Update of the Life Cycle Inventories of Solar Collectors

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1 Introduction

1.1 Solar thermal systems in Switzerland

The latest statistical data of the situation of solar thermal systems in Switzerland are published by Hostettler (2010) for the year 2009. In this year, the total installed capacity of solar thermal systems amounted to 850 MW. In 2008, solar systems generated 1’633 TJ of heat. 14’791 systems with flat plate collectors were sold in CH in 2008, which corresponds to an area of 135’355 m^2 and 1’545 systems with tube collectors were sold, which corresponds to an area of 10’285 m^2.

1.2 Purpose of dataset

The ecoinvent database v2.2 (ecoinvent Centre 2010) contains life cycle inventory data of the four solar thermal systems described in the first part of Tab. 1.1. These datasets were created by Jungbluth (2003) in the years 2002 and 2003 and are outdated now. They cannot be considered as reasonable case studies and therefore they should not be used any longer.

Within the framework of this update, life cycle inventories of eight new solar thermal systems are investigated. These systems are characterised in the second part of Tab. 1.1 and represent typical solar thermal installations in the city of Zurich. The new system Nr. 1 and Nr. 2 and Nr. 8 can be considered as updates of the old systems B, A, and D whereas system C is not updated.

The newly considered solar thermal systems include installations on flat roofs and slanted roofs, as well as flat plate collectors with copper or aluminium-copper absorbers, and evacuated tube collectors.

The considered solar thermal systems represent typical installations in the city of Zurich, Switzerland, and do not reflect a representative average of solar collectors in Switzerland. When using the LCI datasets presented in this report, it has to be considered that the differences in amount and type of material, as well as in amount of converted solar energy, is very large between single solar thermal systems in the same country. This fact makes it difficult to compare the environmental impacts from solar thermal systems with other systems for heating and hot water generation. However, the transparent unit process data presented in this report enable users to model their own solar thermal installation in order to make a qualified assessment of the environmental impacts from that specific installation.

Tab. 1.1 Solar thermal systems in ecoinvent v2.2 and new solar thermal systems considered in this report

Solar thermal system	Collector	House	Collector area (m^2)	Hot water (HW), Heat supply (HS)	Slanted roof (SR), Flat roof (FR)
ecoinvent v2.2, A	Flat plate collector with copper absorber	One-family house	12.3	HW + HS	SR
ecoinvent v2.2, B	Flat plate collector with copper absorber	One-family house	4	HW	SR
ecoinvent v2.2, C	Flat plate collector with copper absorber	Multiple dwelling	58.3	HW	SR
ecoinvent v2.2, D	Evacuated tube collector	One-family house	10.5	HW + HS	SR
New, Nr. 1	Flat plate collector with copper absorber	One-family house	5	HW	SR
New, Nr. 2	Flat plate collector with copper absorber	One-family house	12	HW + HS	SR
New, Nr. 3	Flat plate collector with copper absorber	Multiple dwelling	20	HW	SR
New, Nr. 4	Flat plate collector with copper absorber	Multiple dwelling	30	HW	SR
New, Nr. 5	Flat plate collector with copper absorber	Multiple dwelling	30	HW	FR
New, Nr. 6	Flat plate collector with aluminium-copper absorber	Multiple dwelling	30	HW	SR
New, Nr. 7	Flat plate collector with copper absorber	Multiple dwelling	81	HW	SR
New, Nr. 8	Evacuated tube collector	One-family house	10.5	HW + HS	SR

The inventory datasets in EcoSpold1 format established within this project can be downloaded free of charge from www.lc-inventories.ch.

1.3 System boundaries

The life cycle inventories of energy from solar thermal systems refer to solar heat at hot water tank or at heat storage. The additional expenses compared to a conventional reference of heat generation are included, which means that the share of hot water tank that would also be needed for a conventional installation is excluded from the inventory investigated “at hot water tank”. Circulation and distribution losses after the heat storage are not considered. Also the heat supply with a supplementary heating system using natural gas, wood or electricity is not part of this report. Neither is any credit given for savings of the supplementary heating system due to the dimensioning of the solar thermal installation. Thus these inventories are theoretical examples, because in practice such systems need an additional heating for operation.

2 Life cycle inventories of the construction and the disposal of solar thermal installations

2.1 Collector

Jungbluth (2003) established life cycle inventories of a flat plate collector with a copper absorber and of an evacuated tube collector. Within this project a new life cycle inventory dataset of a flat plate collector with an aluminium-copper absorber is established based on data received from one manufacturer.[1]

2.1.1 Flat plate collector with an aluminium-copper absorber

The data provided by a collector manufacturer cover the amount of aluminium, copper, high-alloyed steel, solar glass, mineral wool, EPDM rubber, HDPE, and silicone, that is contained in a collector with an aperture area of 2.335 m^2 (gross area is 2.55 m^2) and an empty weight of 42 kg. The packaging amounts to 2 kg pallet used per collector module. The solar glass is tempered but in contrast to the solar glass of the flat plate collector with a copper absorber, no anti-reflex-coating is applied.[1] The aluminium-copper absorber has a selective coating of nickel pigmented aluminium oxide (Miro-therm). The amount of electricity, tap water, solder and factory infrastructure used for assembly of the collector, the amount demineralised water and propylene glycol used for the heat carrier medium, as well as the amount of generated wastewater, is adopted from the flat plate collector with a copper absorber.

Based on the inventory of a flat plate collector with a copper absorber, it is assumed that the share of 3.9 kg aluminium is used for the frames which are shaped in an extrusion process. The remaining 1.4 kg of aluminium is used for the absorber which is shaped in a sheet rolling process.

The collector has a filling volume of 2.5 litres, which is filled with a heat transfer medium that is composed of 35 % glycol and 65 % purified water and needs to be exchanged every ten years. After use, it is sent to a municipal wastewater treatment.

The solar glass is produced by two German companies. One of them produces its glass feedstock itself whereas the other one imports it from the UK. Therefore, estimated 50 % of the glass feedstock is transported from the UK to Germany over a distance of 1’260 km by lorry and 60 km through the Channel Tunnel, where the lorry is transported by rail. According to Spielmann at al. (2007), the net vehicle weight of such a lorry is 15.1 tons and the average load is 9.51 tons, which leads to 1.59 kg lorry per kg glass that needs to be transported by rail.

The final solar glass is transported by lorry over a distance of 650 km to the production site of the collector.[2] The absorber is also produced in Germany and is transported over a distance of 750 km.[3]

[1] Personal communication with the division manager of solar energy systems at a manufacturer of metal works (18.05.2010)

[2] Fürth (DE) – manufacturing site (CH): 450 km; Brandenburg (DE) – manufacturing site (CH): 860 km

[3] Braunschweig (DE) – manufacturing site (CH): 750 km

2.1.2 Flat plate collector with a copper absorber

The life cycle inventory of a flat plate collector with a copper absorber is described by Jungbluth (2003). Within this project, the dataset is adjusted by adding a tempering process to the solar glass and by excluding the materials used for the mounting of the collector. These materials are now considered separately in the assembly of the solar systems (see Sections 2.6 and 2.8). Furthermore, the composition of the heat transfer medium, the amount of packaging and the transport distance of the solar glass is corrected in order to be consistent with the dataset of the new considered flat plate collector with an aluminium-copper absorber. The aluminium frame is now assumed to be shaped in a section bar extrusion process.

2.1.3 Evacuated tube collector

An example of a solar thermal installation with evacuated tube collectors is presented in Fig. 2.1. The life cycle inventory of an evacuated tube collector produced in Northern Ireland is described by Jungbluth (2003). Within this project, the dataset is adjusted by excluding the chromium steel used for the mounting of the collector. The material for mounting the collector is now considered separately in the assembly of the solar systems (see Sections 2.6 and 2.8). Furthermore, the composition of the heat transfer medium is corrected in order to be consistent with the dataset of the new considered flat plate collector.

Fig. 2.1 Example of a solar thermal system with evacuated tube collectors installed in Italy

2.1.4 Unit process raw data

In Tab. 2.1, the life cycle inventories of a flat plate collector with a copper absorber and of a flat plate collector with an aluminium-copper collector are displayed. In Tab. 2.2, the life cycle inventory of an evacuated tube collector is displayed. Tab. 2.3 displays the EcoSpold meta information.

Tab. 2.1 Unit process raw data of construction and disposal of flat plate collectors with copper and aluminium-copper absorbers

