Energy Audit Summary Report

AEE INTEC

Audit no. *17* – UK07

Office Building

11th 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 no. 17 – UK07

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: 9
Date of the audit: 11/11/2011
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

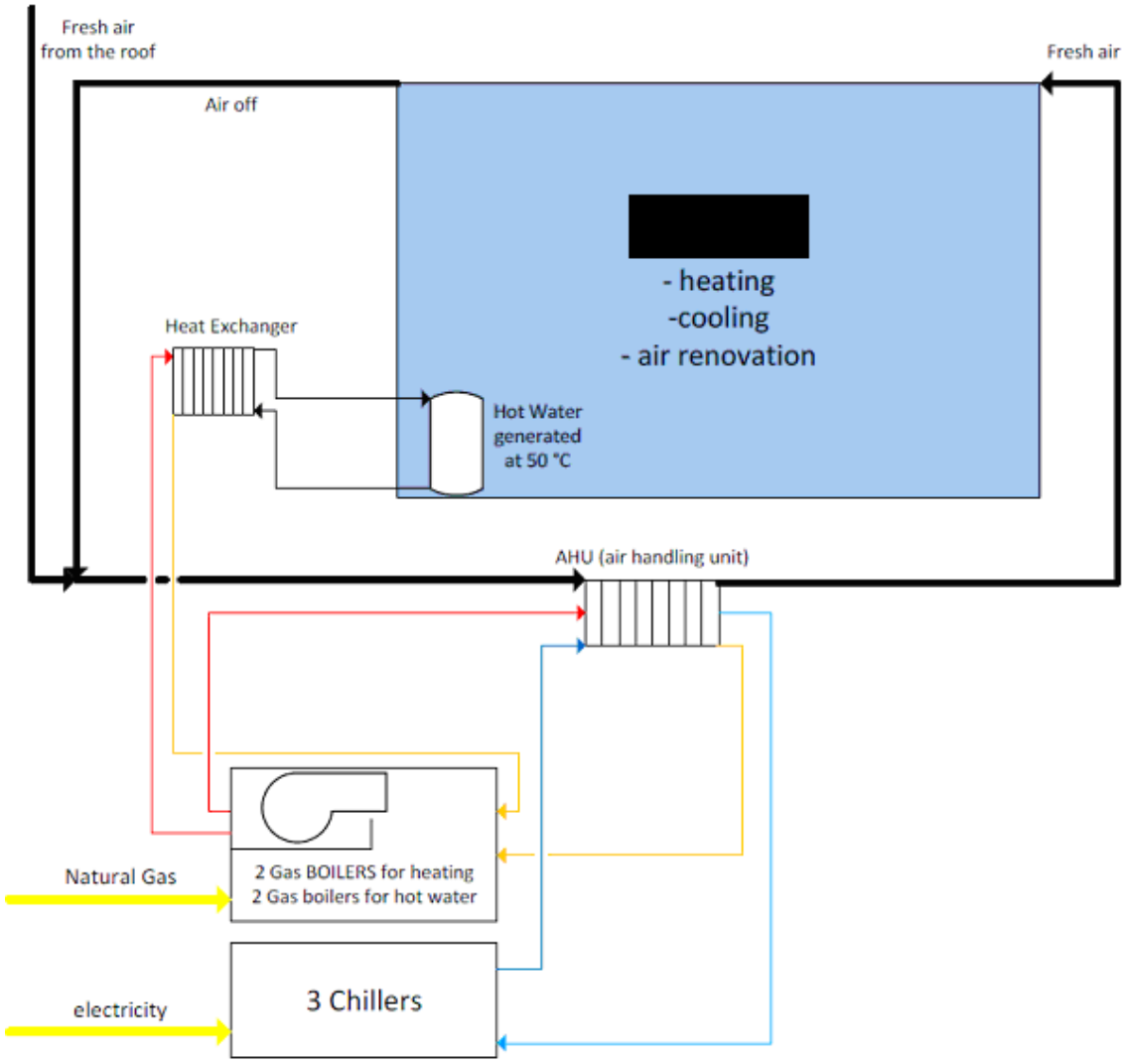

Figure 1: flow sheet

3.3. Description of the existing system

At the company site there are two gas fired water heaters for generating the needed hot water and to meet the heating demand two gas burners are installed. Additionally three chillers are installed with a nominal power of 589 kW each.
The gas burners and chillers support the AHU (air handling unit) either for heating or cooling the air for the rooms in the building. For heat recovery of the exhaust/used air of the offices a run-a-round coil system is already in operation and minimizes the energy demand of the AHU.

