017)
Natural gas, burned in industrial furnace	1'752.16	4'704.00	8'925.78	MJ	(Viessmann Werke GmbH & Co. KG, 2017)
Chimney	5.14	7.40	11.45	m	(Bauer, 2007) and calculation with the average weight from datasheets
Aluminium, primary	0.00	0.18	0.21	kg	(Bauer, 2007) and calculation with the average weight from datasheets
Cast iron	0.00	12.78	15.12	kg	(Bauer, 2007) and calculation with the average weight from datasheets
Concrete, normal	0.11	0.16	0.28	m^3	(Bauer, 2007) and calculation with the average weight from datasheets
Copper	0.00	5.80	6.80	kg	(Bauer, 2007) and calculation with the average weight from datasheets
Lubricating oil	0.18	0.59	1.26	kg	(Bauer, 2007) and calculation with the average weight from datasheets
Polyethylene, HDPE, granulate	0.00	1.28	1.43	kg	(Bauer, 2007) and calculation with the average weight from datasheets
Polyurethane, rigid foam	0.00	23.59	26.87	kg	(Bauer, 2007) and calculation with the average weight from datasheets
Rock wool	3.12	4.42	9.24	kg	(Bauer, 2007) and calculation with the average weight from datasheets
Steel, low-alloyed	185.38	449.25	881.72	kg	(Bauer, 2007) and calculation with the average weight from datasheets
Sheet rolling	1.56	2.21	4.62	kg	(Bauer, 2007) and calculation with the average weight from datasheets
Drawing of pipes	1.56	2.21	4.62	kg	(Bauer, 2007) and calculation with the average weight from datasheets
Heat, waste	1165	3128	5935	MJ	(Bauer, 2007) and calculation with the average weight from datasheets
Disposal, concrete, 5% water, to inert landfill	778.8	1’135.6	1’836.4	kg	(Bauer, 2007) and calculation with the average weight from datasheets
Disposal, polyurethane, 0.2% water, to municipal incineration	0.00	23.59	26.87	kg	(Bauer, 2007) and calculation with the average weight from datasheets
Disposal, polyethylene, 0.4% water, to municipal incineration/kg/CH U	0.00	1.28	1.43	kg	(Bauer, 2007) and calculation with the average weight from datasheets
Disposal, used mineral oil, 10% water, to hazardous waste incineration/CH U	0.18	0.59	1.26	kg	(Bauer, 2007) and calculation with the average weight from datasheets
Disposal, mineral wool, 0% water, to inert material landfill/CH U	3.12	4.42	9.24	kg	(Bauer, 2007) and calculation with the average weight from datasheets

Table 39: Average amount of space for wood logs storage. Source: (Bauer, 2007) and calculation with the average weight from datasheets.

		Transformation, from unknown	Transformation, to industrial area	Occupation, industrial area
	Unit	m^2	m^2	m^2a
Softwood	**6kW**	4.5	4.5	90.4
	15kW	22.4	22.4	333.7
	50kW	30.9	30.9	459.2
Mixed wood	**6kW**	4.0	4.0	80.0
	15kW	21.0	21.0	314.2
	50kW	28.4	28.4	426.1
Hardwood	**6kW**	3.0	3.0	59.1
	15kW	16.6	16.6	248.8
	50kW	22.6	22.6	338.4

2.7.1.4 Chimney

As already mentioned, the materials for the chimney, rock wool and concrete, were taken out of the old wood heating system inventories and got replaced by the process "chimney". The amount of meters of the new process "chimney" meets the amount of materials contained in the old inventory. That means that the height of the chimney was estimated by the materials in the old inventory. The whole chimney per wood heating system was divided by 4 in the inventory, because the life span of a chimney is estimated to be 80 years, but the life span of the wood heating systems is only 20 years. So in the lifetime of a chimney, four wood heating systems can be used (Bauer, 2007; Jungbluth, 2004).

2.7.1.5 Transports

The standard transport distances of the materials used for producing and building the wood heating systems in Switzerland are assumed to be between 100 km and 600 km by rail and between 20 km and 50 km by truck (16-32 t) depending on the kind of material (Frischknecht u. a., 2007).

2.7.1.6 Heating period, lifetime

The lifetime of the boilers is estimated with 20 years for logs and 15 years for pellets and wood chips furnaces according to Stettler et al. (2019). The assumption that a single stove is in operation for 1000 hours per year is based on the fact that it is only used as a supplementary heating system (Bauer 2007). For the other log furnaces, a running time of 1600 hours per year was assumed. For pellet and wood chip firing systems, it is assumed that they are in operation for a maximum of 16 hours per day and that within this period they cover the heat demand for the whole day even during the coldest season. From the number of annual heating degree days and the maximum temperature difference, a running time of 2100h can be calculated (Bauer 2007). For the 5MW heating system an operation time of 5000h per year was assumed (see also Table 40).

2.7.1.7 Heat efficiencies

Losses occur during heat generation in the boiler and during distribution in the house. The efficiencies of furnaces are dependent on the output temperature during operation on the one hand and the provided warm water temperature on the other hand. Whereas in modern buildings the warm water temperatures tend to be 30° to 40° C and thus achieve higher operation efficiencies of the boilers, larger furnaces in the industry have to provide higher output temperatures and thus reach lower efficiencies.
Technical data sheets by wood furnace manufacturers (TDS wood furnace, 2020) were used for the efficiencies. The annual efficiency is slightly lower than the boiler efficiency, as losses always occur during

periods of heating system standstill. According to some technical data sheets (TDS wood furnace, 2020) the annual efficiency was 3.1% to 7% lower for pellets furnaces, 3.7% to 5.7% lower for logs furnaces and 4.6% to 6.8% lower for wood chips furnaces. In this study we assumed a 5% reduction for all wood heating systems with the exception of the 5MW furnace (see Table 40).
Distribution losses in the house (unheated rooms) are not considered in the inventory for furnaces.

As efficiencies depend largely on operating conditions and less on size or type of heating, the efficiencies should be adapted to known values if datasets for "heat, at ..." are used in a life cycle inventory.

Table 40: Key parameters for furnace operation

System	Power kW	Lifespan a	operation h/a	efficiency	MJ / a (Hu)	Furnace input p/MJ	Electricity demand in % of MJ output
logs furnace 6kW	6	20	1000	77%	28052	1.78241E-06	0.70%
logs furnace 15kW	15	20	1600	80%	108000	4.62963E-07	0.40%
logs furnace 50kW	50	20	1600	81%	355556	1.40625E-07	0.20%
pellets furnace 15kW	15	15	2100	87%	130345	5.11464E-07	0.40%
pellets furnace 50kW	50	15	2100	88%	429545	1.55203E-07	0.10%
pellets furnace 300kW	300	15	2100	90%	2520000	2.6455E-08	0.10%
wood chips 50kW	50	15	2100	84%	450000	1.48148E-07	0.10%
wood chips 300kW	300	15	2100	84%	2700000	2.46914E-08	0.10%
wood chips 1MW	1000	15	2100	85%	8894118	7.49559E-09	1.80%
wood chips 5MW	5000	15	5000	86%	104651163	6.37037E-10	1.80%

2.7.1.8 Auxiliary electricity

Information about the electricity demand for the operation of the furnaces were taken from from technical datasheets (TDS wood furnace, 2020). For the 1MW furnace, data is based on personal communication. For the 5MW furnace, the same demand per MJ output was assumed as for the 1MW furnace (see Table 40).

2.7.2 Emissions to air

The previous inventories (Bauer, 2007) used the same emission factors for all of the different wood types and furnace sizes. In the meantime more differentiating data on emission factors for the different wood furnaces have become available and are incorporated in this report. Most of the updated emission factors come from Switzerland's Informative Inventory Report 2020 (IIR) submitted under the UNECE Convention on Long-range Transboundary Air Pollution (FOEN, 2020). Slightly older data (BAFU, 2015) was used for the emissions that are not covered by the IIR. For minor emissions without newer data in neither source, the older values of the previous inventories were used.
Where the power related categories of the furnaces in the sources did not match the categories of the inventories, linear interpolation was used to achieve meaningful values for emissions.
Neither source differentiates between emissions from softwood and hardwood. There is also no information on differences in emissions between wood from forests and wood from industry.
Differences in emissions between the different wood types – logs, wood chips and pellets – are influenced by the varying degrees of moisture content and the corresponding lower heating value. However, SO_2 and CO_2 emissions are the same for all wood types and furnace sizes. SO_2 emissions mainly depend on the sulfur content of the fuel itself, whilst CO_2 emissions are directly linked to the carbon content and therefore to the energy content of the fuel wood.
Larger furnaces tend to have lower emissions due to higher temperatures, less frequent dips into lower temperature ranges and better circulation of burnable gasses and air. This results in lower emissions of carbon monoxide and organic compounds, e.g. CH4 and NMVOC. Furthermore, automatic furnaces operate under consistent surplus of air and thus with a better burnout quality. Smaller furnaces that are for instance

operated by hand have higher emissions due to suboptimal conditions during the more frequent starting and burning-out phases (BAFU, 2015).

2.7.2.1 Wood chips

All categories – softwood, mixed wood, hardwood, from forest and from industry – have the same emission factors.

Table 41: Emissions per MJ heat for the different furnace classes

	50kW furnace	300kW furnace	1000kW furnace	5000kW furnace	source
Acetaldehyde	6.10E-08	6.10E-08	6.10E-08	6.10E-08	(Bauer, 2007)
Ammonia	2.00E-06	2.00E-06	2.00E-06	2.00E-06	(FOEN, 2020)
Arsenic	1.00E-09	1.00E-09	1.00E-09	1.00E-09	(Bauer, 2007)
Benzene	9.10E-07	9.10E-07	9.10E-07	9.10E-07	(Bauer, 2007)
Benzene, ethyl-	3.00E-08	3.00E-08	3.00E-08	3.00E-08	(Bauer, 2007)
Benzene, hexachloro-	4.00E-12	3.34E-12	1.00E-12	2.50E-13	(FOEN, 2020)
Benzo(a)pyrene	3.89E-09	2.42E-09	1.80E-09	1.28E-09	(FOEN, 2020)
Bromine	6.00E-08	6.00E-08	6.00E-08	6.00E-08	(Bauer, 2007)
Cadmium	1.30E-08	1.30E-08	1.30E-08	1.30E-08	(FOEN, 2020)
Calcium	5.85E-06	5.85E-06	5.85E-06	5.85E-06	(Bauer, 2007)
Carbon dioxide, biogenic	9.20E-02	9.20E-02	9.20E-02	9.20E-02	(BAFU, 2015)
Carbon monoxide, biogenic	4.98E-04	3.96E-04	2.62E-04	2.03E-04	(FOEN, 2020)
Chlorine	1.80E-07	1.80E-07	1.80E-07	1.80E-07	(Bauer, 2007)
Chromium	3.96E-09	3.96E-09	3.96E-09	3.96E-09	(Bauer, 2007)
Chromium VI	4.00E-11	4.00E-11	4.00E-11	4.00E-11	(Bauer, 2007)
Copper	2.20E-08	2.20E-08	2.20E-08	2.20E-08	(Bauer, 2007)
Dinitrogen monoxide	3.00E-06	2.50E-06	2.30E-06	2.30E-06	(Bauer, 2007)
Dioxin, 2,3,7,8 Tetrachlorodibenzo-p-	8.70E-14	8.70E-14	8.70E-14	8.70E-14	(FOEN, 2020)
Fluorine	5.00E-08	5.00E-08	5.00E-08	5.00E-08	(Bauer, 2007)
Formaldehyde	1.30E-07	1.30E-07	1.30E-07	1.30E-07	(Bauer, 2007)
Heat, waste	1.08E+00	1.08E+00	1.08E+00	1.08E+00	(Bauer, 2007)
Hydrocarbons, aliphatic, alkanes, unspecified	9.10E-07	9.10E-07	9.10E-07	9.10E-07	(Bauer, 2007)
Hydrocarbons, aliphatic, unsaturated	3.10E-06	3.10E-06	3.10E-06	3.10E-06	(Bauer, 2007)
Lead	2.70E-08	2.70E-08	2.70E-08	2.70E-08	(FOEN, 2020)
Magnesium	3.60E-07	3.60E-07	3.60E-07	3.60E-07	(Bauer, 2007)
Manganese	1.70E-07	1.70E-07	1.70E-07	1.70E-07	(Bauer, 2007)
Mercury	6.00E-10	6.00E-10	6.00E-10	6.00E-10	(FOEN, 2020)
Methane, biogenic	7.72E-06	6.34E-06	4.00E-06	3.07E-06	(BAFU, 2015)
m-Xylene	1.20E-07	1.20E-07	1.20E-07	1.20E-07	(Bauer, 2007)

Nickel	6.00E-09	6.00E-09	6.00E-09	6.00E-09	(Bauer, 2007)
Nitrogen oxides	1.20E-04	1.23E-04	1.32E-04	1.35E-04	(FOEN, 2020)
	50kW furnace	**300kW furnace**	**1000kW furnace**	**5000kW furnace**	**source**
NMVOC, non-methane volatile organic compounds, unspecified origin	9.72E-06	8.12E-06	5.00E-06	3.82E-06	(FOEN, 2020)
PAH, polycyclic aromatic hydrocarbons	1.11E-08	1.11E-08	1.11E-08	1.11E-08	(Bauer, 2007)
Particulates, < 2.5 um	7.84E-05	6.18E-05	5.40E-05	4.79E-05	(FOEN, 2020)
Particulates, 2.5–10 um	2.00E-06	2.00E-06	2.00E-06	2.00E-06	(FOEN, 2020)
Phenol, pentachloro-	8.10E-12	8.10E-12	8.10E-12	8.10E-12	(Bauer, 2007)
Phosphorus	3.00E-07	3.00E-07	3.00E-07	3.00E-07	(Bauer, 2007)
Potassium	2.34E-05	2.34E-05	2.34E-05	2.34E-05	(Bauer, 2007)
Sodium	1.30E-06	1.30E-06	1.30E-06	1.30E-06	(Bauer, 2007)
Sulfur dioxide	1.00E-05	1.00E-05	1.00E-05	1.00E-05	(FOEN, 2020)
Toluene	3.00E-07	3.00E-07	3.00E-07	3.00E-07	(Bauer, 2007)
Zinc	3.00E-07	3.00E-07	3.00E-07	3.00E-07	(Bauer, 2007)

2.7.2.2 Logs

All categories – softwood, mixed wood and hardwood – have the same emission factors.

Table 42: Emissions per MJ heat for the different wood heater and furnace classes

	6kW wood heater	**15kW furnace**	**50kW furnace**	**source**
Acetaldehyde	6.10E-08	6.10E-08	6.10E-08	(Bauer, 2007)
Ammonia	2.00E-06	2.00E-06	2.00E-06	(FOEN, 2020)
Arsenic	1.00E-09	1.00E-09	1.00E-09	(Bauer, 2007)
Benzene	9.10E-07	9.10E-07	9.10E-07	(Bauer, 2007)
Benzene, ethyl-	3.00E-08	3.00E-08	3.00E-08	(Bauer, 2007)
Benzene, hexachloro-	4.00E-12	4.00E-12	4.00E-12	(FOEN, 2020)
Benzo(a)pyrene	2.20E-08	2.20E-08	2.20E-08	(FOEN, 2020)
Bromine	6.00E-08	6.00E-08	6.00E-08	(Bauer, 2007)
Cadmium	1.30E-08	1.30E-08	1.30E-08	(FOEN, 2020)
Calcium	5.85E-06	5.85E-06	5.85E-06	(Bauer, 2007)
Carbon dioxide, biogenic	9.20E-02	9.20E-02	9.20E-02	(BAFU, 2015)
Carbon monoxide, biogenic	1.11E-03	1.11E-03	1.11E-03	(FOEN, 2020)
Chlorine	1.80E-07	1.80E-07	1.80E-07	(Bauer, 2007)
Chromium	3.96E-09	3.96E-09	3.96E-09	(Bauer, 2007)
Chromium VI	4.00E-11	4.00E-11	4.00E-11	(Bauer, 2007)

Copper	2.20E-08	2.20E-08	2.20E-08	(Bauer, 2007)
Dinitrogen monoxide	7.00E-06	7.00E-06	7.00E-06	(Bauer, 2007)
	6kW wood heater	**15kW furnace**	**50kW furnace**	**source**
Dioxin, 2,3,7,8 Tetrachlorodibenzo-p-	8.90E-14	8.90E-14	8.90E-14	(FOEN, 2020)
Fluorine	5.00E-08	5.00E-08	5.00E-08	(Bauer, 2007)
Formaldehyde	1.30E-07	1.30E-07	1.30E-07	(Bauer, 2007)
Heat, waste	1.07E+00	1.07E+00	1.07E+00	(Bauer, 2007)
Hydrocarbons, aliphatic, alkanes, unspecified	9.10E-07	9.10E-07	9.10E-07	(Bauer, 2007)
Hydrocarbons, aliphatic, unsaturated	3.10E-06	3.10E-06	3.10E-06	(Bauer, 2007)
Lead	2.70E-08	2.70E-08	2.70E-08	(FOEN, 2020)
Magnesium	3.60E-07	3.60E-07	3.60E-07	(Bauer, 2007)
Manganese	1.70E-07	1.70E-07	1.70E-07	(Bauer, 2007)
Mercury	6.00E-10	6.00E-10	6.00E-10	(FOEN, 2020)
Methane, biogenic	6.60E-05	6.60E-05	6.60E-05	(BAFU, 2015)
m-Xylene	1.20E-07	1.20E-07	1.20E-07	(Bauer, 2007)
Nickel	6.00E-09	6.00E-09	6.00E-09	(Bauer, 2007)
Nitrogen oxides	8.00E-05	8.00E-05	8.00E-05	(FOEN, 2020)
NMVOC, non-methane volatile organic compounds, unspecified origin	7.50E-05	7.50E-05	7.50E-05	(FOEN, 2020)
PAH, polycyclic aromatic hydrocarbons	1.11E-08	1.11E-08	1.11E-08	(Bauer, 2007)
Particulates, < 2.5 µm	4.10E-05	4.10E-05	4.10E-05	(FOEN, 2020)
Particulates, > 2.5 and < 10 µm	1.00E-06	1.00E-06	1.00E-06	(FOEN, 2020)
Phenol, pentachloro-	8.10E-12	8.10E-12	8.10E-12	(Bauer, 2007)
Phosphorus	3.00E-07	3.00E-07	3.00E-07	(Bauer, 2007)
Potassium	2.34E-05	2.34E-05	2.34E-05	(Bauer, 2007)
Sodium	1.30E-06	1.30E-06	1.30E-06	(Bauer, 2007)
Sulfur dioxide	1.00E-05	1.00E-05	1.00E-05	(FOEN, 2020)
Toluene	3.00E-07	3.00E-07	3.00E-07	(Bauer, 2007)
Zinc	3.00E-07	3.00E-07	3.00E-07	(Bauer, 2007)

2.7.2.3 Wood pellets

Table 43: Emissions per MJ heat for the different furnace classes

	15kW furnace	50kW furnace	300kW furnace	source
Acetaldehyde	6.10E-08	6.10E-08	6.10E-08	(Bauer, 2007)
Ammonia	2.00E-06	2.00E-06	2.00E-06	(FOEN, 2020)
Arsenic	1.00E-09	1.00E-09	1.00E-09	(Bauer, 2007)
Benzene	9.10E-07	9.10E-07	9.10E-07	(Bauer, 2007)
Benzene, ethyl-	3.00E-08	3.00E-08	3.00E-08	(Bauer, 2007)
Benzene, hexachloro-	4.00E-12	4.00E-12	3.25E-12	(FOEN, 2020)
Benzo(a)pyrene	2.67E-09	1.80E-09	1.80E-09	(FOEN, 2020)
Bromine	6.00E-08	6.00E-08	6.00E-08	(Bauer, 2007)
Cadmium	1.30E-08	1.30E-08	1.30E-08	(FOEN, 2020)
Calcium	5.85E-06	5.85E-06	5.85E-06	(Bauer, 2007)
Carbon dioxide, biogenic	9.20E-02	9.20E-02	9.20E-02	(BAFU, 2015)
Carbon monoxide, biogenic	2.01E-04	1.59E-04	1.28E-04	(FOEN, 2020)
Chlorine	1.80E-07	1.80E-07	1.80E-07	(Bauer, 2007)
Chromium	3.96E-09	3.96E-09	3.96E-09	(Bauer, 2007)
Chromium VI	4.00E-11	4.00E-11	4.00E-11	(Bauer, 2007)
Copper	2.20E-08	2.20E-08	2.20E-08	(Bauer, 2007)
Dinitrogen monoxide	3.00E-06	2.50E-06	2.50E-06	(Bauer, 2007)
Dioxin, 2,3,7,8 Tetrachlorodibenzo-p-	4.33E-14	4.30E-14	4.28E-14	(FOEN, 2020)
Fluorine	5.00E-08	5.00E-08	5.00E-08	(Bauer, 2007)
Formaldehyde	1.30E-07	1.30E-07	1.30E-07	(Bauer, 2007)
Heat, waste	1.08E+00	1.08E+00	1.08E+00	(Bauer, 2007)
Hydrocarbons, aliphatic, alkanes, unspecified	9.10E-07	9.10E-07	9.10E-07	(Bauer, 2007)
Hydrocarbons, aliphatic, unsaturated	3.10E-06	3.10E-06	3.10E-06	(Bauer, 2007)
Lead	2.70E-08	2.70E-08	2.70E-08	(FOEN, 2020)
Magnesium	3.60E-07	3.60E-07	3.60E-07	(Bauer, 2007)
Manganese	1.70E-07	1.70E-07	1.70E-07	(Bauer, 2007)
Mercury	6.00E-10	6.00E-10	6.00E-10	(FOEN, 2020)
Methane, biogenic	6.00E-06	2.72E-06	2.00E-06	(BAFU, 2015)
m-Xylene	1.20E-07	1.20E-07	1.20E-07	(Bauer, 2007)
Nickel	6.00E-09	6.00E-09	6.00E-09	(Bauer, 2007)
Nitrogen oxides	6.00E-05	6.00E-05	6.25E-05	(FOEN, 2020)

	15kW furnace	50kW furnace	300kW furnace	source
NMVOC, non-methane volatile organic compounds, unspecified origin	7.33E-06	3.00E-06	3.00E-06	(FOEN, 2020)
PAH, polycyclic aromatic hydrocarbons	1.11E-08	1.11E-08	1.11E-08	(Bauer, 2007)
Particulates, < 2.5 um	4.27E-05	3.77E-05	3.10E-05	(FOEN, 2020)
Particulates, 2.5–10 um	1.00E-06	1.00E-06	1.00E-06	(FOEN, 2020)
Phenol, pentachloro-	8.10E-12	8.10E-12	8.10E-12	(Bauer, 2007)
Phosphorus	3.00E-07	3.00E-07	3.00E-07	(Bauer, 2007)
Potassium	2.34E-05	2.34E-05	2.34E-05	(Bauer, 2007)
Sodium	1.30E-06	1.30E-06	1.30E-06	(Bauer, 2007)
Sulfur dioxide	1.00E-05	1.00E-05	1.00E-05	(FOEN, 2020)
Toluene	3.00E-07	3.00E-07	3.00E-07	(Bauer, 2007)
Zinc	3.00E-07	3.00E-07	3.00E-07	(Bauer, 2007)

2.7.3 Summary of life cycle inventory data

In this chapter the life cycle inventories for the newly modelled and updated processes are presented. All data are provided as unit process raw data in the EcoSpold v1 format (unit process in SimaPro). The electronic data is including full EcoSpold v1 documentation.
For each investigated process, two types of tables (X-Process and X-Exchange) are provided in this report.

ReferenceFunction	Name	furnace, logs, hardwood, 6kW	furnace, logs, mixed, 6kW	furnace, logs, softwood, 6kW
Geography	Location	CH	CH	CH
ReferenceFunction	InfrastructureProcess	1	1	1
ReferenceFunction	Unit	unit	unit	unit
	IncludedProcesses	Includes materials, transports and energy used for the fabrication of the furnace, the chimney and the automatic control technique.	Includes materials, transports and energy used for the fabrication of the furnace, the chimney and the automatic control technique.	Includes materials, transports and energy used for the fabrication of the furnace, the chimney and the automatic control technique.
	LocalName	Einzelofen, Stückholz, Laubholz, 6kW	Einzelofen, Stückholz, Holzmix, 6kW	Einzelofen, Stückholz, Nadelholz, 6kW
	Synonyms			
	GeneralComment	Inventory refers to the production of a logs furnace 6kW. Composition of the previous inventory was used and updated with the average weight of current logs furnaces available in Switzerland.	Inventory refers to the production of a logs furnace 6kW. Composition of the previous inventory was used and updated with the average weight of current logs furnaces available in Switzerland.	Inventory refers to the production of a logs furnace 6kW. Composition of the previous inventory was used and updated with the average weight of current logs furnaces available in Switzerland.
	InfrastructureIncluded	1	1	1
	Category	wood energy	wood energy	wood energy
	SubCategory	heating systems	heating systems	heating systems
	LocalCategory	Holzenergie	Holzenergie	Holzenergie
	LocalSubCategory	Heizungssysteme	Heizungssysteme	Heizungssysteme
	Formula			
	StatisticalClassification			
	CASNumber			
TimePeriod	StartDate	2015	2015	2015
	EndDate	2020	2020	2020
	DataValidForEntirePeriod	1	1	1
	OtherPeriodText	Time of publications.	Time of publications.	Time of publications.
Geography	Text			
Technology	Text	average technology	average technology	average technology
Representativeness	Percent			
	ProductionVolume			
	SamplingProcedure			
	Extrapolations	none	none	none
	UncertaintyAdjustments	none	none	none

Figure 94: Metadata of furnace, logs, 6kW

	Name	Location	Infrastructure Process	Unit	furnace, logs, hardwood, 6kW	furnace, logs, mixed, 6kW	furnace, logs, softwood, 6kW	Uncertainty Type	Standard Deviation 95%	General Comment
	Location				CH	CH	CH			
	Infrastructure Process				1	1	1			
	Unit				unit	unit	unit			
product	furnace, logs, hardwood, 6kW	CH	1	unit	1	0	0			
	furnace, logs, mixed, 6kW	CH	1	unit	0	1	0			
	furnace, logs, softwood, 6kW	CH	1	unit	0	0	1	0		
resource, land	Transformation, from unknown	-	-	m2	3.00E+0	4.00E+0	4.52E+0	1	2.11	(3,3,2,1,3,5,BU:2); ;
	Transformation, to industrial area	-	-	m2	3.00E+0	4.00E+0	4.52E+0	1	2.34	(3,5,5,1,1,5,BU:2); ;
	Occupation, industrial area	-	-	m2a	5.91E+1	8.00E+1	9.04E+1	1	1.64	(3,3,2,1,3,5,BU:1.5); ;
resource, in water	Water, unspecified natural origin/m3	-	-	m3	7.00E-1	7.00E-1	7.00E-1	1	1.68	(4,5,2,2,4,5,BU:1.05); ;
technosphere	electricity, medium voltage, production ENTSO, at grid	ENTSO	0	kWh	3.24E+2	3.24E+2	3.24E+2	1	1.68	(4,5,2,2,4,5,BU:1.05); ;
technosphere	natural gas, burned in industrial furnace 1MW	CH	0	MJ	1.75E+3	1.75E+3	1.75E+3	1	1.68	(4,5,2,2,4,5,BU:1.05); ;
	chimney	CH	1	m	1.28E+0	1.28E+0	1.28E+0	1	3.36	(4,5,2,2,4,5,BU:3); ;
	aluminium, primary, at plant	RER	0	kg	0	0	0	1	1.64	(3,5,5,1,1,5,BU:1.05); ;
	cast iron, at plant	RER	0	kg	0	0	0	1	1.64	(3,5,5,1,1,5,BU:1.05); ;
	concrete, normal, at plant	CH	0	m3	1.00E-01	1.00E-1	1.00E-1	1	1.64	(3,5,5,1,1,5,BU:1.05); ;
	copper, at regional storage	RER	0	kg	0.00E+00	0	0	1	1.64	(3,5,5,1,1,5,BU:1.05); ;
	lubricating oil, at plant	RER	0	kg	1.70E-01	1.70E-1	1.70E-1	1	1.21	(1,1,2,1,1,5,BU:1.05); ;
	polyethylene, HDPE, granulate, at plant	RER	0	kg	0.00E+00	0	0	1	1.64	(3,5,5,1,1,5,BU:1.05); ;
	polyurethane, rigid foam, at plant	RER	0	kg	0.00E+00	0	0	1	1.64	(3,5,5,1,1,5,BU:1.05); ;
	rock wool, at plant	CH	0	kg	3.06E+00	3.06E+0	3.06E+0	1	1.64	(3,5,5,1,1,5,BU:1.05); ;
	steel, low-alloyed, at plant	RER	0	kg	1.82E+02	1.82E+2	1.82E+2	1	1.21	(1,1,2,1,1,5,BU:1.05); ;
	sheet rolling, steel	RER	0	kg	1.53E+00	1.53E+0	1.53E+0	1	1.21	(1,1,2,1,1,5,BU:1.05); ;
	drawing of pipes, steel	RER	0	kg	1.53E+00	1.53E+0	1.53E+0	1	1.64	(3,5,5,1,1,5,BU:1.05); ;
	transport, freight, lorry 16-32 metric ton, fleet average	CH	0	tkm	1.68E+01	1.68E+1	1.68E+1	1	2.05	(1,1,2,1,1,5,BU:2); ;
	transport, freight, rail	RER	0	tkm	1.10E+02	1.10E+2	1.10E+2	1	2.05	(1,1,2,1,1,5,BU:2); ;
air, high population density	Heat, waste	-	-	MJ	1.17E+03	1.17E+3	1.17E+3	1	1.21	(1,1,2,1,1,5,BU:1.05); ;
technosphere	disposal, concrete, 5% water, to inert material landfill	CH	0	kg	3.78E+02	3.78E+2	3.78E+2	1	1.64	(3,5,5,1,1,5,BU:1.05); ;
	disposal, polyethylene, 0.4% water, to municipal incineration	CH	0	kg	0.00E+00	0	0	1	1.64	(3,5,5,1,1,5,BU:1.05); ;
	disposal, polyurethane, 0.2% water, to municipal incineration	CH	0	kg	0.00E+00	0	0	1	1.64	(3,5,5,1,1,5,BU:1.05); ;
	disposal, used mineral oil, 10% water, to hazardous waste incineration	CH	0	kg	1.70E-01	1.70E-1	1.70E-1	1	1.64	(3,5,5,1,1,5,BU:1.05); ;
	disposal, mineral wool, 0% water, to inert material landfill	CH	0	kg	3.06E+00	3.06E+0	3.06E+0	1	1.64	(3,5,5,1,1,5,BU:1.05); ;