	Name	Location	InfrastructureProcess	Unit	flat plate collector, copper absorber, at plant	flat plate collector, aluminium copper absorber, at plant	UncertaintyType	StandardDeviation95%	GeneralComment
	Location				CH	CH			
	InfrastructureProcess				1	1			
	Unit				m2	m2			
product	flat plate collector, copper absorber, at plant	CH	1	m2	1.00E+0	-			
	flat plate collector, aluminium copper absorber, at plant	CH	1	m2	-	1.00E+0			
technosphere	electricity, medium voltage, at grid	CH	0	kWh	1.16E+0	1.16E+0	1	1.61	(2,5,3,1,3,5); Questionnaire 2001
	tap water, at user	CH	0	kg	9.40E+0	9.40E+0	1	1.61	(2,5,3,1,3,5); Questionnaire 2001
	water, completely softened, at plant	RER	0	kg	1.50E+0	1.74E+0	1	1.39	(3,4,1,1,1,5); Questionnaires 2002 and 2010, extrapolation for life time 10a
	solar collector factory	RER	1	unit	2.00E-7	2.00E-7	1	5.04	(2,5,1,1,3,5); Questionnaire 2002
	rock wool, packed, at plant	CH	0	kg	2.43E+0	1.59E+0	1	1.39	(3,4,1,1,1,5); Questionnaires 2002 and 2010
	EUR-flat pallet	RER	0	unit	4.51E-2	4.51E-2	1	1.39	(3,4,1,1,1,5); Questionnaire 2010, pallet weight 19kg; used amount: 2kg/collector
	solar glass, low-iron, at regional storage	RER	0	kg	9.12E+0	8.27E+0	1	1.39	(3,4,1,1,1,5); Questionnaires 2002 and 2010
	synthetic rubber, at plant	RER	0	kg	7.32E-1	8.57E-1	1	1.39	(3,4,1,1,1,5); Questionnaires 2002 and 2010
	polyethylene, HDPE, granulate, at plant	RER	0	kg	-	8.57E-3	1	1.39	(3,4,1,1,1,5); Questionnaire 2010
	silicone product, at plant	RER	0	kg	5.88E-2	8.57E-2	1	1.39	(3,4,1,1,1,5); Questionnaires 2002 and 2010
	propylene glycol, liquid, at plant	RER	0	kg	8.80E-1	1.02E+0	1	1.39	(3,4,1,1,1,5); Questionnaires 2002 and 2010, extrapolation for life time 10a
	aluminium, production mix, wrought alloy, at plant	RER	0	kg	3.93E+0	5.34E+0	1	1.39	(3,4,1,1,1,5); Questionnaires 2002 and 2010
	brazing solder, cadmium free, at plant	RER	0	kg	3.68E-3	3.68E-3	1	1.49	(2,5,3,1,1,5); Questionnaire 2002
	soft solder, Sn97Cu3, at plant	RER	0	kg	5.88E-2	5.88E-2	1	1.49	(2,5,3,1,1,5); Questionnaire 2002
	copper, at regional storage	RER	0	kg	2.82E+0	1.73E+0	1	1.39	(3,4,1,1,1,5); Questionnaires 2002 and 2010
	chromium steel 18/8, at plant	RER	0	kg	-	7.71E-2	1	1.39	(3,4,1,1,1,5); Questionnaire 2010, fixing parts
	transport, transoceanic freight ship	OCE	0	tkm	2.25E+1	-	1	2.83	(3,4,3,1,1,5); Questionnaire 2002, Copper from US
	transport, lorry 20-28t, fleet average	CH	0	tkm	1.00E+0	9.55E-1	2	2.85	(4,5,na,na,na,na); Standard distance 50km
	transport, lorry >16t, fleet average	RER	0	tkm	1.63E+1	1.59E+1	1	2.83	(3,4,3,1,1,5); 1260 km for glass from UK to DE, 450 km (890 km resp.) for glass from DE to CH, 750km for ALU-Cu absorber from DE, 600km for Cu absorber from US
	transport, freight, rail	RER	0	tkm	7.26E+0	7.12E+0	1	2.83	(3,4,3,1,1,5); Standard distance 600km; 60 km solar glass + lorry
	selective coating, aluminium sheet, nickel pigmented aluminium oxide	SK	0	m2	-	1.00E+0	1	1.39	(3,4,1,1,1,5); Questionnaire 2010, absorber coating
	selective coating, copper sheet, black chrome	RER	0	m2	1.00E+0	-	1	1.49	(2,5,3,1,1,5); Questionnaire 2002, absorber coating
	anti-reflex-coating, etching, solar glass	DK	0	m2	1.00E+0	-	1	1.49	(2,5,3,1,1,5); Questionnaire 2002
	tempering, flat glass	RER	0	kg	9.12E+0	8.27E+0	1	1.39	(3,4,1,1,1,5); Questionnaire 2010
	sheet rolling, copper	RER	0	kg	2.82E+0	-	1	1.49	(2,5,3,1,1,5); Questionnaire 2002
	sheet rolling, aluminium	RER	0	kg	-	1.41E+0	1	1.46	(2,5,1,1,1,5); Questionnaire 2010
	section bar extrusion, aluminium	RER	0	kg	3.93E+0	3.93E+0	1	1.46	(2,5,1,1,1,5); Questionnaire 2002
	drawing of pipes, steel	RER	0	kg	-	1.73E+0	1	1.46	(2,5,1,1,1,5);
	disposal, building, glass sheet, to sorting plant	CH	0	kg	9.12E+0	8.27E+0	1	1.48	(3,5,1,1,1,5); Estimation
	disposal, building, mineral wool, to sorting plant	CH	0	kg	2.43E+0	1.59E+0	1	1.48	(3,5,1,1,1,5); Estimation
	disposal, plastics, mixture, 15.3% water, to municipal incineration	CH	0	kg	7.90E-1	9.42E-1	1	1.48	(3,5,1,1,1,5); Estimation
	disposal, building, waste wood, untreated, to final disposal	CH	0	kg	8.57E-1	8.57E-1	1	1.48	(3,5,1,1,1,5); Estimation
	treatment, sewage, from residence, to wastewater treatment, class 2	CH	0	m3	9.40E-3	9.40E-3	1	1.49	(2,5,3,1,1,5); Questionnaire 2002
	treatment, heat carrier liquid, 40% C3H8O2, to wastewater treatment, class 2	CH	0	m3	2.38E-3	2.76E-3	1	1.46	(2,5,1,1,1,5); Questionnaire 2010
emission air, high population density	Heat, waste	-	-	MJ	4.16E+0	4.16E+0	1	1.46	(2,5,1,1,1,5); calculated from electricity consumption

Tab. 2.2 Unit process raw data of construction and disposal of an evacuated tube collector

	Name	Location	Infrastructure	Unit	*evacuated tube collector, at plant*	UncertaintyType	StandardDeviation95%	GeneralComment
	Location				*GB*			
	InfrastructureProcess				*1*			
	Unit				*m2*			
product	evacuated tube collector, at plant	GB	1	m2	1.00E+0			
technosphere	electricity, medium voltage, at grid	GB	0	kWh	1.70E+1	1	1.57	(2,2,1,3,4,5); Questionnaire, data for other type of collector plus data for flat plate collector production
	natural gas, burned in industrial furnace low-NOx >100kW	RER	0	MJ	1.65E+1	1	1.57	(2,2,1,3,4,5); Questionnaire, data for other type of collector
	tap water, at user	RER	0	kg	5.36E+1	1	1.57	(2,2,1,3,4,5); Questionnaire, data for other type of collector plus data for flat plate collector production
	water, completely softened, at plant	RER	0	kg	7.80E-1	1	1.31	(2,5,1,1,1,5); Questionnaire, heat transfer fluid
	solar collector factory	RER	1	unit	2.00E-7	1	3.14	(2,5,1,1,3,5); Estimation for flat plate collector
	chemicals organic, at plant	GLO	0	kg	1.13E-2	1	1.57	(2,2,1,3,4,5); Questionnaire, data for other type of collector
	hydrochloric acid, 30% in H2O, at plant	RER	0	kg	1.13E-1	1	1.57	(2,2,1,3,4,5); Questionnaire, data for other type of collector
	corrugated board, mixed fibre, single wall, at plant	RER	0	kg	3.33E+0	1	1.20	(3,4,3,1,1,3); Company information, packaging
	glass tube, borosilicate, at plant	DE	0	kg	1.42E+1	1	1.31	(2,5,1,1,1,5); Questionnaire plus 5% losses
	synthetic rubber, at plant	RER	0	kg	6.67E-1	1	1.31	(2,5,1,1,1,5); Questionnaire
	rock wool, packed, at plant	CH	0	kg	2.03E+0	1	1.31	(2,5,1,1,1,5); Questionnaire
	silicone product, at plant	RER	0	kg	5.33E-2	1	1.31	(2,5,1,1,1,5); Questionnaire
	copper, at regional storage	RER	0	kg	2.80E+0	1	1.31	(2,5,1,1,1,5); Questionnaire
	brazing solder, cadmium free, at plant	RER	0	kg	1.00E-1	1	1.31	(2,5,1,1,1,5); Questionnaire
	propylene glycol, liquid, at plant	RER	0	kg	5.72E-1	1	1.31	(2,5,1,1,1,5); Questionnaire, heat transfer fluid
	chromium steel 18/8, at plant	RER	0	kg	1.00E+0	1	1.31	(2,5,1,1,1,5); Questionnaire
	transport, lorry >16t, fleet average	RER	0	tkm	1.49E+1	1	2.09	(4,5,na,na,na,na); Estimation 600km
	transport, freight, rail	RER	0	tkm	1.49E+1	1	2.09	(4,5,na,na,na,na); Estimation 600km
	selective coating, copper sheet, physical vapour deposition	DE	0	m2	1.00E+0	1	1.31	(2,5,1,1,1,5); Questionnaire
	anti-reflex-coating, etching, solar glass	DK	0	m2	1.00E+0	1	1.31	(2,5,1,1,1,5); Questionnaire
	sheet rolling, copper	RER	0	kg	2.80E+0	1	1.31	(2,5,1,1,1,5); Questionnaire
	disposal, building, glass sheet, to sorting plant	CH	0	kg	1.42E+1	1	1.32	(3,5,1,1,1,5); Estimation
	disposal, plastics, mixture, 15.3% water, to municipal incineration	CH	0	kg	7.20E-1	1	1.32	(3,5,1,1,1,5); Estimation
	disposal, packaging cardboard, 19.6% water, to municipal incineration	CH	0	kg	3.33E+0	1	1.32	(3,5,1,1,1,5); Estimation
	disposal, building, mineral wool, to sorting plant	CH	0	kg	2.03E+0	1	1.32	(3,5,1,1,1,5); Estimation
	treatment, heat carrier liquid, 40% C3H8O2, to wastewater treatment, class 2	CH	0	m3	1.35E-3	1	1.32	(3,5,1,1,1,5); Estimation
	disposal, municipal solid waste, 22.9% water, to municipal incineration	CH	0	kg	2.84E-2	1	1.57	(2,2,1,3,4,5); Questionnaire, data for other type of collector
	disposal, glass, 0% water, to inert material landfill	CH	0	kg	6.80E-1	1	1.57	(2,2,1,3,4,5); Questionnaire, data for other type of collector
	disposal, hazardous waste, 25% water, to hazardous waste incineration	CH	0	kg	2.27E-1	1	1.57	(2,2,1,3,4,5); Questionnaire, data for other type of collector
	treatment, sewage, from residence, to wastewater treatment, class 2	CH	0	m3	4.42E-2	1	1.57	(2,2,1,3,4,5); Questionnaire, data for other type of collector
emission air, high population density	Heat, waste	-	-	MJ	6.13E+1	1	1.32	(3,5,1,1,1,5); Estimation
weight				kg	24.7			

