Reference System, Austria
Solar Domestic Hot Water System for Multi-Family House

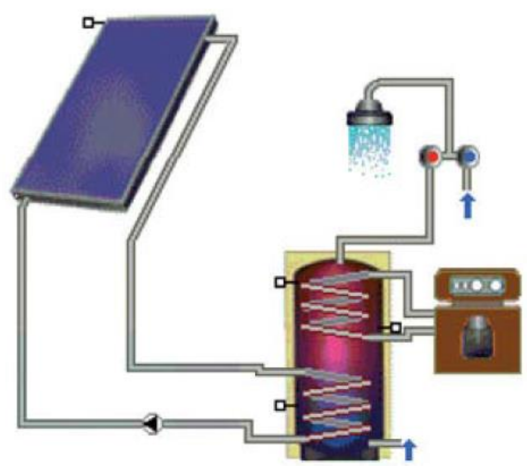
INFO Sheet A06

Description:	*Definition of the reference solar domestic hot water (SDHW) system for multi-family house (MFH), Austria*
Date:	30.11.2016, revised 10.04.2018[1]
Authors:	Thomas Ramschak (AEE INTEC), François Veynandt (AEE INTEC)
Download possible at:	http://task54.iea-shc.org/

Introduction

This document describes the reference solar domestic hot water (SDHW) system for domestic hot water preparation in a multi-family house (MFH) in Austria. The system is modelled with TSol to calculate the fuel consumption and electric energy, as well as the substituted fuel provided by the SDHW system, which are needed to provide the required domestic hot water and space heating. Using this result the levelized costs of heat (LCoH) for the substituted fuel is calculated using Equation 1, with the reference costs for the investment of the system, installation costs, fuel and electricity costs.

Hydraulic Scheme of the System



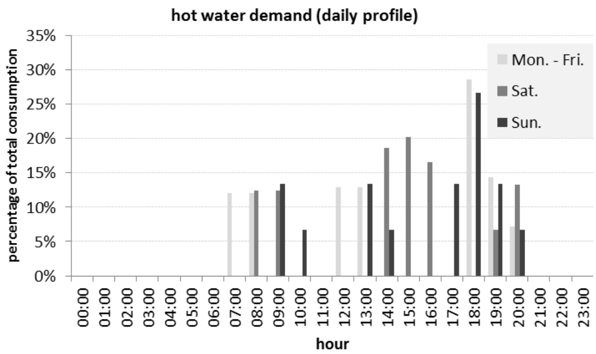
Key data	
Collector area (one collector)	2.5 m²
Heat store volume	4 000 l
Location	Austria, Graz
Hemispherical irradiance on horizontal surface	$\Sigma G_{hem,hor}$ =1126 kWh/(m^2 a)
Lifetime of system	25 years

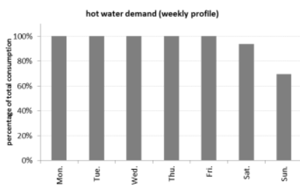
Levelized Cost of Heat (LCoH)

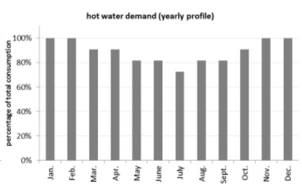
LCoHs solar part without VAT	**0.0564 €/kWh**
LCoHc conventional part without VAT	**0.0733 €/kWh**
LCoHo complete system without VAT	**0.0707 €/kWh**

Details of the System

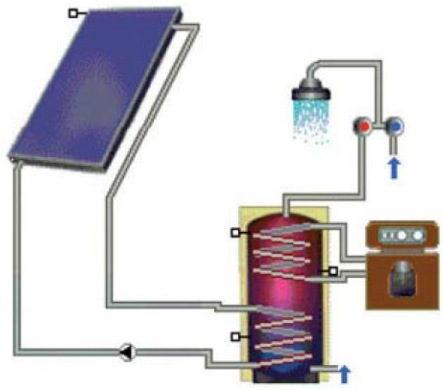
Location	Austria, Graz
Type of system	Solar domestic hot water (SDHW) system
Weather data including - Hemispherical irradiance on horizontal surface - Beam irradiance on horizontal surface - Diffuse irradiance on horizontal surface - Ambient temperature in hourly values	TSol $\Sigma G_{hem,hor}$ =1126 kWh/(m^2 a) $\Sigma G_{beam,hor}$ = 482 kWh/(m^2 a) $\Sigma G_{diff,hor}$ = 644 kWh/m^2 a) $T_{amb,av}$ = 9.2 °C
Collector orientation - Collector tilt angle to horizontal - South deviation of collector - Ground reflectance - Resulting hemispherical irradiance on tilted surface	 35 ° south = 0° 0.2 $\Sigma G_{hem,tilt}$ =1280 kWh/(m^2 a)
Load information including - Heat demand space heating - Tapping profile	 110.4 MWh/a [1] 42.53 MWh/a [1]