Figure 95: Unit process raw data of furnace, logs, 6kW

ReferenceFunction	Name	furnace, logs, hardwood, 15kW	furnace, logs, mixed, 15kW	furnace, logs, softwood, 15kW
Geography	Location	CH	CH	CH
ReferenceFunction	InfrastructureProcess	1	1	1
ReferenceFunction	Unit	unit	unit	unit
	IncludedProcesses	Includes materials, transports and energy used for the fabrication of the furnace, the chimney and the automatic control technique.	Includes materials, transports and energy used for the fabrication of the furnace, the chimney and the automatic control technique.	Includes materials, transports and energy used for the fabrication of the furnace, the chimney and the automatic control technique.
	LocalName	Feuerung, Stückholz, Laubholz, 15kW	Feuerung, Stückholz, Holzmix, 15kW	Feuerung, Stückholz, Nadelbholz, 15kW
	Synonyms	0	0	0
	GeneralComment	Inventory refers to the production of a logs furnace 15kW. Composition of the previous inventory was used and updated with the average weight of current logs furnaces available in Switzerland.	Inventory refers to the production of a logs furnace 15kW. Composition of the previous inventory was used and updated with the average weight of current logs furnaces available in Switzerland.	Inventory refers to the production of a logs furnace 15kW. Composition of the previous inventory was used and updated with the average weight of current logs furnaces available in Switzerland.
	InfrastructureIncluded	1	1	1
	Category	wood energy	wood energy	wood energy
	SubCategory	heating systems	heating systems	heating systems
	LocalCategory	Holzenergie	Holzenergie	Holzenergie
	LocalSubCategory	Heizungssysteme	Heizungssysteme	Heizungssysteme
	Formula			
	StatisticalClassification			
	CASNumber			
TimePeriod	StartDate	2015	2015	2015
	EndDate	2020	2020	2020
	DataValidForEntirePeriod	1	1	1
	OtherPeriodText	Time of publications.	Time of publications.	Time of publications.
Geography	Text			
Technology	Text	average technology	average technology	average technology
Representativeness	Percent			
	ProductionVolume			
	SamplingProcedure			
	Extrapolations	none	none	none
	UncertaintyAdjustments	none	none	none

Figure 96: Metadata of furnace, logs, 15kW

	Name	Location	Infrastructure Process	Unit	furnace, logs, hardwood, 15kW	furnace, logs, mixed, 15kW	furnace, logs, softwood, 15kW	Uncertainty Type	Standard Deviation 95%	General Comment
	Location				CH	CH	CH			
	Infrastructure Process				1	1	1			
	Unit				unit	unit	unit			
product	furnace, logs, hardwood, 15kW	CH	1	unit	1	0	0			
	furnace, logs, mixed, 15kW	CH	1	unit	0	1	0			
	furnace, logs, softwood, 15kW	CH	1	unit	0	0	1	0		
resource, land	Transformation, from unknown	-	-	m2	1.66E+1	2.10E+1	2.24E+1	1	2.11	(3,3,2,1,3,5,BU:2); ;
	Transformation, to industrial area	-	-	m2	1.66E+1	2.10E+1	2.24E+1	1	2.34	(3,5,5,1,1,5,BU:2); ;
	Occupation, industrial area	-	-	m2a	2.49E+2	3.14E+2	3.37E+2	1	1.64	(3,3,2,1,3,5,BU:1.5); ;
resource, in water	Water, unspecified natural origin/m3	-	-	m3	1.90E+0	1.90E+0	1.90E+0	1	1.68	(4,5,2,2,4,5,BU:1.05); ;
technosphere	electricity, medium voltage, production ENTSO, at grid	ENTSO	0	kWh	8.69E+2	8.69E+2	8.69E+2	1	1.68	(4,5,2,2,4,5,BU:1.05); ;
	natural gas, burned in industrial furnace 1MW	CH	0	MJ	4.70E+3	4.70E+3	4.70E+3	1	1.68	(4,5,2,2,4,5,BU:1.05); ;
	chimney	CH	1	m	1.85E+0	1.85E+0	1.85E+0	1	3.36	(4,5,2,2,4,5,BU:3); ;
	aluminium, primary, at plant	RER	0	kg	1.80E-1	1.80E-1	1.80E-1	1	1.64	(3,5,5,1,1,5,BU:1.05); ;
	cast iron, at plant	RER	0	kg	1.27E+1	1.27E+1	1.27E+1	1	1.64	(3,5,5,1,1,5,BU:1.05); ;
	concrete, normal, at plant	CH	0	m3	1.60E-01	1.60E-01	1.60E-01	1	1.64	(3,5,5,1,1,5,BU:1.05); ;
	copper, at regional storage	RER	0	kg	5.77E+00	5.77E+00	5.77E+00	1	1.64	(3,5,5,1,1,5,BU:1.05); ;
	lubricating oil, at plant	RER	0	kg	5.90E-01	5.90E-01	5.90E-01	1	1.21	(1,1,2,1,1,5,BU:1.05); ;
	polyethylene, HDPE, granulate, at plant	RER	0	kg	1.27E+00	1.27E+00	1.27E+00	1	1.64	(3,5,5,1,1,5,BU:1.05); ;
	polyurethane, rigid foam, at plant	RER	0	kg	2.35E+01	2.35E+01	2.35E+01	1	1.64	(3,5,5,1,1,5,BU:1.05); ;
	rock wool, at plant	CH	0	kg	4.40E+00	4.40E+00	4.40E+00	1	1.64	(3,5,5,1,1,5,BU:1.05); ;
	steel, low-alloyed, at plant	RER	0	kg	4.47E+02	4.47E+02	4.47E+02	1	1.21	(1,1,2,1,1,5,BU:1.05); ;
	sheet rolling, steel	RER	0	kg	2.20E+00	2.20E+00	2.20E+00	1	1.21	(1,1,2,1,1,5,BU:1.05); ;
	drawing of pipes, steel	RER	0	kg	2.20E+00	2.20E+00	2.20E+00	1	1.64	(3,5,5,1,1,5,BU:1.05); ;
	transport, freight, lorry 16-32 metric ton, fleet average	CH	0	tkm	3.60E+01	3.60E+01	3.60E+01	1	2.05	(1,1,2,1,1,5,BU:2); ;
	transport, freight, rail	RER	0	tkm	2.85E+02	2.85E+02	2.85E+02	1	2.05	(1,1,2,1,1,5,BU:2); ;
air, high population density	Heat, waste	-	-	MJ	3.13E+03	3.13E+03	3.13E+03	1	1.21	(1,1,2,1,1,5,BU:1.05); ;
technosphere	disposal, concrete, 5% water, to inert material landfill	CH	0	kg	5.63E+02	5.63E+02	5.63E+02	1	1.64	(3,5,5,1,1,5,BU:1.05); ;
	disposal, polyethylene, 0.4% water, to municipal incineration	CH	0	kg	2.35E+01	2.35E+01	2.35E+01	1	1.64	(3,5,5,1,1,5,BU:1.05); ;
	disposal, polyurethane, 0.2% water, to municipal incineration	CH	0	kg	1.27E+00	1.27E+00	1.27E+00	1	1.64	(3,5,5,1,1,5,BU:1.05); ;
	disposal, used mineral oil, 10% water, to hazardous waste incineration	CH	0	kg	5.90E-01	5.90E-01	5.90E-01	1	1.64	(3,5,5,1,1,5,BU:1.05); ;
	disposal, mineral wool, 0% water, to inert material landfill	CH	0	kg	4.40E+00	4.40E+00	4.40E+00	1	1.64	(3,5,5,1,1,5,BU:1.05); ;

Figure 97: Unit process raw data of furnace, logs, 15kW

ReferenceFunction	Name	furnace, logs, hardwood, 50kW	furnace, logs, mixed, 50kW	furnace, logs, softwood, 50kW
Geography	Location	CH	CH	CH
ReferenceFunction	InfrastructureProcess	1	1	1
ReferenceFunction	Unit	unit	unit	unit
DataSetInformation	Type	1	1	1
	Version	1.0	1.0	1.0
	energyValues	0	0	0
	LanguageCode	en	en	en
	LocalLanguageCode	de	de	de
DataEntryBy	Person	101	101	101
	QualityNetwork	1	1	1
ReferenceFunction	DataSetRelatesToProduct	1	1	1
	IncludedProcesses	Includes materials, transports and energy used for the fabrication of the furnace, the chimney and the automatic control technique.	Includes materials, transports and energy used for the fabrication of the furnace, the chimney and the automatic control technique.	Includes materials, transports and energy used for the fabrication of the furnace, the chimney and the automatic control technique.
	LocalName	Feuerung, Stückholz, Laubholz, 50kW	Feuerung, Stückholz, Holzmix, 50kW	Feuerung, Stückholz, Nadelholz, 50kW
	Synonyms	0	0	0
	GeneralComment	Inventory refers to the production of a logs furnace 50kW. Composition of the previous inventory was used and updated with the average weight of current logs furnaces available in Switzerland.	Inventory refers to the production of a logs furnace 50kW. Composition of the previous inventory was used and updated with the average weight of current logs furnaces available in Switzerland.	Inventory refers to the production of a logs furnace 50kW. Composition of the previous inventory was used and updated with the average weight of current logs furnaces available in Switzerland.
	InfrastructureIncluded	1	1	1
	Category	wood energy	wood energy	wood energy
	SubCategory	heating systems	heating systems	heating systems
	LocalCategory	Holzenergie	Holzenergie	Holzenergie
	LocalSubCategory	Heizungssysteme	Heizungssysteme	Heizungssysteme
	Formula			
	StatisticalClassification			
	CASNumber			
TimePeriod	StartDate	2015	2015	2015
	EndDate	2020	2020	2020
	DataValidForEntirePeriod	1	1	1
	OtherPeriodText	Time of publications.	Time of publications.	Time of publications.
Geography	Text			
Technology	Text	average technology	average technology	average technology
Representativeness	Percent			
	ProductionVolume			
	SamplingProcedure			
	Extrapolations	none	none	none

Figure 98: Metadata of furnace, logs, 50kW

	Name	Location	Infrastructure Process	Unit	furnace, logs, hardwood, 50kW	furnace, logs, mixed, 50kW	furnace, logs, softwood, 50kW	Uncertainty Type	Standard Deviation 95%	General Comment
	Location				CH	CH	CH			
	Infrastructure Process				1	1	1			
	Unit				unit	unit	unit			
product	furnace, logs, hardwood, 50kW	CH	1	unit	1	0	0			
	furnace, logs, mixed, 50kW	CH	1	unit	0	1	0			
	furnace, logs, softwood, 50kW	CH	1	unit	0	0	1	0		
resource, land	Transformation, from unknown	-	-	m2	2.26E+1	2.84E+1	3.09E+1	1	2.11	(3,3,2,1,3,5,BU:2); ;
	Transformation, to industrial area	-	-	m2	2.26E+1	2.84E+1	3.09E+1	1	2.34	(3,5,5,1,1,5,BU:2); ;
	Occupation, industrial area	-	-	m2a	3.38E+2	4.26E+2	4.59E+2	1	1.64	(3,3,2,1,3,5,BU:1.5); ;
resource, in water	Water, unspecified natural origin/m3	-	-	m3	3.57E+0	3.57E+0	3.57E+0	1	1.68	(4,5,2,2,4,5,BU:1.05); ;
technosphere	electricity, medium voltage, production ENTSO, at grid	ENTSO	0	kWh	1.65E+3	1.65E+3	1.65E+3	1	1.68	(4,5,2,2,4,5,BU:1.05); ;
technosphere	natural gas, burned in industrial furnace 1MW	CH	0	MJ	8.93E+3	8.93E+3	8.93E+3	1	1.68	(4,5,2,2,4,5,BU:1.05); ;
	chimney	CH	1	m	2.86E+0	2.86E+0	2.86E+0	1	3.36	(4,5,2,2,4,5,BU:3); ;
	aluminium, primary, at plant	RER	0	kg	2.09E-1	2.09E-1	2.09E-1	1	1.64	(3,5,5,1,1,5,BU:1.05); ;
	cast iron, at plant	RER	0	kg	1.51E+1	1.51E+1	1.51E+1	1	1.64	(3,5,5,1,1,5,BU:1.05); ;
	concrete, normal, at plant	CH	0	m3	2.77E-01	2.77E-01	2.77E-01	1	1.64	(3,5,5,1,1,5,BU:1.05); ;
	copper, at regional storage	RER	0	kg	6.78E+00	6.78E+00	6.78E+00	1	1.64	(3,5,5,1,1,5,BU:1.05); ;
	lubricating oil, at plant	RER	0	kg	1.25E+00	1.25E+00	1.25E+00	1	1.21	(1,1,2,1,1,5,BU:1.05); ;
	polyethylene, HDPE, granulate, at plant	RER	0	kg	1.42E+00	1.42E+00	1.42E+00	1	1.64	(3,5,5,1,1,5,BU:1.05); ;
	polyurethane, rigid foam, at plant	RER	0	kg	2.68E+01	2.68E+01	2.68E+01	1	1.64	(3,5,5,1,1,5,BU:1.05); ;
	rock wool, at plant	CH	0	kg	9.20E+00	9.20E+00	9.20E+00	1	1.64	(3,5,5,1,1,5,BU:1.05); ;
	steel, low-alloyed, at plant	RER	0	kg	8.78E+02	8.78E+02	8.78E+02	1	1.21	(1,1,2,1,1,5,BU:1.05); ;
	sheet rolling, steel	RER	0	kg	4.60E+00	4.60E+00	4.60E+00	1	1.21	(1,1,2,1,1,5,BU:1.05); ;
	drawing of pipes, steel	RER	0	kg	4.60E+00	4.60E+00	4.60E+00	1	1.64	(3,5,5,1,1,5,BU:1.05); ;
	transport, freight, lorry 16-32 metric ton, fleet average	CH	0	tkm	8.39E+01	8.39E+01	8.39E+01	1	2.05	(1,1,2,1,1,5,BU:2); ;
	transport, freight, rail	RER	0	tkm	7.34E+02	7.34E+02	7.34E+02	1	2.05	(1,1,2,1,1,5,BU:2); ;
air, high population density	Heat, waste	-	-	MJ	5.94E+03	5.94E+03	5.94E+03	1	1.21	(1,1,2,1,1,5,BU:1.05); ;
technosphere	disposal, concrete, 5% water, to inert material landfill	CH	0	kg	6.60E+02	6.60E+02	6.60E+02	1	1.64	(3,5,5,1,1,5,BU:1.05); ;
	disposal, polyethylene, 0.4% water, to municipal incineration	CH	0	kg	2.68E+01	2.68E+01	2.68E+01	1	1.64	(3,5,5,1,1,5,BU:1.05); ;
	disposal, polyurethane, 0.2% water, to municipal incineration	CH	0	kg	1.42E+00	1.42E+00	1.42E+00	1	1.64	(3,5,5,1,1,5,BU:1.05); ;
	disposal, used mineral oil, 10% water, to hazardous waste incineration	CH	0	kg	1.25E+00	1.25E+00	1.25E+00	1	1.64	(3,5,5,1,1,5,BU:1.05); ;
	disposal, mineral wool, 0% water, to inert material landfill	CH	0	kg	9.20E+00	9.20E+00	9.20E+00	1	1.64	(3,5,5,1,1,5,BU:1.05); ;

Figure 99: Unit process raw data of furnace, logs, 50kW

ReferenceFunction	Name	furnace, wood chips, hardwood, 50kW	furnace, wood chips, mixed, 50kW	furnace, wood chips, softwood, 50kW
Geography	Location	CH	CH	CH
ReferenceFunction	InfrastructureProcess	1	1	1
ReferenceFunction	Unit	unit	unit	unit
	IncludedProcesses	Includes materials, transports and energy used for the fabrication of the furnace, the chimney, the storage silo, the automatic fuel supply and the automatic control technique.	Includes materials, transports and energy used for the fabrication of the furnace, the chimney, the storage silo, the automatic fuel supply and the automatic control technique.	Includes materials, transports and energy used for the fabrication of the furnace, the chimney, the storage silo, the automatic fuel supply and the automatic control technique.
	LocalName	Feuerung, Holzschnitzel, Laubholz, 50kW	Feuerung, Holzschnitzel, Holzmix, 50kW	Feuerung, Holzschnitzel, Nadelholz, 50kW
	Synonyms			
	GeneralComment	Inventory refers to the production of a wood chips furnace 50kW. Composition of the previous inventory was used and updated with the average weight of current wood chips furnaces available in Switzerland.	Inventory refers to the production of a wood chips furnace 50kW. Composition of the previous inventory was used and updated with the average weight of current wood chips furnaces available in Switzerland.	Inventory refers to the production of a wood chips furnace 50kW. Composition of the previous inventory was used and updated with the average weight of current wood chips furnaces available in Switzerland.
	InfrastructureIncluded	1	1	1
	Category	wood energy	wood energy	wood energy
	SubCategory	heating systems	heating systems	heating systems
	LocalCategory	Holzenergie	Holzenergie	Holzenergie
	LocalSubCategory	Heizungssysteme	Heizungssysteme	Heizungssysteme
	Formula			
	StatisticalClassification			
	CASNumber			
TimePeriod	StartDate	2015	2015	2015
	EndDate	2020	2020	2020
	DataValidForEntirePeriod	1	1	1
	OtherPeriodText	Time of publications.	Time of publications.	Time of publications.
Geography	Text			
Technology	Text	average technology	average technology	average technology
Representativeness	Percent			
	ProductionVolume			
	SamplingProcedure			
	Extrapolations	none	none	none
	UncertaintyAdjustments	none	none	none

Figure 100: Metadata of furnace, wood chips, 50kW

	Name	Location	Infrastructure Process	Unit	furnace, wood chips, hardwood, 50kW	furnace, wood chips, mixed, 50kW	furnace, wood chips, softwood, 50kW	Uncertainty Type	Standard Deviation 95%	General Comment
	Location				CH	CH	CH			
	Infrastructure Process				1	1	1			
	Unit				unit	unit	unit			
product	furnace, wood chips, hardwood, 50kW	CH	1	unit	1	0	0			
	furnace, wood chips, mixed, 50kW	CH	1	unit	0	1	0			
	furnace, wood chips, softwood, 50kW	CH	1	unit	0	0	1	0		
resource, land	Transformation, from unknown	-	-	m2	6.82E+1	8.52E+1	9.22E+1	1	2.11	(3,3,2,1,3,5,BU:2); ;
	Transformation, to industrial area	-	-	m2	6.82E+1	8.52E+1	9.22E+1	1	2.34	(3,5,5,1,1,5,BU:2); ;
	Occupation, industrial area	-	-	m2a	1.36E+3	1.70E+3	1.84E+3	1	1.64	(3,3,2,1,3,5,BU:1.5); ;
resource, in water	Water, unspecified natural origin/m3	-	-	m3	3.10E+0	3.10E+0	3.10E+0	1	1.68	(4,5,2,2,4,5,BU:1.05); ;
technosphere	electricity, medium voltage, production ENTSO, at grid	ENTSO	0	kWh	1.42E+3	1.42E+3	1.42E+3	1	1.68	(4,5,2,2,4,5,BU:1.05); ;
	natural gas, burned in industrial furnace 1MW	CH	0	MJ	7.68E+3	7.68E+3	7.68E+3	1	1.68	(4,5,2,2,4,5,BU:1.05); ;
	chimney	CH	1	m	3.80E+0	3.80E+0	3.80E+0	1	3.36	(4,5,2,2,4,5,BU:3); ;
	concrete, normal, at plant	CH	0	m3	3.09E+1	3.71E+1	3.96E+1	1	1.64	(3,5,5,1,1,5,BU:1.05); ;
	aluminium, primary, at plant	RER	0	kg	2.53E-1	2.53E-1	2.53E-1	1	1.64	(3,5,5,1,1,5,BU:1.05); ;
	cast iron, at plant	RER	0	kg	1.77E+1	1.77E+1	1.77E+1	1	1.64	(3,5,5,1,1,5,BU:1.05); ;
	concrete, normal, at plant	CH	0	m3	6.00E-02	6.00E-2	6.00E-2	1	1.64	(3,5,5,1,1,5,BU:1.05); ;
	copper, at regional storage	RER	0	kg	8.21E+00	8.21E+0	8.21E+0	1	1.21	(1,1,2,1,1,5,BU:1.05); ;
	lubricating oil, at plant	RER	0	kg	8.84E-01	8.84E-1	8.84E-1	1	1.64	(3,5,5,1,1,5,BU:1.05); ;
	polyethylene, HDPE, granulate, at plant	RER	0	kg	1.77E+00	1.77E+0	1.77E+0	1	1.64	(3,5,5,1,1,5,BU:1.05); ;
	rock wool, at plant	CH	0	kg	1.26E+00	1.26E+0	1.26E+0	1	1.64	(3,5,5,1,1,5,BU:1.05); ;
	steel, low-alloyed, at plant	RER	0	kg	7.77E+02	7.77E+2	7.77E+2	1	1.21	(1,1,2,1,1,5,BU:1.05); ;
	sheet rolling, steel	RER	0	kg	4.42E+00	4.42E+0	4.42E+0	1	1.21	(1,1,2,1,1,5,BU:1.05); ;
	drawing of pipes, steel	RER	0	kg	4.42E+00	4.42E+0	4.42E+0	1	1.64	(3,5,5,1,1,5,BU:1.05); ;
	transport, freight, lorry 16-32 metric ton, fleet average	CH	0	tkm	1.52E+03	1.81E+03	1.93E+03	1	2.05	(1,1,2,1,1,5,BU:2); ;
	transport, freight, rail	RER	0	tkm	7.86E+03	9.33E+03	9.93E+03	1	2.05	(1,1,2,1,1,5,BU:2); ;
air, high population density	Heat, waste	-	-	MJ	5.11E+03	5.11E+3	5.11E+3	1	1.21	(1,1,2,1,1,5,BU:1.05); ;
technosphere	disposal, concrete, 5% water, to inert material landfill	CH	0	kg	7.38E+04	8.85E+4	9.44E+4	1	1.64	(3,5,5,1,1,5,BU:1.05); ;
	disposal, polyethylene, 0.4% water, to municipal incineration	CH	0	kg	1.77E+00	1.77E+0	1.77E+0	1	1.64	(3,5,5,1,1,5,BU:1.05); ;
	disposal, used mineral oil, 10% water, to hazardous waste incineration	CH	0	kg	8.80E-01	8.80E-1	8.80E-1	1	1.64	(3,5,5,1,1,5,BU:1.05); ;
	disposal, mineral wool, 0% water, to inert material landfill	CH	0	kg	1.26E+00	1.26E+0	1.26E+0	1	1.64	(3,5,5,1,1,5,BU:1.05); ;

Figure 101: Unit process raw data of furnace, wood chips, 50kW

ReferenceFunction	Name	furnace, wood chips, hardwood, 300kW	furnace, wood chips, mixed, 300kW	furnace, wood chips, softwood, 300kW
Geography	Location	CH	CH	CH
ReferenceFunction	InfrastructureProcess	1	1	1
ReferenceFunction	Unit	unit	unit	unit
DataSetInformation	Type	1	1	1
	Version	1.0	1.0	1.0
	energyValues	0	0	0
	LanguageCode	en	en	en
	LocalLanguageCode	de	de	de
DataEntryBy	Person	101	101	101
	QualityNetwork	1	1	1
ReferenceFunction	DataSetRelatesToProduct	1	1	1
	IncludedProcesses	Includes materials, transports and energy used for the fabrication of the furnace, the chimney, the storage silo, the automatic fuel supply and the automatic control technique.	Includes materials, transports and energy used for the fabrication of the furnace, the chimney, the storage silo, the automatic fuel supply and the automatic control technique.	Includes materials, transports and energy used for the fabrication of the furnace, the chimney, the storage silo, the automatic fuel supply and the automatic control technique.
	LocalName	Feuerung, Holzschnitzel, Laubholz, 300kW	Feuerung, Holzschnitzel, Holzmix 300kW	Feuerung, Holzschnitzel, Nadelholz, 300kW
	Synonyms			
	GeneralComment	Inventory refers to the production of a wood chips furnace 300kW. Composition of the previous inventory was used and updated with the average weight of current wood chips furnaces available in Switzerland.	Inventory refers to the production of a wood chips furnace 300kW. Composition of the previous inventory was used and updated with the average weight of current wood chips furnaces available in Switzerland.	Inventory refers to the production of a wood chips furnace 300kW. Composition of the previous inventory was used and updated with the average weight of current wood chips furnaces available in Switzerland.
	InfrastructureIncluded	1	1	1
	Category	wood energy	wood energy	wood energy
	SubCategory	heating systems	heating systems	heating systems
	LocalCategory	Holzenergie	Holzenergie	Holzenergie
	LocalSubCategory	Heizungssysteme	Heizungssysteme	Heizungssysteme
	Formula			
	StatisticalClassification			
	CASNumber			
TimePeriod	StartDate	2015	2015	2015
	EndDate	2020	2020	2020
	DataValidForEntirePeriod	1	1	1
	OtherPeriodText	Time of publications.	Time of publications.	Time of publications.
Geography	Text			
Technology	Text	average technology	average technology	average technology
Representativeness	Percent			
	ProductionVolume			
	SamplingProcedure			
	Extrapolations	none	none	none
	UncertaintyAdjustments	none	none	none

Figure 102: Metadata of furnace, wood chips, 300kW

	Name	Location	Infrastructure Process	Unit	furnace, wood chips, hardwood, 300kW	furnace, wood chips, mixed, 300kW	furnace, wood chips, softwood, 300kW	Uncertainty Type	Standard Deviation 95%	General Comment
	Location				CH	CH	CH			
	Infrastructure Process				1	1	1			
	Unit				unit	unit	unit			
product	furnace, wood chips, hardwood, 300kW	CH	1	unit	1	0	0			
	furnace, wood chips, mixed, 300kW	CH	1	unit	0	1	0			
	furnace, wood chips, softwood, 300kW	CH	1	unit	0	0	1	0		
resource, land	Transformation, from unknown	-	-	m2	9.91E+1	1.24E+2	1.34E+2	1	2.11	(3,3,2,1,3,5,BU:2); ;
	Transformation, to industrial area	-	-	m2	9.91E+1	1.24E+2	1.34E+2	1	2.34	(3,5,5,1,1,5,BU:2); ;
	Occupation, industrial area	-	-	m2a	1.98E+3	2.48E+3	2.67E+3	1	1.64	(3,3,2,1,3,5,BU:1.5); ;
resource, in water	Water, unspecified natural origin/m3	-	-	m3	9.50E+0	9.50E+0	9.50E+0	1	1.68	(4,5,2,2,4,5,BU:1.05); ;
technosphere	electricity, medium voltage, production ENTSO, at grid	ENTSO	0	kWh	4.39E+3	4.39E+3	4.39E+3	1	1.68	(4,5,2,2,4,5,BU:1.05); ;
	natural gas, burned in industrial furnace 1MW	CH	0	MJ	2.38E+4	2.38E+4	2.38E+4	1	1.68	(4,5,2,2,4,5,BU:1.05); ;
	chimney	CH	1	m	7.05E+0	7.05E+0	7.05E+0	1	3.36	(4,5,2,2,4,5,BU:3); ;
	concrete, normal, at plant	CH	0	m3	4.96E+0	5.99E+1	6.41E+1	1	1.64	(3,5,5,1,1,5,BU:1.05); ;
	aluminium, primary, at plant	RER	0	kg	5.95E-1	5.95E-1	5.95E-1	1	1.64	(3,5,5,1,1,5,BU:1.05); ;
	cast iron, at plant	RER	0	kg	4.17E+1	4.17E+1	4.17E+1	1	1.64	(3,5,5,1,1,5,BU:1.05); ;
	concrete, normal, at plant	CH	0	m3	3.50E-01	3.50E-01	3.50E-01	1	1.64	(3,5,5,1,1,5,BU:1.05); ;
	copper, at regional storage	RER	0	kg	1.92E+01	1.92E+01	1.92E+01	1	1.21	(1,1,2,1,1,5,BU:1.05); ;
	lubricating oil, at plant	RER	0	kg	3.13E+00	3.13E+00	3.13E+00	1	1.64	(3,5,5,1,1,5,BU:1.05); ;
	polyethylene, HDPE, granulate, at plant	RER	0	kg	4.07E+00	4.07E+00	4.07E+00	1	1.64	(3,5,5,1,1,5,BU:1.05); ;
	rock wool, at plant	CH	0	kg	9.91E+00	9.91E+00	9.91E+00	1	1.64	(3,5,5,1,1,5,BU:1.05); ;
	steel, low-alloyed, at plant	RER	0	kg	2.42E+03	2.42E+03	2.42E+03	1	1.21	(1,1,2,1,1,5,BU:1.05); ;
	sheet rolling, steel	RER	0	kg	1.23E+01	1.23E+01	1.23E+01	1	1.21	(1,1,2,1,1,5,BU:1.05); ;
	drawing of pipes, steel	RER	0	kg	1.23E+01	1.23E+01	1.23E+01	1	1.64	(3,5,5,1,1,5,BU:1.05); ;
	transport, freight, lorry 16-32 metric ton, fleet average	CH	0	tkm	2.50E+03	2.99E+03	3.19E+03	1	2.05	(1,1,2,1,1,5,BU:2); ;
	transport, freight, rail	RER	0	tkm	1.34E+04	1.58E+04	1.68E+04	1	2.05	(1,1,2,1,1,5,BU:2); ;
air, high population density	Heat, waste	-	-	MJ	1.58E+04	1.58E+04	1.58E+04	1	1.21	(1,1,2,1,1,5,BU:1.05); ;
technosphere	disposal, concrete, 5% water, to inert material landfill	CH	0	kg	1.19E+05	1.43E+05	1.54E+05	1	1.64	(3,5,5,1,1,5,BU:1.05); ;
	disposal, polyethylene, 0.4% water, to municipal incineration	CH	0	kg	4.07E+00	4.07E+00	4.07E+00	1	1.64	(3,5,5,1,1,5,BU:1.05); ;
	disposal, used mineral oil, 10% water, to hazardous waste incineration	CH	0	kg	3.13E+00	3.13E+00	3.13E+00	1	1.64	(3,5,5,1,1,5,BU:1.05); ;
	disposal, mineral wool, 0% water, to inert material landfill	CH	0	kg	9.91E+00	9.91E+00	9.91E+00	1	1.64	(3,5,5,1,1,5,BU:1.05); ;

