Energy Audit Summary Report

AEE INTEC

Audit no. 12 – UK02

Office Building

10th of November 2011

Supported by INTELLIGENT ENERGY EUROPE

This energy audit has been carried out with cofunding of the European Commission (EACI) in the Framework of the EU funded project EINSTEIN-II (ProjectNo. IEE/09/702/SI2.558239)

AUDIT n. 12 – UK02

1. Data of the auditor

1.1. Contact data of the auditor

Name: Matthäus Hubmann
Organisation: AEE INTEC
Country: Austria
Profession: engineer
Number of audits performed: 4
Date of the audit: 10/11/2011
Duration of the audit: 4 weeks

2. Introduction

2.1. Objectives

The main objective of this audit was to determine the energy and CO2 saving potentials.

3. Status Quo: processes, distribution, energy supply

3.1. General info of company

Sector: office building
Number of employees: n.a.

3.2. Flow sheet of the whole manufacturing side (processes, distribution, energy supply)

in form of a block diagram

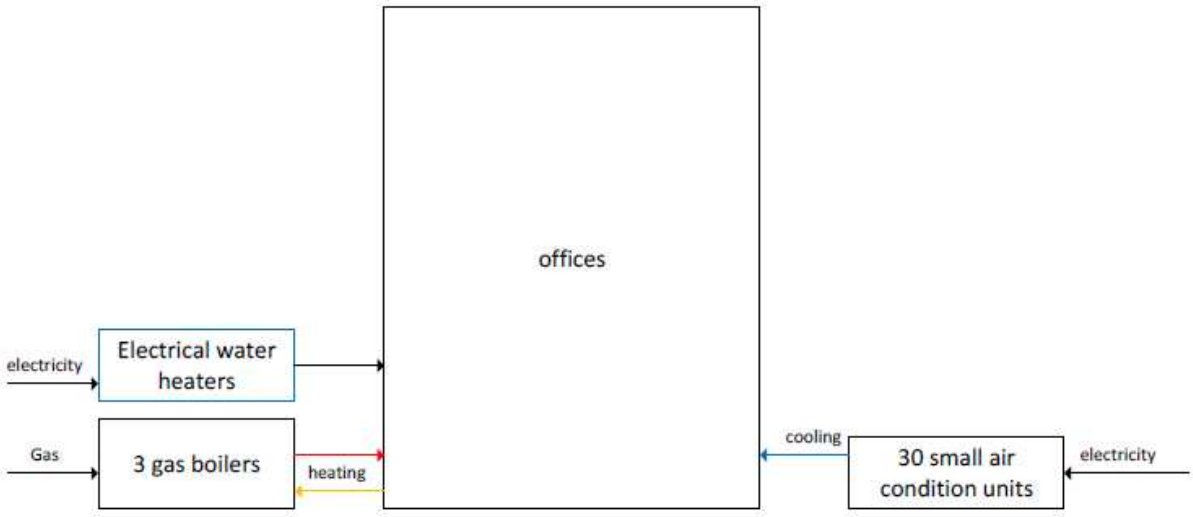

Figure 1: Flow sheet of the existing energy supply

3.3. Description of the existing system

The office building is 3 storey building and has several meeting rooms and is designed to accommodate flexible office space.
The existing three gas boilers with a total nominal capacity of 447 kW and an efficiency of 83 % meet the heating demand of the office building. Additionally the hot water is heated electrically and there are around 30 air conditioning units with an installed capacity less than 12 kW each.
The evaluation of the present state can be seen in the following tables (Table 1 to Table 7) and figures (Figure 2 to Figure 11). The results of the EINSTEIN calculation match to the real state of the building that could be well split based on the data made available by the company.

- Energy Supply:

Table 1: Total primary energy consumption (PEC) and primary energy consumption for thermal use (PET)

Energy type (fuels / electricity)	PEC		PET	
	[MWh]	[% of Total]	[MWh]	[% of Total]
Total fuels	707	24.49	707	89.15
Total electricity	2,181	75.51	86	10.85
Total (fuels + electricity)	**2,888**	**100.00**	**793**	**100.00**

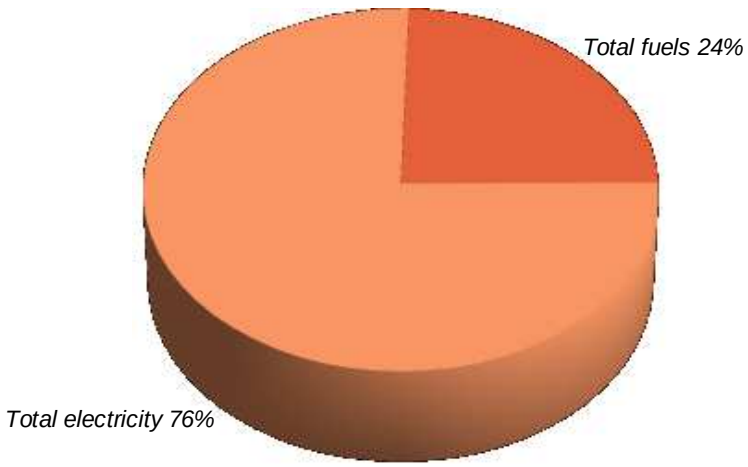

Figure 2: Distribution of PEC by fuel type

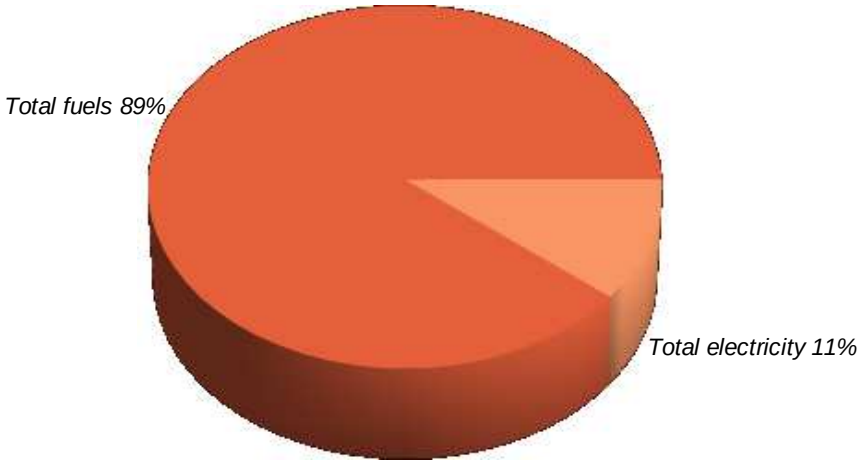

Figure 3: Distribution of PET by fuel type

- Primary energy consumption, Final energy consumption (FEC) per fuel, final energy demand thermal (FET):

Table 2: Total final energy consumption (FEC) and final energy for thermal use (FET); present state

Fuel type	FEC		FET	
	[MWh]	[% of Total]	[MWh]	[% of Total]
Natural gas	643	46.93	643	95.73
Electricity	727	53.07	29	4.27
Total	1,370	100.00	672	100.00

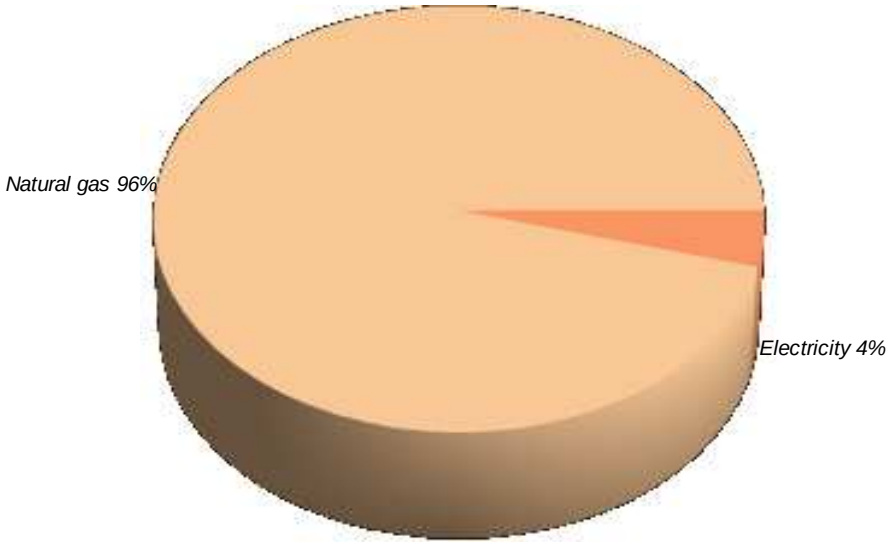

Figure 4: Total final energy consumption for thermal use (FET); present state.