Tab. 2.3 EcoSpold meta information of construction and disposal of evacuated tube collectors and flat plate collectors with copper and aluminium-copper absorbers

Name	evacuated tube collector, at plant	flat plate collector, aluminium copper absorber, at plant	flat plate collector, copper absorber, at plant
Location	GB	CH	CH
InfrastructureProcess	1	1	1
Unit	m2	m2	m2
IncludedProcesses	Production of an evacuated tube collector in Northern-Ireland. Including materials and energy use of production. Disposal in CH. Materials for mounting on roof are excluded.	Production and disposal of a flat plate collector with am aluminium absorber in Switzerland. Including materials, water and energy use of production. Materials for mounting on roof are excluded.	Production and disposal of a flat plate collector with a copper absorber in Switzerland. Including materials, water and energy use of production. Materials for mounting on roof are excluded.
LocalName	Vakuumröhrenkollektor, ab Werk	Flachkollektor, Aluminium-Kupfer-Absorber, ab Werk	Flachkollektor, Kupfer-Absorber, ab Werk
Synonyms	VTC//vacuum tube collector		
GeneralComment	The collector has selective TINOX-coating on copper made in DE.	One collector has an aparture area of 2.335 m^2 and an empty weight of 42 kg. The dataset refers to 1 m^2 aparture area, which is equal to 1.09 m^2 collector area. The flat plate collector has a selective nickel pigmented aluminium oxide coating on an aluminium absorber.	One collector has an aparture area of 2.72 m^2 and an empty weight of 52 kg. The dataset refers to 1 m^2 aparture area. The flat plate collector has a selective black chrome coating on copper produced in the US.
Category	solar collector systems	solar collector systems	solar collector systems
SubCategory	production of components	production of components	production of components
LocalCategory	Sonnenkollektoranlagen	Sonnenkollektoranlagen	Sonnenkollektoranlagen
LocalSubCategory	Herstellung Komponenten	Herstellung Komponenten	Herstellung Komponenten
Formula			
StatisticalClassification			
CASNumber			
StartDate	2000	2010	2000
EndDate	2010	2010	2010
OtherPeriodText	Material data have been investigated for a collector produced in 2002. Data for energy uses during production have been investigated for 2001.	Material data have been investigated for a collector produced in 2010. Data for energy uses during production have been investigated for 2001.	Material data have been investigated for a collector produced in 2002. Data for energy uses during production have been investigated for 2001.
Text	Production in GB. Main components are imported from DE.	Production in CH. Main components are imported from the Germany.	Production in CH. Main components are imported from the US. The glass is coated in DK.
Text	Assembly of an evacuated tube collector. The collector has selective TINOX-coating on copper made in DE.	Assembly of a flat plate collector. The collector has a aluminium sheet coated by a nickel pigmented aluminium oxide coating.	Assembly of a flat plate collector. The collector has a copper sheet coated by black chrome coating.
Percent			
ProductionVolume	In 2009 10'285 m^2 of flat plate collectors (7.2 MW capacity) were sold in CH.	In 2009 135'355 m^2 of flat plate collectors (95 MW capacity) were sold in CH.	In 2009 135'355 m^2 of flat plate collectors (95 MW capacity) were sold in CH.
SamplingProcedure	Questionnaires.	Questionnaires.	Questionnaires.
Extrapolations	Energy uses during production investigated in an other factory	Energy use during production investigated in an other factory.	Energy use during production investigated in an other factory.

2.2 Hot water tank and heat storage

Hot water tanks and heat storages are considered with the ecoinvent datasets of a 600 l hot water tank and a 2’000 l heat storage. The used amount of hot water tank and heat storage in the solar thermal systems is calculated by using the extrapolation factors in Tab. 2.4 that are based on the relation between storage volume and storage size.

Tab. 2.4 Extrapolation factors for the calculation of different storage sizes

Volume	l	200	400	800	**600**	1100	1200	1500	4200	**2000**
Weight	kg	259	271	295	**283**	313	319	337	498	**367**
Factor	1	0.92	0.96	1.04	**1.00**	0.85	0.87	0.92	1.36	**1.00**

2.3 Pumps

Jungbluth (2003) established a life cycle inventory dataset of a Grundfos pump with a capacity of 40 W and a gross weight of 2.4 kg. Tab. 2.5 shows the gross weights of pumps with different capacities which are used for scaling the 40 W pump to the pumps with higher capacity that are used in the solar thermal systems, considered in this project.

Tab. 2.5 Gross weights of pumps with different capacities

Capacity	40 W[1]	50 W - 60 W	70 W - 90 W	500 W
Pump name	Grundfos UP 15-35x20	Grundfos UPS Solar 25-40 180mm	Grundfos UPS Solar 15-80 130mm	Grundfos UPS 40-120 F
Gross weight	2.4 kg	2.8 kg	2.8 kg	19.6 kg

1 considered in ecoinvent (Jungbluth 2003)

2.4 Heat transfer medium

The heat transfer medium that is used in solar thermal installations is composed typically of 35 % glycol and 65 % purified water. The heat transfer medium needs to be exchanged every ten years and is disposed of in a municipal wastewater treatment.

2.5 Expansion vessel

The used amount of expansion vessel in the solar thermal systems is scaled over the specific vessel volumes of the considered installations. Only the smallest one-family house installation with a collector area of 5 m^2 and a vessel volume of 35 litres is considered with the dataset of a 25 litre expansion vessel. The other systems all have vessels with a volume larger than 50 litres and are considered with the dataset of an 80 litre expansion vessel.

2.6 Mounting

The solar thermal systems are assumed to be transported by a van over a distance of 50 km from the system provider to the place of installation, as described by Jungbluth (2003). The collector can be mounted either on slanted roofs or on flat roofs. In this study, slanted roof mounting systems are based on aluminium sheets whereas flat roof mounting systems are based on zinc coated low-alloyed steel and concrete (see Tab. 2.6). Since the ecoinvent dataset for zinc coatings refers to the surface area (m^2) of coated steel, 0.064 m^2 surface per kg steel is assumed (Werner et al. 2007).

Tab. 2.6 Foundation material of the considered solar thermal systems.

	Unit	solar system, 12 m2 Cu flat plate collector, one-family house, combined system	solar system, 5 m2 Cu flat plate collector, one-family house, hot water	solar system, 20 m2 Cu flat plate collector, on slanted roof, hot water	solar system, 30 m2 Cu flat plate collector, on slanted roof, hot water	solar system, 30 m2 Al flat plate collector, on slanted roof, hot water	solar system, 30 m2 Cu flat plate collector, on flat roof, hot water	solar system, 81 m2 Cu flat plate collector, multiple dwelling, hot water	solar system, 10.5 m2 evacuated tube collector, one-family house, combined system
Aluminium sheet	kg/m^2	1.2	1.6	0.9	0.7	0.7	-	0.5	1.5
Zinc coated steel	kg/m^2	-	-	-	-	-	4	-	-
Concrete	kg/m^2	-	-	-	-	-	50	-	-

2.7 Pipes

For the pipes of the solar thermal systems chromium steel or copper is used. EPDM foam and mineral wool are used as insulation materials (see Tab. 2.7). The pipe insulation has a coating of polyethylene and fibre glass meshwork, except the pipe insulation of the 81 m^2 system, which as an aluminium coating.

Tab. 2.7 Specification of pipes, pipe insulation, and pipe insulation coating of the considered solar thermal systems.

Parameter	solar system, 12 m2 Cu flat plate collector, one-family house, combined system	solar system, 5 m2 Cu flat plate collector, one-family house, hot water	solar system, 20 m2 Cu flat plate collector, on slanted roof, hot water	solar system, 30 m2 Cu flat plate collector, on slanted roof, hot water	solar system, 30 m2 Al flat plate collector, on slanted roof, hot water	solar system, 30 m2 Cu flat plate collector, on flat roof, hot water	solar system, 81 m2 Cu flat plate collector, multiple dwelling, hot water	solar system, 10.5 m2 evacuated tube collector, one-family house, combined system
Pipe material	Chromium steel	Copper	Corrugated chromium steel	Corrugated chromium steel	Corrugated chromium steel	Corrugated chromium steel	Copper	Chromium steel
Pipe length (inlet and outlet)	35 m	32 m	51 m	57 m	57 m	65 m	141 m	35 m
Pipe dimension (external diameter, wall thickness)	25 x 0.4 mm	12 x 0.8 mm	25 x 0.5 mm	28 x 0.5 mm	28 x 0.5 mm	28 x 0.5 mm	28 x 1.2 mm	26 x 0.4 mm
Total mass of pipes	**8.5 kg**	**8.0 kg**	**13.2 kg**	**16.6 kg**	**16.6 kg**	**18.9 kg**	**127.1 kg**	**8.8 kg**
Pipe insulation material	EPDM foam	EPDM foam	EPDM foam	EPDM foam	EPDM foam	EPDM foam	Mineral wool	EPDM foam
Insulation dimension (thickness)	20 mm	20 mm	20 mm	20 mm	20 mm	20 mm	30 mm	20 mm
Total mass of insulation	**7.4 kg**	**4.8 kg**	**10.8 kg**	**12.9 kg**	**12.9 kg**	**14.7 kg**	**77.1 kg**	**7.6 kg**
Pipe insulation coating	Polyethylene	Polyethylene	Polyethylene	Polyethylene	Polyethylene	Polyethylene	Aluminium	Polyethylene
Total mass of pipe insulation coating	**0.7 kg**	**0.5 kg**	**1.0 kg**	**1.2 kg**	**1.2 kg**	**1.4 kg**	**1.3 kg**	**0.7 kg**

The used volume of pipe and insulation materials is calculated from the pipe length and the pipe and insulation dimensions defined in Tab. 2.7. For those systems, where corrugated pipes are used, a correction factor of 4-Pi is applied in order to take into account the reduced material demand of corrugated pipes. Then, the specific volumes are multiplied with the material densities in Tab. 2.8 in order to obtain the total used amount of pipe, pipe insulation, and coating materials (see Tab. 2.7).