Figure 103: Unit process raw data of furnace, wood chips, 300kW

ReferenceFunction	Name	furnace, wood chips, hardwood, 1000kW	furnace, wood chips, mixed, 1000kW	furnace, wood chips, softwood, 1000kW
Geography	Location	CH	CH	CH
ReferenceFunction	InfrastructureProcess	1	1	1
ReferenceFunction	Unit	unit	unit	unit
	IncludedProcesses	Includes materials, transports and energy used for the fabrication of the furnace, the chimney, the storage silo, the automatic fuel supply and the automatic control technique.	Includes materials, transports and energy used for the fabrication of the furnace, the chimney, the storage silo, the automatic fuel supply and the automatic control technique.	Includes materials, transports and energy used for the fabrication of the furnace, the chimney, the storage silo, the automatic fuel supply and the automatic control technique.
	LocalName	Feuerung, Holzschnitzel, Laubholz, 1000kW	Feuerung, Holzschnitzel, Holzmix, 1000kW	Feuerung, Holzschnitzel, Nadelholz, 1000kW
	Synonyms	In UVEK2018 enthalten	In UVEK2018 enthalten	In UVEK2018 enthalten
	GeneralComment	Inventory refers to the production of a wood chips furnace 1MW. Composition of the previous inventory was used and updated with the average weight of current wood chips furnaces available in Switzerland.	Inventory refers to the production of a wood chips furnace 1MW. Composition of the previous inventory was used and updated with the average weight of current wood chips furnaces available in Switzerland.	Inventory refers to the production of a wood chips furnace 1MW. Composition of the previous inventory was used and updated with the average weight of current wood chips furnaces available in Switzerland.
	InfrastructureIncluded	1	1	1
	Category	wood energy	wood energy	wood energy
	SubCategory	heating systems	heating systems	heating systems
	LocalCategory	Holzenergie	Holzenergie	Holzenergie
	LocalSubCategory	Heizungssysteme	Heizungssysteme	Heizungssysteme
	Formula			
	StatisticalClassification			
	CASNumber			
TimePeriod	StartDate	2015	2015	2015
	EndDate	2020	2020	2020
	DataValidForEntirePeriod	1	1	1
	OtherPeriodText	Time of publications.	Time of publications.	Time of publications.
Geography	Text			
Technology	Text	average technology	average technology	average technology
Representativeness	Percent			
	ProductionVolume			
	SamplingProcedure			
	Extrapolations	none	none	none
	UncertaintyAdjustments	none	none	none

Figure 104: Metadata of furnace, wood chips, 1000kW

	Name	Location	Infrastructure Process	Unit	furnace, wood chips, hardwood, 1000kW	furnace, wood chips, mixed, 1000kW	furnace, wood chips, softwood, 1000kW	Uncertainty Type	Standard Deviation 95%	General Comment
	Location				CH	CH	CH			
	Infrastructure Process				1	1	1			
	Unit				unit	unit	unit			
product	furnace, wood chips, hardwood, 1000kW	CH	1	unit	1	0	0			
	furnace, wood chips, mixed, 1000kW	CH	1	unit	0	1	0			
	furnace, wood chips, softwood, 1000kW	CH	1	unit	0	0	1	0		
resource, land	Transformation, from unknown	-	-	m2	2.65E+2	3.30E+2	3.58E+2	1	2.11	(3,3,2,1,3,5,BU:2); ;
	Transformation, to industrial area	-	-	m2	2.65E+2	3.30E+2	3.58E+2	1	2.34	(3,5,5,1,1,5,BU:2); ;
	Occupation, industrial area	-	-	m2a	5.30E+3	6.59E+3	7.17E+3	1	1.64	(3,3,2,1,3,5,BU:1.5); ;
resource, in water	Water, unspecified natural origin/m3	-	-	m3	6.38E+1	6.38E+1	6.38E+1	1	1.68	(4,5,2,3,4,5,BU:1.05); ;
technosphere	electricity, medium voltage, production ENTSO, at grid	ENTSO	0	kWh	2.95E+4	2.95E+4	2.95E+4	1	1.68	(4,5,2,3,4,5,BU:1.05); ;
	natural gas, burned in industrial furnace 1MW	CH	0	MJ	1.60E+5	1.60E+5	1.60E+5	1	1.68	(4,5,2,3,4,5,BU:1.05); ;
	chimney	CH	1	m	9.08E+0	9.08E+0	9.08E+0	1	3.36	(4,5,2,3,4,5,BU:3); ;
	concrete, normal, at plant	CH	0	m3	5.27E+01	6.37E+01	6.81E+01	1	1.64	(3,5,5,1,1,5,BU:1.05); ;
	aluminium, primary, at plant	RER	0	kg	4.83E+00	4.83E+00	4.83E+00	1	1.64	(3,5,5,1,1,5,BU:1.05); ;
	cast iron, at plant	RER	0	kg	3.27E+02	3.27E+02	3.27E+02	1	1.64	(3,5,5,1,1,5,BU:1.05); ;
	concrete, normal, at plant	CH	0	m3	2.40E+00	2.40E+00	2.40E+00	1	1.64	(3,5,5,1,1,5,BU:1.05); ;
	copper, at regional storage	RER	0	kg	1.56E+02	1.56E+02	1.56E+02	1	1.21	(1,1,2,1,1,5,BU:1.05); ;
	lubricating oil, at plant	RER	0	kg	1.56E+01	1.56E+01	1.56E+01	1	1.64	(3,5,5,1,1,5,BU:1.05); ;
	polyethylene, HDPE, granulate, at plant	RER	0	kg	3.30E+01	3.30E+01	3.30E+01	1	1.64	(3,5,5,1,1,5,BU:1.05); ;
	rock wool, at plant	CH	0	kg	9.09E+01	9.09E+01	9.09E+01	1	1.64	(3,5,5,1,1,5,BU:1.05); ;
	steel, low-alloyed, at plant	RER	0	kg	1.61E+04	1.61E+04	1.61E+04	1	1.21	(1,1,2,1,1,5,BU:1.05); ;
	sheet rolling, steel	RER	0	kg	7.14E+01	7.14E+01	7.14E+01	1	1.21	(1,1,2,1,1,5,BU:1.05); ;
	drawing of pipes, steel	RER	0	kg	7.14E+01	7.14E+01	7.14E+01	1	1.64	(3,5,5,1,1,5,BU:1.05); ;
	transport, freight, lorry 16-32 metric ton, fleet average	CH	0	tkm	3.46E+03	3.98E+03	4.20E+03	1	2.34	(3,5,5,1,1,5,BU:2); ;
	transport, freight, rail	RER	0	tkm	2.31E+04	2.57E+04	2.68E+04	1	2.05	(1,1,2,1,1,5,BU:2); ;
air, high population density	Heat, waste	-	-	MJ	1.06E+05	1.06E+05	1.06E+05	1	1.21	(1,1,2,1,1,5,BU:1.05); ;
technosphere	disposal, concrete, 5% water, to inert material landfill	CH	0	kg	1.31E+05	1.57E+05	1.69E+05	1	1.64	(3,5,5,1,1,5,BU:1.05); ;
	disposal, polyethylene, 0.4% water, to municipal incineration	CH	0	kg	3.30E+01	3.30E+01	3.30E+01	1	1.64	(3,5,5,1,1,5,BU:1.05); ;
	disposal, used mineral oil, 10% water, to hazardous waste incineration	CH	0	kg	1.56E+01	1.56E+01	1.56E+01	1	1.64	(3,5,5,1,1,5,BU:1.05); ;
	disposal, mineral wool, 0% water, to inert material landfill	CH	0	kg	9.09E+01	9.09E+01	9.09E+01	1	1.64	(3,5,5,1,1,5,BU:1.05); ;

Figure 105: Unit process raw data of furnace, wood chips, 1000kW

ReferenceFunction	Name	furnace, wood chips, hardwood, 5000kW	furnace, wood chips, mixed, 5000kW	furnace, wood chips, softwood, 5000kW
Geography	Location	CH	CH	CH
ReferenceFunction	InfrastructureProcess	1	1	1
ReferenceFunction	Unit	unit	unit	unit
	IncludedProcesses	Includes materials, transports and energy used for the fabrication of the furnace, the chimney, the storage silo, the automatic fuel supply and the automatic control technique.	Includes materials, transports and energy used for the fabrication of the furnace, the chimney, the storage silo, the automatic fuel supply and the automatic control technique.	Includes materials, transports and energy used for the fabrication of the furnace, the chimney, the storage silo, the automatic fuel supply and the automatic control technique.
	LocalName	Feuerung, Holzschnitzel, Laubholz, 5000kW	Feuerung, Holzschnitzel, Holzmix, 5000kW	Feuerung, Holzschnitzel, Nadelholz, 5000kW
	Synonyms	0	0	0
	GeneralComment	Inventory refers to the production of a wood chips furnace 5MW. Composition of the previous inventory was used and updated with the average weight of current wood chips furnaces available in Switzerland.	Inventory refers to the production of a wood chips furnace 5MW. Composition of the previous inventory was used and updated with the average weight of current wood chips furnaces available in Switzerland.	Inventory refers to the production of a wood chips furnace 5MW. Composition of the previous inventory was used and updated with the average weight of current wood chips furnaces available in Switzerland.
	InfrastructureIncluded	1	1	1
	Category	wood energy	wood energy	wood energy
	SubCategory	heating systems	heating systems	heating systems
	LocalCategory	Holzenergie	Holzenergie	Holzenergie
	LocalSubCategory	Heizungssysteme	Heizungssysteme	Heizungssysteme
	Formula			
	StatisticalClassification			
	CASNumber			
TimePeriod	StartDate	2015	2015	2015
	EndDate	2020	2020	2020
	DataValidForEntirePeriod	1	1	1
	OtherPeriodText	Time of publications.	Time of publications.	Time of publications.
Geography	Text			
Technology	Text	average technology	average technology	average technology
Representativeness	Percent			
	ProductionVolume			
	SamplingProcedure			
	Extrapolations	none	none	none
	UncertaintyAdjustments	none	none	none

Figure 106: Metadata of furnace, wood chips, 5000kW

	Name	Location	Infrastructure Process	Unit	furnace, wood chips, hardwood, 5000kW	furnace, wood chips, mixed, 5000kW	furnace, wood chips, softwood, 5000kW	Uncertainty Type	Standard Deviation 95%	General Comment
	Location				CH	CH	CH			
	Infrastructure Process				1	1	1			
	Unit				unit	unit	unit			
product	furnace, wood chips, hardwood, 5000kW	CH	1	unit	1	0	0			
	furnace, wood chips, mixed, 5000kW	CH	1	unit	0	1	0			
	furnace, wood chips, softwood, 5000kW	CH	1	unit	0	0	1	0		
resource, land	Transformation, from unknown	-	-	m2	6.76E+3	8.45E+3	9.14E+3	1	2.11	(3,3,2,1,3,5,BU:2); ;
	Transformation, to industrial area	-	-	m2	6.76E+3	8.45E+3	9.14E+3	1	2.34	(3,5,5,1,1,5,BU:2); ;
	Occupation, industrial area	-	-	m2a	1.35E+5	1.69E+5	1.83E+5	1	1.64	(3,3,2,1,3,5,BU:1.5); ;
resource, in water	Water, unspecified natural origin/m3	-	-	m3	3.04E+2	3.04E+2	3.04E+2	1	1.68	(4,5,2,2,4,5,BU:1.05); ;
technosphere	electricity, medium voltage, production ENTSO, at grid	ENTSO	0	kWh	1.41E+5	1.41E+5	1.41E+5	1	1.68	(4,5,2,2,4,5,BU:1.05); ;
	natural gas, burned in industrial furnace 1MW	CH	0	MJ	7.61E+5	7.61E+5	7.61E+5	1	1.68	(4,5,2,2,4,5,BU:1.05); ;
	chimney	CH	1	m	1.67E+1	1.67E+1	1.67E+1	1	3.36	(4,5,2,2,4,5,BU:3); ;
	concrete, normal, at plant	CH	0	m3	7.53E+01	9.15E+1	9.80E+1	1	1.64	(3,5,5,1,1,5,BU:1.05); ;
	aluminium, primary, at plant	RER	0	kg	2.51E+1	2.51E+1	2.51E+1	1	1.64	(3,5,5,1,1,5,BU:1.05); ;
	cast iron, at plant	RER	0	kg	1.75E+3	1.75E+3	1.75E+3	1	1.64	(3,5,5,1,1,5,BU:1.05); ;
	concrete, normal, at plant	CH	0	m3	6.31E+00	6.31E+0	6.31E+0	1	1.64	(3,5,5,1,1,5,BU:1.05); ;
	copper, at regional storage	RER	0	kg	8.14E+02	8.14E+02	8.14E+02	1	1.21	(1,1,2,1,1,5,BU:1.05); ;
	lubricating oil, at plant	RER	0	kg	8.77E+01	8.77E+01	8.77E+01	1	1.64	(3,5,5,1,1,5,BU:1.05); ;
	polyethylene, HDPE, granulate, at plant	RER	0	kg	1.75E+02	1.75E+02	1.75E+02	1	1.64	(3,5,5,1,1,5,BU:1.05); ;
	rock wool, at plant	CH	0	kg	1.25E+02	1.25E+02	1.25E+02	1	1.64	(3,5,5,1,1,5,BU:1.05); ;
	steel, low-alloyed, at plant	RER	0	kg	7.70E+04	7.70E+04	7.70E+04	1	1.21	(1,1,2,1,1,5,BU:1.05); ;
	sheet rolling, steel	RER	0	kg	4.38E+02	4.38E+02	4.38E+02	1	1.21	(1,1,2,1,1,5,BU:1.05); ;
	drawing of pipes, steel	RER	0	kg	4.38E+02	4.38E+02	4.38E+02	1	1.64	(3,5,5,1,1,5,BU:1.05); ;
	transport, freight, lorry 16-32 metric ton, fleet average	CH	0	tkm	7.89E+03	8.66E+3	8.97E+3	1	2.05	(1,1,2,1,1,5,BU:2); ;
	transport, freight, rail	RER	0	tkm	6.73E+04	7.11E+4	7.27E+4	1	2.05	(1,1,2,1,1,5,BU:2); ;
air, high population density	Heat, waste	-	-	MJ	5.06E+05	5.06E+5	5.06E+5	1	1.21	(1,1,2,1,1,5,BU:1.05); ;
technosphere	disposal, concrete, 5% water, to inert material landfill	CH	0	kg	1.94E+05	2.33E+5	2.50E+5	1	1.64	(3,5,5,1,1,5,BU:1.05); ;
	disposal, polyethylene, 0.4% water, to municipal incineration	CH	0	kg	1.75E+02	1.75E+02	1.75E+02	1	1.64	(3,5,5,1,1,5,BU:1.05); ;
	disposal, used mineral oil, 10% water, to hazardous waste incineration	CH	0	kg	8.77E+01	8.77E+01	8.77E+01	1	1.64	(3,5,5,1,1,5,BU:1.05); ;
	disposal, mineral wool, 0% water, to inert material landfill	CH	0	kg	1.25E+02	1.25E+02	1.25E+02	1	1.64	(3,5,5,1,1,5,BU:1.05); ;

Figure 107: Unit process raw data of furnace, wood chips, 5000kW

ReferenceFunction	Name	furnace, pellets, 15kW	furnace, pellets, 50kW	furnace, pellets, 300kW
Geography	Location	CH	CH	CH
ReferenceFunction	InfrastructureProcess	1	1	1
ReferenceFunction	Unit	unit	unit	unit
	IncludedProcesses	Includes materials, transports and energy used for the fabrication of the furnace, the chimney, the storage silo, the automatic fuel supply and the automatic control technique.	Includes materials, transports and energy used for the fabrication of the furnace, the chimney, the storage silo, the automatic fuel supply and the automatic control technique.	Includes materials, transports and energy used for the fabrication of the furnace, the chimney, the storage silo, the automatic fuel supply and the automatic control technique.
	LocalName	Feuerung, Pellets, 15kW	Feuerung, Pellets, 50kW	Feuerung, Pellets, 300kW
	Synonyms			
	GeneralComment	Inventory refers to the production of a pellets furnace 15kW. Composition of the previous inventory was used and updated with the average weight of current pellet furnaces available in Switzerland.	Inventory refers to the production of a pellets furnace 15kW. Composition of the previous inventory was used and updated with the average weight of current pellet furnaces available in Switzerland.	Inventory refers to the production of a pellets furnace 15kW. Composition of the previous inventory was used and updated with the average weight of current pellet furnaces available in Switzerland.
	InfrastructureIncluded	1	1	1
	Category	wood energy	wood energy	wood energy
	SubCategory	heating systems	heating systems	heating systems
	LocalCategory	Holzenergie	Holzenergie	Holzenergie
	LocalSubCategory	Heizungssysteme	Heizungssysteme	Heizungssysteme
	Formula			
	StatisticalClassification			
	CASNumber			
TimePeriod	StartDate	2015	2015	2015
	EndDate	2020	2020	2020
	DataValidForEntirePeriod	1	1	1
	OtherPeriodText	Time of publications.	Time of publications.	Time of publications.
Geography	Text			
Technology	Text	average technology	average technology	average technology
Representativeness	Percent			
	ProductionVolume			
	SamplingProcedure			
	Extrapolations	none	none	none
	UncertaintyAdjustments	none	none	none

Figure 108: Metadata of furnace, pellets

	Name	Location	Infrastructure Process	Unit	furnace, pellets, 15kW	furnace, pellets, 50kW	furnace, pellets, 300kW	Uncertainty Type	Standard Deviation 95%	General Comment
	Location				CH	CH	CH			
	Infrastructure Process				1	1	1			
	Unit				unit	unit	unit			
product	furnace, pellets, 15kW	CH	1	unit	1	0	0			
	furnace, pellets, 50kW	CH	1	unit	0	1	0			
	furnace, pellets, 300kW	CH	1	unit	0	0	1	0		
resource, land	Transformation, from unknown	-	-	m2	2.94E+0	1.71E+1	5.76E+1	1	2.11	(3,3,2,1,3,5,BU:2); ;
	Transformation, to industrial area	-	-	m2	2.94E+0	1.71E+1	5.76E+1	1	2.34	(3,5,5,1,1,5,BU:2); ;
	Occupation, industrial area	-	-	m2a	4.40E+1	2.56E+2	8.64E+2	1	1.64	(3,3,2,1,3,5,BU:1.5); ;
resource, in water	Water, unspecified natural origin/m3	-	-	m3	1.24E+0	2.68E+0	9.04E+0	1	1.33	(3,3,2,1,3,5,BU:1.05); ;
technosphere	electricity, medium voltage, production ENTSO, at grid	ENTSO	0	kWh	5.72E+2	1.24E+3	4.18E+3	1	1.68	(4,5,2,2,4,5,BU:1.05); ;
	natural gas, burned in industrial furnace 1MW	CH	0	MJ	3.10E+3	6.71E+3	2.26E+4	1	1.68	(4,5,2,2,4,5,BU:1.05); ;
	chimney	CH	1	m	2.10E+0	3.80E+0	7.05E+0	1	3.36	(4,5,2,2,4,5,BU:3); ;
	concrete, normal, at plant	CH	0	m3	5.49E+0	1.27E+1	7.64E+1	1	1.64	(3,5,5,1,1,5,BU:1.05); ;
	aluminium, primary, at plant	RER	0	kg	9.00E-2	1.90E-1	6.40E-1	1	1.64	(3,5,5,1,1,5,BU:1.05); ;
	cast iron, at plant	RER	0	kg	6.40E+0	1.33E+1	4.48E+1	1	1.64	(3,5,5,1,1,5,BU:1.05); ;
	ceramic tiles, at regional storage	CH	0	kg	4.80E+01	1.14E+2	3.84E+2	1	1.64	(3,5,5,1,1,5,BU:1.05); ;
#BEZUG!	copper, at regional storage	RER	0	kg	2.99E+00	6.17E+0	2.08E+1	1	1.64	(3,5,5,1,1,5,BU:1.05); ;
	lubricating oil, at plant	RER	0	kg	2.10E-01	6.60E-1	2.24E+0	1	1.64	(3,5,5,1,1,5,BU:1.05); ;
	polyethylene, HDPE, granulate, at plant	RER	0	kg	6.40E-01	1.33E+0	4.48E+2	1	1.64	(3,5,5,1,1,5,BU:1.05); ;
	rock wool, at plant	CH	0	kg	0.00E+00	0	0	1	1.21	(1,1,2,1,1,5,BU:1.05); ;
	steel, low-alloyed, at plant	RER	0	kg	2.67E+02	5.69E+2	1.92E+3	1	1.21	(1,1,2,1,1,5,BU:1.05); ;
	sheet rolling, steel	RER	0	kg	1.33E+00	3.80E+0	9.60E+0	1	1.64	(3,5,5,1,1,5,BU:1.05); ;
	drawing of pipes, steel	RER	0	kg	1.33E+00	3.80E+0	9.60E+0	1	1.21	(1,1,2,1,1,5,BU:1.05); ;
	transport, freight, lorry 16-32 metric ton, fleet average	CH	0	tkm	2.78E+02	6.42E+2	3.76E+3	1	2.05	(1,1,2,1,1,5,BU:2); ;
	transport, freight, rail	RER	0	tkm	1.50E+03	3.45E+3	1.96E+4	1	2.05	(1,1,2,1,1,5,BU:2); ;
air, high population density	Heat, waste	-	-	MJ	2.06E+03	4.46E+3	1.50E+4	1	1.64	(3,5,5,1,1,5,BU:1.05); ;
technosphere	disposal, concrete, 5% water, to inert material landfill	CH	0	kg	1.31E+04	3.03E+4	1.82E+5	1	1.64	(3,5,5,1,1,5,BU:1.05); ;
	disposal, polyethylene, 0.4% water, to municipal incineration	CH	0	kg	6.40E-01	1.33E+0	4.48E+0	1	1.64	(3,5,5,1,1,5,BU:1.05); ;
	disposal, used mineral oil, 10% water, to hazardous waste incineration	CH	0	kg	2.10E-01	6.60E-1	2.24E+0	1	1.64	(3,5,5,1,1,5,BU:1.05); ;
	disposal, mineral wool, 0% water, to inert material landfill	CH	0	kg	0.00E+00	0	0	1	1.64	(3,5,5,1,1,5,BU:1.05); ;

Figure 109: Unit process raw data of furnace, pellets

ReferenceFunction	Name	logs, hardwood, burned in wood heater 6kW	logs, mixed, burned in wood heater 6kW	logs, softwood, burned in wood heater 6kW
Geography	Location	CH	CH	CH
ReferenceFunction	InfrastructureProcess	0	0	0
ReferenceFunction	Unit	MJ	MJ	MJ
	IncludedProcesses	Included are the infrastructure, the wood requirements , the emissions to air, the transport of the fuel, the electricity needed for operation, and the disposal of the ashes.	Included are the infrastructure, the wood requirements , the emissions to air, the transport of the fuel, the electricity needed for operation, and the disposal of the ashes.	Included are the infrastructure, the wood requirements , the emissions to air, the transport of the fuel, the electricity needed for operation, and the disposal of the ashes.
	LocalName	Stückholz, Laubholz, in Einzelofen 6kW	Stückholz, Holzmix, in Einzelofen 6kW	Stückholz, Nadelholz, in Einzelofen 6kW
	Synonyms			
	GeneralComment	Inventory refers to the combustion of wood logs in a 6 kW wood heater with 1000 operating hours per year. The lower heating value is 18.0 MJ/kg dry matter. Air emission factors are calculated from the weighted average of measurements of log stoves	Inventory refers to the combustion of wood logs in a 6 kW wood heater with 1000 operating hours per year. The lower heating value is 18.0 MJ/kg dry matter. Air emission factors are calculated from the weighted average of measurements of log stoves	Inventory refers to the combustion of wood logs in a 6 kW wood heater with 1000 operating hours per year. The lower heating value is 18.0 MJ/kg dry matter. Air emission factors are calculated from the weighted average of measurements of log stoves
	InfrastructureIncluded	1	1	1
	Category	wood energy	wood energy	wood energy
	SubCategory	heating systems	heating systems	heating systems
	LocalCategory	Holzenergie	Holzenergie	Holzenergie
	LocalSubCategory	Heizungssysteme	Heizungssysteme	Heizungssysteme
	Formula			
	StatisticalClassification			
	CASNumber			
TimePeriod	StartDate	2015	2015	2015
	EndDate	2020	2020	2020
	DataValidForEntirePeriod	1	1	1
	OtherPeriodText	Time of publications.	Time of publications.	Time of publications.
Geography	Text	Could be used for central European conditions	Could be used for central European conditions	Could be used for central European conditions
Technology	Text	Boiler of average technology available on market	Boiler of average technology available on market	Boiler of average technology available on market
Representativeness	Percent			
	ProductionVolume			
	SamplingProcedure	literature	literature	literature
	Extrapolations	none	none	none
	UncertaintyAdjustments	none	none	none

Figure 110: Metadata of logs, burned in furnace 6kW

	Name	Location	Infrastructure Process	Unit	logs, hardwood, burned in wood heater 6kW	logs, mixed, burned in wood heater 6kW	logs, softwood, burned in wood heater 6kW	Uncertainty Type	Standard Deviation 95%	General Comment
	Location				CH	CH	CH			
	Infrastructure Process				0	0	0			
	Unit				MJ	MJ	MJ			
product	logs, hardwood, burned in wood heater 6kW	CH	0	MJ	1	0	0			
	logs, mixed, burned in wood heater 6kW	CH	0	MJ	0	1	0			
	logs, softwood, burned in wood heater 6kW	CH	0	MJ	0	0	1	0		
technosphere	electricity, low voltage, at grid	CH	0	kWh	1.94E-3	1.94E-3	1.94E-3	1	1.22	(2,3,1,1,1,5,BU:1.05); ;
	cleft timber, softwood, sustainable forest management, measured as dry mass, at forest road	CH	0	kg		3.40E-2	5.31E-2	1	1.22	(2,3,1,1,1,5,BU:1.05); ;
	cleft timber, hardwood, sustainable forest management, measured as dry mass, at forest road	CH	0	kg	5.56E-2	2.00E-2		1	1.22	(2,3,1,1,1,5,BU:1.05); ;
	furnace, logs, softwood, 6kW	CH	1	unit			1.78E-6	1	3.05	(2,3,1,1,1,5,BU:3); ;
	furnace, logs, hardwood, 6kW	CH	1	unit	1.78E-6			1	3.05	(2,3,1,1,1,5,BU:3); ;
	furnace, logs, mixed, 6kW	CH	1	unit		1.78E-6		1	3.05	(2,3,1,1,1,5,BU:3); ;
	transport, tractor and trailer	CH	0	tkm	2.78E-3	2.70E-3	2.65E-3	1	2.05	(2,3,1,1,1,5,BU:2); ;
	disposal, wood ash mixture, pure, 0% water, to municipal incineration	CH	0	kg	5.80E-4	5.80E-4	5.80E-4	1	1.22	(2,3,1,1,1,5,BU:1.05); ;
air, high population density	Acetaldehyde	-	-	kg	6.10E-8	6.10E-8	6.10E-8	1	1.89	(3,5,5,1,1,5,BU:1.5); ;
	Ammonia	-	-	kg	2.00E-06	2.00E-6	2.00E-6	1	1.30	(1,1,2,1,1,5,BU:1.2); ;
	Arsenic	-	-	kg	1.00E-09	1.00E-9	1.00E-9	1	5.38	(3,5,5,1,1,5,BU:5); ;
	Benzene	-	-	kg	9.10E-07	9.10E-7	9.10E-7	1	3.33	(3,5,5,1,1,5,BU:3); ;
	Benzene, ethyl-	-	-	kg	3.00E-08	3.00E-8	3.00E-8	1	3.33	(3,5,5,1,1,5,BU:3); ;
	Benzene, hexachloro-	-	-	kg	4.00E-12	4.00E-12	4.00E-12	1	3.05	(1,1,2,1,1,5,BU:3); ;
	Benzo(a)pyrene	-	-	kg	2.20E-08	2.20E-8	2.20E-8	1	3.05	(1,1,2,1,1,5,BU:3); ;
	Bromine	-	-	kg	6.00E-08	6.00E-8	6.00E-8	1	5.38	(3,5,5,1,1,5,BU:5); ;
	Cadmium	-	-	kg	1.30E-08	1.30E-8	1.30E-8	1	5.05	(1,1,2,1,1,5,BU:5); ;
	Calcium	-	-	kg	5.85E-06	5.85E-6	5.85E-6	1	5.38	(3,5,5,1,1,5,BU:5); ;
	Carbon dioxide, biogenic	-	-	kg	9.20E-02	9.20E-2	9.20E-2	1	1.21	(1,1,2,1,1,5,BU:1.05); ;
	Carbon monoxide, biogenic	-	-	kg	1.11E-03	1.11E-3	1.11E-3	1	5.05	(1,1,2,1,1,5,BU:5); ;
	Chlorine	-	-	kg	1.80E-07	1.80E-7	1.80E-7	1	1.89	(3,5,5,1,1,5,BU:1.5); ;
	Chromium	-	-	kg	3.96E-09	3.96E-9	3.96E-9	1	5.38	(3,5,5,1,1,5,BU:5); ;
	Chromium VI	-	-	kg	4.00E-11	4.00E-11	4.00E-11	1	5.38	(3,5,5,1,1,5,BU:5); ;
	Copper	-	-	kg	2.20E-08	2.20E-8	2.20E-8	1	5.38	(3,5,5,1,1,5,BU:5); ;
	Dinitrogen monoxide	-	-	kg	7.00E-06	7.00E-6	7.00E-6	1	1.89	(3,5,5,1,1,5,BU:1.5); ;
	Dioxins, measured as 2,3,7,8-tetrachlorodibenzo-p-dioxin	-	-	kg	8.90E-14	8.90E-14	8.90E-14	1	3.05	(1,1,2,1,1,5,BU:3); ;
	Fluorine	-	-	kg	5.00E-08	5.00E-8	5.00E-8	1	1.89	(3,5,5,1,1,5,BU:1.5); ;
	Formaldehyde	-	-	kg	1.30E-07	1.30E-7	1.30E-7	1	1.89	(3,5,5,1,1,5,BU:1.5); ;
	Heat, waste	-	-	MJ	1.07E+00	1.07E+0	1.07E+0	1	1.64	(3,5,5,1,1,5,BU:1.05); ;
	Hydrocarbons, aliphatic, alkanes, unspecified	-	-	kg	9.10E-07	9.10E-7	9.10E-7	1	1.89	(3,5,5,1,1,5,BU:1.5); ;
	Hydrocarbons, aliphatic, unsaturated	-	-	kg	3.10E-06	3.10E-6	3.10E-6	1	1.89	(3,5,5,1,1,5,BU:1.5); ;
	Lead	-	-	kg	2.70E-08	2.70E-8	2.70E-8	1	5.05	(1,1,2,1,1,5,BU:5); ;
	Magnesium	-	-	kg	3.60E-07	3.60E-7	3.60E-7	1	5.38	(3,5,5,1,1,5,BU:5); ;
	Manganese	-	-	kg	1.70E-07	1.70E-7	1.70E-7	1	5.38	(3,5,5,1,1,5,BU:5); ;
	Mercury	-	-	kg	6.00E-10	6.00E-10	6.00E-10	1	5.05	(1,1,2,1,1,5,BU:5); ;
	Methane, biogenic	-	-	kg	6.60E-05	6.60E-5	6.60E-5	1	1.56	(1,1,2,1,1,5,BU:1.5); ;
	m-Xylene	-	-	kg	1.20E-07	1.20E-7	1.20E-7	1	1.89	(3,5,5,1,1,5,BU:1.5); ;
	Nickel	-	-	kg	6.00E-09	6.00E-9	6.00E-9	1	5.38	(3,5,5,1,1,5,BU:5); ;
	Nitrogen oxides	-	-	kg	8.00E-05	8.00E-5	8.00E-5	1	1.56	(1,1,2,1,1,5,BU:1.5); ;
	NMVOC, non-methane volatile organic compounds, unspecified origin	-	-	kg	7.50E-05	7.50E-5	7.50E-5	1	1.56	(1,1,2,1,1,5,BU:1.5); ;
	PAH, polycyclic aromatic hydrocarbons	-	-	kg	1.11E-08	1.11E-8	1.11E-8	1	3.33	(3,5,5,1,1,5,BU:3); ;
	Particulates, < 2.5 um	-	-	kg	4.10E-05	4.10E-5	4.10E-5	1	3.05	(1,1,2,1,1,5,BU:3); ;
	Particulates, > 2.5 um, and < 10um	-	-	kg	1.00E-06	1.00E-6	1.00E-6	1	2.05	(1,1,2,1,1,5,BU:2); ;
	Phenol, pentachloro-	-	-	kg	8.10E-12	8.10E-12	8.10E-12	1	1.89	(3,5,5,1,1,5,BU:1.5); ;
	Phosphorus	-	-	kg	3.00E-07	3.00E-7	3.00E-7	1	1.89	(3,5,5,1,1,5,BU:1.5); ;
	Potassium	-	-	kg	2.34E-05	2.34E-5	2.34E-5	1	5.38	(3,5,5,1,1,5,BU:5); ;
	Sodium	-	-	kg	1.30E-06	1.30E-6	1.30E-6	1	5.38	(3,5,5,1,1,5,BU:5); ;
	Sulfur dioxide	-	-	kg	1.00E-05	1.00E-5	1.00E-5	1	1.21	(1,1,2,1,1,5,BU:1.05); ;
	Toluene	-	-	kg	3.00E-07	3.00E-7	3.00E-7	1	1.89	(3,5,5,1,1,5,BU:1.5); ;
	Zinc	-	-	kg	3.00E-07	3.00E-7	3.00E-7	1	5.38	(3,5,5,1,1,5,BU:5); ;