- **Energy Supply:**

Primary energy consumption:

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	1.574	14,66	1.574	63,32
Total electricity	9.162	85,34	912	36,68
Total (fuels + electricity)	**10.736**	**100,00**	**2.486**	**100,00**

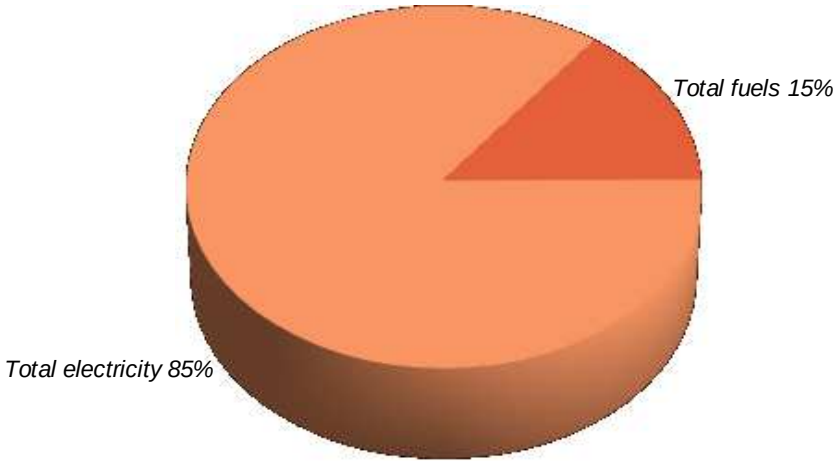

Figure 2: Distribution of PEC by fuel type

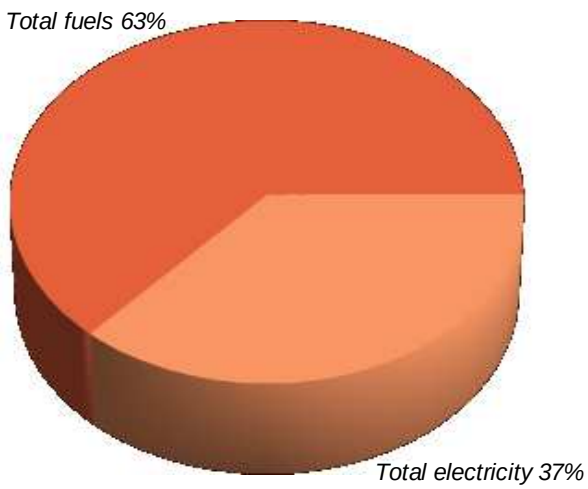

Figure 3: Distribution of PET by fuel type

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	1.431	31,91	1.431	82,48
Electricity	3.054	68,09	304	17,52
Total	4.485	100,00	1.735	100,00

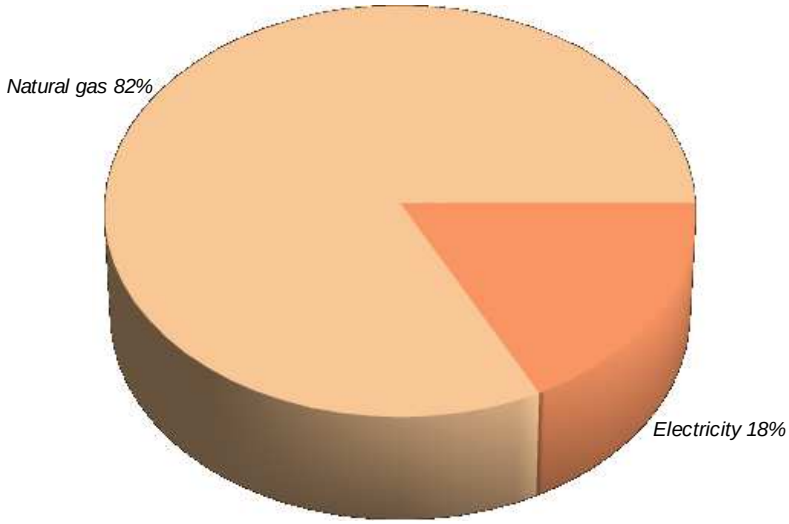

Figure 4: Total final energy consumption for thermal use (FET); present state.