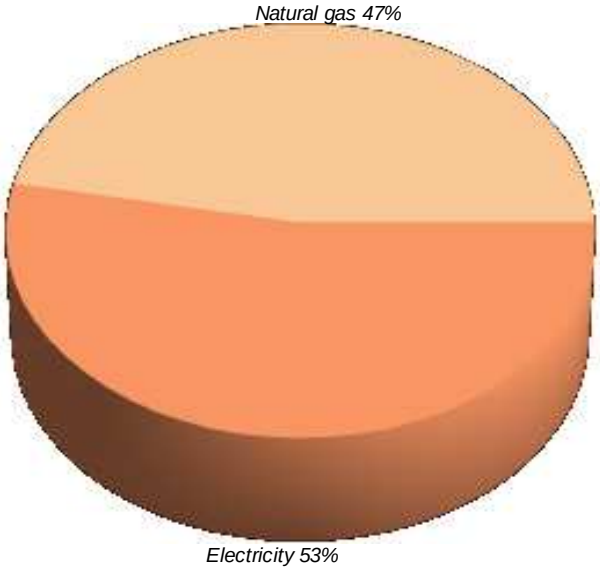

Figure 5: Total final energy consumption (FEC); present state.

Table 3: Final energy consumption for thermal use (FET) by equipment (present state).

Equipment	Fuel type	FET by equipment	
		[MWh]	[% of Total]
small AC	Electricity	3	0.40
Gas Boiler	Natural gas	643	95.73
water heater	Electricity	26	3.87
Total		**672**	**100.00**

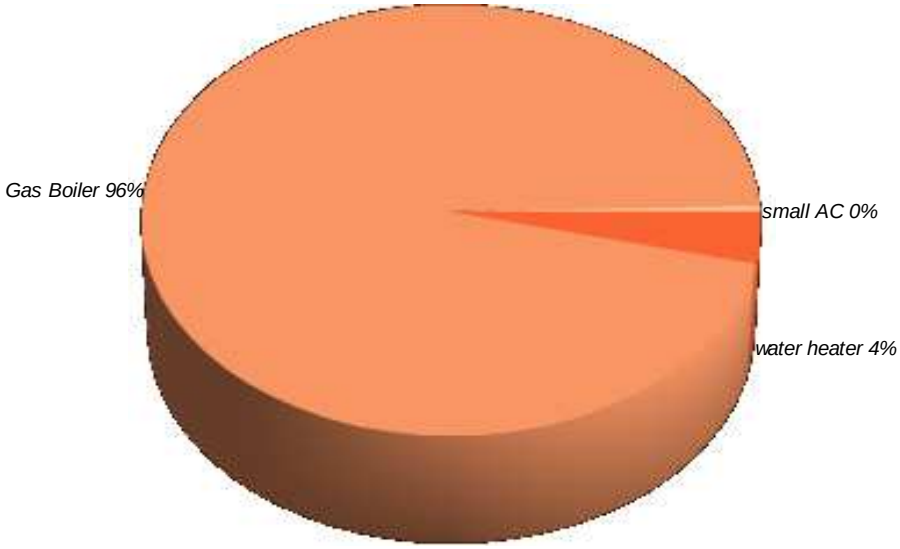

Figure 6: Final energy consumption for thermal use (FET) by equipment

- Useful supply heat (USH), Fuel and electricity demand:

Table 4: Useful supply heat (USH) by equipment; present state

Equipment	USH by equipment	
	[MWh]	[% of Total]
Gas Boiler	534	95.44
water heater	25	4.56
Total	**559**	**100.00**

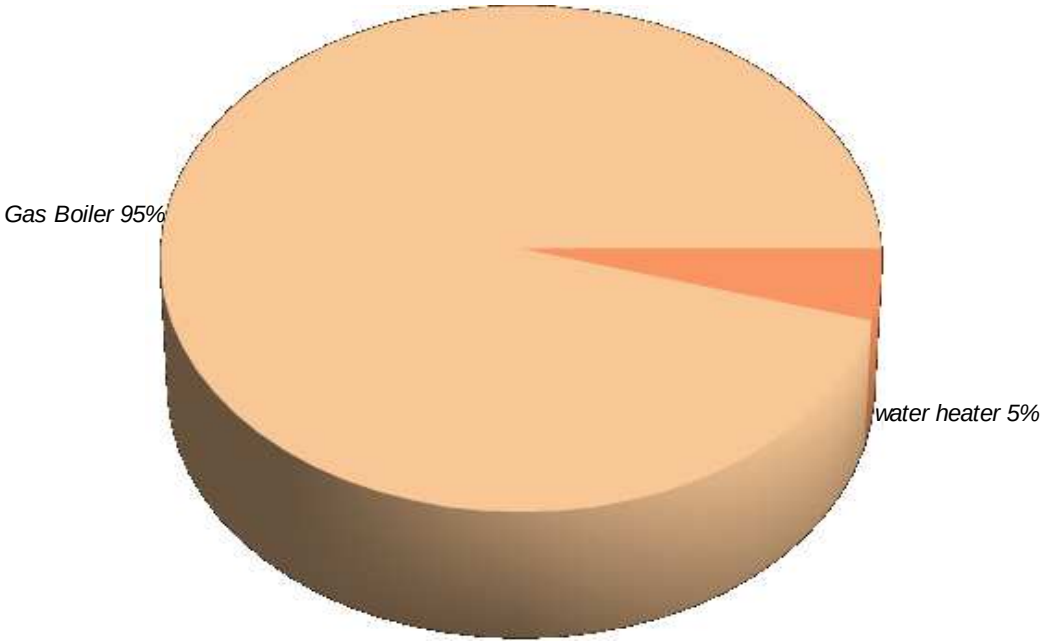

Figure 7: *Useful supply heat (USH) by equipment. Present state.*

Table 5: Useful supply cooling (USC) by equipment; present state

Equipment	USC by equipment	
	[MWh]	[% of Total]
small AC	6	100.00
Total	**6**	**100.00**

- Distribution system; Media and temperatures:

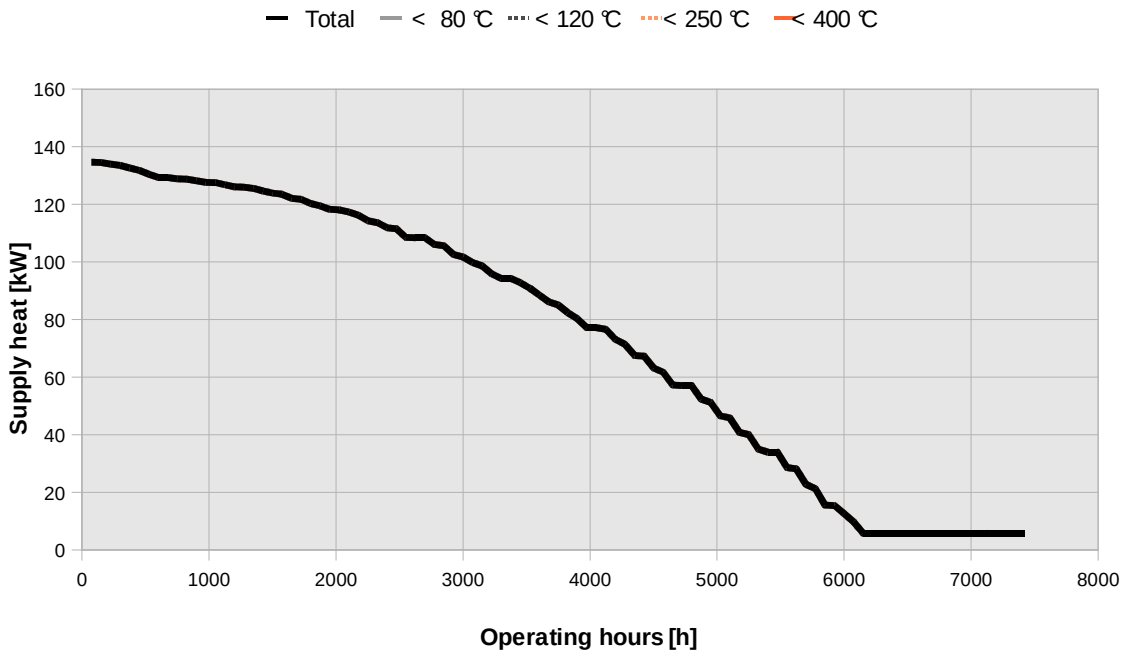

Figure 8: Distribution of supply heat by temperature levels and annual operating hours. Present state.

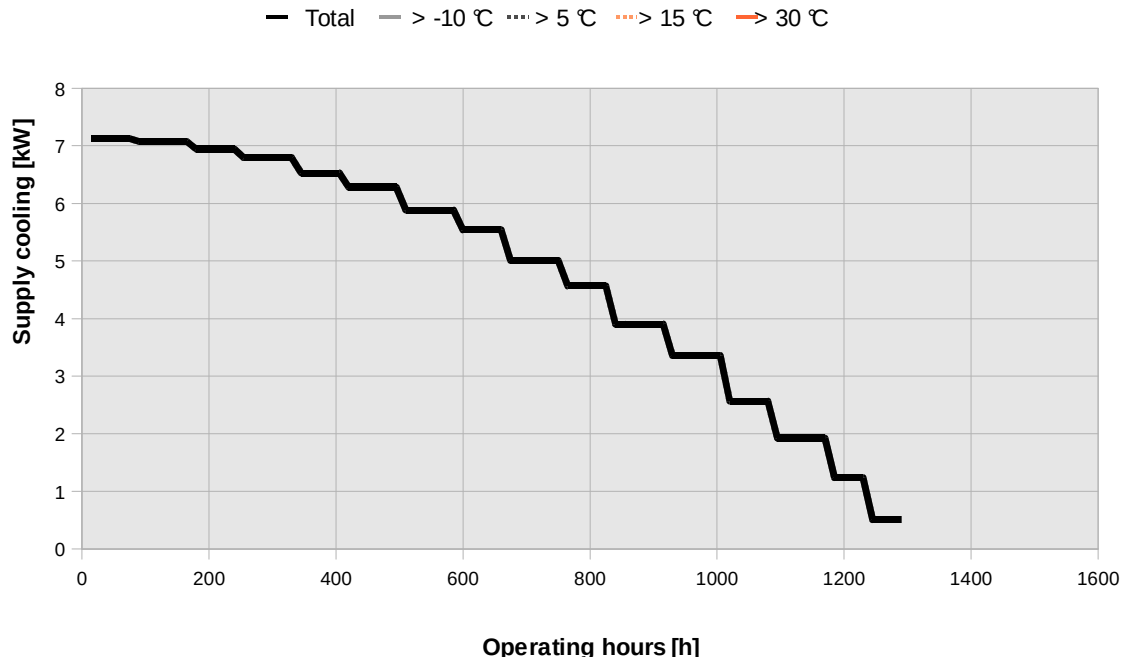

Figure 9: Distribution of supply cooling by temperature levels and annual operating hours. Present state.