Figure 111: Unit process raw data of logs, burned in furnace 6kW

ReferenceFunction	Name	logs, hardwood, burned in furnace 15kW	logs, mixed, burned in furnace 15kW	logs, softwood, burned in furnace 15kW
Geography	Location	CH	CH	CH
ReferenceFunction	InfrastructureProcess	0	0	0
ReferenceFunction	Unit	MJ	MJ	MJ
	IncludedProcesses	Included are the infrastructure, the wood requirements , the emissions to air, the transport of the fuel, the electricity needed for operation, and the disposal of the ashes.	Included are the infrastructure, the wood requirements , the emissions to air, the transport of the fuel, the electricity needed for operation, and the disposal of the ashes.	Included are the infrastructure, the wood requirements , the emissions to air, the transport of the fuel, the electricity needed for operation, and the disposal of the ashes.
	LocalName	Stückholz, Laubholz, in Feuerung 15kW	Stückholz, Holzmix, in Feuerung 15kW	Stückholz, Nadelholz, in Feuerung 15kW
	Synonyms			
	GeneralComment	Inventory refers to the combustion of wood logs in a 15 kW wood heater. 1600 operating hours per year. The lower heating value is 18.0 MJ/kg dry matter. Air emission factors are calculated from the weighted average of measurements of log stoves	Inventory refers to the combustion of wood logs in a 15 kW wood heater. 1600 operating hours per year. The lower heating value is 18.0 MJ/kg dry matter. Air emission factors are calculated from the weighted average of measurements of log stoves	Inventory refers to the combustion of wood logs in a 15 kW wood heater. 1600 operating hours per year. The lower heating value is 18.0 MJ/kg dry matter. Air emission factors are calculated from the weighted average of measurements of log stoves
	InfrastructureIncluded	1	1	1
	Category	wood energy	wood energy	wood energy
	SubCategory	heating systems	heating systems	heating systems
	LocalCategory	Holzenergie	Holzenergie	Holzenergie
	LocalSubCategory	Heizungssysteme	Heizungssysteme	Heizungssysteme
	Formula			
	StatisticalClassification			
	CASNumber			
TimePeriod	StartDate	2015	2015	2015
	EndDate	2020	2020	2020
	DataValidForEntirePeriod	1	1	1
	OtherPeriodText	Time of publications.	Time of publications.	Time of publications.
Geography	Text	Could be used for central European conditions	Could be used for central European conditions	Could be used for central European conditions
Technology	Text	Boiler of average technology available on market	Boiler of average technology available on market	Boiler of average technology available on market
Representativeness	Percent			
	ProductionVolume			
	SamplingProcedure	literature	literature	literature
	Extrapolations	none	none	none
	UncertaintyAdjustments	none	none	none

Figure 112: Metadata of logs, burned in furnace 15kW

	Name	Location	Infrastructure Process	Unit	logs, hardwood, burned in furnace 15kW	logs, mixed, burned in furnace 15kW	logs, softwood, burned in furnace 15kW	Uncertainty Type	Standard Deviation 95%	General Comment
	Location				CH	CH	CH			
	Infrastructure Process				0	0	0			
	Unit				MJ	MJ	MJ			
product	logs, hardwood, burned in furnace 15kW	CH	0	MJ	1	0	0			
	logs, mixed, burned in furnace 15kW	CH	0	MJ	0	1	0			
	logs, softwood, burned in furnace 15kW	CH	0	MJ	0	0	1	0		
technosphere	electricity, low voltage, at grid	CH	0	kWh	1.11E-03	1.11E-3	1.11E-3	1	1.22	(2,3,1,1,1,5,BU:1.05); ;
	cleft timber, softwood, sustainable forest management, measured as dry mass, at forest road	CH	0	kg		3.40E-2	5.31E-2	1	1.22	(2,3,1,1,1,5,BU:1.05); ;
	cleft timber, hardwood, sustainable forest management, measured as dry mass, at forest road	CH	0	kg	5.56E-02	2.00E-2		1	1.22	(2,3,1,1,1,5,BU:1.05); ;
	furnace, logs, softwood, 15kW	CH	1	unit			4.63E-7	1	3.05	(2,3,1,1,1,5,BU:3); ;
	furnace, logs, hardwood, 15kW	CH	1	unit	4.63E-07			1	3.05	(2,3,1,1,1,5,BU:3); ;
	furnace, logs, mixed, 15kW	CH	1	unit		4.63E-7		1	3.05	(2,3,1,1,1,5,BU:3); ;
	transport, tractor and trailer	CH	0	tkm	2.78E-03	2.70E-3	2.65E-3	1	2.05	(2,3,1,1,1,5,BU:2); ;
	disposal, wood ash mixture, pure, 0% water, to municipal incineration	CH	0	kg	5.80E-03	5.80E-3	5.80E-3	1	1.22	(2,3,1,1,1,5,BU:1.05); ;
air, high population density	Acetaldehyde	-	-	kg	6.10E-08	6.10E-8	6.10E-8	1	1.89	(3,5,5,1,1,5,BU:1.5); ;
	Ammonia	-	-	kg	2.00E-06	2.00E-6	2.00E-6	1	1.30	(1,1,2,1,1,5,BU:1.2); ;
	Arsenic	-	-	kg	1.00E-09	1.00E-9	1.00E-9	1	5.38	(3,5,5,1,1,5,BU:5); ;
	Benzene	-	-	kg	9.10E-07	9.10E-7	9.10E-7	1	3.33	(3,5,5,1,1,5,BU:3); ;
	Benzene, ethyl-	-	-	kg	3.00E-08	3.00E-8	3.00E-8	1	3.33	(3,5,5,1,1,5,BU:3); ;
	Benzene, hexachloro-	-	-	kg	4.00E-12	4.00E-12	4.00E-12	1	3.05	(1,1,2,1,1,5,BU:3); ;
	Benzo(a)pyrene	-	-	kg	2.20E-08	2.20E-8	2.20E-8	1	3.05	(1,1,2,1,1,5,BU:3); ;
	Bromine	-	-	kg	6.00E-08	6.00E-8	6.00E-8	1	5.38	(3,5,5,1,1,5,BU:5); ;
	Cadmium	-	-	kg	1.30E-08	1.30E-8	1.30E-8	1	5.05	(1,1,2,1,1,5,BU:5); ;
	Calcium	-	-	kg	5.85E-06	5.85E-6	5.85E-6	1	5.38	(3,5,5,1,1,5,BU:5); ;
	Carbon dioxide, biogenic	-	-	kg	9.20E-02	9.20E-2	9.20E-2	1	1.21	(1,1,2,1,1,5,BU:1.05); ;
	Carbon monoxide, biogenic	-	-	kg	1.11E-03	1.11E-3	1.11E-3	1	5.05	(1,1,2,1,1,5,BU:5); ;
	Chlorine	-	-	kg	1.80E-07	1.80E-7	1.80E-7	1	1.89	(3,5,5,1,1,5,BU:1.5); ;
	Chromium	-	-	kg	3.96E-09	3.96E-9	3.96E-9	1	5.38	(3,5,5,1,1,5,BU:5); ;
	Chromium VI	-	-	kg	4.00E-11	4.00E-11	4.00E-11	1	5.38	(3,5,5,1,1,5,BU:5); ;
	Copper	-	-	kg	2.20E-08	2.20E-8	2.20E-8	1	5.38	(3,5,5,1,1,5,BU:5); ;
	Dinitrogen monoxide	-	-	kg	7.00E-06	7.00E-6	7.00E-6	1	1.89	(3,5,5,1,1,5,BU:1.5); ;
	Dioxins, measured as 2,3,7,8-tetrachlorodibenzo-p-dioxin	-	-	kg	8.90E-14	8.90E-14	8.90E-14	1	3.05	(1,1,2,1,1,5,BU:3); ;
	Fluorine	-	-	kg	5.00E-08	5.00E-8	5.00E-8	1	1.89	(3,5,5,1,1,5,BU:1.5); ;
	Formaldehyde	-	-	kg	1.30E-07	1.30E-7	1.30E-7	1	1.89	(3,5,5,1,1,5,BU:1.5); ;
	Heat, waste	-	-	MJ	1.07E+00	1.07E+0	1.07E+0	1	1.64	(3,5,5,1,1,5,BU:1.05); ;
	Hydrocarbons, aliphatic, alkanes, unspecified	-	-	kg	9.10E-07	9.10E-7	9.10E-7	1	1.89	(3,5,5,1,1,5,BU:1.5); ;
	Hydrocarbons, aliphatic, unsaturated	-	-	kg	3.10E-06	3.10E-6	3.10E-6	1	1.89	(3,5,5,1,1,5,BU:1.5); ;
	Lead	-	-	kg	2.70E-08	2.70E-8	2.70E-8	1	5.05	(1,1,2,1,1,5,BU:5); ;
	Magnesium	-	-	kg	3.60E-07	3.60E-7	3.60E-7	1	5.38	(3,5,5,1,1,5,BU:5); ;
	Manganese	-	-	kg	1.70E-07	1.70E-7	1.70E-7	1	5.38	(3,5,5,1,1,5,BU:5); ;
	Mercury	-	-	kg	6.00E-10	6.00E-10	6.00E-10	1	5.05	(1,1,2,1,1,5,BU:5); ;
	Methane, biogenic	-	-	kg	6.60E-05	6.60E-5	6.60E-5	1	1.56	(1,1,2,1,1,5,BU:1.5); ;
	m-Xylene	-	-	kg	1.20E-07	1.20E-7	1.20E-7	1	1.89	(3,5,5,1,1,5,BU:1.5); ;
	Nickel	-	-	kg	6.00E-09	6.00E-9	6.00E-9	1	5.38	(3,5,5,1,1,5,BU:5); ;
	Nitrogen oxides	-	-	kg	8.00E-05	8.00E-5	8.00E-5	1	1.56	(1,1,2,1,1,5,BU:1.5); ;
	NMVOC, non-methane volatile organic compounds, unspecified origin	-	-	kg	7.50E-05	7.50E-5	7.50E-5	1	1.56	(1,1,2,1,1,5,BU:1.5); ;
	PAH, polycyclic aromatic hydrocarbons	-	-	kg	1.11E-08	1.11E-8	1.11E-8	1	3.33	(3,5,5,1,1,5,BU:3); ;
	Particulates, < 2.5 um	-	-	kg	4.10E-05	4.10E-5	4.10E-5	1	3.05	(1,1,2,1,1,5,BU:3); ;
	Particulates, > 2.5 um, and < 10um	-	-	kg	1.00E-06	1.00E-06	1.00E-06	1	2.05	(1,1,2,1,1,5,BU:2); ;
	Phenol, pentachloro-	-	-	kg	8.10E-12	8.10E-12	8.10E-12	1	1.89	(3,5,5,1,1,5,BU:1.5); ;
	Phosphorus	-	-	kg	3.00E-07	3.00E-7	3.00E-7	1	1.89	(3,5,5,1,1,5,BU:1.5); ;
	Potassium	-	-	kg	2.34E-05	2.34E-5	2.34E-5	1	5.38	(3,5,5,1,1,5,BU:5); ;
	Sodium	-	-	kg	1.30E-06	1.30E-6	1.30E-6	1	5.38	(3,5,5,1,1,5,BU:5); ;
	Sulfur dioxide	-	-	kg	1.00E-05	1.00E-5	1.00E-5	1	1.21	(1,1,2,1,1,5,BU:1.05); ;
	Toluene	-	-	kg	3.00E-07	3.00E-7	3.00E-7	1	1.89	(3,5,5,1,1,5,BU:1.5); ;
	Zinc	-	-	kg	3.00E-07	3.00E-7	3.00E-7	1	5.38	(3,5,5,1,1,5,BU:5); ;

Figure 113: Unit process raw data of logs, burned in furnace 15kW

ReferenceFunction	Name	logs, hardwood, burned in furnace 50kW	logs, mixed, burned in furnace 50kW	logs, softwood, burned in furnace 50kW
Geography	Location	CH	CH	CH
ReferenceFunction	InfrastructureProcess	0	0	0
ReferenceFunction	Unit	MJ	MJ	MJ
	IncludedProcesses	Included are the infrastructure, the wood requirements , the emissions to air, the transport of the fuel, the electricity needed for operation, and the disposal of the ashes.	Included are the infrastructure, the wood requirements , the emissions to air, the transport of the fuel, the electricity needed for operation, and the disposal of the ashes.	Included are the infrastructure, the wood requirements , the emissions to air, the transport of the fuel, the electricity needed for operation, and the disposal of the ashes.
	LocalName	Stückholz, Laubholz, in Feuerung 50kW	Stückholz, Holzmix, in Feuerung 50kW	Stückholz, Nadelholz, in Feuerung 50kW
	Synonyms	0	0	0
	GeneralComment	Inventory refers to the combustion of wood logs in a 6 kW wood heater. The lower heating value is 18.0 MJ/kg dry matter. 1600 operating hours per year. Air emission factors are calculated from the weighted average of measurements of log stoves	Inventory refers to the combustion of wood logs in a 6 kW wood heater. The lower heating value is 18.0 MJ/kg dry matter. 1600 operating hours per year. Air emission factors are calculated from the weighted average of measurements of log stoves	Inventory refers to the combustion of wood logs in a 6 kW wood heater. The lower heating value is 18.0 MJ/kg dry matter. 1600 operating hours per year. Air emission factors are calculated from the weighted average of measurements of log stoves
	InfrastructureIncluded	1	1	1
	Category	wood energy	wood energy	wood energy
	SubCategory	heating systems	heating systems	heating systems
	LocalCategory	Holzenergie	Holzenergie	Holzenergie
	LocalSubCategory	Heizungssysteme	Heizungssysteme	Heizungssysteme
	Formula			
	StatisticalClassification			
	CASNumber			
TimePeriod	StartDate	2015	2015	2015
	EndDate	2020	2020	2020
	DataValidForEntirePeriod	1	1	1
	OtherPeriodText	Time of publications.	Time of publications.	Time of publications.
Geography	Text	Could be used for central European conditions	Could be used for central European conditions	Could be used for central European conditions
Technology	Text	Boiler of average technology available on market	Boiler of average technology available on market	Boiler of average technology available on market
Representativeness	Percent			
	ProductionVolume			
	SamplingProcedure	literature	literature	literature
	Extrapolations	none	none	none
	UncertaintyAdjustments	none	none	none

Figure 114: Metadata of logs, burned in furnace 50kW

	Name	Location	Infrastructure Process	Unit	logs, hardwood, burned in furnace 50kW	logs, mixed, burned in furnace 50kW	logs, softwood, burned in furnace 50kW	Uncertainty Type	Standard Deviation 95%	General Comment
	Location				CH	CH	CH			
	Infrastructure Process				0	0	0			
	Unit				MJ	MJ	MJ			
product	logs, hardwood, burned in furnace 50kW	CH	0	MJ	1	0	0			
	logs, mixed, burned in furnace 50kW	CH	0	MJ	0	1	0			
	logs, softwood, burned in furnace 50kW	CH	0	MJ	0	0	1	0		
technosphere	electricity, low voltage, at grid	CH	0	kWh	5.56E-04	5.56E-4	5.56E-4	1	1.22	(2,3,1,1,1,5,BU:1.05); ;
	cleft timber, softwood, sustainable forest management, measured as dry mass, at forest road	CH	0	kg	5.56E-02	3.40E-2		1	1.22	(2,3,1,1,1,5,BU:1.05); ;
	cleft timber, hardwood, sustainable forest management, measured as dry mass, at forest road	CH	0	kg		2.00E-2	5.31E-2	1	1.22	(2,3,1,1,1,5,BU:1.05); ;
	furnace, logs, softwood, 50kW	CH	1	unit			1.41E-7	1	3.05	(2,3,1,1,1,5,BU:3); ;
	furnace, logs, hardwood, 50kW	CH	1	unit	1.41E-07			1	3.05	(2,3,1,1,1,5,BU:3); ;
	furnace, logs, mixed, 50kW	CH	1	unit		1.41E-7		1	3.05	(2,3,1,1,1,5,BU:3); ;
	transport, tractor and trailer	CH	0	tkm	2.78E-03	2.70E-3	2.65E-3	1	2.05	(2,3,1,1,1,5,BU:2); ;
	disposal, wood ash mixture, pure, 0% water, to municipal incineration	CH	0	kg	2.90E-04	2.90E-4	2.90E-4	1	1.22	(2,3,1,1,1,5,BU:1.05); ;
	disposal, wood ash mixture, pure, 0% water, to sanitary landfill	CH	0	kg	2.90E-4	2.90E-4	2.90E-4	1	1.22	(2,3,1,1,1,5,BU:1.05); ;
air, high population density	Acetaldehyde	-	-	kg	6.10E-08	6.10E-8	6.10E-8	1	1.89	(3,5,5,1,1,5,BU:1.5); ;
	Ammonia	-	-	kg	2.00E-06	2.00E-6	2.00E-6	1	1.30	(1,1,2,1,1,5,BU:1.2); ;
	Arsenic	-	-	kg	1.00E-09	1.00E-9	1.00E-9	1	5.38	(3,5,5,1,1,5,BU:5); ;
	Benzene	-	-	kg	9.10E-07	9.10E-7	9.10E-7	1	3.33	(3,5,5,1,1,5,BU:3); ;
	Benzene, ethyl-	-	-	kg	3.00E-08	3.00E-8	3.00E-8	1	3.33	(3,5,5,1,1,5,BU:3); ;
	Benzene, hexachloro-	-	-	kg	4.00E-12	4.00E-12	4.00E-12	1	3.05	(1,1,2,1,1,5,BU:3); ;
	Benzo(a)pyrene	-	-	kg	2.20E-08	2.20E-8	2.20E-8	1	3.05	(1,1,2,1,1,5,BU:3); ;
	Bromine	-	-	kg	6.00E-08	6.00E-8	6.00E-8	1	5.38	(3,5,5,1,1,5,BU:5); ;
	Cadmium	-	-	kg	1.30E-08	1.30E-8	1.30E-8	1	5.05	(1,1,2,1,1,5,BU:5); ;
	Calcium	-	-	kg	5.85E-06	5.85E-6	5.85E-6	1	5.38	(3,5,5,1,1,5,BU:5); ;
	Carbon dioxide, biogenic	-	-	kg	9.20E-02	9.20E-2	9.20E-2	1	1.21	(1,1,2,1,1,5,BU:1.05); ;
	Carbon monoxide, biogenic	-	-	kg	1.11E-03	1.11E-3	1.11E-3	1	5.05	(1,1,2,1,1,5,BU:5); ;
	Chlorine	-	-	kg	1.80E-07	1.80E-7	1.80E-7	1	1.89	(3,5,5,1,1,5,BU:1.5); ;
	Chromium	-	-	kg	3.96E-09	3.96E-9	3.96E-9	1	5.38	(3,5,5,1,1,5,BU:5); ;
	Chromium VI	-	-	kg	4.00E-11	4.00E-11	4.00E-11	1	5.38	(3,5,5,1,1,5,BU:5); ;
	Copper	-	-	kg	2.20E-08	2.20E-8	2.20E-8	1	5.38	(3,5,5,1,1,5,BU:5); ;
	Dinitrogen monoxide	-	-	kg	7.00E-06	7.00E-6	7.00E-6	1	1.89	(3,5,5,1,1,5,BU:1.5); ;
	Dioxins, measured as 2,3,7,8-tetrachlorodibenzo-p-dioxin	-	-	kg	8.90E-14	8.90E-14	8.90E-14	1	3.05	(1,1,2,1,1,5,BU:3); ;
	Fluorine	-	-	kg	5.00E-08	5.00E-8	5.00E-8	1	1.89	(3,5,5,1,1,5,BU:1.5); ;
	Formaldehyde	-	-	kg	1.30E-07	1.30E-7	1.30E-7	1	1.89	(3,5,5,1,1,5,BU:1.5); ;
	Heat, waste	-	-	MJ	1.07E+00	1.07E+0	1.07E+0	1	1.64	(3,5,5,1,1,5,BU:1.05); ;
	Hydrocarbons, aliphatic, alkanes, unspecified	-	-	kg	9.10E-07	9.10E-7	9.10E-7	1	1.89	(3,5,5,1,1,5,BU:1.5); ;
	Hydrocarbons, aliphatic, unsaturated	-	-	kg	3.10E-06	3.10E-6	3.10E-6	1	1.89	(3,5,5,1,1,5,BU:1.5); ;
	Lead	-	-	kg	2.70E-08	2.70E-8	2.70E-8	1	5.05	(1,1,2,1,1,5,BU:5); ;
	Magnesium	-	-	kg	3.60E-07	3.60E-7	3.60E-7	1	5.38	(3,5,5,1,1,5,BU:5); ;
	Manganese	-	-	kg	1.70E-07	1.70E-7	1.70E-7	1	5.38	(3,5,5,1,1,5,BU:5); ;
	Mercury	-	-	kg	6.00E-10	6.00E-10	6.00E-10	1	5.05	(1,1,2,1,1,5,BU:5); ;
	Methane, biogenic	-	-	kg	6.60E-05	6.60E-5	6.60E-5	1	1.56	(1,1,2,1,1,5,BU:1.5); ;
	m-Xylene	-	-	kg	1.20E-07	1.20E-7	1.20E-7	1	1.89	(3,5,5,1,1,5,BU:1.5); ;
	Nickel	-	-	kg	6.00E-09	6.00E-9	6.00E-9	1	5.38	(3,5,5,1,1,5,BU:5); ;
	Nitrogen oxides	-	-	kg	8.00E-05	8.00E-5	8.00E-5	1	1.56	(1,1,2,1,1,5,BU:1.5); ;
	NMVOC, non-methane volatile organic compounds, unspecified origin	-	-	kg	7.50E-05	7.50E-5	7.50E-5	1	1.56	(1,1,2,1,1,5,BU:1.5); ;
	PAH, polycyclic aromatic hydrocarbons	-	-	kg	1.11E-08	1.11E-8	1.11E-8	1	3.33	(3,5,5,1,1,5,BU:3); ;
	Particulates, < 2.5 um	-	-	kg	4.10E-05	4.10E-5	4.10E-5	1	3.05	(1,1,2,1,1,5,BU:3); ;
	Particulates, > 2.5 um, and < 10um	-	-	kg	1.00E-06	1.00E-06	1.00E-06	1	2.05	(1,1,2,1,1,5,BU:2); ;
	Phenol, pentachloro-	-	-	kg	8.10E-12	8.10E-12	8.10E-12	1	1.89	(3,5,5,1,1,5,BU:1.5); ;
	Phosphorus	-	-	kg	3.00E-07	3.00E-7	3.00E-7	1	1.89	(3,5,5,1,1,5,BU:1.5); ;
	Potassium	-	-	kg	2.34E-05	2.34E-5	2.34E-5	1	5.38	(3,5,5,1,1,5,BU:5); ;
	Sodium	-	-	kg	1.30E-06	1.30E-6	1.30E-6	1	5.38	(3,5,5,1,1,5,BU:5); ;
	Sulfur dioxide	-	-	kg	1.00E-05	1.00E-5	1.00E-5	1	1.21	(1,1,2,1,1,5,BU:1.05); ;
	Toluene	-	-	kg	3.00E-07	3.00E-7	3.00E-7	1	1.89	(3,5,5,1,1,5,BU:1.5); ;
	Zinc	-	-	kg	3.00E-07	3.00E-7	3.00E-7	1	5.38	(3,5,5,1,1,5,BU:5); ;

Figure 115: Unit process raw data of logs, burned in furnace 50kW

ReferenceFunction	Name	pellets, mixed, burned in furnace 15kW	pellets, mixed, burned in furnace 50kW	pellets, mixed, burned in furnace 300kW
Geography	Location	CH	CH	CH
ReferenceFunction	InfrastructureProcess	0	0	0
ReferenceFunction	Unit	MJ	MJ	MJ
DataSetInformation	Type	1	1	1
	Version	1.0	1.0	1.0
	energyValues	0	0	0
	LanguageCode	en	en	en
	LocalLanguageCode	de	de	de
DataEntryBy	Person	101	101	101
	QualityNetwork	1	1	1
ReferenceFunction	DataSetRelatesToProduct	1	1	1
	IncludedProcesses	This module describes the combustion of wood pellets. Included are the infrastructure, the wood requirements (average pellets, u=33%), the emissions to air, the transport of the fuel, the electricity needed for operation, and the disposal of the ashes.	This module describes the combustion of wood pellets. Included are the infrastructure, the wood requirements (average pellets, u=33%), the emissions to air, the transport of the fuel, the electricity needed for operation, and the disposal of the ashes.	This module describes the combustion of wood pellets. Included are the infrastructure, the wood requirements (average pellets, u=33%), the emissions to air, the transport of the fuel, the electricity needed for operation, and the disposal of the ashes.
	Amount	1	1	1
	LocalName	Pellets, Holzmix, in Feuerung 15kW	Pellets, Holzmix, in Feuerung 50kW	Pellets, Holzmix, in Feuerung 300kW
	Synonyms			
	GeneralComment	Heat of combustion of wood pellets based on lower heating value. 2100 operating hours per year. Air emission factors are calculated from the weighted average of measurements of pellet furnaces	Heat of combustion of wood pellets based on lower heating value. 2100 operating hours per year. Air emission factors are calculated from the weighted average of measurements of pellet furnaces	Heat of combustion of wood pellets based on lower heating value. 2100 operating hours per year. Air emission factors are calculated from the weighted average of measurements of pellet furnaces
	InfrastructureIncluded	1	1	1
	Category	wood energy	wood energy	wood energy
	SubCategory	heating systems	heating systems	heating systems
	LocalCategory	Holzenergie	Holzenergie	Holzenergie
	LocalSubCategory	Heizungssysteme	Heizungssysteme	Heizungssysteme
	Formula			
	StatisticalClassification			
	CASNumber			
TimePeriod	StartDate	2015	2015	2015
	EndDate	2020	2020	2020
	DataValidForEntirePeriod	1	1	1
	OtherPeriodText	Time of publications.	Time of publications.	Time of publications.
Geography	Text	Could be used for central European conditions	Could be used for central European conditions	Could be used for central European conditions
Technology	Text	Boiler of average technology available on market	Boiler of average technology available on market	Boiler of average technology available on market
Representativeness	Percent			
	ProductionVolume			
	SamplingProcedure	literature	literature	literature
	Extrapolations	none	none	none
	UncertaintyAdjustments	none	none	none