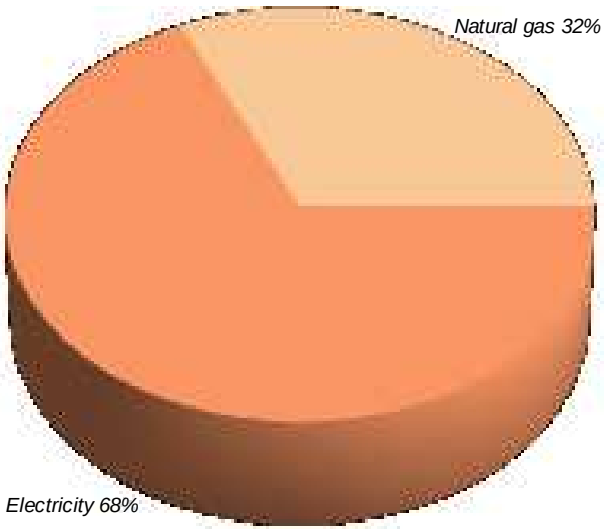

Figure 5: Total final energy consumption (FEC); present state.

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

Equipment	Fuel type	FET by equipment	
		[MWh]	[% of Total]
hot water 1	Natural gas	41	2.33
hot water 2	Natural gas	41	2.34
boiler heating 1	Natural gas	693	39.14
boiler heating 2	Natural gas	693	39.14
chiller 1	Electricity	101	5.68
chiller 2	Electricity	101	5.68
chiller 3	Electricity	101	5.68
Total		**1,770**	**100.00**

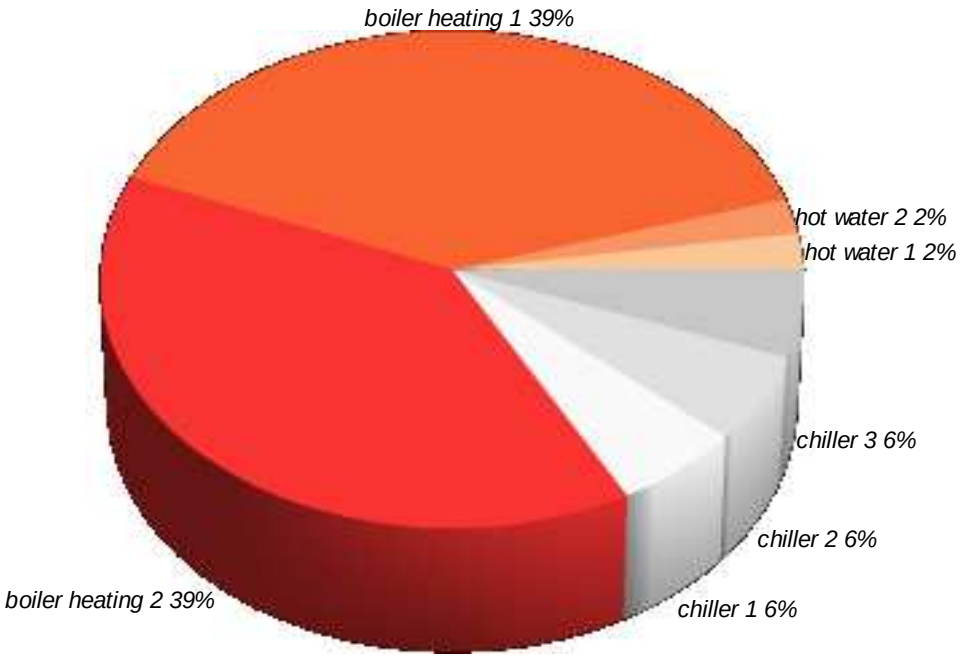

Figure 6: Final energy consumption for thermal use (FET) by equipment

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]
hot water 1	41	2.88
hot water 2	41	2.89
boiler heating 1	665	47.11
boiler heating 2	665	47.11
Total	**1,412**	**100.00**

