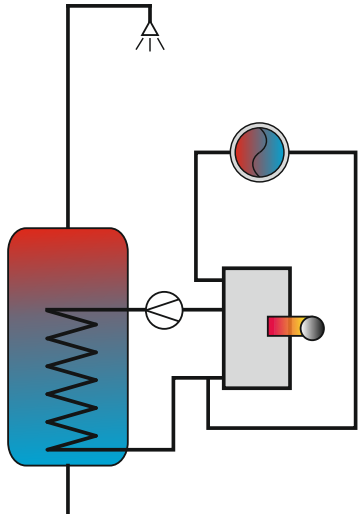


Description:	<i>Description of the conventional reference system for domestic hot water preparation and space heating in single-family houses in Germany</i>
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## Introduction

This document describes the conventional reference system for domestic hot water preparation and space heating in single-family houses 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

	<b>Key data</b>
	Heat store volume      150 l
	Location                      Germany, Würzburg
	Lifetime of system        20 years

## Levelized Cost of Heat (LCOH)

LCOH without VAT	0.112 €/kWh
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## 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
<b>Heat store parameters</b>	<b>TRNSYS-type 340</b>
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	$(kA)_{WT} = 82,3 \cdot \dot{m}^{0,185} \cdot g_m^{0,482} \text{ [W/K]}$
Volume HX	6 l
Ambient temperature of heat store	15 °C
<b>Boiler /3/</b>	
Type of auxiliary heating	Gas condensing boiler
Boiler capacity	19 kW
Mass flow	1090 kg/h ( $\Delta T = 15 \text{ K}$ )
Efficiency factor of boiler	0.9
<b>Controller</b>	
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
<b>Investment costs</b>	
Boiler and heat store	4000 € /3/
Exhaust system	500 € /3/
Installation	1000 € /3/
Installation material	1000 € /3/
<b>Overall investment costs <math>I_0</math></b>	<b>6500 € /3/</b>
<b>Operation costs per year</b>	
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
<b>Fuel demand hot water + space heating <math>E_t</math></b>	<b>15666 kWh/a</b>
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/
<b>Yearly operation and maintenance cost <math>C_t</math></b>	<b>1427 €</b>
Type of incentives	None
Amount of incentives	0 €
Lifetime of system	20 year
Discount rate r	0 %
Inflation rate	0 %
<b>Corporate tax rate TR</b>	<b>0 %</b>
<b>Asset depreciation (year t) <math>DEP_t</math></b>	<b>0 €</b>
<b>Subsidies and incentives (year t) <math>S_t</math></b>	<b>0 €</b>
<b>Residual value RV</b>	<b>0 €</b>
Saved final energy (year t) $E_t$	0 kWh
Discount rate r	0 %
VAT rate	19 %

Calculation of levelized cost LCoH /5, 6/:

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

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 €

$E_t$ : Fuel demand (year t) in kWh

$r$ : Discount rate in %

$T$ : Period of analysis in year

## 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/ E-Mail from Bernd Hafner, dated 13.06.2016
- /4/ [www.check24.com](http://www.check24.com), Würzburg reference costs, Sept. 2016
- /5/ Y. Louvet, S. Fischer et. al. IEA SHC Task 54 Info Sheet A01: Guideline for levelized cost of heat (LCOH) calculations for solar thermal applications“, March 2017. Download: <http://task54.iea-shc.org/>
- /6/ Y. Louvet, S. Fischer et.al. Entwicklung einer Richtlinie für die Wirtschaftlichkeitsberechnung solarthermischer Anlagen: die LCOH Methode. 27. May 2017. Symposium Thermische Solarenergie, Bad Staffelstein.