Figure 116: Metadata of pellets, burned in furnace

	Name	Location	Infrastructure Process	Unit	pellets, mixed, burned in furnace 15kW	pellets, mixed, burned in furnace 50kW	pellets, mixed, burned in furnace 300kW	Uncertainty Type	Standard Deviation 95%	General Comment
	Location				CH	CH	CH			
	Infrastructure Process				0	0	0			
	Unit				MJ	MJ	MJ			
product	pellets, mixed, burned in furnace 15kW	CH	0	MJ	1	0	0			
	pellets, mixed, burned in furnace 50kW	CH	0	MJ	0	1	0			
	pellets, mixed, burned in furnace 300kW	CH	0	MJ	0	0	1	0		
technosphere	wood pellet, measured as dry mass, at plant	RER	0	kg	5.45E-2	5.42E-2	5.33E-2	1	1.33	(3,3,2,1,3,5,BU:1.05); ;
	electricity, low voltage, at grid	CH	0	kWh	1.22E-3	3.50E-4	3.31E-4	1	1.64	(3,5,5,1,1,5,BU:1.05); ;
	furnace, pellets, 15kW	CH	1	unit	5.11E-7	0	0	1	3.11	(3,3,2,1,3,5,BU:3); ;
	furnace, pellets, 50kW	CH	1	unit	0	1.55E-7	0	1	3.11	(3,3,2,1,3,5,BU:3); ;
	furnace, pellets, 300kW	CH	1	unit	0	0	2.65E-8	1	3.11	(3,3,2,1,3,5,BU:3); ;
	transport, freight, lorry 16-32 metric ton, fleet average	CH	0	tkm	7.25E-3	7.20E-3	7.09E-3	1	2.34	(3,5,5,1,1,5,BU:2); ;
	disposal, wood ash mixture, pure, 0% water, to municipal incineration	CH	0	kg	2.72E-4	2.72E-4	1.33E-4	1	1.64	(3,5,5,1,1,5,BU:1.05); ;
	disposal, wood ash mixture, pure, 0% water, to sanitary landfill	CH	0	kg			1.33E-4	1	1.64	(3,5,5,1,1,5,BU:1.05); ;
air, high population density	Acetaldehyde	-	-	kg	6.10E-08	6.10E-8	6.10E-8	1	1.89	(3,5,5,1,1,5,BU:1.5); ;
	Ammonia	-	-	kg	2.00E-06	2.00E-6	2.00E-6	1	1.30	(1,1,2,1,1,5,BU:1.2); ;
	Arsenic	-	-	kg	1.00E-09	1.00E-9	1.00E-9	1	5.38	(3,5,5,1,1,5,BU:5); ;
	Benzene	-	-	kg	9.10E-07	9.10E-7	9.10E-7	1	3.33	(3,5,5,1,1,5,BU:3); ;
	Benzene, ethyl-	-	-	kg	3.00E-08	3.00E-8	3.00E-8	1	3.33	(3,5,5,1,1,5,BU:3); ;
	Benzene, hexachloro-	-	-	kg	4.00E-12	4.00E-12	3.25E-12	1	3.05	(1,1,2,1,1,5,BU:3); ;
	Benzo(a)pyrene	-	-	kg	2.67E-09	1.80E-9	1.80E-9	1	3.05	(1,1,2,1,1,5,BU:3); ;
	Bromine	-	-	kg	6.00E-08	6.00E-8	6.00E-8	1	5.38	(3,5,5,1,1,5,BU:5); ;
	Cadmium	-	-	kg	1.30E-08	1.30E-8	1.30E-8	1	5.05	(1,1,2,1,1,5,BU:5); ;
	Calcium	-	-	kg	5.85E-06	5.85E-6	5.85E-6	1	5.38	(3,5,5,1,1,5,BU:5); ;
	Carbon dioxide, biogenic	-	-	kg	9.20E-02	9.20E-2	9.20E-2	1	1.21	(1,1,2,1,1,5,BU:1.05); ;
	Carbon monoxide, biogenic	-	-	kg	2.01E-04	1.59E-4	1.28E-4	1	5.05	(1,1,2,1,1,5,BU:5); ;
	Chlorine	-	-	kg	1.80E-07	1.80E-7	1.80E-7	1	1.89	(3,5,5,1,1,5,BU:1.5); ;
	Chromium	-	-	kg	3.96E-09	3.96E-9	3.96E-9	1	5.38	(3,5,5,1,1,5,BU:5); ;
	Chromium VI	-	-	kg	4.00E-11	4.00E-11	4.00E-11	1	5.38	(3,5,5,1,1,5,BU:5); ;
	Copper	-	-	kg	2.20E-08	2.20E-8	2.20E-8	1	5.38	(3,5,5,1,1,5,BU:5); ;
	Dinitrogen monoxide	-	-	kg	3.00E-06	2.50E-6	2.50E-6	1	1.89	(3,5,5,1,1,5,BU:1.5); ;
	Dioxins, measured as 2,3,7,8-tetrachlorodibenzo-p-dioxin	-	-	kg	4.33E-14	4.30E-14	4.28E-14	1	3.05	(1,1,2,1,1,5,BU:3); ;
	Fluorine	-	-	kg	5.00E-08	5.00E-8	5.00E-8	1	1.89	(3,5,5,1,1,5,BU:1.5); ;
	Formaldehyde	-	-	kg	1.30E-07	1.30E-7	1.30E-7	1	1.89	(3,5,5,1,1,5,BU:1.5); ;
	Heat, waste	-	-	MJ	1.08E+00	1.08E+0	1.08E+0	1	1.64	(3,5,5,1,1,5,BU:1.05); ;
	Hydrocarbons, aliphatic, alkanes, unspecified	-	-	kg	9.10E-07	9.10E-7	9.10E-7	1	1.89	(3,5,5,1,1,5,BU:1.5); ;
	Hydrocarbons, aliphatic, unsaturated	-	-	kg	3.10E-06	3.10E-6	3.10E-6	1	1.89	(3,5,5,1,1,5,BU:1.5); ;
	Lead	-	-	kg	2.70E-08	2.70E-8	2.70E-8	1	5.05	(1,1,2,1,1,5,BU:5); ;
	Magnesium	-	-	kg	3.60E-07	3.60E-7	3.60E-7	1	5.38	(3,5,5,1,1,5,BU:5); ;
	Manganese	-	-	kg	1.70E-07	1.70E-7	1.70E-7	1	5.38	(3,5,5,1,1,5,BU:5); ;
	Mercury	-	-	kg	6.00E-10	6.00E-10	6.00E-10	1	5.05	(1,1,2,1,1,5,BU:5); ;
	Methane, biogenic	-	-	kg	6.00E-06	2.72E-6	2.00E-6	1	1.56	(1,1,2,1,1,5,BU:1.5); ;
	m-Xylene	-	-	kg	1.20E-07	1.20E-7	1.20E-7	1	1.89	(3,5,5,1,1,5,BU:1.5); ;
	Nickel	-	-	kg	6.00E-09	6.00E-9	6.00E-9	1	5.38	(3,5,5,1,1,5,BU:5); ;
	Nitrogen oxides	-	-	kg	6.00E-05	6.00E-5	6.25E-5	1	1.56	(1,1,2,1,1,5,BU:1.5); ;
	NMVOC, non-methane volatile organic compounds, unspecified origin	-	-	kg	7.33E-06	3.00E-6	3.00E-6	1	1.56	(1,1,2,1,1,5,BU:1.5); ;
	PAH, polycyclic aromatic hydrocarbons	-	-	kg	1.11E-08	1.11E-8	1.11E-8	1	3.33	(3,5,5,1,1,5,BU:3); ;
	Particulates, < 2.5 um	-	-	kg	4.27E-05	3.77E-5	3.10E-5	1	3.05	(1,1,2,1,1,5,BU:3); ;
	Particulates, > 2.5 um, and < 10um	-	-	kg	1.00E-06	1.00E-6	1.00E-6	1	2.05	(1,1,2,1,1,5,BU:2); ;
	Phenol, pentachloro-	-	-	kg	8.10E-12	8.10E-12	8.10E-12	1	1.89	(3,5,5,1,1,5,BU:1.5); ;
	Phosphorus	-	-	kg	3.00E-07	3.00E-7	3.00E-7	1	1.89	(3,5,5,1,1,5,BU:1.5); ;
	Potassium	-	-	kg	2.34E-05	2.34E-5	2.34E-5	1	5.38	(3,5,5,1,1,5,BU:5); ;
	Sodium	-	-	kg	1.30E-06	1.30E-6	1.30E-6	1	5.38	(3,5,5,1,1,5,BU:5); ;
	Sulfur dioxide	-	-	kg	1.00E-05	1.00E-5	1.00E-5	1	1.21	(1,1,2,1,1,5,BU:1.05); ;
	Toluene	-	-	kg	3.00E-07	3.00E-7	3.00E-7	1	1.89	(3,5,5,1,1,5,BU:1.5); ;
	Zinc	-	-	kg	3.00E-07	3.00E-7	3.00E-7	1	5.38	(3,5,5,1,1,5,BU:5); ;

Figure 117: Unit process raw data of pellets, burned in furnace

ReferenceFunction	Name	wood chips, from forest, hardwood, burned in furnace 50kW	wood chips, from forest, mixed, burned in furnace 50kW	wood chips, from forest, softwood, burned in furnace 50kW	wood chips, from industry, hardwood, burned in furnace 50kW	wood chips, from industry, mixed, burned in furnace 50kW	wood chips, from industry, softwood, burned in furnace 50kW
Geography	Location	CH	CH	CH	CH	CH	CH
ReferenceFunction	InfrastructureProcess	0	0	0	0	0	0
ReferenceFunction	Unit	MJ	MJ	MJ	MJ	MJ	MJ
	IncludedProcesses	This module describes the combustion of wood chips. Included are the infrastructure, the wood requirements, the emissions to air, the transport of the fuel, the electricity needed for operation, and the disposal of the ashes.	This module describes the combustion of wood chips. Included are the infrastructure, the wood requirements, the emissions to air, the transport of the fuel, the electricity needed for operation, and the disposal of the ashes.	This module describes the combustion of wood chips. Included are the infrastructure, the wood requirements, the emissions to air, the transport of the fuel, the electricity needed for operation, and the disposal of the ashes.	This module describes the combustion of wood chips. Included are the infrastructure, the wood requirements, the emissions to air, the transport of the fuel, the electricity needed for operation, and the disposal of the ashes.	This module describes the combustion of wood chips. Included are the infrastructure, the wood requirements, the emissions to air, the transport of the fuel, the electricity needed for operation, and the disposal of the ashes.	This module describes the combustion of wood chips. Included are the infrastructure, the wood requirements, the emissions to air, the transport of the fuel, the electricity needed for operation, and the disposal of the ashes.
	LocalName	Holzschnitzel, aus Wald, Laubholz, in Feuerung 50kW	Holzschnitzel, aus Wald, Holzmix, in Feuerung 50kW	Holzschnitzel, aus Wald, Nadelholz, in Feuerung 50kW	Holzschnitzel, aus Industrie, Laubholz, in Feuerung 50kW	Holzschnitzel, aus Industrie, Holzmix, in Feuerung 50kW	Holzschnitzel, aus Industrie, Nadelholz, in Feuerung 50kW
	Synonyms						
	GeneralComment	Heat of combustion of wood chips based on lower heating value. 2100 operating hours per year. Air emission factors are calculated from the weighted average of measurements of automatic chip boilers.	Heat of combustion of wood chips based on lower heating value. 2100 operating hours per year. Air emission factors are calculated from the weighted average of measurements of automatic chip boilers.	Heat of combustion of wood chips based on lower heating value. 2100 operating hours per year. Air emission factors are calculated from the weighted average of measurements of automatic chip boilers.	Heat of combustion of wood chips based on lower heating value. 2100 operating hours per year. Air emission factors are calculated from the weighted average of measurements of automatic chip boilers.	Heat of combustion of wood chips based on lower heating value. 2100 operating hours per year. Air emission factors are calculated from the weighted average of measurements of automatic chip boilers.	Heat of combustion of wood chips based on lower heating value. 2100 operating hours per year. Air emission factors are calculated from the weighted average of measurements of automatic chip boilers.
	InfrastructureIncluded	1	1	1	1	1	1
	Category	wood energy	wood energy	wood energy	wood energy	wood energy	wood energy
	SubCategory	heating systems	heating systems	heating systems	heating systems	heating systems	heating systems
	LocalCategory	Holzenergie	Holzenergie	Holzenergie	Holzenergie	Holzenergie	Holzenergie
	LocalSubCategory	Heizungssysteme	Heizungssysteme	Heizungssysteme	Heizungssysteme	Heizungssysteme	Heizungssysteme
	Formula						
	StatisticalClassification						
	CASNumber						
TimePeriod	StartDate	2015	2015	2015	2015	2015	2015
	EndDate	2020	2020	2020	2020	2020	2020
	DataValidForEntirePeriod	1	1	1	1	1	1
	OtherPeriodText	Time of publications.	Time of publications.	Time of publications.	Time of publications.	Time of publications.	Time of publications.
Geography	Text	Could be used for central European conditions	Could be used for central European conditions	Could be used for central European conditions	Could be used for central European conditions	Could be used for central European conditions	Could be used for central European conditions
Technology	Text	Boiler of average technology available on market	Boiler of average technology available on market	Boiler of average technology available on market	Boiler of average technology available on market	Boiler of average technology available on market	Boiler of average technology available on market
Representativeness	Percent						
	ProductionVolume						
	SamplingProcedure	literature	literature	literature	literature	literature	literature
	Extrapolations	none	none	none	none	none	none
	UncertaintyAdjustments	none	none	none	none	none	none

Figure 118: Metadata of wood chips, burned in furnace 50kW

	Name	Location	Infrastructure Process	Unit	wood chips, from forest, hardwood, burned in furnace 50kW	wood chips, from forest, mixed, burned in furnace 50kW	wood chips, from forest, softwood, burned in furnace 50kW	wood chips, from industry, hardwood, burned in furnace 50kW	wood chips, from industry, mixed, burned in furnace 50kW	wood chips, from industry, softwood, burned in furnace 50kW	Uncertainty Type	Standard Deviation 95%	General Comment
	Location				CH	CH	CH	CH	CH	CH			
	Infrastructure Process				0	0	0	0	0	0			
	Unit				MJ	MJ	MJ	MJ	MJ	MJ			
product	wood chips, from forest, hardwood, burned in furnace 50kW	CH	0	MJ	1	0	0	0	0	0			
	wood chips, from forest, mixed, burned in furnace 50kW	CH	0	MJ	0	1	0	0	0	0			
	wood chips, from forest, softwood, burned in furnace 50kW	CH	0	MJ	0	0	1	0	0	0			
	wood chips, from industry, hardwood, burned in furnace 50kW	CH	0	MJ	0	0	0	1	0	0			
	wood chips, from industry, mixed, burned in furnace 50kW	CH	0	MJ	0	0	0	0	1	0			
	wood chips, from industry, softwood, burned in furnace 50kW	CH	0	MJ	0	0	0	0	0	1	0		
technosphere	electricity, low voltage, at grid	CH	0	kWh	3.81E-4	3.81E-4	3.81E-4	3.81E-4	3.81E-4	3.81E-4	1	1.24	(3,2,1,1,1,5,BU:1.05); ;
	wood chips, hardwood, wet, sustainable forest management, measured as dry mass, at forest road	CH	0	kg	5.67E-02	3.16E-2					1	1.24	(3,2,1,1,1,5,BU:1.05); ;
	wood chips, hardwood, wet, measured as dry mass, at sawmill	CH	0	kg				5.67E-2	3.16E-2		1	1.24	(3,2,1,1,1,5,BU:1.05); ;
	wood chips, softwood, wet, sustainable forest management, measured as dry mass, at forest road	CH	0	kg		2.36E-2	5.33E-2				1	1.24	(3,2,1,1,1,5,BU:1.05); ;
	wood chips, softwood, wet, measured as dry mass, at sawmill	CH	0	kg					2.36E-2	5.33E-2	1	1.24	(3,2,1,1,1,5,BU:1.05); ;
	furnace, wood chips, hardwood, 50kW	CH	1	unit	1.48E-7			1.48E-7			1	3.06	(3,2,1,1,1,5,BU:3); ;
	furnace, wood chips, mixed, 50kW	CH	1	unit		1.48E-7			1.48E-7		1	3.06	(3,2,1,1,1,5,BU:3); ;
	furnace, wood chips, softwood, 50kW	CH	1	unit			1.48E-7			1.48E-7	1	3.06	(3,2,1,1,1,5,BU:3); ;
	transport, freight, lorry 16-32 metric ton, fleet average	CH	0	tkm	2.76E-3	2.76E-3	2.76E-3	2.76E-3	2.76E-3	2.76E-3	1	2.06	(3,2,1,1,1,5,BU:2); ;
	disposal, wood ash mixture, pure, 0% water, to municipal incineration	CH	0	kg	1.18E-4	1.18E-4	1.18E-4	1.18E-4	1.18E-4	1.18E-4	1	1.24	(3,2,1,1,1,5,BU:1.05); ;
	disposal, wood ash mixture, pure, 0% water, to sanitary landfill	CH	0	kg	1.18E-4	1.18E-4	1.18E-4	1.18E-4	1.18E-4	1.18E-4	1	1.24	(3,2,1,1,1,5,BU:1.05); ;
air, high population density	Acetaldehyde	-	-	kg	6.10E-08	6.10E-8	6.10E-8	6.10E-8	6.10E-8	6.10E-8	1	1.89	(3,5,5,1,1,5,BU:1.5); ;
	Ammonia	-	-	kg	2.00E-06	2.00E-6	2.00E-6	2.00E-6	2.00E-6	2.00E-6	1	1.30	(1,1,2,1,1,5,BU:1.2); ;
	Arsenic	-	-	kg	1.00E-09	1.00E-9	1.00E-9	1.00E-9	1.00E-9	1.00E-9	1	5.38	(3,5,5,1,1,5,BU:5); ;
	Benzene	-	-	kg	9.10E-07	9.10E-7	9.10E-7	9.10E-7	9.10E-7	9.10E-7	1	3.33	(3,5,5,1,1,5,BU:3); ;
	Benzene, ethyl-	-	-	kg	3.00E-08	3.00E-8	3.00E-8	3.00E-8	3.00E-8	3.00E-8	1	3.33	(3,5,5,1,1,5,BU:3); ;
	Benzene, hexachloro-	-	-	kg	4.00E-12	4.00E-12	4.00E-12	4.00E-12	4.00E-12	4.00E-12	1	3.05	(1,1,2,1,1,5,BU:3); ;
	Benzo(a)pyrene	-	-	kg	3.89E-09	3.89E-9	3.89E-9	3.89E-9	3.89E-9	3.89E-9	1	3.05	(1,1,2,1,1,5,BU:3); ;
	Bromine	-	-	kg	6.00E-08	6.00E-8	6.00E-8	6.00E-8	6.00E-8	6.00E-8	1	5.38	(3,5,5,1,1,5,BU:5); ;
	Cadmium	-	-	kg	1.30E-08	1.30E-8	1.30E-8	1.30E-8	1.30E-8	1.30E-8	1	5.05	(1,1,2,1,1,5,BU:5); ;
	Calcium	-	-	kg	5.85E-06	5.85E-6	5.85E-6	5.85E-6	5.85E-6	5.85E-6	1	5.38	(3,5,5,1,1,5,BU:5); ;
	Carbon dioxide, biogenic	-	-	kg	9.20E-02	9.20E-2	9.20E-2	9.20E-2	9.20E-2	9.20E-2	1	1.21	(1,1,2,1,1,5,BU:1.05); ;
	Carbon monoxide, biogenic	-	-	kg	4.98E-04	4.98E-4	4.98E-4	4.98E-4	4.98E-4	4.98E-4	1	5.05	(1,1,2,1,1,5,BU:5); ;
	Chlorine	-	-	kg	1.80E-07	1.80E-7	1.80E-7	1.80E-7	1.80E-7	1.80E-7	1	1.89	(3,5,5,1,1,5,BU:1.5); ;
	Chromium	-	-	kg	3.96E-09	3.96E-9	3.96E-9	3.96E-9	3.96E-9	3.96E-9	1	5.38	(3,5,5,1,1,5,BU:5); ;
	Chromium VI	-	-	kg	4.00E-11	4.00E-11	4.00E-11	4.00E-11	4.00E-11	4.00E-11	1	5.38	(3,5,5,1,1,5,BU:5); ;
	Copper	-	-	kg	2.20E-08	2.20E-8	2.20E-8	2.20E-8	2.20E-8	2.20E-8	1	5.38	(3,5,5,1,1,5,BU:5); ;
	Dinitrogen monoxide	-	-	kg	3.00E-06	3.00E-6	3.00E-6	3.00E-6	3.00E-6	3.00E-6	1	1.89	(3,5,5,1,1,5,BU:1.5); ;
	Dioxins, measured as 2,3,7,8-tetrachlorodibenzo-p-dioxin	-	-	kg	8.70E-14	8.70E-14	8.70E-14	8.70E-14	8.70E-14	8.70E-14	1	3.05	(1,1,2,1,1,5,BU:3); ;
	Fluorine	-	-	kg	5.00E-08	5.00E-8	5.00E-8	5.00E-8	5.00E-8	5.00E-8	1	1.89	(3,5,5,1,1,5,BU:1.5); ;
	Formaldehyde	-	-	kg	1.30E-07	1.30E-7	1.30E-7	1.30E-7	1.30E-7	1.30E-7	1	1.89	(3,5,5,1,1,5,BU:1.5); ;
	Heat, waste	-	-	MJ	1.08E+00	1.08E+0	1.08E+0	1.08E+0	1.08E+0	1.08E+0	1	1.64	(3,5,5,1,1,5,BU:1.05); ;
	Hydrocarbons, aliphatic, alkanes, unspecified	-	-	kg	9.10E-07	9.10E-7	9.10E-7	9.10E-7	9.10E-7	9.10E-7	1	1.89	(3,5,5,1,1,5,BU:1.5); ;
	Hydrocarbons, aliphatic, unsaturated	-	-	kg	3.10E-06	3.10E-6	3.10E-6	3.10E-6	3.10E-6	3.10E-6	1	1.89	(3,5,5,1,1,5,BU:1.5); ;
	Lead	-	-	kg	2.70E-08	2.70E-8	2.70E-8	2.70E-8	2.70E-8	2.70E-8	1	5.05	(1,1,2,1,1,5,BU:5); ;
	Magnesium	-	-	kg	3.60E-07	3.60E-7	3.60E-7	3.60E-7	3.60E-7	3.60E-7	1	5.38	(3,5,5,1,1,5,BU:5); ;
	Manganese	-	-	kg	1.70E-07	1.70E-7	1.70E-7	1.70E-7	1.70E-7	1.70E-7	1	5.38	(3,5,5,1,1,5,BU:5); ;
	Mercury	-	-	kg	6.00E-10	6.00E-10	6.00E-10	6.00E-10	6.00E-10	6.00E-10	1	5.05	(1,1,2,1,1,5,BU:5); ;
	Methane, biogenic	-	-	kg	7.72E-06	7.72E-6	7.72E-6	7.72E-6	7.72E-6	7.72E-6	1	1.56	(1,1,2,1,1,5,BU:1.5); ;
	m-Xylene	-	-	kg	1.20E-07	1.20E-7	1.20E-7	1.20E-7	1.20E-7	1.20E-7	1	1.89	(3,5,5,1,1,5,BU:1.5); ;
	Nickel	-	-	kg	6.00E-09	6.00E-9	6.00E-9	6.00E-9	6.00E-9	6.00E-9	1	5.38	(3,5,5,1,1,5,BU:5); ;
	Nitrogen oxides	-	-	kg	1.20E-04	1.20E-4	1.20E-4	1.20E-4	1.20E-4	1.20E-4	1	1.56	(1,1,2,1,1,5,BU:1.5); ;
	NMVOC, non-methane volatile organic compounds, unspecified origin	-	-	kg	9.72E-06	9.72E-6	9.72E-6	9.72E-6	9.72E-6	9.72E-6	1	1.56	(1,1,2,1,1,5,BU:1.5); ;
	PAH, polycyclic aromatic hydrocarbons	-	-	kg	1.11E-08	1.11E-8	1.11E-8	1.11E-8	1.11E-8	1.11E-8	1	3.33	(3,5,5,1,1,5,BU:3); ;
	Particulates, < 2.5 um	-	-	kg	7.84E-05	7.84E-5	7.84E-5	7.84E-5	7.84E-5	7.84E-5	1	3.05	(1,1,2,1,1,5,BU:3); ;
	Particulates, > 2.5 um, and < 10um	-	-	kg	2.00E-06	2.00E-6	2.00E-6	2.00E-6	2.00E-6	2.00E-6	1	2.05	(1,1,2,1,1,5,BU:2); ;
	Phenol, pentachloro-	-	-	kg	8.10E-12	8.10E-12	8.10E-12	8.10E-12	8.10E-12	8.10E-12	1	1.89	(3,5,5,1,1,5,BU:1.5); ;
	Phosphorus	-	-	kg	3.00E-07	3.00E-7	3.00E-7	3.00E-7	3.00E-7	3.00E-7	1	1.89	(3,5,5,1,1,5,BU:1.5); ;
	Potassium	-	-	kg	2.34E-05	2.34E-5	2.34E-5	2.34E-5	2.34E-5	2.34E-5	1	5.38	(3,5,5,1,1,5,BU:5); ;
	Sodium	-	-	kg	1.30E-06	1.30E-6	1.30E-6	1.30E-6	1.30E-6	1.30E-6	1	5.38	(3,5,5,1,1,5,BU:5); ;
	Sulfur dioxide	-	-	kg	1.00E-05	1.00E-5	1.00E-5	1.00E-5	1.00E-5	1.00E-5	1	1.21	(1,1,2,1,1,5,BU:1.05); ;
	Toluene	-	-	kg	3.00E-07	3.00E-7	3.00E-7	3.00E-7	3.00E-7	3.00E-7	1	1.89	(3,5,5,1,1,5,BU:1.5); ;
	Zinc	-	-	kg	3.00E-07	3.00E-7	3.00E-7	3.00E-7	3.00E-7	3.00E-7	1	5.38	(3,5,5,1,1,5,BU:5); ;

Figure 119: Unit process raw data of wood chips, burned in furnace 50kW

ReferenceFunction	Name	wood chips, from forest, hardwood, burned in furnace 300kW	wood chips, from forest, mixed, burned in furnace 300kW	wood chips, from forest, softwood, burned in furnace 300kW	wood chips, from industry, hardwood, burned in furnace 300kW	wood chips, from industry, mixed, burned in furnace 300kW	wood chips, from industry, softwood, burned in furnace 300kW
Geography	Location	CH	CH	CH	CH	CH	CH
ReferenceFunction	InfrastructureProcess	0	0	0	0	0	0
ReferenceFunction	Unit	MJ	MJ	MJ	MJ	MJ	MJ
	IncludedProcesses	This module describes the combustion of wood chips. Included are the infrastructure, the wood requirements , the emissions to air, the transport of the fuel, the electricity needed for operation, and the disposal of the ashes.	This module describes the combustion of wood chips. Included are the infrastructure, the wood requirements , the emissions to air, the transport of the fuel, the electricity needed for operation, and the disposal of the ashes.	This module describes the combustion of wood chips. Included are the infrastructure, the wood requirements , the emissions to air, the transport of the fuel, the electricity needed for operation, and the disposal of the ashes.	This module describes the combustion of wood chips. Included are the infrastructure, the wood requirements , the emissions to air, the transport of the fuel, the electricity needed for operation, and the disposal of the ashes.	This module describes the combustion of wood chips. Included are the infrastructure, the wood requirements , the emissions to air, the transport of the fuel, the electricity needed for operation, and the disposal of the ashes.	This module describes the combustion of wood chips. Included are the infrastructure, the wood requirements , the emissions to air, the transport of the fuel, the electricity needed for operation, and the disposal of the ashes.
	LocalName	Holzschnitzel, aus Wald, Laubholz, in Feuerung 300kW	Holzschnitzel, aus Wald, Holzmix, in Feuerung 300kW	Holzschnitzel, aus Wald, Nadelholz, in Feuerung 300kW	Holzschnitzel, aus Industrie, Laubholz, in Feuerung 300kW	Holzschnitzel, aus Industrie, Holzmix, in Feuerung 300kW	Holzschnitzel, aus Industrie, Nadelholz, in Feuerung 300kW
	Synonyms						
	GeneralComment	Heat of combustion of wood chips based on lower heating value. 2100 operating hours per year. Air emission factors are calculated from the weighted average of measurements of automatic chip boilers 50–500 kW.	Heat of combustion of wood chips based on lower heating value. 2100 operating hours per year. Air emission factors are calculated from the weighted average of measurements of automatic chip boilers 50–500 kW.	Heat of combustion of wood chips based on lower heating value. 2100 operating hours per year. Air emission factors are calculated from the weighted average of measurements of automatic chip boilers 50–500 kW.	Heat of combustion of wood chips based on lower heating value. 2100 operating hours per year. Air emission factors are calculated from the weighted average of measurements of automatic chip boilers 50–500 kW.	Heat of combustion of wood chips based on lower heating value. 2100 operating hours per year. Air emission factors are calculated from the weighted average of measurements of automatic chip boilers 50–500 kW.	Heat of combustion of wood chips based on lower heating value. 2100 operating hours per year. Air emission factors are calculated from the weighted average of measurements of automatic chip boilers 50–500 kW.
	InfrastructureIncluded	1	1	1	1	1	1
	Category	wood energy	wood energy	wood energy	wood energy	wood energy	wood energy
	SubCategory	heating systems	heating systems	heating systems	heating systems	heating systems	heating systems
	LocalCategory	Holzenergie	Holzenergie	Holzenergie	Holzenergie	Holzenergie	Holzenergie
	LocalSubCategory	Heizungssysteme	Heizungssysteme	Heizungssysteme	Heizungssysteme	Heizungssysteme	Heizungssysteme
	Formula						
	StatisticalClassification						
	CASNumber						
TimePeriod	StartDate	2015	2015	2015	2015	2015	2015
	EndDate	2020	2020	2020	2020	2020	2020
	DataValidForEntirePeriod	1	1	1	1	1	1
	OtherPeriodText	Time of publications.	Time of publications.	Time of publications.	Time of publications.	Time of publications.	Time of publications.
Geography	Text	Could be used for central European conditions	Could be used for central European conditions	Could be used for central European conditions	Could be used for central European conditions	Could be used for central European conditions	Could be used for central European conditions
Technology	Text	Boiler of average technology available on market	Boiler of average technology available on market	Boiler of average technology available on market	Boiler of average technology available on market	Boiler of average technology available on market	Boiler of average technology available on market
Representativeness	Percent						
	ProductionVolume						
	SamplingProcedure	literature	literature	literature	literature	literature	literature
	Extrapolations	none	none	none	none	none	none
	UncertaintyAdjustments	none	none	none	none	none	none