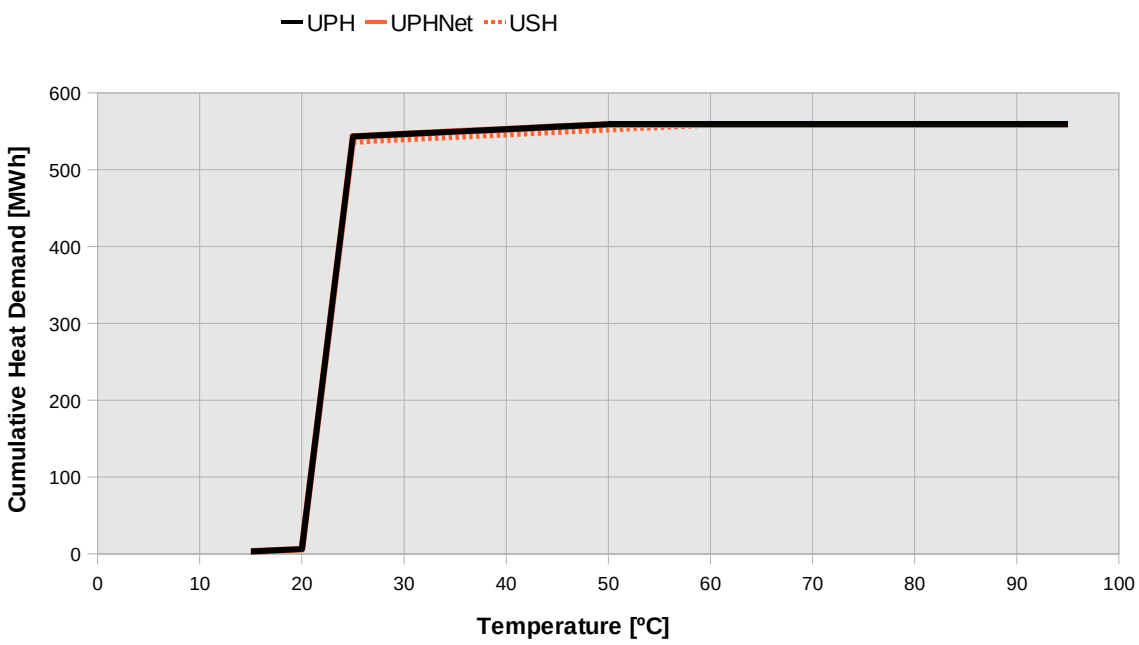

Figure 10: Distribution of the heat demand by temperature levels

- - Main energy consuming energy processes and buildings:

Table 6: Useful process heat demand (UPH) by process. Present state

Process	Total	Circulation	Maintenance	Start-up
	[MWh]	[MWh]	[MWh]	[MWh]
Faraday Wharf_heating	534	0	534	0
Faraday Wharf_HW	25	25	0	0
Total	**559**			

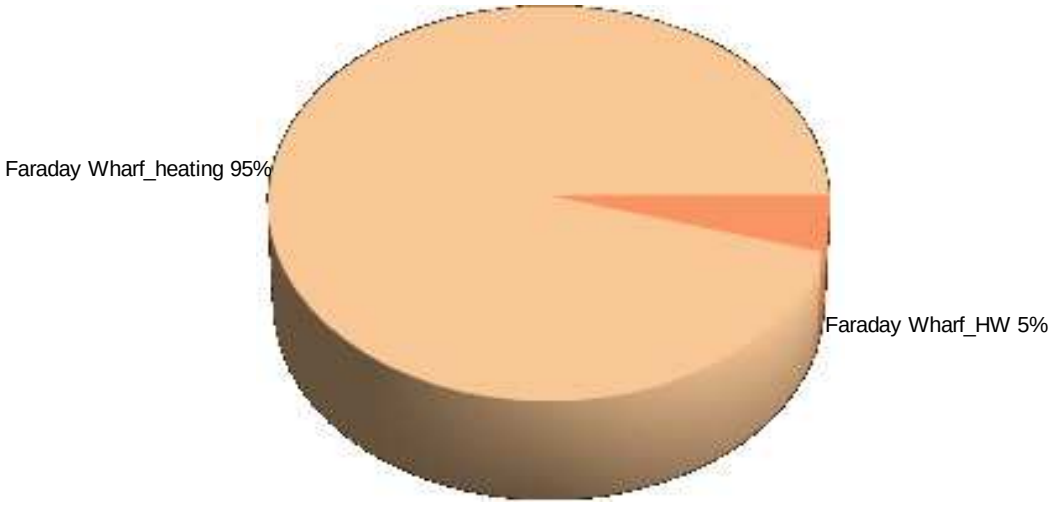

Figure 11: Useful process heat (UPH) by process

Table 7: Useful process cooling demand (UPC) by process. Present state

Process	Total	Circulation	Maintenance	Start-up
	[MWh]	[MWh]	[MWh]	[MWh]
Faraday Wharf_cooling	6	0	6	0
Total	**6**			

3.4. General

- The audited company is an office building, where the main energy consumption derives from the heating demand of the building itself, the hot water demand, the cooling demand and the electrical demand in the offices.
- Due to the fact that no data of the hot water demand was available and assumption was made that 1.5 m³ of water is needed. This assumption is based on studies of office buildings which mention a consumption of 22 litres per occupant and day and the assumption of 68 occupants per day.
- Further on the cooling demand was assumed in comparison to the heat demand of the building (130 kWh/m²a) and was defined as 1.5 kWh/m²a. And for the installed air condition units an total cooling capacity of 105 KW was assumed, as no detailed data of the small cooling devices was available.

4. Comparative study

Table 8: Overview of the alternative proposals studied

Short Name	Description
HW by gas boiler	based on present state + HW (hot water) is produced by the existing gas boiler
solar + HW by gas boiler	based on present state + solar thermal system + HW by gas boiler
CHP + HW	based on present state + CHP (combined heat and power)
CHP + HW + adchiller	based on present state + CHP + installation of an absorption chiller
solar HW	based on present state + small solar thermal system

4.1. Proposed alternative 1: HW by gas boiler

- HW by gas boiler

This alternative takes the change of the hot water production in account, from electric heating to the generation through the already existing gas boiler. No new equipment has to be installed.

Table 9: Heat and cooling supply equipment and contribution to total heat and cooling supply

Equipment	Type	Heat and cooling supplied to pipe/duct	Nominal capacity	Contribution to total heat and cooling supply	
			[kW]	[MWh]	[%]
small AC	compression chiller (air cooled)	o==cooling==o	105	6	1.11
Gas Boiler	hot water boiler	o==hot water==o o==heating building==o	447	559	98.89
water heater	hot water boiler	o==hot water==o	42	0	0.00
Total			**594**	**565**	**100**

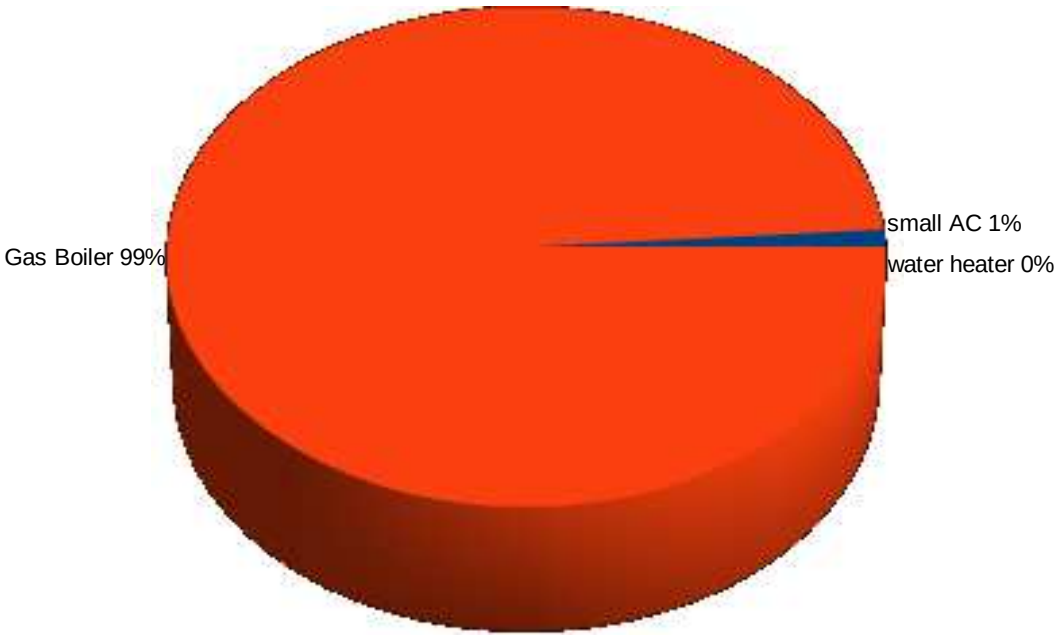

Figure 12: Contribution of each equipment to the total useful heat and useful cooling supply (USH & USC).