Tab. 2.8 Density of pipe and insulation materials

Material	**Density (kg/m3)**
EPDM-foam (tube insulation)	75
copper	8920
steel	7850
mineral wool	100

The pipe insulation coating is considered with 100 g LDPE packaging film per square meter. The total area of the insulation coating is calculated from the pipe and insulation dimension as well as the pipe length. The total amount of aluminium contained in the aluminium coating of the pipe insulation of the 81 m^2 solar thermal system is calculated as 1.26 kg by considering that 32.2 g aluminium per square meter is applied, which is the weight of aluminium household foil.

The life cycle inventories of solar thermal systems investigated by Jungbluth (2003) are updated by adjusting the pipe insulation and the insulation coating to be compliant with the new datasets. Thereby, the insulation and coating materials are scaled over the pipe length from the 5 m^2 solar thermal systems.

2.8 Solar thermal systems

The datasets of the considered solar thermal systems contain the solar collector, the hot water tank or heat storage, the pump, the heat transfer medium, the expansion vessel, the mounting of the system, and the pipes, as described in the previous subchapters (see Tab. 2.9). The EcoSpold meta information is presented in Tab. 2.10.The basic information about the solar thermal systems is presented in the Annex.

Tab. 2.9 Unit process raw data of the construction and disposal of solar thermal systems, the last two datasets are updates of previous ecoinvent datasets

	Name	Location	InfrastructureProcess	Unit	solar system, 5 m2 Cu flat plate collector, one-family house, hot water	solar system, 12 m2 Cu flat plate collector, one-family house, combined system	solar system, 20 m2 Cu flat plate collector, on slanted roof, hot water	solar system, 30 m2 Cu flat plate collector, on slanted roof, hot water	solar system, 30 m2 Cu flat plate collector, on flat roof, hot water	solar system, 30 m2 Al-Cu flat plate collector, on slanted roof, hot water	solar system, 81 m2 Cu flat plate collector, multiple dwelling, hot water	solar system, 10.5 m2 evacuated tube collector, one-family house, combined system	UncertaintyType	StandardDeviation95%	GeneralComment
	Location				*CH*	*CH*	*CH*	*CH*	*CH*	*CH*	*CH*	*CH*			
	InfrastructureProcess				*1*	*1*	*1*	*1*	*1*	*1*	*1*	*1*			
	Unit				*unit*	*unit*	*unit*	*unit*	*unit*	*unit*	*unit*	*unit*			
product	solar system, 5 m2 Cu flat plate collector, one-family house, hot water	CH	1	unit	1.00E+0	-	-	-	-	-	-	-			
	solar system, 12 m2 Cu flat plate collector, one-family house, combined system	CH	1	unit	-	1.00E+0	-	-	-	-	-	-			
	solar system, 20 m2 Cu flat plate collector, on slanted roof, hot water	CH	1	unit	-	-	1.00E+0	-	-	-	-	-			
	solar system, 30 m2 Cu flat plate collector, on slanted roof, hot water	CH	1	unit	-	-	-	1.00E+0	-	-	-	-			
	solar system, 30 m2 Cu flat plate collector, on flat roof, hot water	CH	1	unit	-	-	-	-	1.00E+0	-	-	-			
	solar system, 30 m2 Al-Cu flat plate collector, on slanted roof, hot water	CH	1	unit	-	-	-	-	-	1.00E+0	-	-			
	solar system, 81 m2 Cu flat plate collector, multiple dwelling, hot water	CH	1	unit	-	-	-	-	-	-	1.00E+0				
	solar system, 10.5 m2 evacuated tube collector, one-family house, combined system	CH	1	unit	-	-	-	-	-	-		1.00E+0			
materials	water, completely softened, at plant	RER	0	kg	1.63E+1	4.06E+1	4.88E+1	5.69E+1	5.69E+1	5.69E+1	8.13E+1	3.25E+1	1	3.07	(3,5,3,1,1,na); Plant data, exchange after 10a life time
	propylene glycol, liquid, at plant	RER	0	kg	9.54E+0	2.38E+1	2.86E+1	3.34E+1	3.34E+1	3.34E+1	4.77E+1	1.91E+1	1	3.07	(3,5,3,1,1,na); Plant data, exchange after 10a life time
	tube insulation, elastomere, at plant	DE	0	kg	4.83E+0	7.42E+0	1.08E+1	1.29E+1	1.47E+1	1.29E+1	-	7.59E+0	1	3.07	(3,5,3,1,1,na); Plant data
	rock wool, packed, at plant	CH	0	kg	-	-	-	-	-	-	7.71E+1	-	1	3.07	(3,5,3,1,1,na); Tube insulation
	packaging film, LDPE, at plant	RER	0	kg	5.23E-1	7.15E-1	1.04E+0	1.22E+0	1.39E+0	1.22E+0		7.26E-1	1	3.07	(3,5,3,1,1,na); Tube coating
	copper, at regional storage	RER	0	kg	8.03E+0	-	-	-	-	-	1.27E+2	-	1	3.07	(3,5,3,1,1,na); Plant data, warm water pipes
	chromium steel 18/8, at plant	RER	0	kg	-	8.49E+0	1.32E+1	1.66E+1	1.89E+1	1.66E+1	-	8.84E+0	1	3.07	(3,5,3,1,1,na); Plant data, warm water pipes
	steel, low-alloyed, at plant	RER	0	kg	-	-	-	-	1.20E+2	-	-	-	1	3.07	(3,5,3,1,1,na); Foundation
	aluminium, production mix, wrought alloy, at plant	RER	0	kg	8.00E+0	1.44E+1	1.80E+1	2.10E+1	-	2.10E+1	4.18E+1	1.58E+1	1	3.07	(3,5,3,1,1,na); Foundation
	zinc coating, coils	RER	0	m2	-	-	-	-	7.68E+0	-	-	-	1	3.07	(3,5,3,1,1,na); Foundation
	concrete, normal, at plant	CH	0	m3	-	-	-	-	6.30E-1	-	-	-	1	3.07	(3,5,3,1,1,na); Foundation, 2380 kg/m2
components	pump 40W, at plant	CH	1	unit	1.94E+0	1.94E+0	1.94E+0	1.94E+0	1.94E+0	1.94E+0	1.36E+1	1.94E+0	1	4.81	(3,5,3,1,1,na); Estimation, extrapolation for life time of 15a
	expansion vessel 25l, at plant	CH	1	unit	1.40E+0	-	-	-	-	-	-	-	1	4.81	(3,5,3,1,1,na); Estimation
	hot water tank 600l, at plant	CH	1	unit	9.15E-1	-	1.04E+0	-	-	-	-	-	1	4.81	(3,5,3,1,1,na); Extrapolated by weight
	heat storage 2000l, at plant	CH	1	unit	-	8.53E-1	-	9.18E-1	9.18E-1	9.18E-1	1.36E+0	8.53E-1	1	4.81	(3,5,3,1,1,na); Extrapolated by weight
	expansion vessel 80l, at plant	CH	1	unit	-	6.25E-1	1.00E+0	1.75E+0	1.75E+0	1.75E+0	5.00E+0	6.25E-1	1	4.81	(3,5,3,1,1,na); Estimation
	flat plate collector, aluminium copper absorber, at plant	CH	1	m2	-	-	-	-	-	3.00E+1	-	-	1	4.81	(3,5,3,1,1,na); Estimation
	flat plate collector, copper absorber, at plant	CH	1	m2	5.00E+0	1.20E+1	2.00E+1	3.00E+1	3.00E+1	-	8.10E+1	-	1	4.81	(3,5,3,1,1,na); Estimation
	evacuated tube collector, at plant	GB	1	m2	-	-	-	-	-	-	-	1.05E+1	1	4.81	(3,5,3,1,1,na); Estimation
processing	drawing of pipes, steel	RER	0	kg	8.03E+0	8.49E+0	1.32E+1	1.66E+1	1.89E+1	1.66E+1	1.27E+2	8.84E+0	1	3.12	(3,5,3,1,3,na); Estimation for pipes
	sheet rolling, aluminium	RER	0	kg	8.00E+0	1.44E+1	1.80E+1	2.10E+1	-	2.10E+1	4.18E+1	1.58E+1	1	3.07	(3,5,3,1,1,na); Foundation
	powder coating, aluminium sheet	RER	0	m2	4.00E-1	7.20E-1	9.00E-1	1.05E+0	-	1.05E+0	2.09E+0	7.88E-1	1	3.07	(3,5,3,1,1,na); Foundation lacquering
transport	transport, van <3.5t	CH	0	tkm	1.10E+2	2.64E+2	4.40E+2	6.60E+2	6.60E+2	6.60E+2	1.78E+3	2.31E+2	1	3.79	(3,5,3,1,1,5); Questionnaire 50km per m2
	transport, lorry 20-28t, fleet average	CH	0	tkm	2.36E+0	4.77E+0	6.02E+0	7.10E+0	1.23E+1	7.10E+0	1.87E+1	4.22E+0	1	3.76	(4,5,na,na,na,na); Standard distance 50km
	transport, freight, rail	RER	0	tkm	2.83E+1	5.73E+1	7.23E+1	8.52E+1	1.47E+2	8.52E+1	2.25E+2	5.07E+1	1	3.76	(4,5,na,na,na,na); Standard distance 600km
disposal	treatment, heat carrier liquid, 40% C3H8O2, to wastewater treatment, class 2	CH	0	m3	2.58E-2	6.45E-2	7.74E-2	9.03E-2	9.03E-2	9.03E-2	1.29E-1	5.16E-2	1	3.07	(3,5,3,1,1,na); Estimation
	disposal, plastics, mixture, 15.3% water, to municipal incineration	CH	0	kg	5.35E+0	8.14E+0	1.19E+1	1.41E+1	1.61E+1	1.41E+1	-	8.31E+0	1	3.07	(3,5,3,1,1,na); Estimation for disposal of plastics