Figure 120: Metadata of wood chips, burned in furnace 300kW

	Name	Location	Infrastructure Process	Unit	wood chips, from forest, hardwood, burned in furnace 300kW	wood chips, from forest, mixed, burned in furnace 300kW	wood chips, from forest, softwood, burned in furnace 300kW	wood chips, from industry, hardwood, burned in furnace 300kW	wood chips, from industry, mixed, burned in furnace 300kW	wood chips, from industry, softwood, burned in furnace 300kW	Uncertainty Type	Standard Deviation 95%	General Comment
	Location				CH	CH	CH	CH	CH	CH			
	Infrastructure Process				0	0	0	0	0	0			
	Unit				MJ	MJ	MJ	MJ	MJ	MJ			
product	wood chips, from forest, hardwood, burned in furnace 300kW	CH	0	MJ	1	0	0	0	0	0			
	wood chips, from forest, mixed, burned in furnace 300kW	CH	0	MJ	0	1	0	0	0	0			
	wood chips, from forest, softwood, burned in furnace 300kW	CH	0	MJ	0	0	1	0	0	0			
	wood chips, from industry, hardwood, burned in furnace 300kW	CH	0	MJ	0	0	0	1	0	0			
	wood chips, from industry, mixed, burned in furnace 300kW	CH	0	MJ	0	0	0	0	1	0			
	wood chips, from industry, softwood, burned in furnace 300kW	CH	0	MJ	0	0	0	0	0	1	0		
technosphere	electricity, low voltage, at grid	CH	0	kWh	3.89E-4	3.06E-4	3.06E-4	3.06E-4	3.06E-4	3.06E-4	1	1.22	(2,3,1,1,1,5,BU:1.05); ;
	wood chips, hardwood, wet, sustainable forest management, measured as dry mass, at forest road	CH	0	kg	5.67E-2	3.16E-2					1	1.22	(2,3,1,1,1,5,BU:1.05); ;
	wood chips, hardwood, wet, measured as dry mass, at sawmill	CH	0	kg				5.67E-2	3.16E-2		1	1.22	(2,3,1,1,1,5,BU:1.05); ;
	wood chips, softwood, wet, sustainable forest management, measured as dry mass, at forest road	CH	0	kg		2.36E-2	5.33E-2				1	1.22	(2,3,1,1,1,5,BU:1.05); ;
	wood chips, softwood, wet, measured as dry mass, at sawmill	CH	0	kg					2.36E-2	5.33E-2	1	1.22	(2,3,1,1,1,5,BU:1.05); ;
	furnace, wood chips, hardwood, 300kW	CH	1	unit	2.47E-8			2.47E-8			1	3.05	(2,3,1,1,1,5,BU:3); ;
	furnace, wood chips, mixed, 300kW	CH	1	unit		2.47E-8			2.47E-8		1	3.05	(2,3,1,1,1,5,BU:3); ;
	furnace, wood chips, softwood, 300kW	CH	1	unit			2.47E-8			2.47E-8	1	3.05	(2,3,1,1,1,5,BU:3); ;
	transport, freight, lorry 16-32 metric ton, fleet average	CH	0	tkm	2.83E-3	2.83E-3	2.83E-3	2.83E-3	2.83E-3	2.83E-3	1	2.05	(2,3,1,1,1,5,BU:2); ;
	disposal, wood ash mixture, pure, 0% water, to municipal incineration	CH	0	kg	1.20E-4	1.20E-4	1.20E-4	1.20E-4	1.20E-4	1.20E-4	1	1.22	(2,3,1,1,1,5,BU:1.05); ;
	disposal, wood ash mixture, pure, 0% water, to sanitary landfill	CH	0	kg	1.20E-4	1.20E-4	1.20E-4	1.20E-4	1.20E-4	1.20E-4	1	1.22	(2,3,1,1,1,5,BU:1.05); ;
air, high population density	Acetaldehyde	-	-	kg	6.10E-08	6.10E-8	6.10E-8	6.10E-8	6.10E-8	6.10E-8	1	1.89	(3,5,5,1,1,5,BU:1.5); ;
	Ammonia	-	-	kg	2.00E-06	2.00E-6	2.00E-6	2.00E-6	2.00E-6	2.00E-6	1	1.30	(1,1,2,1,1,5,BU:1.2); ;
	Arsenic	-	-	kg	1.00E-09	1.00E-9	1.00E-9	1.00E-9	1.00E-9	1.00E-9	1	5.38	(3,5,5,1,1,5,BU:5); ;
	Benzene	-	-	kg	9.10E-07	9.10E-7	9.10E-7	9.10E-7	9.10E-7	9.10E-7	1	3.33	(3,5,5,1,1,5,BU:3); ;
	Benzene, ethyl-	-	-	kg	3.00E-08	3.00E-8	3.00E-8	3.00E-8	3.00E-8	3.00E-8	1	3.33	(3,5,5,1,1,5,BU:3); ;
	Benzene, hexachloro-	-	-	kg	3.34E-12	3.34E-12	3.34E-12	3.34E-12	3.34E-12	3.34E-12	1	3.05	(1,1,2,1,1,5,BU:3); ;
	Benzo(a)pyrene	-	-	kg	2.42E-09	2.42E-9	2.42E-9	2.42E-9	2.42E-9	2.42E-9	1	3.05	(1,1,2,1,1,5,BU:3); ;
	Bromine	-	-	kg	6.00E-08	6.00E-8	6.00E-8	6.00E-8	6.00E-8	6.00E-8	1	5.38	(3,5,5,1,1,5,BU:5); ;
	Cadmium	-	-	kg	1.30E-08	1.30E-8	1.30E-8	1.30E-8	1.30E-8	1.30E-8	1	5.05	(1,1,2,1,1,5,BU:5); ;
	Calcium	-	-	kg	5.85E-06	5.85E-6	5.85E-6	5.85E-6	5.85E-6	5.85E-6	1	5.38	(3,5,5,1,1,5,BU:5); ;
	Carbon dioxide, biogenic	-	-	kg	9.20E-02	9.20E-2	9.20E-2	9.20E-2	9.20E-2	9.20E-2	1	1.21	(1,1,2,1,1,5,BU:1.05); ;
	Carbon monoxide, biogenic	-	-	kg	3.96E-04	3.96E-4	3.96E-4	3.96E-4	3.96E-4	3.96E-4	1	5.05	(1,1,2,1,1,5,BU:5); ;
	Chlorine	-	-	kg	1.80E-07	1.80E-7	1.80E-7	1.80E-7	1.80E-7	1.80E-7	1	1.89	(3,5,5,1,1,5,BU:1.5); ;
	Chromium	-	-	kg	3.96E-09	3.96E-9	3.96E-9	3.96E-9	3.96E-9	3.96E-9	1	5.38	(3,5,5,1,1,5,BU:5); ;
	Chromium VI	-	-	kg	4.00E-11	4.00E-11	4.00E-11	4.00E-11	4.00E-11	4.00E-11	1	5.38	(3,5,5,1,1,5,BU:5); ;
	Copper	-	-	kg	2.20E-08	2.20E-8	2.20E-8	2.20E-8	2.20E-8	2.20E-8	1	5.38	(3,5,5,1,1,5,BU:5); ;
	Dinitrogen monoxide	-	-	kg	2.50E-06	2.50E-6	2.50E-6	2.50E-6	2.50E-6	2.50E-6	1	1.89	(3,5,5,1,1,5,BU:1.5); ;
	Dioxins, measured as 2,3,7,8-tetrachlorodibenzo-p-dioxin	-	-	kg	8.70E-14	8.70E-14	8.70E-14	8.70E-14	8.70E-14	8.70E-14	1	3.05	(1,1,2,1,1,5,BU:3); ;
	Fluorine	-	-	kg	5.00E-08	5.00E-8	5.00E-8	5.00E-8	5.00E-8	5.00E-8	1	1.89	(3,5,5,1,1,5,BU:1.5); ;
	Formaldehyde	-	-	kg	1.30E-07	1.30E-7	1.30E-7	1.30E-7	1.30E-7	1.30E-7	1	1.89	(3,5,5,1,1,5,BU:1.5); ;
	Heat, waste	-	-	MJ	1.08E+00	1.08E+0	1.08E+0	1.08E+0	1.08E+0	1.08E+0	1	1.64	(3,5,5,1,1,5,BU:1.05); ;
	Hydrocarbons, aliphatic, alkanes, unspecified	-	-	kg	9.10E-07	9.10E-7	9.10E-7	9.10E-7	9.10E-7	9.10E-7	1	1.89	(3,5,5,1,1,5,BU:1.5); ;
	Hydrocarbons, aliphatic, unsaturated	-	-	kg	3.10E-06	3.10E-6	3.10E-6	3.10E-6	3.10E-6	3.10E-6	1	1.89	(3,5,5,1,1,5,BU:1.5); ;
	Lead	-	-	kg	2.70E-08	2.70E-8	2.70E-8	2.70E-8	2.70E-8	2.70E-8	1	5.05	(1,1,2,1,1,5,BU:5); ;
	Magnesium	-	-	kg	3.60E-07	3.60E-7	3.60E-7	3.60E-7	3.60E-7	3.60E-7	1	5.38	(3,5,5,1,1,5,BU:5); ;
	Manganese	-	-	kg	1.70E-07	1.70E-7	1.70E-7	1.70E-7	1.70E-7	1.70E-7	1	5.38	(3,5,5,1,1,5,BU:5); ;
	Mercury	-	-	kg	6.00E-10	6.00E-10	6.00E-10	6.00E-10	6.00E-10	6.00E-10	1	5.05	(1,1,2,1,1,5,BU:5); ;
	Methane, biogenic	-	-	kg	6.34E-06	6.34E-6	6.34E-6	6.34E-6	6.34E-6	6.34E-6	1	1.56	(1,1,2,1,1,5,BU:1.5); ;
	m-Xylene	-	-	kg	1.20E-07	1.20E-7	1.20E-7	1.20E-7	1.20E-7	1.20E-7	1	1.89	(3,5,5,1,1,5,BU:1.5); ;
	Nickel	-	-	kg	6.00E-09	6.00E-9	6.00E-9	6.00E-9	6.00E-9	6.00E-9	1	5.38	(3,5,5,1,1,5,BU:5); ;
	Nitrogen oxides	-	-	kg	1.23E-04	1.23E-4	1.23E-4	1.23E-4	1.23E-4	1.23E-4	1	1.56	(1,1,2,1,1,5,BU:1.5); ;
	NMVOC, non-methane volatile organic compounds, unspecified origin	-	-	kg	8.12E-06	8.12E-6	8.12E-6	8.12E-6	8.12E-6	8.12E-6	1	1.56	(1,1,2,1,1,5,BU:1.5); ;
	PAH, polycyclic aromatic hydrocarbons	-	-	kg	1.11E-08	1.11E-8	1.11E-8	1.11E-8	1.11E-8	1.11E-8	1	3.33	(3,5,5,1,1,5,BU:3); ;
	Particulates, < 2.5 um	-	-	kg	6.18E-05	6.18E-5	6.18E-5	6.18E-5	6.18E-5	6.18E-5	1	3.05	(1,1,2,1,1,5,BU:3); ;
	Particulates, > 2.5 um, and < 10um	-	-	kg	2.00E-06	2.00E-6	2.00E-6	2.00E-6	2.00E-6	2.00E-6	1	2.05	(1,1,2,1,1,5,BU:2); ;
	Phenol, pentachloro-	-	-	kg	8.10E-12	8.10E-12	8.10E-12	8.10E-12	8.10E-12	8.10E-12	1	1.89	(3,5,5,1,1,5,BU:1.5); ;
	Phosphorus	-	-	kg	3.00E-07	3.00E-7	3.00E-7	3.00E-7	3.00E-7	3.00E-7	1	1.89	(3,5,5,1,1,5,BU:1.5); ;
	Potassium	-	-	kg	2.34E-05	2.34E-5	2.34E-5	2.34E-5	2.34E-5	2.34E-5	1	5.38	(3,5,5,1,1,5,BU:5); ;
	Sodium	-	-	kg	1.30E-06	1.30E-6	1.30E-6	1.30E-6	1.30E-6	1.30E-6	1	5.38	(3,5,5,1,1,5,BU:5); ;
	Sulfur dioxide	-	-	kg	1.00E-05	1.00E-5	1.00E-5	1.00E-5	1.00E-5	1.00E-5	1	1.21	(1,1,2,1,1,5,BU:1.05); ;
	Toluene	-	-	kg	3.00E-07	3.00E-7	3.00E-7	3.00E-7	3.00E-7	3.00E-7	1	1.89	(3,5,5,1,1,5,BU:1.5); ;
	Zinc	-	-	kg	3.00E-07	3.00E-7	3.00E-7	3.00E-7	3.00E-7	3.00E-7	1	5.38	(3,5,5,1,1,5,BU:5); ;

Figure 121: Unit process raw data of wood chips, burned in furnace 300kW

ReferenceFunction	Name	wood chips, from forest, hardwood, burned in furnace 1000kW	wood chips, from forest, mixed, burned in furnace 1000kW	wood chips, from forest, softwood, burned in furnace 1000kW	wood chips, from industry, hardwood, burned in furnace 1000kW	wood chips, from industry, mixed, burned in furnace 1000kW	wood chips, from industry, softwood, burned in furnace 1000kW
Geography	Location	CH	CH	CH	CH	CH	CH
ReferenceFunction	InfrastructureProcess	0	0	0	0	0	0
ReferenceFunction	Unit	MJ	MJ	MJ	MJ	MJ	MJ
	IncludedProcesses	This module describes the combustion of wood chips. Included are the infrastructure, the wood requirements, the emissions to air, the transport of the fuel, the electricity needed for operation, and the disposal of the ashes.	This module describes the combustion of wood chips. Included are the infrastructure, the wood requirements, the emissions to air, the transport of the fuel, the electricity needed for operation, and the disposal of the ashes.	This module describes the combustion of wood chips. Included are the infrastructure, the wood requirements, the emissions to air, the transport of the fuel, the electricity needed for operation, and the disposal of the ashes.	This module describes the combustion of wood chips. Included are the infrastructure, the wood requirements, the emissions to air, the transport of the fuel, the electricity needed for operation, and the disposal of the ashes.	This module describes the combustion of wood chips. Included are the infrastructure, the wood requirements, the emissions to air, the transport of the fuel, the electricity needed for operation, and the disposal of the ashes.	This module describes the combustion of wood chips. Included are the infrastructure, the wood requirements, the emissions to air, the transport of the fuel, the electricity needed for operation, and the disposal of the ashes.
	LocalName	Holzschnitzel, aus Wald, Laubholz, in Feuerung 1000kW	Holzschnitzel, aus Wald, Holzmix, in Feuerung 1000kW	Holzschnitzel, aus Wald, Nadelholz, in Feuerung 1000kW	Holzschnitzel, aus Industrie, Laubholz, in Feuerung 1000kW	Holzschnitzel, aus Industrie, Holzmix, in Feuerung 1000kW	Holzschnitzel, aus Industrie, Nadelholz, in Feuerung 1000kW
	Synonyms						
	GeneralComment	Heat of combustion of wood chips based on lower heating value. 2100 operating hours per year. Air emission factors are calculated from the weighted average of measurements of automatic chip boilers > 500 kW.	Heat of combustion of wood chips based on lower heating value. 2100 operating hours per year. Air emission factors are calculated from the weighted average of measurements of automatic chip boilers > 500 kW.	Heat of combustion of wood chips based on lower heating value. 2100 operating hours per year. Air emission factors are calculated from the weighted average of measurements of automatic chip boilers > 500 kW.	Heat of combustion of wood chips based on lower heating value. 2100 operating hours per year. Air emission factors are calculated from the weighted average of measurements of automatic chip boilers > 500 kW.	Heat of combustion of wood chips based on lower heating value. 2100 operating hours per year. Air emission factors are calculated from the weighted average of measurements of automatic chip boilers > 500 kW.	Heat of combustion of wood chips based on lower heating value. 2100 operating hours per year. Air emission factors are calculated from the weighted average of measurements of automatic chip boilers > 500 kW.
	InfrastructureIncluded	1	1	1	1	1	1
	Category	wood energy	wood energy	wood energy	wood energy	wood energy	wood energy
	SubCategory	heating systems	heating systems	heating systems	heating systems	heating systems	heating systems
	LocalCategory	Holzenergie	Holzenergie	Holzenergie	Holzenergie	Holzenergie	Holzenergie
	LocalSubCategory	Heizungssysteme	Heizungssysteme	Heizungssysteme	Heizungssysteme	Heizungssysteme	Heizungssysteme
	Formula						
	StatisticalClassification						
	CASNumber						
TimePeriod	StartDate	2015	2015	2015	2015	2015	2015
	EndDate	2020	2020	2020	2020	2020	2020
	DataValidForEntirePeriod	1	1	1	1	1	1
	OtherPeriodText	Time of publications.	Time of publications.	Time of publications.	Time of publications.	Time of publications.	Time of publications.
Geography	Text	Could be used for central European conditions	Could be used for central European conditions	Could be used for central European conditions	Could be used for central European conditions	Could be used for central European conditions	Could be used for central European conditions
Technology	Text	Boiler of average technology available on market	Boiler of average technology available on market	Boiler of average technology available on market	Boiler of average technology available on market	Boiler of average technology available on market	Boiler of average technology available on market
Representativeness	Percent						
	ProductionVolume						
	SamplingProcedure	literature	literature	literature	literature	literature	literature
	Extrapolations	none	none	none	none	none	none
	UncertaintyAdjustments	none	none	none	none	none	none

Figure 122: Metadata of wood chips, burned in furnace 1000kW

	Name	Location	Infrastructure Process	Unit	wood chips, from forest, hardwood, burned in furnace 1000kW	wood chips, from forest, mixed, burned in furnace 1000kW	wood chips, from forest, softwood, burned in furnace 1000kW	wood chips, from industry, hardwood, burned in furnace 1000kW	wood chips, from industry, mixed, burned in furnace 1000kW	wood chips, from industry, softwood, burned in furnace 1000kW	Uncertainty Type	Standard Deviation 95%	General Comment
	Location				CH	CH	CH	CH	CH	CH			
	Infrastructure Process				0	0	0	0	0	0			
	Unit				MJ	MJ	MJ	MJ	MJ	MJ			
product	wood chips, from forest, hardwood, burned in furnace 1000kW	CH	0	MJ	1	0	0	0	0	0			
	wood chips, from forest, mixed, burned in furnace 1000kW	CH	0	MJ	0	1	0	0	0	0			
	wood chips, from forest, softwood, burned in furnace 1000kW	CH	0	MJ	0	0	1	0	0	0			
	wood chips, from industry, hardwood, burned in furnace 1000kW	CH	0	MJ	0	0	0	1	0	0			
	wood chips, from industry, mixed, burned in furnace 1000kW	CH	0	MJ	0	0	0	0	1	0			
	wood chips, from industry, softwood, burned in furnace 1000kW	CH	0	MJ	0	0	0	0	0	1	0		
technosphere	electricity, low voltage, at grid	CH	0	kWh	4.72E-03	4.72E-3	4.72E-3	4.72E-3	4.72E-3	4.72E-3	1	1.22	(2,2,1,1,1,5,BU:1.05); ;
	wood chips, hardwood, wet, sustainable forest management, measured as dry mass, at forest road	CH	0	kg	5.67E-02	3.16E-2					1	1.22	(2,2,1,1,1,5,BU:1.05); ;
	wood chips, hardwood, wet, measured as dry mass, at sawmill	CH	0	kg				5.67E-2	3.16E-2		1	1.22	(2,2,1,1,1,5,BU:1.05); ;
	wood chips, softwood, wet, sustainable forest management, measured as dry mass, at forest road	CH	0	kg		2.36E-2	5.67E-2				1	1.22	(2,2,1,1,1,5,BU:1.05); ;
	wood chips, softwood, wet, measured as dry mass, at sawmill	CH	0	kg					2.36E-2	5.67E-2	1	1.22	(2,2,1,1,1,5,BU:1.05); ;
	furnace, wood chips, hardwood, 1000kW	CH	1	unit	7.50E-09			7.50E-9			1	3.05	(2,2,1,1,1,5,BU:3); ;
	furnace, wood chips, mixed, 1000kW	CH	1	unit		7.50E-9			7.50E-9		1	3.05	(2,2,1,1,1,5,BU:3); ;
	furnace, wood chips, softwood, 1000kW	CH	1	unit			7.50E-9			7.50E-9	1	3.05	(2,2,1,1,1,5,BU:3); ;
	transport, freight, lorry 16-32 metric ton, fleet average	CH	0	tkm	2.76E-03	2.76E-3	2.76E-3	2.76E-3	2.76E-3	2.76E-3	1	2.05	(2,2,1,1,1,5,BU:2); ;
	disposal, wood ash mixture, pure, 0% water, to municipal incineration	CH	0	kg	2.80E-04	2.80E-4	2.80E-4	2.80E-4	2.80E-4	2.80E-4	1	1.22	(2,2,1,1,1,5,BU:1.05); ;
	disposal, wood ash mixture, pure, 0% water, to landfarming	CH	0	kg							1	1.22	(2,2,1,1,1,5,BU:1.05); ;
	disposal, wood ash mixture, pure, 0% water, to sanitary landfill	CH	0	kg	1.40E-04	1.40E-4	1.40E-4	1.40E-4	1.40E-4	1.40E-4	1	1.22	(2,2,1,1,1,5,BU:1.05); ;
air, high population density	Acetaldehyde	-	-	kg	6.10E-08	6.10E-8	6.10E-8	6.10E-8	6.10E-8	6.10E-8	1	1.89	(3,5,5,1,1,5,BU:1.5); ;
	Ammonia	-	-	kg	2.00E-06	2.00E-6	2.00E-6	2.00E-6	2.00E-6	2.00E-6	1	1.30	(1,1,2,1,1,5,BU:1.2); ;
	Arsenic	-	-	kg	1.00E-09	1.00E-9	1.00E-9	1.00E-9	1.00E-9	1.00E-9	1	5.38	(3,5,5,1,1,5,BU:5); ;
	Benzene	-	-	kg	9.10E-07	9.10E-7	9.10E-7	9.10E-7	9.10E-7	9.10E-7	1	3.33	(3,5,5,1,1,5,BU:3); ;
	Benzene, ethyl-	-	-	kg	3.00E-08	3.00E-8	3.00E-8	3.00E-8	3.00E-8	3.00E-8	1	3.33	(3,5,5,1,1,5,BU:3); ;
	Benzene, hexachloro-	-	-	kg	1.00E-12	1.00E-12	1.00E-12	1.00E-12	1.00E-12	1.00E-12	1	3.05	(1,1,2,1,1,5,BU:3); ;
	Benzo(a)pyrene	-	-	kg	1.80E-09	1.80E-9	1.80E-9	1.80E-9	1.80E-9	1.80E-9	1	3.05	(1,1,2,1,1,5,BU:3); ;
	Bromine	-	-	kg	6.00E-08	6.00E-8	6.00E-8	6.00E-8	6.00E-8	6.00E-8	1	5.38	(3,5,5,1,1,5,BU:5); ;
	Cadmium	-	-	kg	1.30E-08	1.30E-8	1.30E-8	1.30E-8	1.30E-8	1.30E-8	1	5.05	(1,1,2,1,1,5,BU:5); ;
	Calcium	-	-	kg	5.85E-06	5.85E-6	5.85E-6	5.85E-6	5.85E-6	5.85E-6	1	5.38	(3,5,5,1,1,5,BU:5); ;
	Carbon dioxide, biogenic	-	-	kg	9.20E-02	9.20E-2	9.20E-2	9.20E-2	9.20E-2	9.20E-2	1	1.21	(1,1,2,1,1,5,BU:1.05); ;
	Carbon monoxide, biogenic	-	-	kg	2.62E-04	2.62E-4	2.62E-4	2.62E-4	2.62E-4	2.62E-4	1	5.05	(1,1,2,1,1,5,BU:5); ;
	Chlorine	-	-	kg	1.80E-07	1.80E-7	1.80E-7	1.80E-7	1.80E-7	1.80E-7	1	1.89	(3,5,5,1,1,5,BU:1.5); ;
	Chromium	-	-	kg	3.96E-09	3.96E-9	3.96E-9	3.96E-9	3.96E-9	3.96E-9	1	5.38	(3,5,5,1,1,5,BU:5); ;
	Chromium VI	-	-	kg	4.00E-11	4.00E-11	4.00E-11	4.00E-11	4.00E-11	4.00E-11	1	5.38	(3,5,5,1,1,5,BU:5); ;
	Copper	-	-	kg	2.20E-08	2.20E-8	2.20E-8	2.20E-8	2.20E-8	2.20E-8	1	5.38	(3,5,5,1,1,5,BU:5); ;
	Dinitrogen monoxide	-	-	kg	2.30E-06	2.30E-6	2.30E-6	2.30E-6	2.30E-6	2.30E-6	1	1.89	(3,5,5,1,1,5,BU:1.5); ;
	Dioxins, measured as 2,3,7,8-tetrachlorodibenzo-p-dioxin	-	-	kg	8.70E-14	8.70E-14	8.70E-14	8.70E-14	8.70E-14	8.70E-14	1	3.05	(1,1,2,1,1,5,BU:3); ;
	Fluorine	-	-	kg	5.00E-08	5.00E-8	5.00E-8	5.00E-8	5.00E-8	5.00E-8	1	1.89	(3,5,5,1,1,5,BU:1.5); ;
	Formaldehyde	-	-	kg	1.30E-07	1.30E-7	1.30E-7	1.30E-7	1.30E-7	1.30E-7	1	1.89	(3,5,5,1,1,5,BU:1.5); ;
	Heat, waste	-	-	MJ	1.08E+00	1.08E+0	1.08E+0	1.08E+0	1.08E+0	1.08E+0	1	1.64	(3,5,5,1,1,5,BU:1.05); ;
	Hydrocarbons, aliphatic, alkanes, unspecified	-	-	kg	9.10E-07	9.10E-7	9.10E-7	9.10E-7	9.10E-7	9.10E-7	1	1.89	(3,5,5,1,1,5,BU:1.5); ;
	Hydrocarbons, aliphatic, unsaturated	-	-	kg	3.10E-06	3.10E-6	3.10E-6	3.10E-6	3.10E-6	3.10E-6	1	1.89	(3,5,5,1,1,5,BU:1.5); ;
	Lead	-	-	kg	2.70E-08	2.70E-8	2.70E-8	2.70E-8	2.70E-8	2.70E-8	1	5.05	(1,1,2,1,1,5,BU:5); ;
	Magnesium	-	-	kg	3.60E-07	3.60E-7	3.60E-7	3.60E-7	3.60E-7	3.60E-7	1	5.38	(3,5,5,1,1,5,BU:5); ;
	Manganese	-	-	kg	1.70E-07	1.70E-7	1.70E-7	1.70E-7	1.70E-7	1.70E-7	1	5.38	(3,5,5,1,1,5,BU:5); ;
	Mercury	-	-	kg	6.00E-10	6.00E-10	6.00E-10	6.00E-10	6.00E-10	6.00E-10	1	5.05	(1,1,2,1,1,5,BU:5); ;
	Methane, biogenic	-	-	kg	4.00E-06	4.00E-6	4.00E-6	4.00E-6	4.00E-6	4.00E-6	1	1.56	(1,1,2,1,1,5,BU:1.5); ;
	m-Xylene	-	-	kg	1.20E-07	1.20E-7	1.20E-7	1.20E-7	1.20E-7	1.20E-7	1	1.89	(3,5,5,1,1,5,BU:1.5); ;
	Nickel	-	-	kg	6.00E-09	6.00E-9	6.00E-9	6.00E-9	6.00E-9	6.00E-9	1	5.38	(3,5,5,1,1,5,BU:5); ;
	Nitrogen oxides	-	-	kg	1.32E-04	1.32E-4	1.32E-4	1.32E-4	1.32E-4	1.32E-4	1	1.56	(1,1,2,1,1,5,BU:1.5); ;
	NMVOC, non-methane volatile organic compounds, unspecified origin	-	-	kg	5.00E-06	5.00E-6	5.00E-6	5.00E-6	5.00E-6	5.00E-6	1	1.56	(1,1,2,1,1,5,BU:1.5); ;
	PAH, polycyclic aromatic hydrocarbons	-	-	kg	1.11E-08	1.11E-8	1.11E-8	1.11E-8	1.11E-8	1.11E-8	1	3.33	(3,5,5,1,1,5,BU:3); ;
	Particulates, < 2.5 um	-	-	kg	5.40E-05	5.40E-5	5.40E-5	5.40E-5	5.40E-5	5.40E-5	1	3.05	(1,1,2,1,1,5,BU:3); ;
	Particulates, > 2.5 um, and < 10um	-	-	kg	2.00E-06	2.00E-6	2.00E-6	2.00E-6	2.00E-6	2.00E-6	1	2.05	(1,1,2,1,1,5,BU:2); ;
	Phenol, pentachloro-	-	-	kg	8.10E-12	8.10E-12	8.10E-12	8.10E-12	8.10E-12	8.10E-12	1	1.89	(3,5,5,1,1,5,BU:1.5); ;
	Phosphorus	-	-	kg	3.00E-07	3.00E-7	3.00E-7	3.00E-7	3.00E-7	3.00E-7	1	1.89	(3,5,5,1,1,5,BU:1.5); ;
	Potassium	-	-	kg	2.34E-05	2.34E-5	2.34E-5	2.34E-5	2.34E-5	2.34E-5	1	5.38	(3,5,5,1,1,5,BU:5); ;
	Sodium	-	-	kg	1.30E-06	1.30E-6	1.30E-6	1.30E-6	1.30E-6	1.30E-6	1	5.38	(3,5,5,1,1,5,BU:5); ;
	Sulfur dioxide	-	-	kg	1.00E-05	1.00E-5	1.00E-5	1.00E-5	1.00E-5	1.00E-5	1	1.21	(1,1,2,1,1,5,BU:1.05); ;
	Toluene	-	-	kg	3.00E-07	3.00E-7	3.00E-7	3.00E-7	3.00E-7	3.00E-7	1	1.89	(3,5,5,1,1,5,BU:1.5); ;
	Zinc	-	-	kg	3.00E-07	3.00E-7	3.00E-7	3.00E-7	3.00E-7	3.00E-7	1	5.38	(3,5,5,1,1,5,BU:5); ;

Figure 123: Unit process raw data of wood chips, burned in furnace 1000kW

ReferenceFunction	Name	wood chips, from forest, hardwood, burned in furnace 5000kW	wood chips, from forest, mixed, burned in furnace 5000kW	wood chips, from forest, softwood, burned in furnace 5000kW	wood chips, from industry, hardwood, burned in furnace 5000kW	wood chips, from industry, mixed, burned in furnace 5000kW	wood chips, from industry, softwood, burned in furnace 5000kW
Geography	Location	CH	CH	CH	CH	CH	CH
ReferenceFunction	InfrastructureProcess	0	0	0	0	0	0
ReferenceFunction	Unit	MJ	MJ	MJ	MJ	MJ	MJ
	IncludedProcesses	This module describes the combustion of wood chips. Included are the infrastructure, the wood requirements, the emissions to air, the transport of the fuel, the electricity needed for operation, and the disposal of the ashes.	This module describes the combustion of wood chips. Included are the infrastructure, the wood requirements, the emissions to air, the transport of the fuel, the electricity needed for operation, and the disposal of the ashes.	This module describes the combustion of wood chips. Included are the infrastructure, the wood requirements, the emissions to air, the transport of the fuel, the electricity needed for operation, and the disposal of the ashes.	This module describes the combustion of wood chips. Included are the infrastructure, the wood requirements, the emissions to air, the transport of the fuel, the electricity needed for operation, and the disposal of the ashes.	This module describes the combustion of wood chips. Included are the infrastructure, the wood requirements, the emissions to air, the transport of the fuel, the electricity needed for operation, and the disposal of the ashes.	This module describes the combustion of wood chips. Included are the infrastructure, the wood requirements, the emissions to air, the transport of the fuel, the electricity needed for operation, and the disposal of the ashes.
	LocalName	Holzschnitzel, aus Wald, Laubholz, in Feuerung 5000kW	Holzschnitzel, aus Wald, Holzmix, in Feuerung 5000kW	Holzschnitzel, aus Wald, Nadelholz, in Feuerung 5000kW	Holzschnitzel, aus Industrie, Laubholz, in Feuerung 5000kW	Holzschnitzel, aus Industrie, Holzmix, in Feuerung 5000kW	Holzschnitzel, aus Industrie, Nadelholz, in Feuerung 5000kW
	Synonyms	0	0	0	0	0	0
	GeneralComment	Heat of combustion of wood chips based on lower heating value. 5000 operating yours per year. Air emission factors are calculated from the weighted average of measurements of automatic chip boilers > 500 kW.	Heat of combustion of wood chips based on lower heating value. 5000 operating yours per year. Air emission factors are calculated from the weighted average of measurements of automatic chip boilers > 500 kW.	Heat of combustion of wood chips based on lower heating value. 5000 operating yours per year. Air emission factors are calculated from the weighted average of measurements of automatic chip boilers > 500 kW.	Heat of combustion of wood chips based on lower heating value. 5000 operating yours per year. Air emission factors are calculated from the weighted average of measurements of automatic chip boilers > 500 kW.	Heat of combustion of wood chips based on lower heating value. 5000 operating yours per year. Air emission factors are calculated from the weighted average of measurements of automatic chip boilers > 500 kW.	Heat of combustion of wood chips based on lower heating value. 5000 operating yours per year. Air emission factors are calculated from the weighted average of measurements of automatic chip boilers > 500 kW.
	InfrastructureIncluded	1	1	1	1	1	1
	Category	wood energy	wood energy	wood energy	wood energy	wood energy	wood energy
	SubCategory	heating systems	heating systems	heating systems	heating systems	heating systems	heating systems
	LocalCategory	Holzenergie	Holzenergie	Holzenergie	Holzenergie	Holzenergie	Holzenergie
	LocalSubCategory	Heizungssysteme	Heizungssysteme	Heizungssysteme	Heizungssysteme	Heizungssysteme	Heizungssysteme
	Formula						
	StatisticalClassification						
	CASNumber						
TimePeriod	StartDate	2015	2015	2015	2015	2015	2015
	EndDate	2020	2020	2020	2020	2020	2020
	DataValidForEntirePeriod	1	1	1	1	1	1
	OtherPeriodText	Time of publications.	Time of publications.	Time of publications.	Time of publications.	Time of publications.	Time of publications.
Geography	Text	Could be used for central European conditions	Could be used for central European conditions	Could be used for central European conditions	Could be used for central European conditions	Could be used for central European conditions	Could be used for central European conditions
Technology	Text	Boiler of average technology available on market	Boiler of average technology available on market	Boiler of average technology available on market	Boiler of average technology available on market	Boiler of average technology available on market	Boiler of average technology available on market
Representativeness	Percent						
	ProductionVolume						
	SamplingProcedure	literature	literature	literature	literature	literature	literature
	Extrapolations	none	none	none	none	none	none
	UncertaintyAdjustments	none	none	none	none	none	none