4.2. Proposed alternative 2: solar + HW by gas boiler

- Solar + HW by gas boiler

In this alternative the installation of a solar thermal system to supply the heating in winter and the hot water production during the whole year was simulated.

Collector type:	FPC (flat plate collectors)
Installed surface:	382 m²
Installed capacity:	267 kW
Solar puffer storage volume:	19 m³
Solar fraction:	14.05 %
Annual energy yield:	294 kWh/kWa

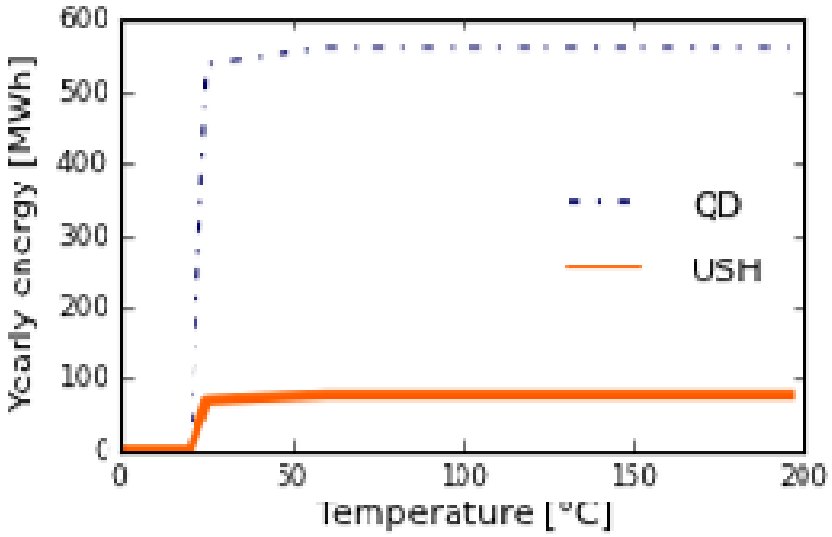

Figure 13: Heat demand and solar contribution

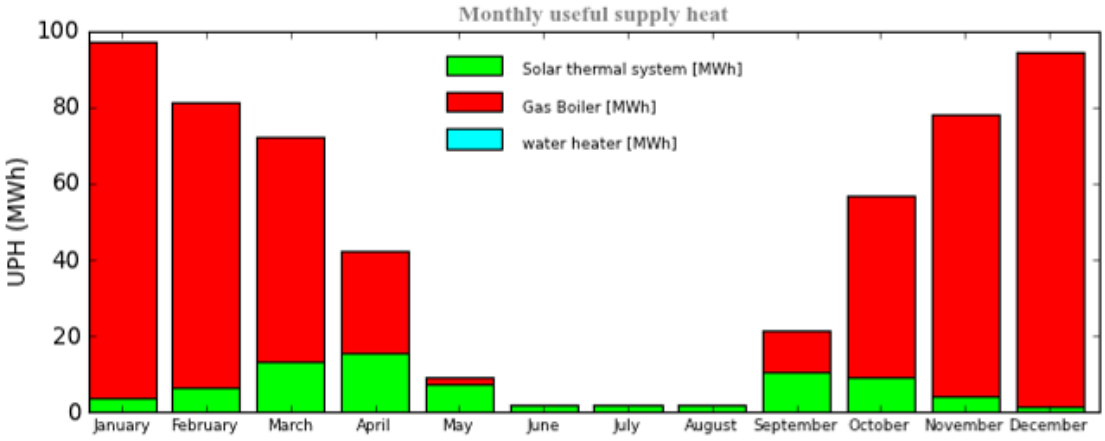

Figure 14: Distribution of useful supply heat per month

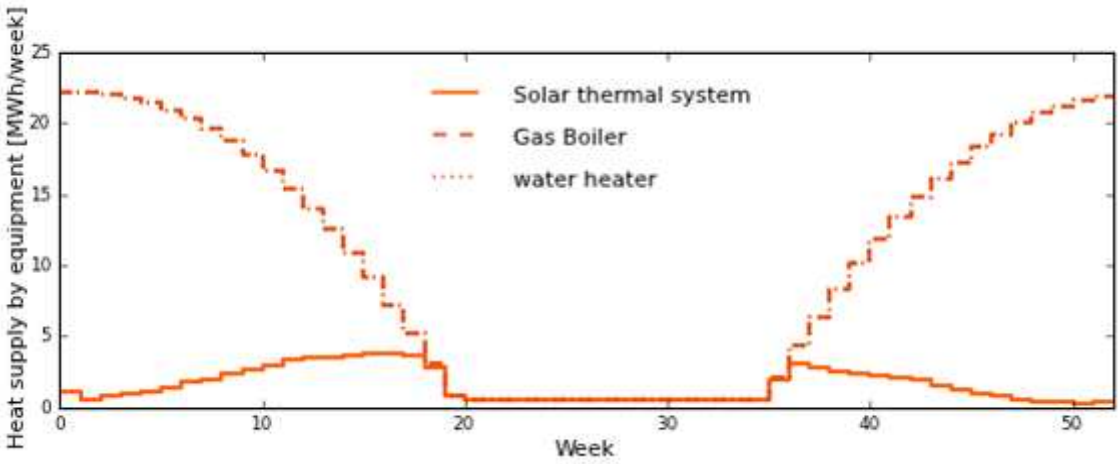

Figure 15: weekly heat supply by equipment

Table 10: Heat and cooling supply equipment and contribution to total heat and cooling supply

Equipment	Type	Heat and cooling supplied to pipe/duct	Nominal capacity	Contribution to total heat and cooling supply	
			[kW]	[MWh]	[%]
Solar thermal system	solar thermal (flat-plate)	o==hot water==o o==heating building==o	267	79	13.89
small AC	compression chiller (air cooled)	o==cooling==o	105	6	1.11
Gas Boiler	hot water boiler	o==hot water==o o==heating building==o	447	481	85.00
water heater	hot water boiler	o==hot water==o	42	0	0.00
Total			**861**	**565**	**100**

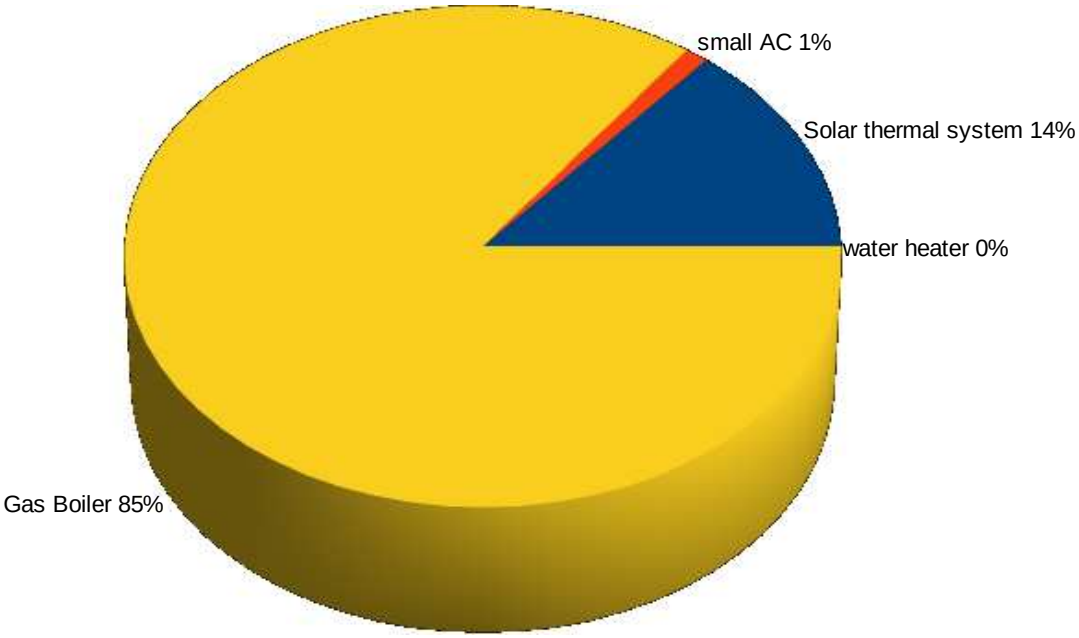

Figure 16: Contribution of each equipment to the total useful heat and useful cooling supply (USH & USC).