- Tapping temperature - Average inlet temperature of cold water - Cold water inlet temperature amplitude	60°C 9.6 °C 0 K

Hydraulic scheme of the system	
Collector information based on gross area	**T*SOL Database Standard Flat-Plate Collector**
Number of collectors	25
Collector area of one collector	2.0 m²
Maximum collector efficiency	0.8
Incidence angle modifier for direct irradiance b_0	0.88 (at 50°)
Incidence angle modifier for diffuse irradiance K_d	0.83
Linear heat loss coefficient a_1	3.69 W/(m²K)
2nd order heat loss coefficient a_2	0.007 W/(m²K²)
Effective heat capacity c_{eff}	6.0 kJ/(m²K)
Heat store parameters	**T*SOL Database**
Heat store volume	4000 l
Auxiliary volume for DHW preparation	1600 l
Store inner diameter	1.5 m
Rel. Height of solar inlet	0.4
Rel. Height of solar outlet	0.02
Rel. Height of auxiliary inlet	0.95
Rel. Height of auxiliary outlet	0.6
Rel. Height of sensor for collector loop	0.19
Rel. Height of sensor for auxiliary heating	0.75
Set temperature for DHW	60.0 °C +- 3 K
Overall heat loss capacity rate of store	7.7 W/K
Effective vertical conductivity	1.2 W/(mK)
Heat transfer capacity rate of solar loop HX	$(kA)_{WT,Sol}$ = 4000 [W/K]
Heat transfer capacity rate of auxiliary loop HX	$(kA)_{WT,Aux}$ = 4000 [W/K]
Volume solar loop HX (Heat eXchanger)	-
Volume auxiliary loop HX	-
Maximum heat store temperature	90 °C
Ambient temperature of heat store	15 °C
Solar thermal controller and hydraulic piping	
Total pipe length of collector loop	23 m
Inner diameter of collector loop pipe	15 mm
Mass flow collector loop	40 kg/(m²h), constant
Temperature difference collector start-up	8 K

Temperature difference collector shut-off	3 K
Electric power of solar thermal controller	3 W
Operating hours of solar thermal controller per year	8760 h
Electric consumption of controller per year	26.3 kWh
Electric power of solar loop pump	25 W
Operating hours of solar loop pump	2760 h
Electric consumption of solar loop pump per year	69 kWh
Conventional back up system	
Type of auxiliary heating	Oil boiler
Boiler capacity	52 kW
Mass flow	-
Efficiency factor of boiler	0.85
Electric power of controller	3 W
Operating hours of controller per year	8760
Electric consumption of controller per year	26.3 kWh
Electric power of pump	12 W
Operating hours of pump (aux. Heating + space heating)	4190 h
Electric consumption of pump per year	50.3 kWh
Investment costs conventional part	
Overall investment costs	18500 €
Investment costs solar thermal system	
Solar thermal collector, heat store, solar thermal controller solar thermal hydraulic components	25150 € [2]
Installation	6300 € [2]
Credit conventional heat store and share of installation	-4710 € [2]
Overall investment costs solar thermal part I_0	26740 €
Operation costs conventional part per year	
Heat demand hot water	19790 kWh/a
Fuel demand hot water	23282 kWh/a
Heat demand space heating	110400 kWh/a
Fuel demand space heating	129882 kWh/a
Fuel demand hot water + space heating E_t	153165 kWh/a
Cost per kWh fuel (oil)	0.066 €/kWh [3]
Fuel costs	10109 €/a
Electricity demand	76.56 kWh/a
Cost per kWh electric energy	0.17 € [4]
Electricity costs	13 €/a
Maintenance costs	370 €/a
Yearly operation and maintenance cost conventional part C_t	10492 €
Operation costs solar part per year	
Electricity demand	95.3 kWh/a
Cost per kWh electric energy	0.17 € [4]
Electricity costs	16.2 €/a