Tab. 2.10 EcoSpold meta information of the construction and disposal of solar thermal systems

Name	solar system, 5 m2 Cu flat plate collector, one-family house, hot water	solar system, 10.5 m2 evacuated tube collector, one-family house, combined system	solar system, 12 m2 Cu flat plate collector, one-family house, combined system	solar system, 20 m2 Cu flat plate collector, on slanted roof, hot water	solar system, 30 m2 Cu flat plate collector, on slanted roof, hot water	solar system, 30 m2 Cu flat plate collector, on flat roof, hot water	solar system, 30 m2 Al-Cu flat plate collector, on slanted roof, hot water	solar system, 81 m2 Cu flat plate collector, multiple dwelling, hot water
Location	CH	CH	CH	CH	CH	CH	CH	CH
InfrastructureProcess	1	1	1	1	1	1	1	1
Unit	unit	unit	unit	unit	unit	unit	unit	unit
IncludedProcesses	Production and disposal of a complete solar system (excluding auxiliary heating). 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 system (excluding auxiliary heating). 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 system (excluding auxiliary heating). 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 system (excluding auxiliary heating). 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 system (excluding auxiliary heating). 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 system (excluding auxiliary heating). 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 system (excluding auxiliary heating). 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 system (excluding auxiliary heating). Including different components, heat exchange fluid, warm water pipes, transports of parts to CH, and delivery with a van.
LocalName	5 m2 Cu-Flachkollektoranlage, EFH, Warmwasserspeicher	10.5 m2 Vakuumröhrenkollektoranlage, EFH, Wärmespeicher	12 m2 Cu-Flachkollektoranlage, EFH, Wärmespeicher	20 m2 Cu-Flachkollektoranlage, MFH mit Schrägdach, Warmwasserspeicher	30 m2 Cu-Flachkollektoranlage, MFH mit Schrägdach, Warmwasserspeicher	30 m2 Cu-Flachkollektoranlage, MFH mit Flachdach, Warmwasserspeicher	30 m2 Al-Cu-Flachkollektoranlage, MFH mit Schrägdach, Warmwasserspeicher	81 m2 Cu-Flachkollektoranlage, MFH, Warmwasserspeicher
Synonyms			SFD//one-family house					
GeneralComment	Solar system with a flat plate collector on a one family house for hot water. 25 years life time, 32 m pipe length and 200 l heat storage.	Solar system with an evacuated tube collector (heat pipes) for hot water and auxiliary heating. 20 years life time, 35 m pipe lentgh and 1100 l heat storage.	Solar system with a flat plate collector on a one family house with a combined system for hot water and heating. 25 years life time, 35 m pipe length and 1100 l heat storage.	Solar system with a flat plate collector on a multiple family dwelling for hot water. 25 years life time, 51 m pipe length and 800 l heat storage.	Solar system with a flat plate collector on a multiple family dwelling for hot water. 25 years life time, 57 m pipe length and 1500 l heat storage.	Solar system with a flat plate collector on a multiple family dwelling for hot water. 25 years life time, 65 m pipe length and 1500 l heat storage.	Solar system with a flat plate collector on a multiple family dwelling for hot water. 25 years life time, 57 m pipe length and 1500 l heat storage.	Solar system with a flat plate collector on a multiple family dwelling for hot water. 25 years life time, 141 m pipe length and 4200 l heat storage.
Category	solar collector systems	solar collector systems	solar collector systems	solar collector systems	solar collector systems	solar collector systems	solar collector systems	solar collector systems
SubCategory	systems	systems	systems	systems	systems	systems	systems	systems
LocalCategory	Sonnenkollektoranlagen	Sonnenkollektoranlagen	Sonnenkollektoranlagen	Sonnenkollektoranlagen	Sonnenkollektoranlagen	Sonnenkollektoranlagen	Sonnenkollektoranlagen	Sonnenkollektoranlagen
LocalSubCategory	Kollektorsysteme	Kollektorsysteme	Kollektorsysteme	Kollektorsysteme	Kollektorsysteme	Kollektorsysteme	Kollektorsysteme	Kollektorsysteme
Formula								
StatisticalClassification								
CASNumber								
StartDate	2000	2000	2000	2000	2000	2000	2000	2000
EndDate	2010	2010	2010	2010	2010	2010	2010	2010
OtherPeriodText	Time of simulation.	Time of simulation.	Time of simulation.	Time of simulation.	Time of simulation.	Time of simulation.	Time of simulation.	Time of simulation.
Text	Solar collector system operated in CH.	Solar collector system operated in CH.	Solar collector system operated in CH.	Solar collector system operated in CH.	Solar collector system operated in CH.	Solar collector system operated in CH.	Solar collector system operated in CH.	Solar collector system operated in CH.
Text	Solar collector system for hot water installed on the roof of a house.	Solar collector system for room heating and hot water installed on the roof of a house.	Solar collector system for room heating and hot water installed on the roof of a house.	Solar collector system for hot water installed on the roof of a house.	Solar collector system for hot water installed on the roof of a house.	Solar collector system for hot water installed on the roof of a house.	Solar collector system for hot water installed on the roof of a house.	Solar collector system for hot water installed on the roof of a house.
Percent								
ProductionVolume	10'433 systems with flat plate collectors were sold in 2008. 36.2% of the area is installed on one-family houses for hot water.	697 systems with tube collectors were sold in 2008. 50% of the area is installed on one-family houses for heating and hot water.	10'433 systems with flat plate collectors were sold in 2008. 29.3% of the area is installed on one-family houses for heating and hot water.	10'433 systems with flat plate collectors were sold in 2008. 27.4% of the area is installed on multiple dwellings for hot water.	10'433 systems with flat plate collectors were sold in 2008. 27.4% of the area is installed on multiple dwellings for hot water.	10'433 systems with flat plate collectors were sold in 2008. 27.4% of the area is installed on multiple dwellings for hot water.	10'433 systems with flat plate collectors were sold in 2008. 27.4% of the area is installed on multiple dwellings for hot water.	10'433 systems with flat plate collectors were sold in 2008. 27.4% of the area is installed on multiple dwellings for hot water.
SamplingProcedure	Own simulation.	Own simulation.	Own simulation.	Own simulation.	Own simulation.	Own simulation.	Own simulation.	Own simulation.
Extrapolations	none	none	none	none	none	none	none	none

3 Life cycle inventories of the operation of solar thermal installations

The operation of the solar thermal installation in the city of Zurich (Switzerland) is simulated with the Polysun software. The underlying assumptions and the simulation results are presented in the Annex.

In compliance with the previous ecoinvent datasets of solar thermal energy, a lifetime of 25 years is applied for solar thermal systems with a flat plate collector. Hostettler (2010) considers the same life time for flat plate collectors and tube collectors. However, the life time of evacuated tube collectors depends on the type of evacuated tubes. Evacuated tube collectors with heat pipes can be considered with the same lifetime as flat plate collectors (25 years), whereas evacuated tube collectors with glass-glass tubes (thermos flask principle) are confronted with a higher risk of glass braking e.g. due to hailstorms. Hence, it is reasonable to consider systems with glass-glass tubes with a reduced life time of 20 years.[4]

The pump is exchanged every 15 years and the heat transfer medium is exchanged every 10 years.[5] In evacuated tube collectors without overheat control the heat transfer medium has to be replaced more often (every 5 years).[6] However, since in this study evacuated tube collectors with overheat control are considered, the exchange rate of the transfer medium is equal for flat plate collectors and evacuated tube collectors.

The amount of solar thermal system that is needed in order to generate one MJ of heat is calculated from the net solar net yield over the lifetime of the system. The heat generated with a glass-glass evacuated tube collector system is approximated by considering a tube collector system with heat pipes and adjusting the life time of the system to 20 years. Both types of evacuated tube collectors can have a similar total weight and similar feedstock materials, as well a roughly the same efficiency.

For the operation the pumps and controllers, electricity is consumed by the solar thermal system. This auxiliary energy as well as the net solar yield over lifetime is presented in Tab. 3.1.

The solar irradiation at the location of the solar thermal systems in Zurich is 1'249 kWh per year and m^2. The amount of converted solar energy that is needed for the system output of one MJ solar heat is equal to the collector yield divided by the annual solar net yield which is the heat output from the hot water tank (see Tab. 3.1).

4 Personal communication with Stefan Brunold project leader at the Rapperswil Institute for Solar Technology SPF (26.10.2010)

5 Personal communication with Felix Schmid from the Department of Industrial Operations of the City of Zurich (02.08.2010)

6 Personal communication with Jürg Marti from Marti Energietechnik (23.08.2010)

Tab. 3.1 Collector yield, solar net yield, converted solar energy, and auxiliary energy consumption

	Annual collector yield	Specific collector yield	Annual solar net yield	Converted solar energy per MJ heat	Solar net yield over life time	Con-sumption of auxiliary energy
	MJ/a	kWh/m^2*a	MJ/a	MJ/MJ	GJ	kWh/a
solar system, 5 m2 Cu flat plate collector, one-family house, hot water	82’22	457	6’404	1.28	160	96
solar system, 10.5 m2 evacuated tube collector, one-family house, combined system	21’962	581	14’549	1.51	291	110
solar system, 12 m2 Cu flat plate collector, one-family house, combined system	17’366	402	11’027	1.57	276	104
solar system, 20 m2 Cu flat plate collector, on slanted roof, hot water	40’270	559	35’899	1.12	897	145
solar system, 30 m2 Cu flat plate collector, on slanted roof, hot water	55’393	513	48’931	1.13	1223	154
solar system, 30 m2 Al flat plate collector, on slanted roof, hot water	55’703	513	48’683	1.14	1217	158
solar system, 30 m2 Cu flat plate collector, on flat roof, hot water	55’393	516	48’931	1.13	1223	154
solar system, 81 m2 Cu flat plate collector, multiple dwelling, hot water	166’691	572	154’235	1.08	3856	938

The maintenance of the solar thermal system includes cleaning of the heat storage and the collectors, as well as controlling of the heat transfer medium. In the life cycle inventory, it is assumed that a maintenance team travels 50 km every 5 years by van. Other aspects of maintenance are not considered.