4.3. Proposed alternative 3:

- CHP + HW

The installation of a CHP plant to fulfil the heat demand during winter and the heating of the domestic hot water during the whole year was considered in this alternative.

CHP type:	gas engine
Electrical efficiency:	0.28
Thermal efficiency:	0.52
Operating hours:	6,256 h
Installed electrical capacity:	50 kW
Installed thermal capacity:	93 kW

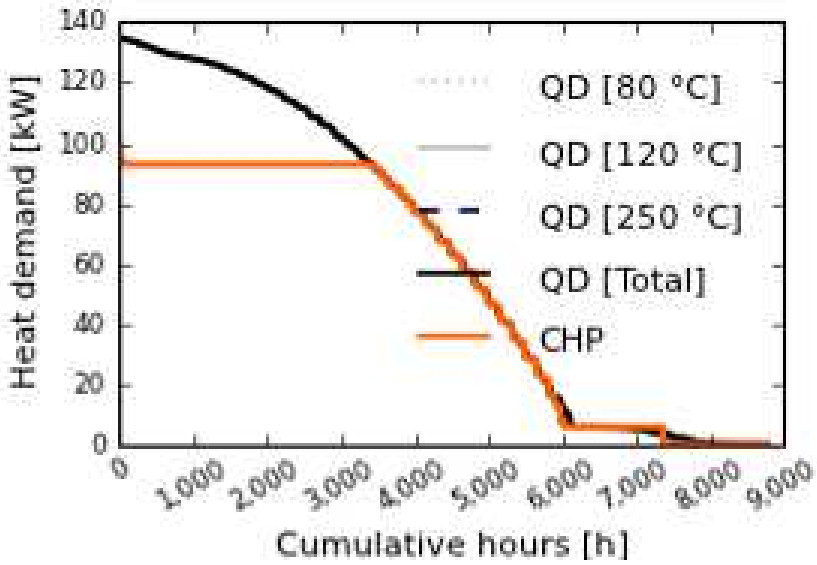

Figure 17: Cumulative heat demand to be covered by CHP

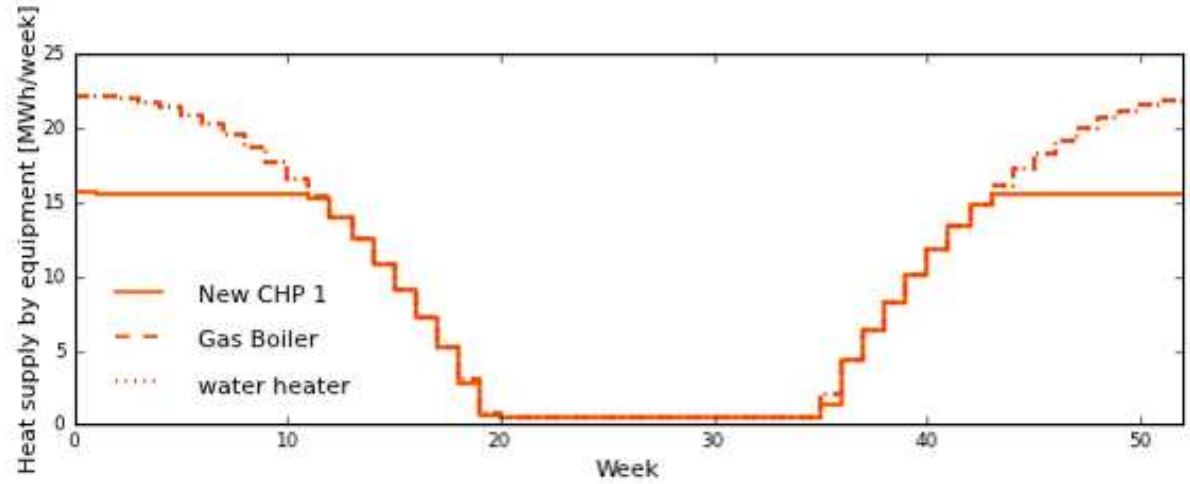

Figure 18: Weekly heat supply by equipment

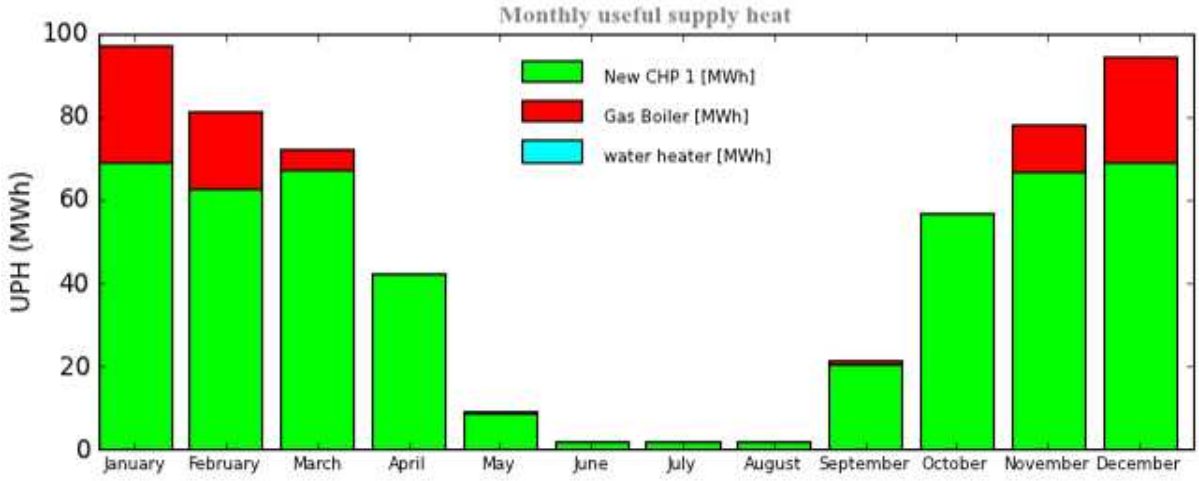

Figure 19: Distribution of useful supply heat per month

Table 11: Heat and cooling supply equipment and contribution to total heat and cooling supply

Equipment	Type	Heat and cooling supplied to pipe/duct	Nominal capacity	Contribution to total heat and cooling supply	
			[kW]	[MWh]	[%]
New CHP 1	CHP engine	o==hot water==o o==heating building==o	93	470	83.10
small AC	compression chiller (air cooled)	o==cooling==o	105	6	1.11
Gas Boiler	hot water boiler	o==hot water==o o==heating building==o	447	89	15.79
water heater	hot water boiler	o==hot water==o	42	0	0.00
Total			**687**	**565**	**100**

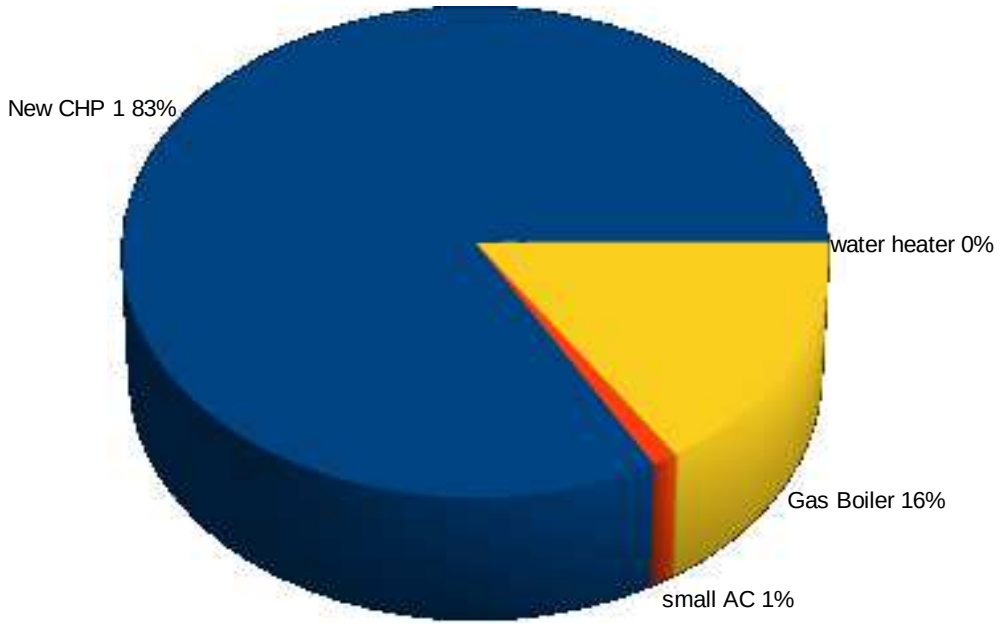

Figure 20: Contribution of each equipment to the total useful heat and useful cooling supply (USH & USC).

4.4. Proposed alternative 4: CHP + HW + adchiller

- CHP + HW + adchiller

In addition to the installation of a CHP plant an absorption chiller with the cooling capacity of 86 kW was installed.