Figure 124: Metadata of wood chips, burned in furnace 5000kW

	Name	wood chips, from forest, hardwood, burned in furnace 5000kW	wood chips, from forest, mixed, burned in furnace 5000kW	wood chips, from forest, softwood, burned in furnace 5000kW	wood chips, from industry, hardwood, burned in furnace 5000kW	wood chips, from industry, mixed, burned in furnace 5000kW	wood chips, from industry, softwood, burned in furnace 5000kW	Uncertainty Type	Standard Deviation 95%	General Comment
	Location	CH	CH	CH	CH	CH	CH			
	Infrastructure Process	0	0	0	0	0	0			
	Unit	MJ	MJ	MJ	MJ	MJ	MJ			
product	wood chips, from forest, hardwood, burned in furnace 5000kW	1	0	0	0	0	0			
	wood chips, from forest, mixed, burned in furnace 5000kW	0	1	0	0	0	0			
	wood chips, from forest, softwood, burned in furnace 5000kW	0	0	1	0	0	0			
	wood chips, from industry, hardwood, burned in furnace 5000kW	0	0	0	1	0	0			
	wood chips, from industry, mixed, burned in furnace 5000kW	0	0	0	0	1	0			
	wood chips, from industry, softwood, burned in furnace 5000kW	0	0	0	0	0	1	0		
technosphere	electricity, low voltage, at grid	4.72E-3	4.72E-3	4.72E-3	4.72E-3	4.72E-3	4.72E-3	1	1.38	(4,3,1,1,3,5,BU:1.05); ;
	wood chips, hardwood, wet, sustainable forest management, measured as dry mass, at forest road	5.67E-2	3.16E-2	0	0	0	0	1	1.38	(4,3,1,1,3,5,BU:1.05); ;
	wood chips, hardwood, wet, measured as dry mass, at sawmill	0	0	0	5.33E-2	3.16E-2	0	1	1.38	(4,3,1,1,3,5,BU:1.05); ;
	wood chips, softwood, wet, sustainable forest management, measured as dry mass, at forest road	0	2.36E-2	5.67E-2	0	0	0	1	1.38	(4,3,1,1,3,5,BU:1.05); ;
	wood chips, softwood, wet, measured as dry mass, at sawmill	0	0	0	0	2.36E-2	5.33E-2	1	1.38	(4,3,1,1,3,5,BU:1.05); ;
	furnace, wood chips, hardwood, 5000kW	6.37E-10	-	0	6.37E-10	-	0	1	1.31	(2,3,1,1,3,5,BU:1.05); ;
	furnace, wood chips, mixed, 5000kW	0	6.37E-10	0	0	6.37E-10	0	1	1.31	(2,3,1,1,3,5,BU:1.05); ;
	furnace, wood chips, softwood, 5000kW	0	0	6.37E-10	0	0	6.37E-10	1	1.31	(2,3,1,1,3,5,BU:1.05); ;
	transport, tractor and trailer	2.83E-3	2.76E-3	2.83E-3	2.83E-3	2.76E-3	2.83E-3	1	2.10	(2,3,1,1,3,5,BU:2); ;
	disposal, wood ash mixture, pure, 0% water, to municipal incineration	2.80E-4	2.80E-4	2.80E-4	2.80E-4	2.80E-4	2.80E-4	1	1.31	(2,3,1,1,3,5,BU:1.05); ;
	disposal, wood ash mixture, pure, 0% water, to sanitary landfill	2.80E-4	2.80E-4	2.80E-4	2.80E-4	2.80E-4	2.80E-4	1	1.31	(2,3,1,1,3,5,BU:1.05); ;
air, high population density	Acetaldehyde	6.10E-08	6.10E-8	6.10E-8	6.10E-8	6.10E-8	6.10E-8	1	1.89	(3,5,5,1,1,5,BU:1.5); ;
	Ammonia	2.00E-06	2.00E-6	2.00E-6	2.00E-6	2.00E-6	2.00E-6	1	1.30	(1,1,2,1,1,5,BU:1.2); ;
	Arsenic	1.00E-09	1.00E-9	1.00E-9	1.00E-9	1.00E-9	1.00E-9	1	5.38	(3,5,5,1,1,5,BU:5); ;
	Benzene	9.10E-07	9.10E-7	9.10E-7	9.10E-7	9.10E-7	9.10E-7	1	3.33	(3,5,5,1,1,5,BU:3); ;
	Benzene, ethyl-	3.00E-08	3.00E-8	3.00E-8	3.00E-8	3.00E-8	3.00E-8	1	3.33	(3,5,5,1,1,5,BU:3); ;
	Benzene, hexachloro-	2.50E-13	2.50E-13	2.50E-13	2.50E-13	2.50E-13	2.50E-13	1	3.05	(1,1,2,1,1,5,BU:3); ;
	Benzo(a)pyrene	1.28E-09	1.28E-9	1.28E-9	1.28E-9	1.28E-9	1.28E-9	1	3.05	(1,1,2,1,1,5,BU:3); ;
	Bromine	6.00E-08	6.00E-8	6.00E-8	6.00E-8	6.00E-8	6.00E-8	1	5.38	(3,5,5,1,1,5,BU:5); ;
	Cadmium	1.30E-08	1.30E-8	1.30E-8	1.30E-8	1.30E-8	1.30E-8	1	5.05	(1,1,2,1,1,5,BU:5); ;
	Calcium	5.85E-06	5.85E-6	5.85E-6	5.85E-6	5.85E-6	5.85E-6	1	5.38	(3,5,5,1,1,5,BU:5); ;
	Carbon dioxide, biogenic	9.20E-02	9.20E-2	9.20E-2	9.20E-2	9.20E-2	9.20E-2	1	1.21	(1,1,2,1,1,5,BU:1.05); ;
	Carbon monoxide, biogenic	2.03E-04	2.03E-4	2.03E-4	2.03E-4	2.03E-4	2.03E-4	1	5.05	(1,1,2,1,1,5,BU:5); ;
	Chlorine	1.80E-07	1.80E-7	1.80E-7	1.80E-7	1.80E-7	1.80E-7	1	1.89	(3,5,5,1,1,5,BU:1.5); ;
	Chromium	3.96E-09	3.96E-9	3.96E-9	3.96E-9	3.96E-9	3.96E-9	1	5.38	(3,5,5,1,1,5,BU:5); ;
	Chromium VI	4.00E-11	4.00E-11	4.00E-11	4.00E-11	4.00E-11	4.00E-11	1	5.38	(3,5,5,1,1,5,BU:5); ;
	Copper	2.20E-08	2.20E-8	2.20E-8	2.20E-8	2.20E-8	2.20E-8	1	5.38	(3,5,5,1,1,5,BU:5); ;
	Dinitrogen monoxide	2.30E-06	2.30E-6	2.30E-6	2.30E-6	2.30E-6	2.30E-6	1	1.89	(3,5,5,1,1,5,BU:1.5); ;
	Dioxins, measured as 2,3,7,8-tetrachlorodibenzo-p-dioxin	8.70E-14	8.70E-14	8.70E-14	8.70E-14	8.70E-14	8.70E-14	1	3.05	(1,1,2,1,1,5,BU:3); ;
	Fluorine	5.00E-08	5.00E-8	5.00E-8	5.00E-8	5.00E-8	5.00E-8	1	1.89	(3,5,5,1,1,5,BU:1.5); ;
	Formaldehyde	1.30E-07	1.30E-7	1.30E-7	1.30E-7	1.30E-7	1.30E-7	1	1.89	(3,5,5,1,1,5,BU:1.5); ;
	Heat, waste	1.08E+00	1.08E+0	1.08E+0	1.08E+0	1.08E+0	1.08E+0	1	1.64	(3,5,5,1,1,5,BU:1.05); ;
	Hydrocarbons, aliphatic, alkanes, unspecified	9.10E-07	9.10E-7	9.10E-7	9.10E-7	9.10E-7	9.10E-7	1	1.89	(3,5,5,1,1,5,BU:1.5); ;
	Hydrocarbons, aliphatic, unsaturated	3.10E-06	3.10E-6	3.10E-6	3.10E-6	3.10E-6	3.10E-6	1	1.89	(3,5,5,1,1,5,BU:1.5); ;
	Lead	2.70E-08	2.70E-8	2.70E-8	2.70E-8	2.70E-8	2.70E-8	1	5.05	(1,1,2,1,1,5,BU:5); ;
	Magnesium	3.60E-07	3.60E-7	3.60E-7	3.60E-7	3.60E-7	3.60E-7	1	5.38	(3,5,5,1,1,5,BU:5); ;
	Manganese	1.70E-07	1.70E-7	1.70E-7	1.70E-7	1.70E-7	1.70E-7	1	5.38	(3,5,5,1,1,5,BU:5); ;
	Mercury	6.00E-10	6.00E-10	6.00E-10	6.00E-10	6.00E-10	6.00E-10	1	5.05	(1,1,2,1,1,5,BU:5); ;
	Methane, biogenic	3.07E-06	3.07E-6	3.07E-6	3.07E-6	3.07E-6	3.07E-6	1	1.56	(1,1,2,1,1,5,BU:1.5); ;
	m-Xylene	1.20E-07	1.20E-7	1.20E-7	1.20E-7	1.20E-7	1.20E-7	1	1.89	(3,5,5,1,1,5,BU:1.5); ;
	Nickel	6.00E-09	6.00E-9	6.00E-9	6.00E-9	6.00E-9	6.00E-9	1	5.38	(3,5,5,1,1,5,BU:5); ;
	Nitrogen oxides	1.35E-04	1.35E-4	1.35E-4	1.35E-4	1.35E-4	1.35E-4	1	1.56	(1,1,2,1,1,5,BU:1.5); ;
	NMVOC, non-methane volatile organic compounds, unspecified origin	3.82E-06	3.82E-6	3.82E-6	3.82E-6	3.82E-6	3.82E-6	1	1.56	(1,1,2,1,1,5,BU:1.5); ;
	PAH, polycyclic aromatic hydrocarbons	1.11E-08	1.11E-8	1.11E-8	1.11E-8	1.11E-8	1.11E-8	1	3.33	(3,5,5,1,1,5,BU:3); ;
	Particulates, < 2.5 um	4.79E-05	4.79E-5	4.79E-5	4.79E-5	4.79E-5	4.79E-5	1	3.05	(1,1,2,1,1,5,BU:3); ;
	Particulates, > 2.5 um, and < 10um	2.00E-06	2.00E-6	2.00E-6	2.00E-6	2.00E-6	2.00E-6	1	2.05	(1,1,2,1,1,5,BU:2); ;
	Phenol, pentachloro-	8.10E-12	8.10E-12	8.10E-12	8.10E-12	8.10E-12	8.10E-12	1	1.89	(3,5,5,1,1,5,BU:1.5); ;
	Phosphorus	3.00E-07	3.00E-7	3.00E-7	3.00E-7	3.00E-7	3.00E-7	1	1.89	(3,5,5,1,1,5,BU:1.5); ;
	Potassium	2.34E-05	2.34E-5	2.34E-5	2.34E-5	2.34E-5	2.34E-5	1	5.38	(3,5,5,1,1,5,BU:5); ;
	Sodium	1.30E-06	1.30E-6	1.30E-6	1.30E-6	1.30E-6	1.30E-6	1	5.38	(3,5,5,1,1,5,BU:5); ;
	Sulfur dioxide	1.00E-05	1.00E-5	1.00E-5	1.00E-5	1.00E-5	1.00E-5	1	1.21	(1,1,2,1,1,5,BU:1.05); ;
	Toluene	3.00E-07	3.00E-7	3.00E-7	3.00E-7	3.00E-7	3.00E-7	1	1.89	(3,5,5,1,1,5,BU:1.5); ;
	Zinc	3.00E-07	3.00E-7	3.00E-7	3.00E-7	3.00E-7	3.00E-7	1	5.38	(3,5,5,1,1,5,BU:5); ;

Figure 125: Unit process raw data of wood chips, burned in furnace 5000kW

The “heat, ….” inventories tables (about addition 20 figures) are not separately listed as the only additional information is the efficiency factor which is already listed in Table 40.

2.7.4 Data quality

The data quality for the main air pollutants and the efficiency are generally very good.
Other inputs such as the furnace materials and outputs such as some trace emissions which have not been updated during this study are usually of low relevance for the calculated environmental impacts.

2.7.5 Life cycle impact assessment

At the infrastructure level, most results are twice as high as in the former inventories. The main reason are higher weights of the updated inventories compared to the former ones and therefore more materials such as steel and more energy for production involved.

At the level of MJ input (wood, burned in…) the new inventories show somewhat higher impacts regarding the ecological scarcity due to higher particulate matter, cadmium and dioxin emissions compared to the former inventory. The CO_2 emissions are higher for the logs inventories due to higher N2O emissions and similar for the pellets and wood chips inventories.

At the level of MJ heat delivered (heat, wood, burned in…) the new inventories for 15kW to 300kW furnaces have higher efficiency rates than the former inventories and therefore the new inventories show still somewhat higher impacts regarding the ecological scarcity due to higher particulate matter, cadmium and dioxin emissions compared to the former inventory but the ratio is lower than at the level of MJ input.

Table 44: LCIA results of wood heat inventories - furnaces

Inventory name/unit	Ecological Scarcity 2013	IPCC 2013, GWP 100a	former inventory (UVEK 2018) that most closely matches the update	Ecological Scarcity 2013	IPCC 2013, GWP 100a	UBP ratio	kg CO2eq ratio
	UBP	kg CO2eq		UBP	kg CO2eq	%	%
furnace, logs, hardwood, 15kW/p/CH/I U	2.95E+06	1.83E+03					
furnace, logs, hardwood, 50kW/p/CH/I U	5.29E+06	3.35E+03	Furnace, logs, hardwood, 30kW/CH/I U	2.66E+06	1.30E+03	199%	258%
furnace, logs, hardwood, 6kW/p/CH/I U	9.90E+05	6.56E+02	Furnace, logs, hardwood, 6kW/CH/I U	5.06E+05	2.72E+02	196%	241%
furnace, logs, mixed, 15kW/p/CH/I U	2.97E+06	1.83E+03					
furnace, logs, mixed, 50kW/p/CH/I U	5.31E+06	3.35E+03	Furnace, logs, mixed, 30kW/CH/I U	2.68E+06	1.30E+03	198%	258%
furnace, logs, mixed, 6kW/p/CH/I U	9.95E+05	6.54E+02	Furnace, logs, mixed, 6kW/CH/I U	5.10E+05	2.72E+02	195%	241%
furnace, logs, softwood, 15kW/p/CH/I U	2.97E+06	1.83E+03					
furnace, logs, softwood, 50kW/p/CH/I U	5.32E+06	3.35E+03	Furnace, logs, softwood, 30kW/CH/I U	2.68E+06	1.30E+03	198%	258%
furnace, logs, softwood, 6kW/p/CH/I U	9.98E+05	6.54E+02	Furnace, logs, softwood, 6kW/CH/I U	5.12E+05	2.72E+02	195%	241%
furnace, pellets, 15kW/p/CH/I U	3.46E+06	2.67E+03	Furnace, pellets, 15kW/CH/I U	4.50E+06	2.89E+03	77%	92%
furnace, pellets, 300kW/p/CH/I U	3.72E+07	3.10E+04					
furnace, pellets, 50kW/p/CH/I U	7.77E+06	6.02E+03	Furnace, pellets, 50kW/CH/I U	7.65E+06	5.54E+03	102%	109%
furnace, wood chips, hardwood, 1000kW/p/CH/I U	1.10E+08	7.12E+04	Furnace, wood chips, hardwood, 1000kW/CH/I U	4.74E+07	2.95E+04	231%	241%
furnace, wood chips, hardwood, 300kW/p/CH/I U	1.81E+07	1.13E+04	Furnace, wood chips, hardwood, 300kW/CH/I U	2.79E+07	2.07E+04	65%	54%
furnace, wood chips, hardwood, 5000kW/p/CH/I U	5.03E+08	2.86E+05					
furnace, wood chips, hardwood, 50kW/p/CH/I U	1.46E+07	1.18E+04	Furnace, wood chips, hardwood, 50kW/CH/I U	1.37E+07	1.12E+04	106%	106%
furnace, wood chips, mixed, 1000kW/p/CH/I U	1.13E+08	7.45E+04	Furnace, wood chips, mixed, 1000kW/CH/I U	5.13E+07	3.31E+04	221%	225%
furnace, wood chips, mixed, 300kW/p/CH/I U	3.30E+07	2.61E+04	Furnace, wood chips, mixed, 300kW/CH/I U	3.14E+07	2.38E+04	105%	109%
furnace, wood chips, mixed, 5000kW/p/CH/I U	5.19E+08	2.91E+05					
furnace, wood chips, mixed, 50kW/p/CH/I U	1.66E+07	1.37E+04	Furnace, wood chips, mixed, 50kW/CH/I U	1.58E+07	1.32E+04	105%	104%
furnace, wood chips, softwood, 1000kW/p/CH/I U	1.15E+08	7.58E+04	Furnace, wood chips, softwood, 1000kW/CH/I U	5.28E+07	3.44E+04	218%	220%
furnace, wood chips, softwood, 300kW/p/CH/I U	3.44E+07	2.73E+04	Furnace, wood chips, softwood, 300kW/CH/I U	3.28E+07	2.52E+04	105%	109%
furnace, wood chips, softwood, 5000kW/p/CH/I U	5.25E+08	2.93E+05					

Inventory name/unit	Ecological Scarcity 2013	IPCC 2013, GWP 100a	former inventory (UVEK 2018) that most closely matches the update	Ecological Scarcity 2013	IPCC 2013, GWP 100a	UBP ratio	kg CO2eq ratio
furnace, wood chips, softwood, 50kW/p/CH/I U	1.74E+07	1.44E+04	Furnace, wood chips, softwood, 50kW/CH/I U	1.66E+07	1.39E+04	105%	103%
	UBP	kg CO2eq		UBP	kg CO2eq	%	%
furnace, wood chips, mixed, 300kW/p/CH/I U	3.30E+07	2.61E+04	Furnace, wood chips, mixed, 300kW/CH/I U	3.14E+07	2.38E+04	105%	109%
furnace, wood chips, mixed, 5000kW/p/CH/I U	5.19E+08	2.91E+05					
furnace, wood chips, mixed, 50kW/p/CH/I U	1.66E+07	1.37E+04	Furnace, wood chips, mixed, 50kW/CH/I U	1.58E+07	1.32E+04	105%	104%
furnace, wood chips, softwood, 1000kW/p/CH/I U	1.15E+08	7.58E+04	Furnace, wood chips, softwood, 1000kW/CH/I U	5.28E+07	3.44E+04	218%	220%
furnace, wood chips, softwood, 300kW/p/CH/I U	3.44E+07	2.73E+04	Furnace, wood chips, softwood, 300kW/CH/I U	3.28E+07	2.52E+04	105%	109%
furnace, wood chips, softwood, 5000kW/p/CH/I U	5.25E+08	2.93E+05					
furnace, wood chips, softwood, 50kW/p/CH/I U	1.74E+07	1.44E+04	Furnace, wood chips, softwood, 50kW/CH/I U	1.66E+07	1.39E+04	105%	103%

Table 45: LCIA results of wood heat inventories - heat

Inventory name/unit	Ecological Scarcity 2013	IPCC 2013, GWP 100a	former inventory (UVEK 2018) that most closely matches the update	Ecological Scarcity 2013	IPCC 2013, GWP 100a	UBP ratio	kg CO2eq ratio
	UBP	kg CO2eq		UBP	kg CO2eq	%	%
heat, hardwood chips from forest, at furnace 1000kW/MJ/CH U	4.32E+01	4.91E-03	Heat, hardwood chips from forest, at furnace 1000kW/CH U	3.83E+01	4.35E-03	113%	113%
heat, hardwood chips from forest, at furnace 300kW/MJ/CH U	4.25E+01	3.88E-03	Heat, hardwood chips from forest, at furnace 300kW/CH U	3.73E+01	4.59E-03	114%	85%
heat, hardwood chips from forest, at furnace 5000kW/MJ/CH U	4.19E+01	4.84E-03					
heat, hardwood chips from forest, at furnace 50kW/MJ/CH U	4.75E+01	5.83E-03	Heat, hardwood chips from forest, at furnace 50kW/CH U	3.94E+01	5.90E-03	120%	99%
heat, hardwood chips from industry, at furnace 1000kW/MJ/CH U	4.39E+01	5.20E-03	Heat, hardwood chips from industry, at furnace 1000kW/CH U	3.37E+01	4.46E-03	130%	117%
heat, hardwood chips from industry, at furnace 300kW/MJ/CH U	4.32E+01	4.15E-03	Heat, hardwood chips from industry, at furnace 300kW/CH U	3.26E+01	4.76E-03	133%	87%
heat, hardwood chips from industry, at furnace 5000kW/MJ/CH U	4.23E+01	4.99E-03					
heat, hardwood chips from industry, at furnace 50kW/MJ/CH U	4.82E+01	6.12E-03	Heat, hardwood chips from industry, at furnace 50kW/CH U	3.45E+01	6.07E-03	139%	101%
heat, hardwood logs, at furnace 15kW/MJ/CH U	4.67E+01	9.07E-03					
heat, hardwood logs, at furnace 50kW/MJ/CH U	4.67E+01	9.54E-03	Heat, hardwood logs, at furnace 30kW/CH U	4.66E+01	6.00E-03	100%	159%
heat, hardwood logs, at wood heater 6kW/MJ/CH U	4.91E+01	9.90E-03	Heat, hardwood logs, at wood heater 6kW/CH U	5.87E+01	6.13E-03	84%	162%
heat, mixed chips from forest, at furnace 1000kW/MJ/CH U	4.39E+01	5.41E-03	Heat, mixed chips from forest, at furnace 1000kW/CH U	3.93E+01	5.18E-03	112%	104%

heat, mixed chips from forest, at furnace 300kW/MJ/CH U	4.36E+01	4.77E-03	Heat, mixed chips from forest, at furnace 300kW/CH U	3.82E+01	5.46E-03	114%	87%
Inventory name/unit	**Ecological Scarcity 2013**	**IPCC 2013, GWP 100a**	**former inventory (UVEK 2018) that most closely matches the update**	**Ecological Scarcity 2013**	**IPCC 2013, GWP 100a**	**UBP ratio**	**kg CO2eq ratio**
	UBP	kg CO2eq		UBP	kg CO2eq	%	%
heat, mixed chips from forest, at furnace 5000kW/MJ/CH U	4.26E+01	5.28E-03					
heat, mixed chips from forest, at furnace 50kW/MJ/CH U	4.85E+01	6.62E-03	Heat, mixed chips from forest, at furnace 50kW/CH U	4.05E+01	6.98E-03	120%	95%
heat, mixed chips from industry, at furnace 1000kW/MJ/CH U	4.41E+01	5.36E-03	Heat, mixed chips from industry, at furnace 1000kW/CH U	3.33E+01	4.63E-03	132%	116%
heat, mixed chips from industry, at furnace 300kW/MJ/CH U	4.38E+01	4.72E-03	Heat, mixed chips from industry, at furnace 300kW/CH U	3.21E+01	4.99E-03	136%	95%
heat, mixed chips from industry, at furnace 5000kW/MJ/CH U	4.27E+01	5.23E-03					
heat, mixed chips from industry, at furnace 50kW/MJ/CH U	4.87E+01	6.57E-03	Heat, mixed chips from industry, at furnace 50kW/CH U	3.43E+01	6.50E-03	142%	101%
heat, mixed logs, at furnace 15kW/MJ/CH U	4.77E+01	9.79E-03					
heat, mixed logs, at furnace 50kW/MJ/CH U	4.58E+01	8.95E-03	Heat, mixed logs, at furnace 30kW/CH U	4.72E+01	6.79E-03	97%	132%
heat, mixed logs, at wood heater 6kW/MJ/CH U	5.01E+01	1.06E-02	Heat, mixed logs, at wood heater 6kW/CH U	5.88E+01	6.84E-03	85%	156%
heat, softwood chips from forest, at furnace 1000kW/MJ/CH U	4.51E+01	6.20E-03	Heat, softwood chips from forest, at furnace 1000kW/CH U	3.99E+01	5.62E-03	113%	110%
heat, softwood chips from forest, at furnace 300kW/MJ/CH U	4.44E+01	5.41E-03	Heat, softwood chips from forest, at furnace 300kW/CH U	3.90E+01	5.91E-03	114%	92%
heat, softwood chips from forest, at furnace 5000kW/MJ/CH U	4.37E+01	6.08E-03					
heat, softwood chips from forest, at furnace 50kW/MJ/CH U	4.94E+01	7.35E-03	Heat, softwood chips from forest, at furnace 50kW/CH U	4.13E+01	7.51E-03	120%	98%
heat, softwood chips from industry, at furnace 1000kW/MJ/CH U	4.46E+01	5.69E-03	Heat, softwood chips from industry, at furnace 1000kW/CH U	3.32E+01	4.74E-03	134%	120%
heat, softwood chips from industry, at furnace 300kW/MJ/CH U	4.40E+01	4.93E-03	Heat, softwood chips from industry, at furnace 300kW/CH U	3.22E+01	5.13E-03	137%	96%
heat, softwood chips from industry, at furnace 5000kW/MJ/CH U	4.30E+01	5.42E-03					
heat, softwood chips from industry, at furnace 50kW/MJ/CH U	4.90E+01	6.87E-03	Heat, softwood chips from industry, at furnace 50kW/CH U	3.43E+01	6.70E-03	143%	103%
heat, softwood logs, at furnace 15kW/MJ/CH U	4.82E+01	1.02E-02					
heat, softwood logs, at furnace 50kW/MJ/CH U	4.45E+01	8.11E-03	Heat, softwood logs, at furnace 30kW/CH U	4.80E+01	7.25E-03	93%	112%
heat, softwood logs, at wood heater 6kW/MJ/CH U	5.07E+01	1.11E-02	Heat, softwood logs, at wood heater 6kW/CH U	5.94E+01	7.26E-03	85%	152%
heat, wood pellets, at furnace 15kW/MJ/CH U	4.34E+01	1.18E-02	Heat, wood pellets, at furnace 15kW/CH U	3.68E+01	1.22E-02	118%	96%

heat, wood pellets, at furnace 300kW/MJ/CH U	3.66E+01	9.65E-03					
heat, wood pellets, at furnace 50kW/MJ/CH U	3.93E+01	1.03E-02	Heat, wood pellets, at furnace 50kW/CH U	3.34E+01	1.10E-02	118%	93%
logs, hardwood, burned in furnace 15kW/MJ/CH U	3.73E+01	7.26E-03					
Inventory name/unit	**Ecological Scarcity 2013**	**IPCC 2013, GWP 100a**	**former inventory (UVEK 2018) that most closely matches the update**	**Ecological Scarcity 2013**	**IPCC 2013, GWP 100a**	**UBP ratio**	**kg CO2eq ratio**
	UBP	kg CO2eq		UBP	kg CO2eq	%	%
logs, hardwood, burned in furnace 50kW/MJ/CH U	3.78E+01	7.73E-03	Logs, hardwood, burned in furnace 30kW/CH U	3.17E+01	4.08E-03	119%	189%
logs, hardwood, burned in wood heater 6kW/MJ/CH U	3.78E+01	7.63E-03	Logs, hardwood, burned in wood heater 6kW/CH U	4.42E+01	4.61E-03	86%	166%
logs, mixed, burned in furnace 15kW/MJ/CH U	3.81E+01	7.83E-03					
logs, mixed, burned in furnace 50kW/MJ/CH U	3.71E+01	7.25E-03	Logs, mixed, burned in furnace 30kW/CH U	3.21E+01	4.62E-03	116%	157%
logs, mixed, burned in wood heater 6kW/MJ/CH U	3.86E+01	8.20E-03	Logs, mixed, burned in wood heater 6kW/CH U	4.42E+01	5.15E-03	87%	159%
logs, softwood, burned in furnace 15kW/MJ/CH U	3.86E+01	8.15E-03					
logs, softwood, burned in furnace 50kW/MJ/CH U	3.61E+01	6.57E-03	Logs, softwood, burned in furnace 30kW/CH U	3.26E+01	4.93E-03	111%	133%
logs, softwood, burned in wood heater 6kW/MJ/CH U	3.91E+01	8.52E-03	Logs, softwood, burned in wood heater 6kW/CH U	4.47E+01	5.46E-03	87%	156%
pellets, mixed, burned in furnace 15kW/MJ/CH U	3.69E+01	9.99E-03	Pellets, mixed, burned in furnace 15kW/CH U	3.01E+01	1.00E-02	122%	100%
pellets, mixed, burned in furnace 300kW/MJ/CH U	3.37E+01	8.88E-03	Pellets, mixed, burned in furnace 50kW/CH U	2.83E+01	9.32E-03	119%	95%
pellets, mixed, burned in furnace 50kW/MJ/CH U	3.50E+01	9.13E-03					
wood chips, from forest, hardwood, burned in furnace 1000kW/MJ/CH U	3.67E+01	4.17E-03	Wood chips, from forest, hardwood, burned in furnace 1000kW/CH U	3.25E+01	3.68E-03	113%	113%
wood chips, from forest, hardwood, burned in furnace 300kW/MJ/CH U	3.57E+01	3.26E-03	Wood chips, from forest, hardwood, burned in furnace 300kW/CH U	3.06E+01	3.76E-03	117%	87%
wood chips, from forest, hardwood, burned in furnace 5000kW/MJ/CH U	3.61E+01	4.16E-03					
wood chips, from forest, hardwood, burned in furnace 50kW/MJ/CH U	3.99E+01	4.89E-03	Wood chips, from forest, hardwood, burned in furnace 50kW/CH U	3.15E+01	4.72E-03	127%	104%
wood chips, from forest, mixed, burned in furnace 1000kW/MJ/CH U	3.73E+01	4.60E-03	Wood chips, from forest, mixed, burned in furnace 1000kW/CH U	3.33E+01	4.39E-03	112%	105%
wood chips, from forest, mixed, burned in furnace 300kW/MJ/CH U	3.66E+01	4.01E-03	Wood chips, from forest, mixed, burned in furnace 300kW/CH U	3.13E+01	4.48E-03	117%	90%
wood chips, from forest, mixed, burned in furnace 5000kW/MJ/CH U	3.66E+01	4.54E-03					
wood chips, from forest, mixed, burned in furnace 50kW/MJ/CH U	4.07E+01	5.56E-03	Wood chips, from forest, mixed, burned in furnace 50kW/CH U	3.24E+01	5.58E-03	126%	100%
wood chips, from forest, softwood, burned in furnace 1000kW/MJ/CH U	3.83E+01	5.27E-03	Wood chips, from forest, softwood, burned in furnace 1000kW/CH U	3.39E+01	4.76E-03	113%	111%
wood chips, from forest, softwood, burned in furnace 300kW/MJ/CH U	3.73E+01	4.54E-03	Wood chips, from forest, softwood, burned in furnace 300kW/CH U	3.19E+01	4.84E-03	117%	94%

wood chips, from forest, softwood, burned in furnace 5000kW/MJ/CH U	3.76E+01	5.22E-03					
wood chips, from forest, softwood, burned in furnace 50kW/MJ/CH U	4.15E+01	6.18E-03	Wood chips, from forest, softwood, burned in furnace 50kW/CH U	3.30E+01	6.00E-03	126%	103%
Inventory name/unit	**Ecological Scarcity 2013**	**IPCC 2013, GWP 100a**	**former inventory (UVEK 2018) that most closely matches the update**	**Ecological Scarcity 2013**	**IPCC 2013, GWP 100a**	**UBP ratio**	**kg CO2eq ratio**
	UBP	kg CO2eq		UBP	kg CO2eq	%	%
wood chips, from industry, hardwood, burned in furnace 1000kW/MJ/CH U	3.73E+01	4.42E-03	Wood chips, from industry, hardwood, burned in furnace 1000kW/CH U	2.85E+01	3.78E-03	131%	117%
wood chips, from industry, hardwood, burned in furnace 300kW/MJ/CH U	3.63E+01	3.49E-03	Wood chips, from industry, hardwood, burned in furnace 300kW/CH U	2.67E+01	3.90E-03	136%	89%
wood chips, from industry, hardwood, burned in furnace 5000kW/MJ/CH U	3.64E+01	4.30E-03					
wood chips, from industry, hardwood, burned in furnace 50kW/MJ/CH U	4.05E+01	5.14E-03	Wood chips, from industry, hardwood, burned in furnace 50kW/CH U	2.76E+01	4.86E-03	146%	106%
wood chips, from industry, mixed, burned in furnace 1000kW/MJ/CH U	3.75E+01	4.56E-03	Wood chips, from industry, mixed, burned in furnace 1000kW/CH U	2.82E+01	3.93E-03	133%	116%
wood chips, from industry, mixed, burned in furnace 300kW/MJ/CH U	3.68E+01	3.97E-03	Wood chips, from industry, mixed, burned in furnace 300kW/CH U	2.63E+01	4.09E-03	140%	97%
wood chips, from industry, mixed, burned in furnace 5000kW/MJ/CH U	3.68E+01	4.50E-03					
wood chips, from industry, mixed, burned in furnace 50kW/MJ/CH U	4.09E+01	5.52E-03	Wood chips, from industry, mixed, burned in furnace 50kW/CH U	2.74E+01	5.20E-03	149%	106%
wood chips, from industry, softwood, burned in furnace 1000kW/MJ/CH U	3.79E+01	4.84E-03	Wood chips, from industry, softwood, burned in furnace 1000kW/CH U	2.81E+01	4.02E-03	135%	120%
wood chips, from industry, softwood, burned in furnace 300kW/MJ/CH U	3.70E+01	4.14E-03	Wood chips, from industry, softwood, burned in furnace 300kW/CH U	2.64E+01	4.20E-03	140%	99%
wood chips, from industry, softwood, burned in furnace 5000kW/MJ/CH U	3.69E+01	4.66E-03					
wood chips, from industry, softwood, burned in furnace 50kW/MJ/CH U	4.12E+01	5.77E-03	Wood chips, from industry, softwood, burned in furnace 50kW/CH U	2.74E+01	5.36E-03	150%	108%