The unit process raw data of the solar thermal systems are displayed in Tab. 3.2. The EcoSpold meta information is shown in Tab. 3.3.

Tab. 3.2 Unit process raw data of the supply of useful heat from solar thermal systems without considering auxiliary heating

	Name	Location	InfrastructureProcess	Unit	heat, at 5 m2 Cu collector, one-family house, for hot water	heat, at 12 m2 Cu collector, one-family house, for combined system	heat, at 20 m2 Cu collector, multiple dwelling, slanted roof, for hot water	heat, at 30 m2 Cu collector, multiple dwelling, slanted roof, for hot water	heat, at 30 m2 Cu collector, multiple dwelling, flat roof, for hot water	heat, at 30 m2 Al-Cu collector, multiple dwelling, slanted roof, for hot water	heat, at 81 m2 Cu collector, multiple dwelling, for hot water	heat, at 10.5 m2 evacuated tube collector, heat pipe, one-family house, for combined system	heat, at 10.5 m2 evacuated tube collector, glass-glass tube, one-family house, for combined system	UncertaintyType	StandardDeviation95%	GeneralComment
	Location				*CH*	*CH*	*CH*	*CH*	*CH*	*CH*	*CH*	*CH*	*CH*			
	InfrastructureProcess				*0*	*0*	*0*	*0*	*0*	*0*	*0*	*0*	*0*			
	Unit				*MJ*	*MJ*	*MJ*	*MJ*	*MJ*	*MJ*	*MJ*	*MJ*	*MJ*			
resource, in air	Energy, solar, converted	-	-	MJ	1.28E+0	1.57E+0	1.12E+0	1.13E+0	1.14E+0	1.13E+0	1.08E+0	1.51E+0	1.51E+0	1	1.07	(2,na,1,1,1,na); Includes losses in the system
technosphere	electricity, low voltage, at grid	CH	0	kWh	1.50E-2	9.46E-3	4.05E-3	3.15E-3	3.25E-3	3.15E-3	6.08E-3	7.58E-3	7.58E-3	1	1.07	(2,na,1,1,1,na); Simulation
	solar system, 5 m2 Cu flat plate collector, one-family house, hot water	CH	1	unit	6.25E-6	-	-	-	-	-	-	-	-	1	3.00	(2,na,1,1,1,na); Simulation
	solar system, 12 m2 Cu flat plate collector, one-family house, combined system	CH	1	unit	-	3.63E-6	-	-	-	-	-	-	-	1	3.00	(2,na,1,1,1,na); Simulation
	solar system, 20 m2 Cu flat plate collector, on slanted roof, hot water	CH	1	unit	-	-	1.11E-6	-	-	-	-	-	-	1	3.00	(2,na,1,1,1,na); Simulation
	solar system, 30 m2 Cu flat plate collector, on slanted roof, hot water	CH	1	unit	-	-	-	8.17E-7	-	-	-	-	-	1	3.00	(2,na,1,1,1,na); Simulation
	solar system, 30 m2 Cu flat plate collector, on flat roof, hot water	CH	1	unit	-	-	-	-	8.22E-7	-	-	-	-	1	3.00	(2,na,1,1,1,na); Simulation
	solar system, 30 m2 Al-Cu flat plate collector, on slanted roof, hot water	CH	1	unit	-	-	-	-	-	8.17E-7	-	-	-	1	3.00	(2,na,1,1,1,na); Simulation
	solar system, 81 m2 Cu flat plate collector, multiple dwelling, hot water	CH	1	unit	-	-	-	-	-	-	2.59E-7	-	-	1	3.00	(2,na,1,1,1,na); Simulation
	solar system, 10.5 m2 evacuated tube collector, one-family house, combined system	CH	1	unit	-	-	-	-	-	-	-	2.75E-6	3.44E-6	1	3.00	(2,na,1,1,1,na); Simulation
	transport, van <3.5t	CH	0	tkm	4.22E-4	2.45E-4	7.52E-5	5.52E-5	5.55E-5	5.52E-5	1.75E-5	1.86E-4	1.86E-4	1	3.00	(2,na,1,1,1,na); 250km per plant for maintenance
emission air, high population density	Heat, waste	-	-	MJ	1.34E+0	1.61E+0	1.14E+0	1.14E+0	1.16E+0	1.14E+0	1.10E+0	1.54E+0	1.54E+0	1	1.07	(2,na,1,1,1,na); Simulation and solar energy

Tab. 3.3 EcoSpold meta information of the supply of useful heat from solar thermal systems without considering auxiliary heating

Name	heat, at 5 m2 Cu collector, one-family house, for hot water	heat, at 10.5 m2 evacuated tube collector, heat pipe, one-family house, for combined system	heat, at 10.5 m2 evacuated tube collector, glass-glass tube, one-family house, for combined system	heat, at 12 m2 Cu collector, one-family house, for combined system	heat, at 20 m2 Cu collector, multiple dwelling, slanted roof, for hot water	heat, at 30 m2 Cu collector, multiple dwelling, slanted roof, for hot water	heat, at 30 m2 Cu collector, multiple dwelling, flat roof, for hot water	heat, at 30 m2 Al-Cu collector, multiple dwelling, slanted roof, for hot water	heat, at 81 m2 Cu collector, multiple dwelling, for hot water
Location	CH	CH	CH	CH	CH	CH	CH	CH	CH
InfrastructureProcess	0	0	0	0	0	0	0	0	0
Unit	MJ	MJ	MJ	MJ	MJ	MJ	MJ	MJ	MJ
IncludedProcesses	Delivery of heat with a solar system including maintenance and electricity use for operation. Excluding the necessary auxiliary heating.	Delivery of heat with a solar system including maintenance and electricity use for operation. Excluding the necessary auxiliary heating.	Delivery of heat with a solar system including maintenance and electricity use for operation. Excluding the necessary auxiliary heating. Rough assumption for a glass-glass tube collector system by considering a heat pipe system correcting the life time from 25 years to 20 years.	Delivery of heat with a solar system including maintenance and electricity use for operation. Excluding the necessary auxiliary heating.	Delivery of heat with a solar system including maintenance and electricity use for operation. Excluding the necessary auxiliary heating.	Delivery of heat with a solar system including maintenance and electricity use for operation. Excluding the necessary auxiliary heating.	Delivery of heat with a solar system including maintenance and electricity use for operation. Excluding the necessary auxiliary heating.	Delivery of heat with a solar system including maintenance and electricity use for operation. Excluding the necessary auxiliary heating.	Delivery of heat with a solar system including maintenance and electricity use for operation. Excluding the necessary auxiliary heating.
LocalName	Nutzwärme, ab 5 m2 Kollektoranlage, EFH, für Warmwasserspeicher	Nutzwärme, ab 10.5 m2 Vakuumröhrenkollektoranlage, Wärmeröhren, EFH, für Wärmespeicher	Nutzwärme, ab 10.5 m2 Vakuumröhrenkollektoranlage, Sidneyröhren, EFH, für Wärmespeicher	Nutzwärme, ab 12 m2 Cu-Kollektoranlage, EFH, für Wärmespeicher	Nutzwärme, ab 20 m2 Cu-Kollektoranlage, auf Schrägdach, für Warmwasserspeicher	Nutzwärme, ab 30 m2 Cu-Kollektoranlage, auf Schrägdach, für Warmwasserspeicher	Nutzwärme, ab 30 m2 CU-Kollektoranlage, auf Flachdach, für Warmwasserspeicher	Nutzwärme, ab 30 m2 Al-Cu-Kollektoranl., auf Schrägdach, für Warmwasserspeicher	Nutzwärme, ab 81 m2 Cu-Kollektoranlage, MFH, für Warmwasserspeicher
Synonyms			Sidney collector, China collector						
GeneralComment	Use of a solar system excluding the necessary auxiliary heating. The simulation is made for solar collector systems in the city of Zurich. The annual irradiation amounts to 1249 kWh/m^2. 65% solar fraction, 30° inclination, 22° southeast orientation.	Use of a solar system with heat pipes excluding the necessary auxiliary heating. The simulation is made for solar collector systems in the city of Zurich. The annual irradiation amounts to 1249 kWh/m^2. 33% solar fraction, 35° inclination, 22° southeast orientation.	Use of a solar system with glass-glass pipes excluding the necessary auxiliary heating. The simulation is made for heat pipe solar collector systems in the city of Zurich. The annual irradiation amounts to 1249 kWh/m^2. 33% solar fraction, 35° inclination, 22° southeast orientation.	Use of a solar system excluding the necessary auxiliary heating. The simulation is made for solar collector systems in the city of Zurich. The annual irradiation amounts to 1249 kWh/m^2. 28% solar fraction, 35° inclination, 22° southeast orientation.	Use of a solar system excluding the necessary auxiliary heating. The simulation is made for solar collector systems in the city of Zurich. The annual irradiation amounts to 1249 kWh/m^2. 37% solar fraction, 30° inclination, 22° southeast orientation.	Use of a solar system excluding the necessary auxiliary heating. The simulation is made for solar collector systems in the city of Zurich. The annual irradiation amounts to 1249 kWh/m^2. 50% solar fraction, 30° inclination, 22° southeast orientation.	Use of a solar system excluding the necessary auxiliary heating. The simulation is made for solar collector systems in the city of Zurich. The annual irradiation amounts to 1249 kWh/m^2. 50% solar fraction, 30° inclination, 22° southeast orientation.	Use of a solar system excluding the necessary auxiliary heating. The simulation is made for solar collector systems in the city of Zurich. The annual irradiation amounts to 1249 kWh/m^2. 50% solar fraction, 30° inclination, 22° southeast orientation.	Use of a solar system excluding the necessary auxiliary heating. The simulation is made for solar collector systems in the city of Zurich. The annual irradiation amounts to 1249 kWh/m^2. 40% solar fraction, 30° inclination, 22° southeast orientation.
Category	solar collector systems	solar collector systems	solar collector systems	solar collector systems	solar collector systems	solar collector systems	solar collector systems	solar collector systems	solar collector systems
SubCategory	systems	systems	systems	systems	systems	systems	systems	systems	systems
LocalCategory	Sonnenkollektoranlagen	Sonnenkollektoranlagen	Sonnenkollektoranlagen	Sonnenkollektoranlagen	Sonnenkollektoranlagen	Sonnenkollektoranlagen	Sonnenkollektoranlagen	Sonnenkollektoranlagen	Sonnenkollektoranlagen
LocalSubCategory	Kollektorsysteme	Kollektorsysteme	Kollektorsysteme	Kollektorsysteme	Kollektorsysteme	Kollektorsysteme	Kollektorsysteme	Kollektorsysteme	Kollektorsysteme
Formula									
StatisticalClassification									
CASNumber									
StartDate	2010	2010	2010	2010	2010	2010	2010	2010	2010
EndDate	2010	2010	2010	2010	2010	2010	2010	2010	2010
OtherPeriodText	Time of simulation.	Time of simulation.	Time of simulation.	Time of simulation.	Time of simulation.	Time of simulation.	Time of simulation.	Time of simulation.	Time of simulation.
Text	Solar collector system operated in CH.	Solar collector system operated in CH.	Solar collector system operated in CH.	Solar collector system operated in CH.	Solar collector system operated in CH.	Solar collector system operated in CH.	Solar collector system operated in CH.	Solar collector system operated in CH.	Solar collector system operated in CH.
Text	Solar collector system for hot water installed on the roof of a house.	Solar collector system for hot water installed on the roof of a house.	Solar collector system for hot water installed on the roof of a house.	Solar collector system for hot water installed on the roof of a house.	Solar collector system for hot water installed on the roof of a house.	Solar collector system for hot water installed on the roof of a house.	Solar collector system for hot water installed on the roof of a house.	Solar collector system for hot water installed on the roof of a house.	Solar collector system for hot water installed on the roof of a house.
Percent									
ProductionVolume	Total heat delivered by flat plate collectors in CH in 2008 was 213'500 MWh.	Total solar heat delivered by evacuated tube collectors in 2001 was 2.3TJ.	Total solar heat delivered by evacuated tube collectors in 2001 was 2.3TJ.	Total heat delivered by flat plate collectors in CH in 2008 was 213'500 MWh.	Total heat delivered by flat plate collectors in CH in 2008 was 213'500 MWh.	Total heat delivered by flat plate collectors in CH in 2008 was 213'500 MWh.	Total heat delivered by flat plate collectors in CH in 2008 was 213'500 MWh.	Total heat delivered by flat plate collectors in CH in 2008 was 213'500 MWh.	Total heat delivered by flat plate collectors in CH in 2008 was 213'500 MWh.
SamplingProcedure	Own simulation.	Own simulation.	Own simulation.	Own simulation.	Own simulation.	Own simulation.	Own simulation.	Own simulation.	Own simulation.
Extrapolations	none	none	none	none	none	none	none	none	none