CHP type:	gas engine
Electrical efficiency:	0.28
Thermal efficiency:	0.52
Operating hours:	6,256 h
Installed electrical capacity:	50 kW
Installed thermal capacity:	93 kW
Absorption chiller	
Nominal power:	86 kW
COP (coefficient of performance):	0.8
Operating hours:	1,296 h

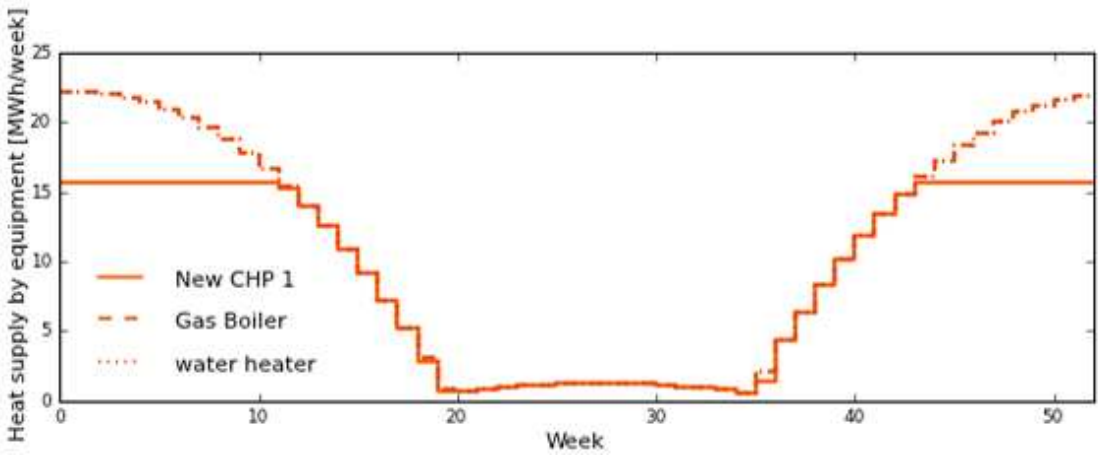

Figure 21: weekly hat supply by equipment

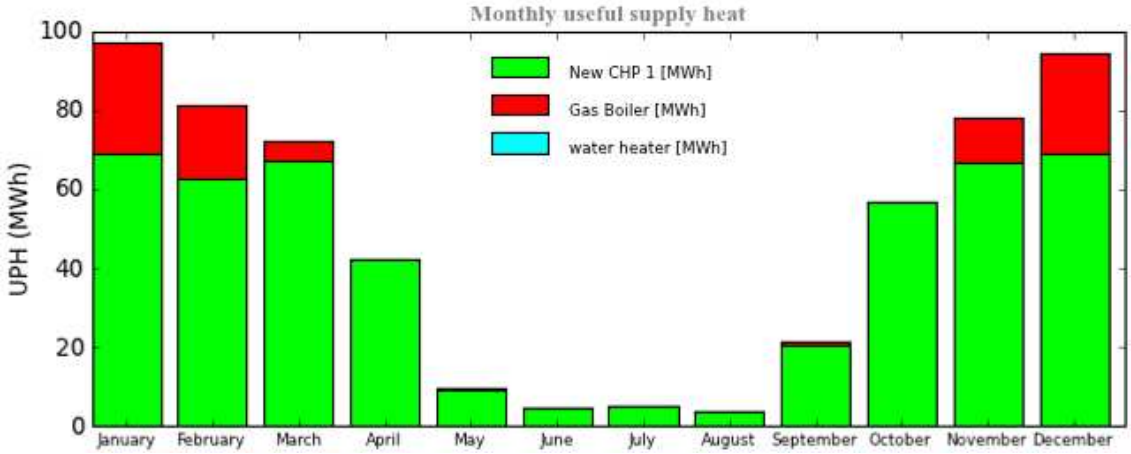

Figure 22: Distribution of useful supply heat per month

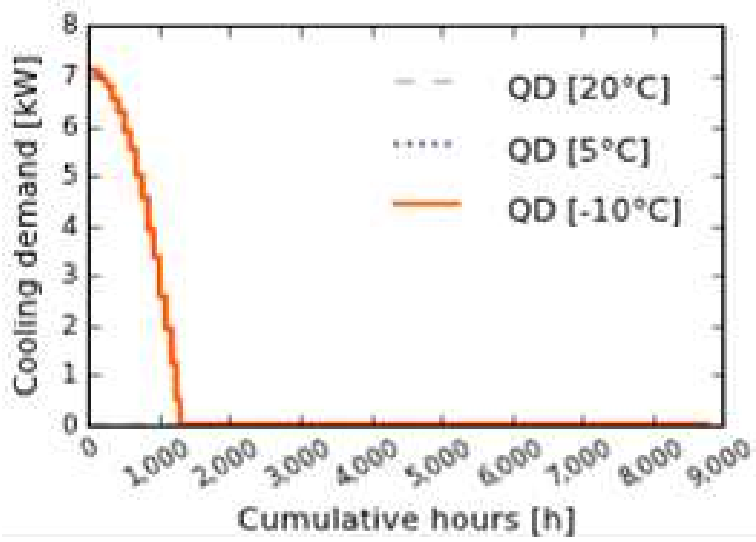

Figure 23: Cumulative cooling demand to be covered by chillers

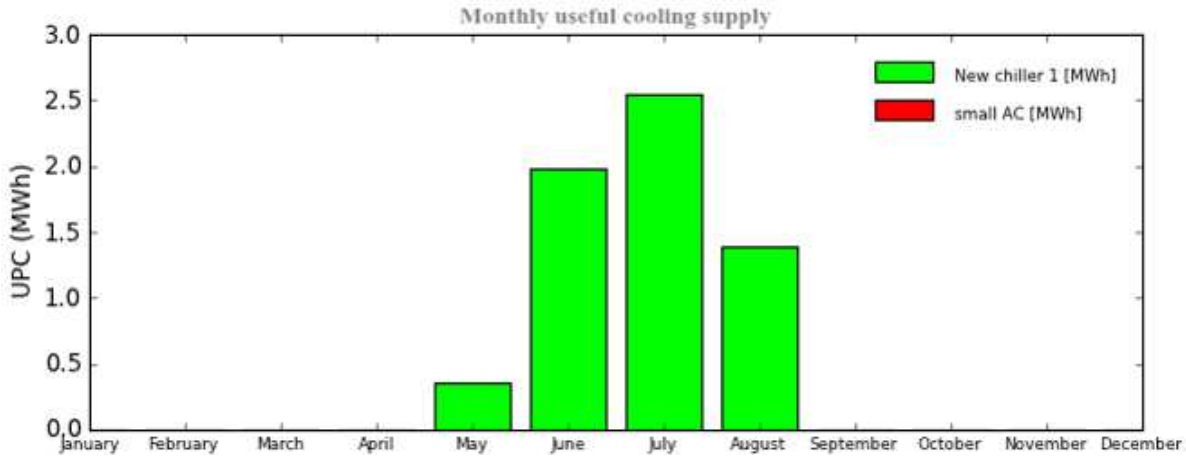

Figure 24: Distribution of useful cooling supply per month

Table 12: Heat and cooling supply equipment and contribution to total heat and cooling supply

Equipment	Type	Heat and cooling supplied to pipe/duct	Nominal capacity	Contribution to total heat and cooling supply	
			[kW]	[MWh]	[%]
Solar thermal system	solar thermal (flat-plate)	o==hot water==o o==heating building==o	56	22	3.88
small AC	compression chiller (air cooled)	o==cooling==o	105	6	1.11
Gas Boiler	hot water boiler	o==hot water==o o==heating building==o	447	537	95.01
water heater	hot water boiler	o==hot water==o	42	0	0.00
Total			**650**	**565**	**100**

Equipment	Type	Heat and cooling supplied to pipe/duct	Nominal capacity	Contribution to total heat and cooling supply	
			[kW]	[MWh]	[%]
New chiller 1	thermal chiller (water cooled)	o==cooling==o	86	6	1.10
New CHP 1	CHP engine	o==hot water==o o==heating building==o	93	478	83.32
small AC	compression chiller (air cooled)	o==cooling==o	105	0	0.00
Gas Boiler	hot water boiler	o==hot water==o o==heating building==o	447	89	15.58
water heater	hot water boiler	o==hot water==o	42	0	0.00
Total			**773**	**573**	**100**

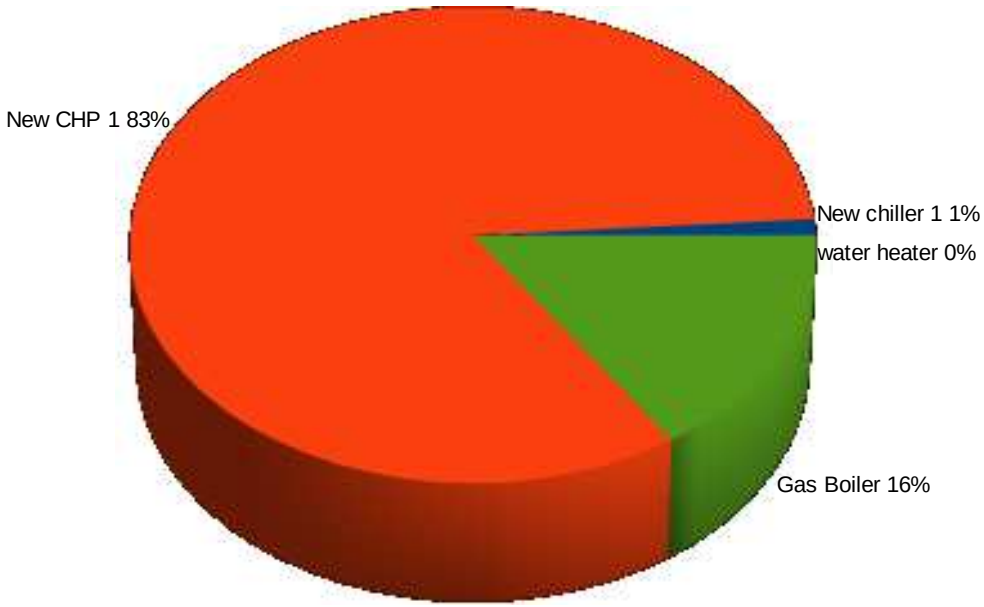

Figure 25: Contribution of each equipment to the total useful heat and useful cooling supply (USH & USC).