Maintenance costs (I_0 * 2%)	535 €/a
Yearly operation and maintenance cost solar part C_t	551 €/a
Fractional energy savings with credit for 1600L-store, UA=6.4 W/K	55.2 %
Saved final energy (year t) E_t	28732 kWh
Type of incentives	None
Amount of incentives	0 €
Lifetime of system	25 year
Discount rate r	0 %
Inflation rate	0 %
Corporate tax rate TR	0 %
Asset depreciation (year t) dep_t	0 €
Subsidies and incentives (year t) S_t (considered in I_0)	0 €
Residual value RV	0 €
Discount rate r	0 %
VAT rate	20 %
LCoHs solar part without VAT	**0.0564 €/kWh**
LCoHc conventional part without VAT	**0.0733 €/kWh**
LCoHo complete system without VAT	**0.0707 €/kWh**

Calculation of levelized cost LCoH [5,6]:

$$LCoH = \frac{I_0 + \sum_{t=0}^{T} \frac{C_t(1-TR) - DEP_t \cdot TR - S_t - RV}{(1+r)^t}}{\sum_{t=1}^{T} \frac{E_t}{(1+r)^t}} \quad (1)$$

Where:

$LCoH$: Levelized cost of heat in €/kWh
I_0: Initial investment in €
C_t: Operation and maintenance costs (year t) in €
TR: Corporate tax rate in %
DEP_t: Asset depreciation (year t) in €
S_t: Subsidies and incentives (year t) in €
RV: Residual value in €
E_t: Saved final energy (year t)/Fuel demand in kWh
r: Discount rate in %
T: Period of analysis in years

Annex: Comparison to Figures Published in Solar Heat Worldwide

To compare the above presented LCoH based on the saved final energy with the $LoCH_{SHWW}$ presented in Solar Heat World Wide based on the collector yield (I_0 without considering the conventional part, C_t: 0.5% of I_0, E_t solar collector yield, r: 3%, T: 25 years) the following table is presented:

Collector yield (year t) E_t	24760 kWh
$LCoH_{SHWW}$ solar part without VAT	**0.0793 €/kWh_{th}**

References

[1] AEE INTEC.

[2] VOLLKOSTENVERGLEICH für neue Heizsysteme in Österreich - ÖNORM M7140, 21.10.2016 (https://www.wko.at/Content.Node/branchen/oe/Mineraloelindustrie/Vollkostenvergleich-Heizungen-nach-OENORM.pdf).

[3] Mauthner F., Weiss, W., Spörk-Dür, M. (2014): "*Solar Heat Worldwide - Markets and Contribution to the Energy Supply 2014 - 2016 EDITION*".

[4] Oesterreichs Energie - Strompreis (http://oesterreichsenergie.at/daten-fakten/statistik/Strompreis.html).

[5] Louvet, Y., Fischer, S. et. al. (2017): "*IEA SHC Task 54 Info Sheet A1: Guideline for levelized cost of heat (LCoH) calculations for solar thermal applications*". URL: http://task54.iea-shc.org/.

[6] Louvet, Y., Fischer, S. et.al. (2017): "*Entwicklung einer Richtlinie für die Wirtschaftlichkeitsberechnung solarthermischer Anlagen: die LCoH Methode*." Symposium Thermische Solarenergie, Bad Staffelstein.

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[1] To avoid confusion with the results of other works ([1], [8], [9]) also using the notion of LCoH for solar thermal systems, new acronyms were introduced in this Info Sheet. As previous studies have considered different assumptions for the definition of the terms of the LCoH equation, it does not make sense to compare the values they obtained with the LCoHs, LCoHc and LCoHo values defined here. A detailed explanation of the differences between the approaches chosen in the framework of IEA-SHC Task 54 and in the Solar Heat Worldwide report [9] can be found in Info Sheet A13 [10].