4 Data quality considerations

The data of the amount of material for the production of the flat plate collector with an aluminium-copper production are up to date and of good quality, since they stem directly from a manufacturer. The data of the production and operation of the solar thermal systems are based on a simulation data received from the Zurich Department of Industrial Services that is considered as a reliable source.

The assumption of the lifetime of the solar thermal systems has a direct proportional impact on the material inputs. This lifetime can differ considerably from our assumption and statistical information about the average lifetime of solar thermal systems is not available.

The dataset of heat from a system with a glass-glass tube collector is approximated by considering an evacuated tube collector system with heat pipes and an adjusted life time of 20 years. This assumption needs to be considered when comparing heat from different evacuated tube collectors. In order to compare specific alternatives of solar thermal systems, it might be reasonable to adjust the life time of the system.

The datasets of solar thermal systems in this report represent case studies of typical installations in the city of Zurich (Switzerland) and do not reflect a representative average of solar collectors in Switzerland. It is recommended to use the transparent unit process data presented in this report in order to model case-specific solar thermal installations. In particular it is reasonable to calculate the datasets of heat from solar thermal installations with the case-specific solar net yield.

The data quality indicators and the standard deviation are determined with the aid of the pedigree matrix used for the ecoinvent database (Frischknecht et al. 2007).

5 Outlook

An assessment of the life cycle impacts on the environment from the solar thermal systems described in this report is presented and discussed in a separate report (Stucki & Jungbluth 2010).

As yet, no ecoinvent datasets of unglazed collectors are established. Unglazed collectors cover metal collectors and plastic collectors, which are typically used for heating swimming pools and for preheating of hot water. According to Hostettler (2010), unglazed solar thermal systems with a total area of 9’749 m^2 and a total capacity of 7.8 MW were sold in Switzerland in 2009. Hence, it would be appropriate to include such systems in the ecoinvent database.

The projected lifetime is a key parameter for the assessment. Thus, future updates could include a survey of statistical data of the actual experienced lifetime of solar thermal systems.

The current ecoinvent datasets of the operation of solar thermal systems consider only installations in Switzerland. Ecoinvent datasets of the operation in other countries with differing climate situations and higher or lower solar irradiation as well as a using a different electricity mix should be established.

Since the copper content of the absorber has a considerable share in the total environmental impacts, the share of recycling copper used for the production of absorbers should be analysed. Furthermore, also the share of used recycling aluminium could be investigated.

So far, no sufficient data exist for the end of life treatment of solar thermal systems. The environmental impacts caused by dismantling, transport to recycling plant and further treatment should be investigated as soon as reliable data are available.

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Annex

Tab. A. 1 Basic information for the life cycle inventory of solar thermal systems (based on a simulation with the Polysun software): Part 1