4.5. Proposed alternative: solar HW

- Solar HW

In this alternative the installation of a solar thermal system to supply the hot water production during the whole year was simulated.

Collector type:	FPC (flat plate collectors)
Installed surface:	80 m²
Installed capacity:	56 kW
Solar fraction:	3.92 %
Annual energy yield:	291 kWh/kWa

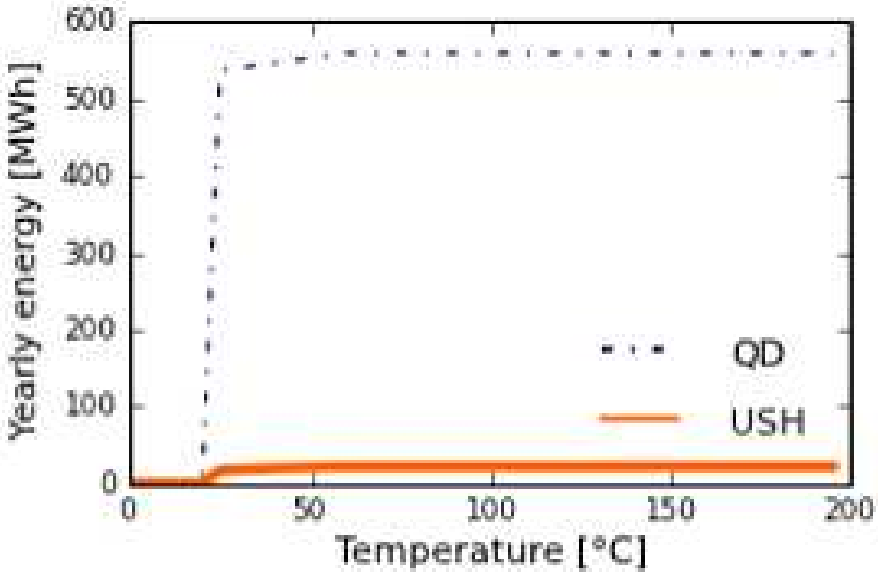

Figure 26: Heat demand and solar contribution

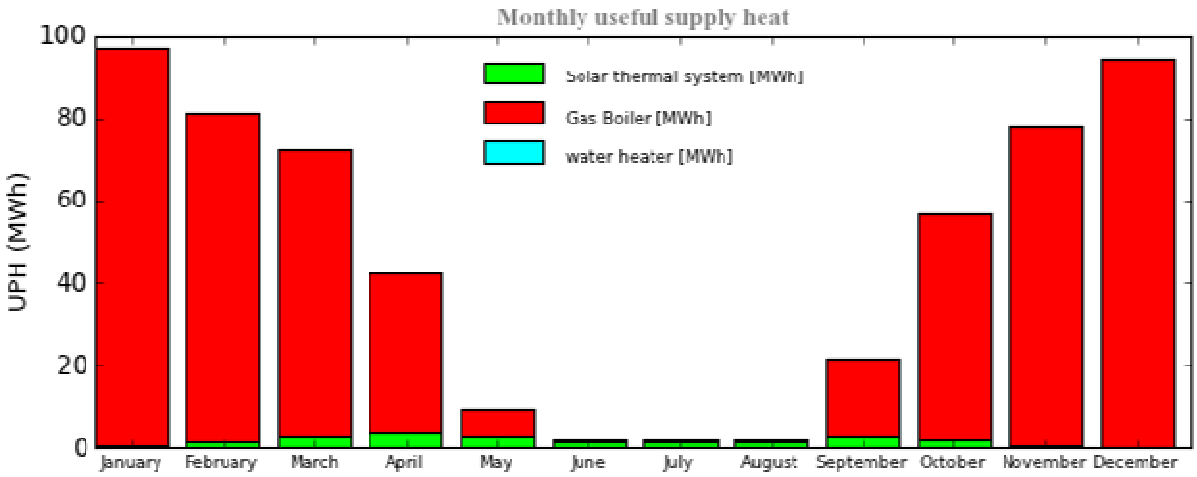

Figure 27: Distribution of useful supply heat per month

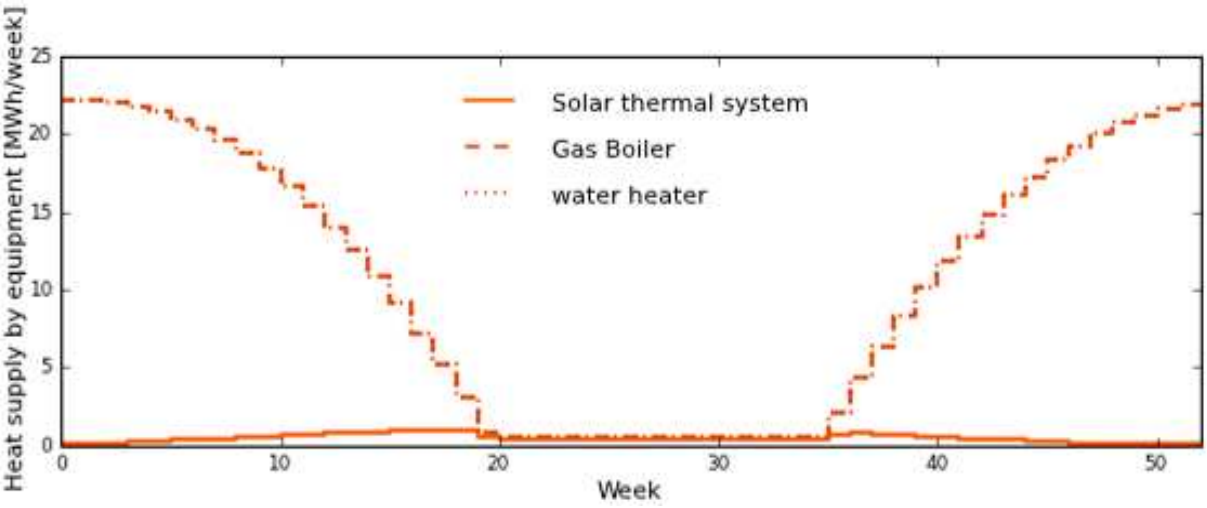

Figure 28: weekly heat supply by equipment

Table 13: Heat and cooling supply equipment and contribution to total heat and cooling supply

Equipment	Type	Heat and cooling supplied to pipe/duct	Nominal capacity	Contribution to total heat and cooling supply	
			[kW]	[MWh]	[%]
Solar thermal system	solar thermal (flat-plate)	o==hot water==o o==heating building==o	56	22	3.88
small AC	compression chiller (air cooled)	o==cooling==o	105	6	1.11
Gas Boiler	hot water boiler	o==hot water==o o==heating building==o	447	537	95.01
water heater	hot water boiler	o==hot water==o	42	0	0.00
Total			**650**	**565**	**100**

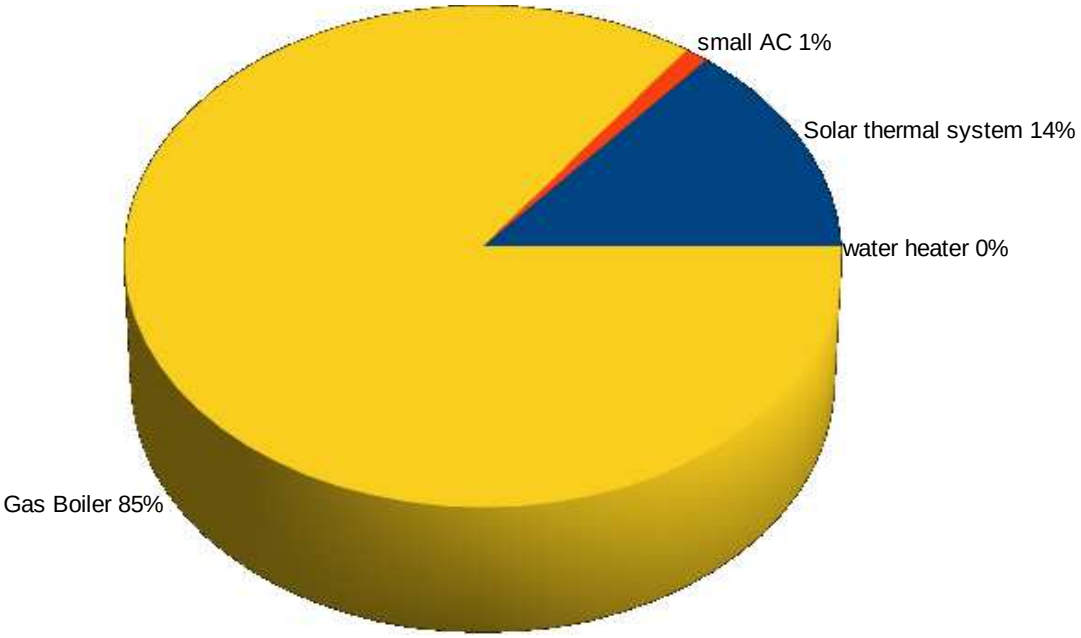

Figure 29: Contribution of each equipment to the total useful heat and useful cooling supply (USH & USC).