2.7.6 Outlook

At the level of heat output, the efficiency of the heating system is very decisive. The efficiencies depend largely on operating conditions and less on size or type of heating. The range for reported efficiencies was very large for each wood heating type. There were even log heating systems reported with 95 % efficiency. Therefore, in addition to inventories of average efficiency, we recommend for future updates that inventories of maximum efficiency be included. It would be even better if the efficiency could be parameterized.

Furthermore, it might be helpful to gather better data on the production process of the furnaces. For the moment there is little to no data on the energy use during the production of the furnaces. However, infrastructure is not very relevant regarding the impacts.

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4 Appendix

4.1 Biogas from biowaste

An update of biogas from biowaste production was reported in Kägi et al. (2019: Technical Report Life Cycle Inventories for Biogas and Biomethane Processes on behalf of VSG). Based on that update, the following changes were made:

Methane emission was corrected from 2.4 g per kg of biowaste to 1.7 g per kg of biowaste based on Dinkel et al. (2012:, Ökobilanzen zur Biomasseverwertung, Tab 4: sum of pre-storage, fermentation and cogen, but without post rotting (not common anymore) and purification (outside the systemboundary)).

In order to comply with the requirements of the UVEK and KBOB database, the following allocation approach was implemented (instead of economic allocation): Composting and fermentation are the two viable, legally prescribed options for organic waste treatment. Fermentation is done to additionally produce energy. This leads to the following allocation approach: only the difference in efforts and emissions between fermentation and composting are attributed
With regard to methane, the composting systems shows 1g of CH_4 per kg of biowaste. Therefore 0.7g of CH_4 is allocated to the biogas production system.

ReferenceFunction	Name	biogas, from biowaste, at storage	disposal, biowaste, to anaerobic digestion
Geography	Location	CH	CH
ReferenceFunction	InfrastructureProcess	0	0
ReferenceFunction	Unit	Nm3	kg
DataSetInformation	Type	1	1
	Version	1.0	1.0
	energyValues	0	0
	LanguageCode	en	en
	LocalLanguageCode	de	de
DataEntryBy	Person	101	101
	QualityNetwork	1	1
ReferenceFunction	DataSetRelatesToProduct	1	1
	IncludedProcesses	Data represents the environmental exchanges due to biowaste pre treatment biowaste digestion and post-composting of digested matter	Data represents the environmental exchanges due to biowaste pre treatment biowaste digestion and post-composting of digested matter
	Amount	0.1	1
	LocalName	Biogas, aus Bioabfall, ab Speicher	disposal, biowaste, to anaerobic digestion
	Synonyms		
	GeneralComment	Inventory refers to 0.1 m3 biogas. Electricity consumption and emissions represent the biogas production in a digestion plant. Infrastructure expenditures are included. Methane emissions are based on Dinkel et al. 2012, Ökobilanzen zur Biomasseverwertung, Tab 4: sum of pre-storage, fermentation and cogen, but without post rotting (not common anymore) and purification (outside the systemboundary). In order to comply with the requirements of the UVEK and KBOB database, the following allocation approach was implemented: Composting and fermentation are the two viable, legally prescribed options for organic waste treatment. Fermentation is done to additionally produce energy. This leads to the following allocation approach: only the difference in efforts and emissions between fermentation and composting are attributed. Data for composting are also based on Dinkel et al 2012.	Inventory refers to 1 kg of biowaste. Electricity consumption and emissions represent the biogas production in a digestion plant. Infrastructure expenditures are included. Methane emissions are based on Dinkel et al. 2012, Ökobilanzen zur Biomasseverwertung, Tab 4: sum of pre-storage, fermentation and cogen, but without post rotting (not common anymore) and purification (outside the systemboundary). In order to comply with the requirements of the UVEK and KBOB database, the following allocation approach was implemented: Composting and fermentation are the two viable, legally prescribed options for organic waste treatment. Fermentation is done to additionally produce energy. This leads to the following allocation approach: only the difference in efforts and emissions between fermentation and composting are attributed.
	InfrastructureIncluded	1	1
	Category	biomass	biomass
	SubCategory	fuels	fuels
	LocalCategory	Biomasse	Biomasse
	LocalSubCategory	Brenn- und Treibstoffe	Brenn- und Treibstoffe
	Formula		
	StatisticalClassification		
	CASNumber		
TimePeriod	StartDate	2016	2016
	EndDate	2016	2016
	DataValidForEntirePeriod	1	1
	OtherPeriodText		
Geography	Text	Data represents conditions of biogas from biowaste production in Switzerland	Data represents conditions of biogas from biowaste production in Switzerland
Technology	Text	Industry data.	Industry data.
Representativeness	Percent		
	ProductionVolume		
	SamplingProcedure	Data provided by factories	Data provided by factories
	Extrapolations	none	none
	UncertaintyAdjustments	none	none

	Name	Location	Infrastructure Process	Unit	biogas, from biowaste, at storage	disposal, biowaste, to anaerobic digestion	Uncertainty Type	Standard Deviation 95%	General Comment
	Location				CH	CH			
	Infrastructure Process				0	0			
	Unit				Nm3	kg			
product	disposal, biowaste, to anaerobic digestion, economic allocation	CH	0	kg	0.0	0.0	0		
product	biogas, from biowaste, at storage, economic allocation	CH	0	Nm3	0.0	0.0	0		
product	biogas, from biowaste, at storage	CH	0	Nm3	0.1	0.0	0		
product	disposal, biowaste, to anaerobic digestion	CH	0	kg	0.0	1.0	0		
technosphere	electricity, low voltage, at grid	CH	0	kWh	0	0.000352	1	1.23	(2,3,2,3,1,5,BU:1.05); ; only difference to reference treatment (composting) is allocated to biogas, rest is allocated to biowaste
	anaerobic digestion plant, biowaste	CH	1	unit	0.00E+00	1.67E-09	1	3.10	(1,4,1,3,3,5,BU:3); ; only difference to reference treatment (composting) is allocated to biogas, rest is allocated to biowaste treatment
	heat, at cogen with biogas engine, allocation exergy	CH	0	MJ	0.242		1	1.40	(4,5,1,5,1,5,BU:1.05); ; only difference to reference treatment (composting) is allocated to biogas, rest is allocated to biowaste treatment
	tap water, at user	CH	0	kg	2.25E-1		1	1.61	(3,4,3,3,4,5,BU:1.05); ; only difference to reference treatment (composting) is allocated to biogas, rest is allocated to biowaste treatment
	treatment, sewage, to wastewater treatment, class 4	CH	0	m3	0	0.000225	1	1.61	(3,4,3,3,4,5,BU:1.05); ; only difference to reference treatment (composting) is allocated to biogas, rest is allocated to biowaste treatment
emission water, unspecified	Ammonium, ion	-	-	kg	9.28E-08		1	1.69	(4,4,4,3,1,5,BU:1.5); ; only difference to reference treatment (composting) is allocated to biogas, rest is allocated to biowaste treatment
emission air, high population density	Carbon dioxide, biogenic	-	-	kg	0	0.210	1	1.31	(4,3,1,1,1,5,BU:1.05); ; only difference to reference treatment (composting) is allocated to biogas, rest is allocated to biowaste treatment
	Methane, biogenic	-	-	kg	0.0007	0.001	1	1.56	(1,1,1,1,1,5,BU:1.5); ; only difference to reference treatment (composting) is allocated to biogas, rest is allocated to biowaste treatment
	Hydrogen sulfide	-	-	kg	0.00E+00	0.0000865	1	1.62	(4,3,1,1,1,5,BU:1.5); ; only difference to reference treatment (composting) is allocated to biogas, rest is allocated to biowaste treatment
emission water, unspecified	Phosphorus	-	-	kg	7.04E-08		1	1.69	(4,4,4,3,1,5,BU:1.5); ; only difference to reference treatment (composting) is allocated to biogas, rest is allocated to biowaste treatment
	Nitrate	-	-	kg	2.97E-06		1	1.69	(4,4,4,3,1,5,BU:1.5); ; only difference to reference treatment (composting) is allocated to biogas, rest is allocated to biowaste treatment
	Nitrite	-	-	kg	9.28E-08		1	1.69	(4,4,4,3,1,5,BU:1.5); ; only difference to reference treatment (composting) is allocated to biogas, rest is allocated to biowaste treatment
	Nitrogen, organic bound	-	-	kg	1.09E-07		1	1.69	(4,4,4,3,1,5,BU:1.5); ; only difference to reference treatment (composting) is allocated to biogas, rest is allocated to biowaste treatment

Kägi, T. Zschokke, M. & Dinkel, F.
Dinkel, F.,

4.2 Biogas from sewage sludge

A minor update of biogas form sewage sludge production (only energy use) was reported in Kägi et al. (2019: Technical Report Life Cycle Inventories for Biogas and Biomethane Processes on behalf of VSG). The burdens are allocated completely to the biogas and not to the waste treatment, due to the fact that the biogas production from sewage sludge is not a disposal service, but an additional treatment with the aim to produce biogas. The disposal service line in a mono-combustion plant must be carried out with or without biogas production. Based on that update, the following changes were made:

Methane emissions are based on geometric mean of measurements at 5 biogas plants from Delre et al. (2017: Greenhouse gas emission quantification from wastewater treatment plants, using a tracer gas dispersion method. Sci. Total Environ. 605: 258-268). With about 12g CH4 per kg of biogas this is substantially higher than the old value of 3.4 g.

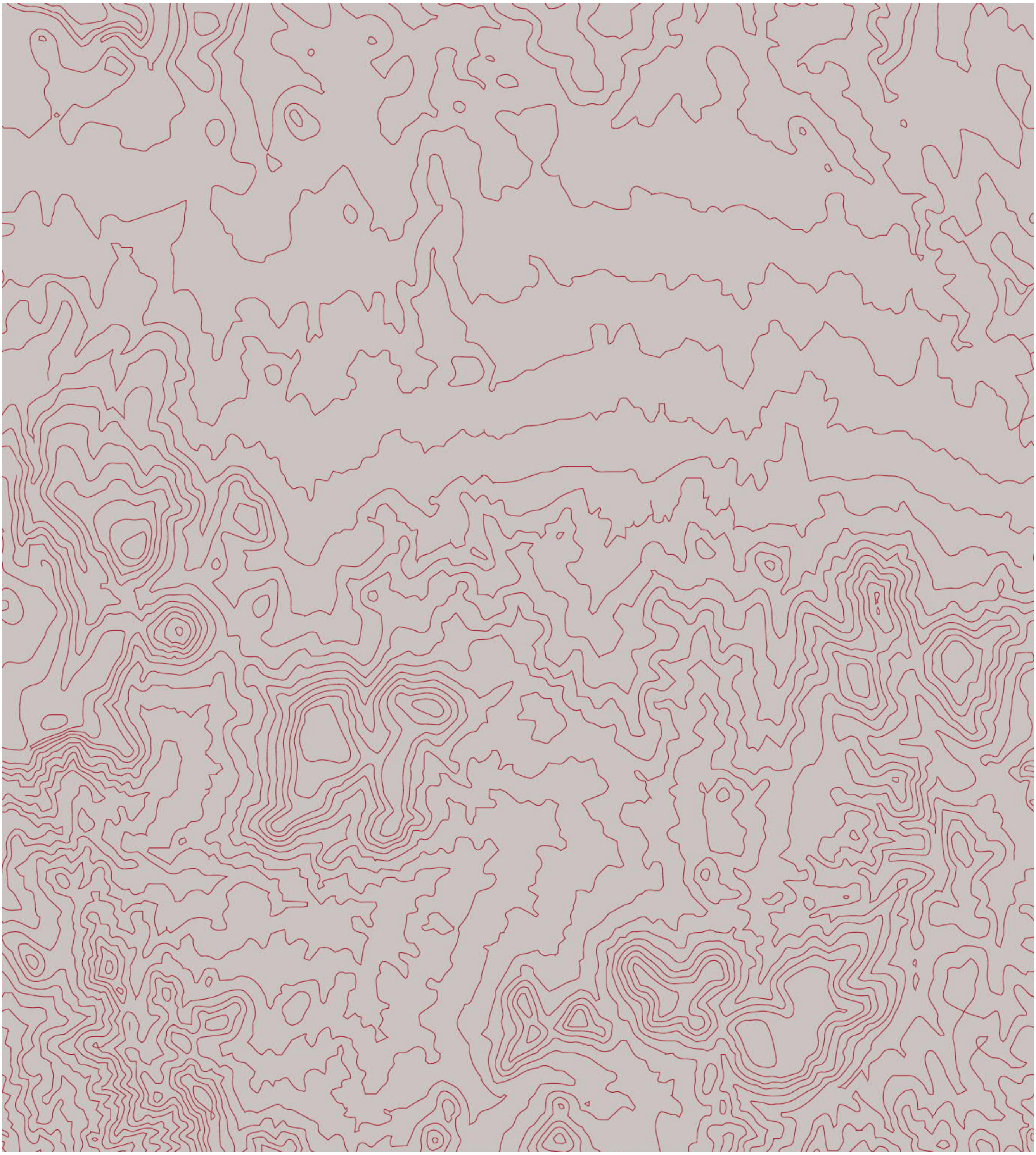
ReferenceFunction	Name	biogas, from sewage sludge, at storage
Geography	Location	CH
ReferenceFunction	InfrastructureProcess	0
ReferenceFunction	Unit	Nm3
DataSetInformation	Type	1
	Version	1.0
	energyValues	0
	LanguageCode	en
	LocalLanguageCode	de
DataEntryBy	Person	101
	QualityNetwork	1
ReferenceFunction	DataSetRelatesToProduct	1
	IncludedProcesses	Data represents the environmental exchanges due to biowaste pre treatment biowaste digestion and post-composting of digested matter
	Amount	1
	LocalName	Biogas, aus Klärschlamm, ab Speicher
	Synonyms	
	GeneralComment	Inventory refers to 1m3 of biogas. Electricity consumption and emissions represent the biogas production in a digestion plant. Infrastructure expenditures are included. Data on energy requirements were updated with data from a current life cycle assessment study on bio-gas production from sewage sludge (Willi, 2019, Ökobilanz Biogasanlage ZASE Zuchwil. Im Auftrag von Regio Energie Solothurn). Methane emissions are based on geometric mean of measurements at 5 biogas plants from Delre et al. 2017. Greenhouse gas emission quantification from wastewater treatment plants, using a tracer gas dispersion method. Sci. Total Environ. 605: 258-268. The burdens are allocated completely to the biogas and not to the waste treatment, due to the fact that the biogas production from sewage sludge is not a disposal service, but an additional treatment with the aim to produce biogas. The disposal service line in a mono-combustion plant must be carried out with or without biogas production.
	InfrastructureIncluded	1
	Category	biomass
	SubCategory	fuels
	LocalCategory	Biomasse
	LocalSubCategory	Brenn- und Treibstoffe
	Formula	
	StatisticalClassification	
	CASNumber	
TimePeriod	StartDate	2016
	EndDate	2018
	DataValidForEntirePeriod	1
	OtherPeriodText	
Geography	Text	Data represents conditions of biogas from biowaste production in Switzerland
Technology	Text	Industry data.
Representativeness	Percent	
	ProductionVolume	
	SamplingProcedure	Data provided by factories
	Extrapolations	none
	UncertaintyAdjustments	none

	Name	Location	Infrastructure Process	Unit	biogas, from sewage sludge, at storage	Uncertainty Type	Standard Deviation 95%	General Comment
	Location				CH			
	Infrastructure Process				0			
	Unit				Nm3			
product	biogas, from sewage sludge, at storage	CH	0	Nm3	1.0	0		
technosphere	electricity, low voltage, at grid	CH	0	kWh	0.197	1	1.23	(2,3,2,3,1,5,BU:1.05); ;
	anaerobic digestion plant, sewage sludge	CH	1	unit	3.65E-08	1	3.10	(1,4,1,3,3,5,BU:3); ;
	heat, natural gas, at industrial furnace 1MW	CH	0	MJ	3.55	1	1.40	(4,5,1,5,1,5,BU:1.05); ;
	chemicals inorganic, at plant	GLO	0	kg	5.17E-03	1	1.61	(3,4,3,3,4,5,BU:1.05); ;
emission air, high population density	Carbon dioxide, biogenic	-	-	kg	0.0999	1	1.31	(4,3,1,1,1,5,BU:1.05); ;
	Methane, biogenic	-	-	kg	0.014	1	1.56	(1,1,1,1,1,5,BU:1.5); ; Based on geometric mean of measurements at 5 biogas plants from Delre et al. 2017. Greenhouse gas emission quantification from wastewater treatment plants, using a tracer gas dispersion method. Sci. Total Environ. 605: 258-268

Federal Office for the Environment

Life cycle inventories of heating sys-tems

External review of the project "Life cycle inventories of heating systems" performed by Carbotech AG
April 28, 2021



Validator / Reviewer

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Table of content

Background of the validated study

With regard to the heating systems used in Switzerland, much of the data in the ecoinvent and DETEC database is not up to date. The goal of the study at hand, commissioned by the Federal Office for the Environment, aims at updating the life cycle inventory data for various heating systems and supplement additional heating systems in the database.

Study to be reviewed

The validation is based on the final version of the report “Life cycle inventories of heating systems: Heat from natural gas, biomethane, district heating, electric heating, heat pumps, PVT, wood, cogeneration” from 4th December 2020 written from the following authors of Carbotech AG: Kägi, Thomas; Waldburger, Livia; Kern, Cyrill; Roberts, Gavin; Zschokke, Mischa; Conte, Flora; Weber, Lea.

Review of the final version of the study

The validation of the study at hand is guided by the reference provided in ecoinvent report No.1 Overview and Methodology (Frischknecht and Jungbluth, 2007)[1]:

Completeness of the documentation	All investigated datasets should be described in the report, and all necessary meta information and flow data should be available for each dataset.
Consistency with the quality guidelines	It is checked whether the unit processes have been modelled according to the ecoinvent quality guidelines. The quality guidelines cover for example the estimation of transport distances or the calculation of energy demands in the inventory.
Plausibility check of the life cycle inventory data	Selected input and output flows are controlled for plausibility
Completeness of inputs and outputs	The completeness of flows is based on the environmental and technical knowledge of the reviewing person. Reviewers are not necessarily technical experts of the processes reviewed. If necessary, they were supported by the person responsible for the report.
Mathematical correctness of calculations	Selected inputs and outputs are controlled in view of mathematical correctness, e.g., the transport service inputs, the waste heat or CO2 emissions.

1 Frischknecht, R., & Jungbluth, N. (2007). Overview and Methodology. Data v2.0. ecoinvent report no. 1. Dübendorf: Swiss Centre for Life Cycle Inventories.

The following validation of the developed life cycle inventories of heating systems is structured according to the five issues (i.e., validation criteria) ending with a short conclusion of the validator, including the validator's proposal for the further procedure.

Completeness of the documentation

Comments

The datasets for all investigated heating systems are well and transparently documented and described in the report at hand. It is clearly described which types of heating systems are considered on which level of details and which ones are excluded from the project, e.g., the different types of burner systems (building: residential and commercial; industrial) and distinguished power levels for the heat produced based on natural gas or biomethane.

The fact that the documentation of each heating systems follows the same structure and uses the same types of illustration (e.g., tables) make the provided information well accessible for the reader and assure a good orientation for the reader. This consistency of displaying the information is much welcomed by the reviewer leading to a high level of transparency. This, for example, becomes already obvious when screening the table of contents, highlighting the consistent structure and the completeness of the documented project.

Regarding the documentation of the underlying data on inputs and outputs, the used flow data on inputs and outputs are from the reviewer's perspective systematically documented and displayed in clearly arranged tables for each of the investigated heating system. For each heating system the single processes (such as infrastructure, transports, heating production) are available in a structured and equal manner, i.e., in well-arranged and readable tables. For the reader it becomes very clear which data and information sources are used for each dataset and to model the different subprocess for providing the are used to model the different processes. The documentation, according to the reviewer, stands out through a high level of detail and completeness, respectively. The underlying literature is also well documented in the bibliography in a high level of detail.

The assumptions and meta information (e.g., lifetime of considered components, conversion efficiencies, differentiation of different power levels) used to process the underlying data and information sources or to deal with missing data (e.g., infrastructure requirements for wood heating systems or electric storage heaters) in the respective life cycle inventories are transparently displayed and described in a comprehensible manner. Illustrating examples in this regard are the derivation of the material composition in modelling the infrastructure requirements for electric storage heaters (cf. table 8 of the report), the transparent assumptions and sources to adapt and update, respectively, the losses in heat distribution in district heating systems, or the transparent foundation of allocation factors used e.g., in the case of cogeneration systems and district heating systems based on cogeneration systems.

Given that, the link between the underlying data and information and the specific data on inputs and outputs in the life cycle inventories being developed in this project, is highly traceable. This leads to the fact that the developed life cycle inventories are well able to be classified.

Summary statement

The documentation at hand impresses with a high level of completeness. The development of the life cycle inventories for the investigated heating systems is all in all documented in a complete, well-structured and, hence highly transparent and accessible form. From the reviewer's perspective, the report fulfills the validation criteria "completeness of the documentation" to all extent.

Consistency with quality guidelines

Comments

In the following the consistency with the quality guidelines of the project at hand is addressed. This basically includes the validation of (1) underlying scope and modelling principles, (2) the documentation of elementary flows, (3) dealing with multi-output and allocation rules, and (4) uncertainty considerations.

Regarding the issue of underlying scopes (temporal and geographic, technical), the developed inventories show considerable differences, being related to the availability of data and information, which varies between the different heating systems. From the perspective of the validator, the developed inventories are generally depicting market mixes, providing actual and representative for the considered geographic markets. Most of the used sources, providing data and information for the LCI, refer to the Swiss context based on actual statistical data. In case of cutbacks, the underlying assumptions are transparently documented, their relevance classified, and the respective uncertainties clearly described and adequately addressed. As conceived by the validator in course of accompanying the project and related discussions, the authors invested everything possible (within the scope of available possibilities) to sample data and information as accurate as possible. In terms of the technical scope, it is to be mentioned that in course of developing the inventories, the market mixes are oriented towards the actual situation and rather depict the near future than the past. This is much appreciated by the validator, due to the fact, the developed inventories provide the fundament for better and more representative assessment from now on.

The developed inventories contain data on the unit process level and are neither vertically nor horizontally aggregated. This is well in line with the quality requirements providing guidance on LCI development and is appreciated by the validator. The data quality – with some exceptions, in which better information was not accessible, e.g., materials of furnaces for the wood heating systems – generally well correlates with the relevance of the respective data (environmental sensitivity) in terms of contributing the life cycle impacts of the heating systems. Hence, the sampled data are – despite some cases, in which it has to relied on old data, e.g., infrastructure data for wood heating systems - are considered valid and of good quality, so that they can be used for valid LCA of heating systems.

In terms of modelling multi-output processes, being relevant for some of the investigated heating system, i.e., all systems that rely on cogeneration of heat and electricity such as selected district heating system and the cogeneration systems, the applied allocation is well and transparently conducted and is considered in line with the allocation rules contained in the common standards. Hereby it is noteworthy that in case of the infrastructure of the wood heating systems, the allocation of the infrastructure on the outputs heat and electricity is based on allocation factors, which was done differently in the previous version based physical-chemical allocation. However, due to the fact of the insignificance of the infrastructure, this potential shortcoming is – from the validator's perspective – only of theoretical relevance with completely negligible impact on the results.

As already state above uncertainties related to the data quality is well and transparently addressed and adequately considered in the uncertainty judgments of the used input and output data.

Summary statement
In summary, the developed life cycle inventories for the investigated heating systems are – with some exceptions with regard to mostly insignificant parameters – of high quality and are of high consistency with the quality guidelines.

Plausibility check for LCI data

Comments
The developed LCI data was checked for plausibility in a two-fold way. On one hand, in course of accompanying review meeting with the authors the developed data was extensively subject to checking. Together with the authors we passed through the underlying data and information sources and assumptions, controlled the values themselves as contained in the tables of the report and additionally had a detailed look at the resulting life cycle impact assessment. On the other hand, the validator additionally made an additional plausibility control based on the report, by checking the accuracy based on random sampling of input and output covering different heating systems investigated in the project. Due to the fact that the validator was involved in a comparative LCA study of heating systems in Switzerland, the developed LCI data could be well mirrored with data used in the performed LCA study.

Summary statement
The performed plausibility check revealed no inconsistencies with regard to the data on inputs and outputs for the investigated heating systems as contained in the project report at hand. In view of the validator, the LCI data is judged as robust and plausible. The validation criteria “Plausibility of the LCI data” is fulfilled.

Completeness of input and outputs

Comments
With regard to the completeness of flows in the life cycle inventories the project reveals a high quality across all investigated heating systems. From the validator’s perspective, the respective product systems, on one hand, contain all relevant processes, including for example the transports, the various infrastructure components, such as the production of the boiler and burner, the chimney in case of gas heating systems, being required for the heat production in the different systems. On the other hand, on the level of the modelled flows, the data inventories exhibit high completeness and comprise all relevant material and energy inputs differentiated according to the production of the required infrastructure, the use or operation phase as well the disposal phase. The same holds true for the output flows. According to the validator, the emissions to the environment (e.g., refrigerant losses for heat pump systems or air emissions related to the thermal conversion of the respective fuels, such as natural gas, biomethane, wood) are captured on to a very meaningful extent.

Summary statement
All in all, the validator ascribes a high and clearly sufficient level of completeness regarding the inputs and outputs being associated with all the processes of the investigated heating systems from a life cycle perspective. The validation criteria “completeness of input and outputs” is fulfilled.

Mathematical correctness of calculations

Comments

Based on the selected control of inputs and outputs calculations as well as on insights and discussions with the authors in course of the accompanying review meetings, the mathematical correctness of the calculations that underly the inputs and outputs seem to be correct from the validator’s view. This judgement is also supported by the analysis of the results of the test LCIA using the developed inventory data, seeming meaningful and reasonable.

Summary statement

From the perspective of the validator, the calculations underlying the development of the data inventories of the investigated heating systems seem to be correct and the validation criteria is fulfilled.

Conclusion from the reviewer

The review showed that the performed study is conducted in a highly careful and sophisticated manner. This relates to all five criteria of the validation process being guided by the reference provided in ecoinvent report No. 1 Overview and Methodology. With regard to all five validation the reviewers ascribes the developed data inventories for the investigated heating systems a high level of quality, fulfilling the guidelines to all extent. In those cases, in which the authors had to rely on old data due to unavailable data, the authors on one hand invested as much as possible under the given constraints, and, on the other hand, the concerned data is very low significance in terms of its contribution to the environmental impacts of the investigated heating systems.

Proposal for the further procedure

From the perspective of the reviewer the developed datasets can be imported in the database without any changes.

Zurich, April 28, 2021

Dr. Andy Spörri