		WW+Heizung	Wassererwärmung							
Parameter	**Grösse**	**0 EFH-Anlage Deckungsgrad 28% bei 8 kW Heizung**	**1 EFH-Anlage Deckungsgrad 65% Schrägdach**	**2 MFH-WW-Anlage Deckungsgrad 37% Schrägdach**	**3 MFH-WW-Anlage Deckungsgrad 50% Schrägdach**	**4 MFH-WW-Anlage Deckungsgrad 50% Schrägdach mit CU/ALU-Absorber**	**5 MFH-WW-Anlage Deckungsgrad 50% Flachdach**	**6 MFH-WW-Anlage Deckungsgrad 60% Schrägdach**	**7 MFH-Grossanlage für WW, Deckungsgrad**	
Anzahl Personen (langjähriges Mittel)		3	3	25	25	25	25	25	100	
Energiebedarf Warmwasser, resp. WW + Heizung (Output Speicher inkl. Zirkulation und Leitungsverluste)	kWh/a	16'000	2'531	24'500	24'500	24'500	24'500	24'500	89'000	davon 15% als Heizanteil (Zirkulation), ausser EFH
Absorberfläche	m2	12	5	20	30	30	30	39	81	
Neigung und Orientierung Kollektor	°Grad	35° Neigung/ 22° Südost	30° Neigung/ 22° Südost	30° Neigung/ 22° Südost	30° Neigung/ 22° Südost	30° Neigung/ 22° Südost	30° Neigung/ 22° Südost	30° Neigung/ 22° Südost	30° Neigung/ 22° Südost	
Spezifische Einstrahlung auf die Absorberfläche am Standort Zürich (aus Polysun)	kWh/a	1249	1249	1249	1249	1249	1249	1239	1229	
Jahresnutzungsgrad Sonnenkollektoren	%	32.2	36.6	44.8	41.1	41.1	41.3	37.4	46.5	
Spezifischer Kollektorertrag (PEF = 1) (=spez. Einstrahlung x Jahresnutzungsgrad)	kWh/m2 a	402	457	559	513	513	516	463	572	Output Kollektor
Kollektor-Jahresertrag total (PEF = 1) (=Spez. Kollektorertrag x Absorberfläche)	kWh/a	4824	2284	11'186	15'387	15'387	15'473	18'067	46'303	
Länge Verrohrung Solarkreis (Vorlauf und Rücklauf)	m	35	32	51	57	57	65	66	141	
Spez. Wärmeverlust Solarkreis	kWh/m a	22.5	8.6	15.1	18.0	18.0	18.4	18.5	19.6	davon 20% als Heizanteil
Wärmeverluste Solarkreis (=Länge Solarkreis x spez. Wärmeverluste)	kWh/a	786	275	768	1028	1028	1198	1223	2766	davon 20% als Heizanteil
Solarer Bruttoertrag (Kollektorertrag - Wärmeverluste Solarkreis)	kWh/a	4'038	2'009	10'418	14'359	14'359	14'275	16'844	43'537	
Spezifischer solarer Bruttoertrag (Solarer Bruttoertrag/Absorberfläche)	kWh/m2a	350	402	521	479	479	476	432	537	
Nachwärmeenergie Kessel (Input Speicher) unter Berücksichtigung Jahresbereitschaftszeit	kWh/a	12347	1'206	18'638	14'902	14'902	14'988	11'788	67'422	
Einsparung Kessel-Bereitschaftsverluste im Sommer (Schätzung)	kWh/a	1000	800	0	0	0	0	2'000	0	
Solarer Deckungsgrad	%	28	65	37	51	51	51	60	40	
Volumen Wassererwärmer Solar (nur Solarteil)	l	0	200	800	1500	1500	1500	2000	200	
Volumen Bereitschaftsspeicher (entspricht Speichervolumen einer konv. Referenzvariante)	l	200 integriert	300	600	800	800	800	800	1000	
Volumen Energiespeicher (gehört zum Solarteil)	l	1400 (-200)	0	0	0	0	0	0	4000	
Differenz Speicherinhalt Solarvariante zu Referenzvariante	l	1100	200	800	1500	1500	1500	2000	4200	
Speicherverluste total	kWh/a	1395	650	1628	1989	1989	1974	1964	2094	
Speicherverluste einer vergleichbaren Referenzvariante ohne Solarenergie	kWh/a	420	420	1182	1222	1222	1222	1222	1400	
Speicherverluste "solarer Anteil" (Differenz Speicherverluste total zu Referenzvariante)	kWh/a	975	230	446	767	767	752	742	694	Heizanteil möglich
Solarer Nettoertrag (= Solarer Bruttoertrag - Speicherverluste solarer Anteil)	kWh/a	3'063	1'779	9'972	13'592	13'592	13'523	16'102	42'843	
Solarer Nettoertrag über die Lebensdauer	kWh	76'575	44'475	249'300	339'800	339'800	338'075	402'550	1'071'075	bei 25 Jahren/Alterung 10%
Verhältnis solarer Nettoertrag zu Kollektorertrag (zentraler Wert für Berechung PEF!)	%									
Stromaufnahme Solar-Regelung (8760 h/a)	W	3	3	3	3	3	3	3	10	
Leistung Solarkreis-Pumpe	W	60	50	60	70	70	70	90	500	
Betriebsstunden Pumpe[3]	h/a	1300	1400	1700	1600	1600	1650	1500	1700	Var. 7 Ø mehrerer Pumpen
Lebensdauer Solaranlage	a	25	25	25	25	25	25	25	25	
Spezifischer Hilfsenergieverbrauch (= 24*25+23*8760)	kWh/a	104	96	145	154	154	158	161	938	
Materialien und Massen Gehäuse, Wärmedämmung und Verglasung Kollektor[2]										
Absorber Werkstoff 1		Kupfer	Kupfer	Kupfer	Kupfer	Kupfer	Kupfer	Kupfer	Kupfer	
Absorber Werkstoff 2		-	-	-	-	Aluminium	-	-	-	
Spezifische Masse des Absorbers, Werkstoff 1	kg/m2	3.6	3.6	3.6	3.6	1.6	3.6	3.6	3.6	
Spezifische Masse des Absorbers, Werkstoff 2	kg/m2		-	-	-	1.35	-	-	-	
Werkstoff 1 Fundation		Alublech lackiert	Alublech lackiert	Alublech lackiert	Alublech lackiert	Alublech lackiert	Stahl verzinkt	Alublech lackiert	Alublech lackiert	
Werkstoff 2 Fundation		-	-		-	-	Beton	-	-	
Spez. Masse Werkstoff 1	kg/m2	1.2	1.6	0.9	0.7	0.7	4	0.6	0.5	
Spez. Masse Werkstoff 2	kg/m2	-	-	-	-	-	50	-	-	
Werkstoff Verrohrung		Chromstahl	Kupfer	Chromstahl-Wellrohr	Chromstahl-Wellrohr	Chromstahl-Wellrohr	Chromstahl-Wellrohr	Chromstahl-Wellrohr	Kupfer	Var. 2-6: z.B. Armaflex
Dimension Verrohrung (Aussendurchmesser, Wandsstärke)	mm	25 x 0.4	12 x 0.8	25 x 0.5	28 x 0.5	28 x 0.5	28 x 0.5	28 x 0.5	28 x 1.2	
Spez. Masse Verrohrung	kg/m									

Tab. A. 2 Basic information for the life cycle inventory of solar thermal systems (based on a simulation with the Polysun software): Part 2

Parameter	Grösse	WW+Heizung	Wassererwärmung							
		0 EFH-Anlage Deckungsgrad 28% bei 8 kW Heizung	1 EFH-Anlage Deckungsgrad 65% Schrägdach	2 MFH-WW-Anlage Deckungsgrad 37% Schrägdach	3 MFH-WW-Anlage Deckungsgrad 50% Schrägdach	4 MFH-WW-Anlage Deckungsgrad 50% Schrägdach mit CU/ALU-Absorber	5 MFH-WW-Anlage Deckungsgrad 50% Flachdach	6 MFH-WW-Anlage Deckungsgrad 60% Schrägdach	7 MFH-Grossanlage für WW, Deckungsgrad	
Anzahl Personen (langjähriges Mittel)		3	3	25	25	25	25	25	100	
Werkstoff Wärmetauscher (intern oder extern)		Stahl 37		Stahl 37 emailliert						
Masse Wärmetauscher (Summe aller Tauscher nur Mehraufwand zu konv. Variante)	kg	25		90						
Werkstoff und Masse Expansionsgefäss[2]										
Volumen Expansionsgefäss	l	50	35	80	140	140	140	200	400	400 l Expansion im Dach
Werkstoff Wassererwärmer solar		-	Stahl emailliert	Stahl emailliert	Chromstahl	Chromstahl	Chromstahl	Chromstahl	-	
Werkstoff Bereitschaftsspeicher (wird nicht in Rechnung einbezogen!)		Chromstahl	-	Stahl emailliert	Chromstahl	Chromstahl	Chromstahl	Chromstahl	Chromstahl	nicht relevant für Solarteil
Werkstoff Energiespeicher		Stahl 37	-	-	-	-	-	-	Stahl 37	
Masse Wassererwärmer solar	kg									
Masse Bereitschaftspeicher (wird nicht in Rechnung einbezogen!)	kg									nicht relevant für Solarteil
Masse Energiespeicher	kg									
Dimension Wärmedämmung Leitungen (Dämmstärke)	mm	20 (Rohr-an-Rohr)	20 (Rohr-an-Rohr)	20 (Rohr-an-Rohr)	20 (Rohr-an-Rohr)	20 (Rohr-an-Rohr)	20 (Rohr-an-Rohr)	20 (Rohr-an-Rohr)	30	
Werkstoff Wärmedämmung Leitungen		EPDM-Schaum	EPDM-Schaum	EPDM-Schaum	EPDM-Schaum	EPDM-Schaum	EPDM-Schaum	EPDM-Schaum	Mineralwolle	
Spezifische Masse Wärmedämmung Leitungen	kg/m									
Werkstoff Ummantelung Wärmedämmung Leitungen		PE/Glasfasergeflecht	E/Glasfasergeflecht	PE/Glasfasergeflecht	PE/Glasfasergeflecht	PE/Glasfasergeflecht	PE/Glasfasergeflecht	PE/Glasfasergeflecht	Alu	
Spezifische Masse Ummantelung Leitungen	kg/m									
Werkstoff Rohrleitungsbefestigung		wie gehabt	wie gehabt	wie gehabt	wie gehabt	wie gehabt	wie gehabt	wie gehabt	wie gehabt	
Gewicht Rohrleitungsbefestigung	kg	wie gehabt	wie gehabt	wie gehabt	wie gehabt	wie gehabt	wie gehabt	wie gehabt	wie gehabt	
Dimension Wärmedämmung Speicher solar	mm	-	80	80	80	80	80	100	160	
Dimension Wärmedämmung Bereitschaftsspeicher	mm	80	80	80	80	80	80	80	80	nicht relevant für Solarteil
Dimension Wärmedämmung Energiesspeicher	mm		-							
Werkstoff Wärmedämmung Speicher solar			PU-Hartschaum	PU-Hartschaum	PU-Hartschaum	PU-Hartschaum	PU-Hartschaum	PU-Hartschaum	PU-Hartschaum	
Werkstoff Wärmedämmung Bereitschaftsspeicher		-	PU-Hartschaum	PU-Hartschaum	PU-Hartschaum	PU-Hartschaum	PU-Hartschaum	PU-Hartschaum	PU-Hartschaum	nicht relevant für Solarteil
Werkstoff Wärmedämmung Energiesspeicher		PU-Hartschaum							Mineralwolle	
Masse Wärmedämmung Speicher solar	kg									
Masse Wärmedämmung Bereitschaftsspeicher	kg									
Masse Wärmedämmung Energiespeicher	kg									
Werkstoff Ummantelung Wärmedämmung Wassererwärmer		-	Kunststoff	Kunststoff	Kunststoff	Kunststoff	Kunststoff	Kunststoff	Kunststoff	
Werkstoff Ummantelung Wärmedämmung Bereitschaftsspeicher			Kunststoff	Kunststoff	Kunststoff	Kunststoff	Kunststoff	Kunststoff	Kunststoff	nicht relevant für Solarteil
Werkstoff Ummantelung Wärmedämmung Energiespeicher		Kunststoff							Alu-Blech	
Masse Ummantelung Speicher solar	kg									
Masse Ummantelung Bereitschaftsspeicher	kg									
Masse Ummantelung Energiespeicher	kg									
Werkstoffe, Massen für Elektroleitungen, Steuerung		wie gehabt	wie gehabt	wie gehabt	wie gehabt	wie gehabt	wie gehabt	wie gehabt	wie gehabt	
Wärmeträgerflüssigkeit im Solarkreis (Glykol 35%)	l	25	10	30	35	35	35	40	50	

[1] Verluste infolge Rückkühlung bei Überhitzung sind bereits eingerechnet!
[2] Grundsätzlich Werte aus Bilanzierung 2003 verwenden, aber vorgängig überprüfen.
[3] Bemerkung 2010: Rückkühlung wird meist nicht mehr angewandt

EFH-Systeme 3 Personen
MFH-Systeme 25 Personen
MFH-System 100 Personen

20.04.2010/ Marti Energietechnik