5. Selected alternative(s) and conclusions

The alternative "solar HW" was chosen due to the fact that this alternative saves 68 MWh of primary energy consumption and low installation effort due to the small solar field.

Table 14: Primary energy consumption: present state and alternative proposals

Alternative	Primary energy consumption	Savings	
	[MWh]	[MWh]	[%]
Present State (checked)	2,888	---	---
HW by gas boiler	2,819	69	2.40
solar + HW by gas boiler	2,717	171	5.92
CHP + HW	2,437	451	15.63
CHP + HW + adchiller	2,434	454	15.71
solar HW	2,791	98	3.38

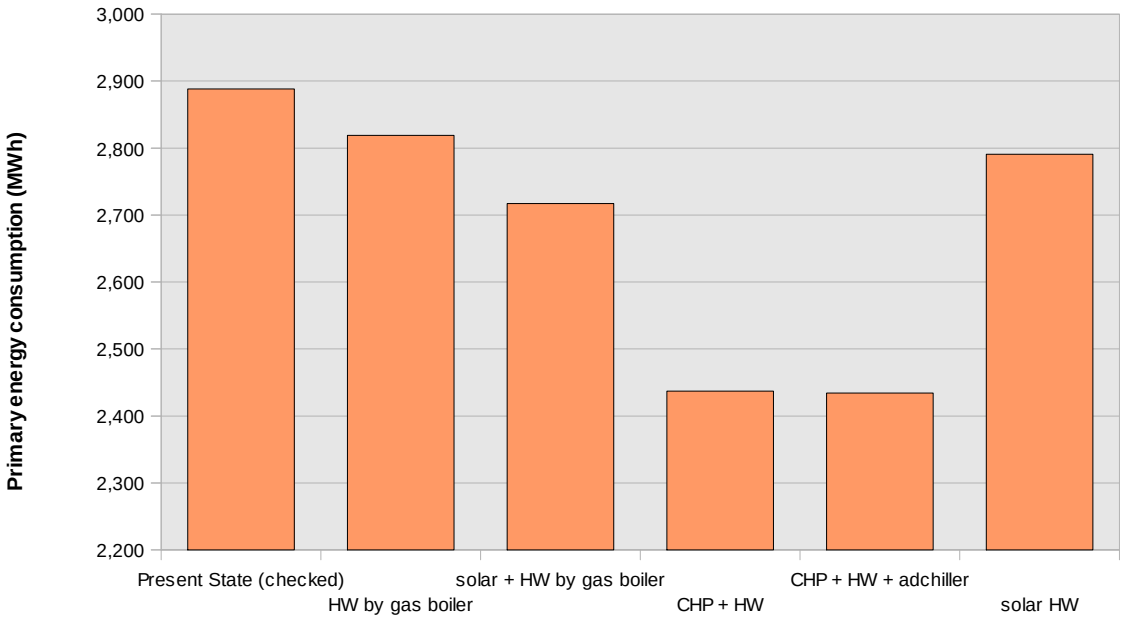

Figure 30: Comparison of alternatives: primary energy consumption

5.1. Selected alternative: Solar HW

5.1.1. Process optimisation (written proposals)

Due to high solar gains during summer in the offices an external shading of the windows is suggested for the building. Additionally a better insulation of the building envelope is also suggested as the heating demand for the building is as high as 130kWh/m² and year. Concerning the installation of a solar thermal system the inlet and out let temperatures of the heat delivering system should be as low as possible to increase the supply by the solar thermal system.

5.1.2. Heat recovery

Based on the available data and measurements performed no heat recovery was proposed.

5.1.3. Heat and Cold Supply

Collector type:	FPC (flat plate collectors)
Installed surface:	80 m²
Installed capacity:	56 kW
Solar fraction:	3.92 %
Annual energy yield:	291 kWh/kWa

5.2. Comparative study and conclusions

Table 15: Comparative study

		Present state	Alternative	Saving
Total primary energy consumption (1)		*2,888*	*2,791*	*97*
- total	[MWh]			*3%*
- fuels	[MWh]	*707*	*712*	*- 5*
- electricity	[MWh]	*2,181*	*2,079*	*102*
Primary energy saving due to renewable energy	[MWh]		*1*	
CO_2 emissions	[t/a]	*524*	*508*	*16*
Annual energy system cost (2)	[EUR]	*59,970*	*57,844*	*2,126*
Total investment costs	[EUR]		*44,028*	
Payback period (3)	[years]		*17*	

(1) including primary energy consumption for non-thermal uses

(2) including energy cost (fuel and electricity bills), operation and maintenance costs and annuity of total investment.

(3) Supposing 30% of funding of total investment (subsidies or equivalent other support mechanisms)

- CO_2-emission savings chart:

The environmental impact for the present state and the different alternatives is presented in terms of CO2 production and water consumption.

Table 16: Environmental impact: present state and alternative proposals.

Alternative	Production of CO2	Highly Radioactive Nuclear Waste	Water consumption
	[t]	[kg]	[m3]
Present State (checked)	524.25	3.64	0.00
HW by gas boiler	514.75	3.46	0.00
solar + HW by gas boiler	491.48	3.47	0.00
CHP + HW	475.05	2.17	0.00

CHP + HW + adchiller	475.70	2.13	0.00
solar HW	508.26	3.46	0.00
New Proposal 6	520.08	3.59	0.00

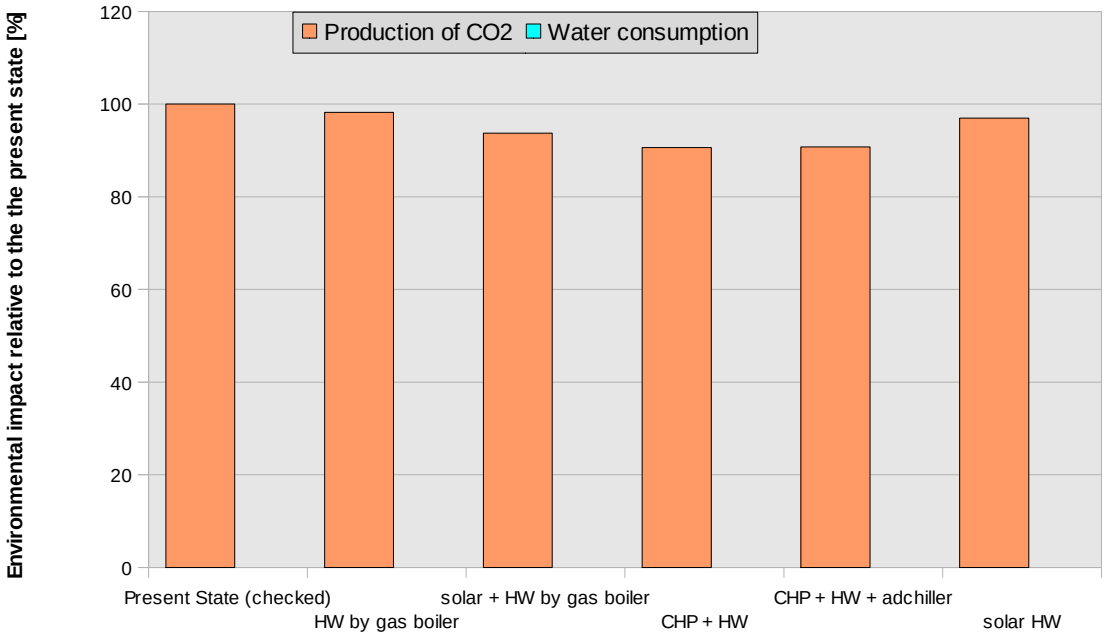

Figure 31: Comparison of alternatives: environmental impact

5.2.1. Energy and environmental analysis

Through installing a solar thermal system which delivers the needed heat for hot water production energy saving potential of 97 MWh per year can be achieved. This savings gain a decrease of 16 tons of CO2 emissions per year compared to the present state.

5.2.2. Economic analysis

The investment costs for the solar thermal system and the heat supply system were assumed by € 30,820. The calculated payback period is therefore 17 years based on a funding rate of 30 %.

5.2.3. Conclusions and outlook

Based on the available data the energy consumption split to the processes and equipments could have been calculated by EINSTEN and the results are well comparable to the present state of the company. For the economic aspects some further calculations will be necessary as the funding rate and the final investment costs are based on first estimations.