Description:	*Description of the conventional reference system for domestic hot water preparation and space heating in Germany*
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Download possible at:	http://task54.iea-shc.org/

Introduction

This document describes the conventional reference system for domestic hot water preparation and space heating in Germany. The system is modelled with TRNSYS to calculate the fuel consumption and electric energy needed to provide the required domestic hot water and space heating. Using this result the levelized costs of heating (LCoH) for the conventional reference system for Germany is calculated using Eq. 1 and the reference costs for the investment of the system, installation costs, fuel and electricity costs.

Hydraulic Scheme of the System
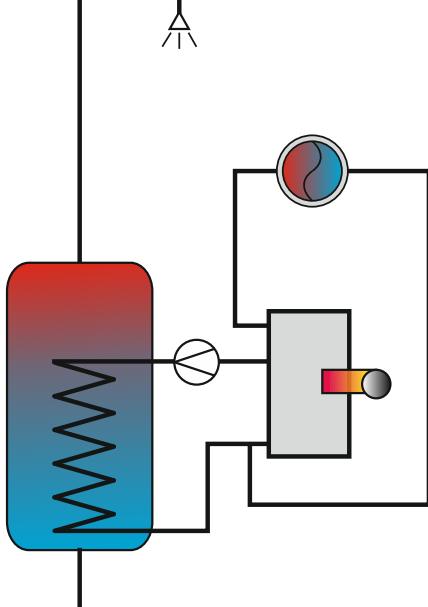
Key data	
Heat store volume	150 l
Location	Germany, Würzburg
Lifetime of system	20 years

Levelized Cost of Heat (LCoH)

LCoHc without VAT	**0.112 €/kWh**

Details of the System

Location	Germany, Würzburg
Type of system	Domestic hot water and space heating system
Load information including - Heat demand space heating - Tapping profile - Store heat losses - Tapping temperature - Average inlet temperature of cold water - Cold water inlet temperature amplitude	 9090 kWh/a /1/ EU-tapping profile L (4254 kWh/a) /2/ 751 kWh 55°C according EU tapping profile 10°C 0 K
heat store parameters	**TRNSYS-type 340**
Heat store volume	150 l
Store inner diameter	0.5 m
Rel. height of boiler inlet	0.8
Rel. height of boiler outlet	0.04
Rel. height of sensor for boiler	0.7
Set temperature for DHW	57.5 °C +- 2.5 K
Overall heat loss capacity rate of store	2.71 W/K
Effective vertical conductivity	1.2 W/(mK)
Heat transfer capacity rate of HX	$(kA)_{WT} = 82{,}3 \cdot \dot{m}^{\,0,185} \cdot \vartheta_m^{\,0,482}$ [W/K]
Volume HX	6 l
Ambient temperature of heat store	15 °C
Boiler /3/	
Type of auxiliary heating	Gas condensing boiler
Boiler capacity	19 kW
Mass flow	1090 kg/h (ΔT = 15 K)
Efficiency factor of boiler	0.9
Controller	
Electric power of controller	3 W
Operating hours of controller per year	8760 h
Electric consumption of controller per year	26.3 kWh
Electric power of pump	55 W
Operating hours of pump (hot water + space heat.)	4041 h
Electric consumption of pump per year	222 kWh
Investment costs	
Boiler and heat store	4000 € /3/
Exhaust system	500 € /3/
Installation	1000 € /3/
Installation material	1000 € /3/
Overall investment costs I_0	6500 € /3/
Operation costs per year	

Heat demand hot water	5009 kWh/a
Fuel demand hot water	5566 kWh/a
Heat demand space heating	9090 kWh/a /1/
Fuel demand space heating	10100 kWh/a
Fuel demand hot water + space heating E_t	15666 kWh/a
Cost per kWh fuel	0.066 € kWh/a /4/
Fuel costs	1034 €/a
Electricity demand	249 kWh/a
Cost per kWh electric energy (demand of 5000 kWh/a) /4/	0.254 €
Electricity costs	63 €/a
Maintenance costs	200 €/a /3/
Gas meter	130 €/a /3/
Yearly operation and maintenance cost C_t	1427 €
Type of incentives	None
Amount of incentives	0 €
Lifetime of system	20 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	0 €
Residual value RV	0 €
Saved final energy (year t) E_t	0 kWh
Discount rate r	0 %
VAT rate	19 %

Calculation of levelized cost LCoH:

$$LCoH = \frac{I_0 - S_0 + \sum_{t=1}^{T} \frac{C_t(1 - TR) - DEP_t \cdot TR}{(1+r)^t} - \frac{RV}{(1+r)^T}}{\sum_{t=1}^{T} \frac{E_t}{(1+r)^t}} \qquad (1)$$

Where:

$LCoH$: levelized cost of heat in €/kWh
I_0: initial investment in €
S_0: subsidies and incentives in €
C_t: operation and maintenance costs (year t) in €
TR: corporate tax rate in %

DEP_t: asset depreciation (year t) in €
RV: residual value in €
E_t: saved final energy (year t) in kWh
r: discount rate in %
T: period of analysis in years

References

[1] EN 12977-2 (2012): "*Thermal solar systems and components – Custom built systems – Part 2: Test methods for solar water heaters and combisystems*".

[2] COMMISSION DELEGATED REGULATION (EU) No 812/2013, ANNEX VII.

[3] Hafner, B. (2016): "*E-Mail*". Dated 13.06.2016.

[4] Check24 (2016): "*Würzburg reference costs*". URL: www.check24.com (accessed in Sept. 2016).

[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].