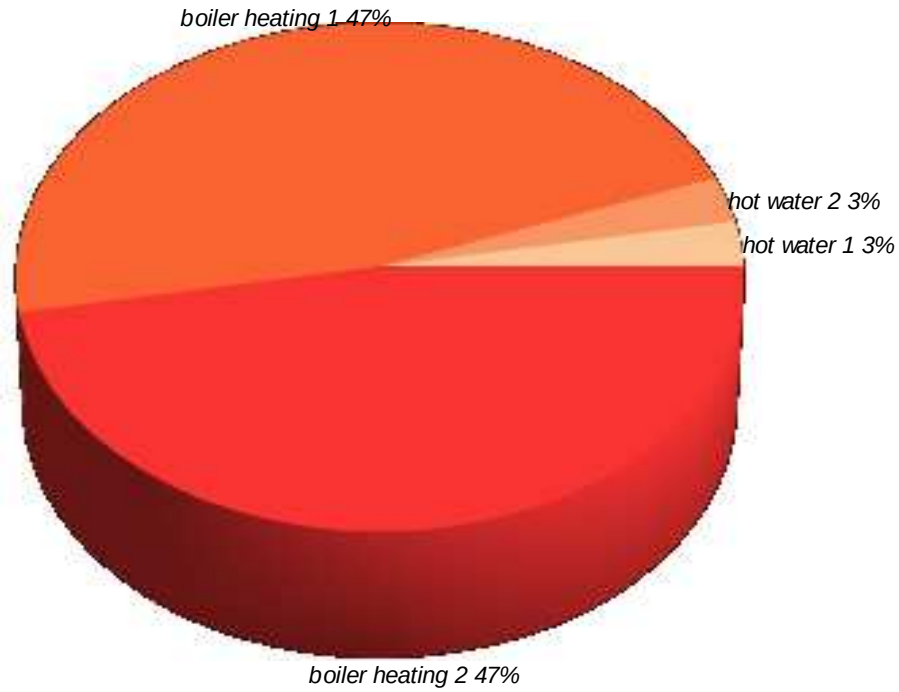

Figure 7: Useful supply heat (USH) by equipment. Present state.

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

Equipment	USC by equipment	
	[MWh]	[% of Total]
chiller 1	210	33.33
chiller 2	210	33.33
chiller 3	210	33.33
Total	**630**	**100.00**

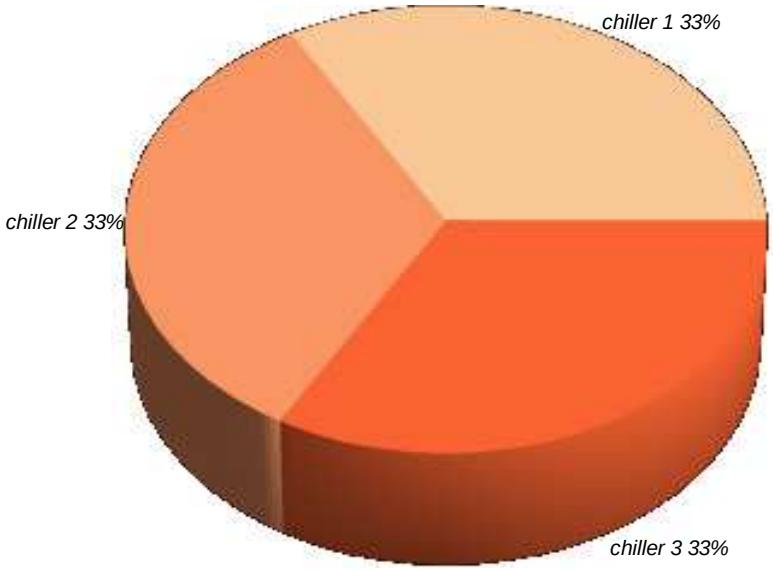

Figure 8: Useful supply cooling (USC) by equipment. Present state.

- **Distribution system:**

  Media and temperatures

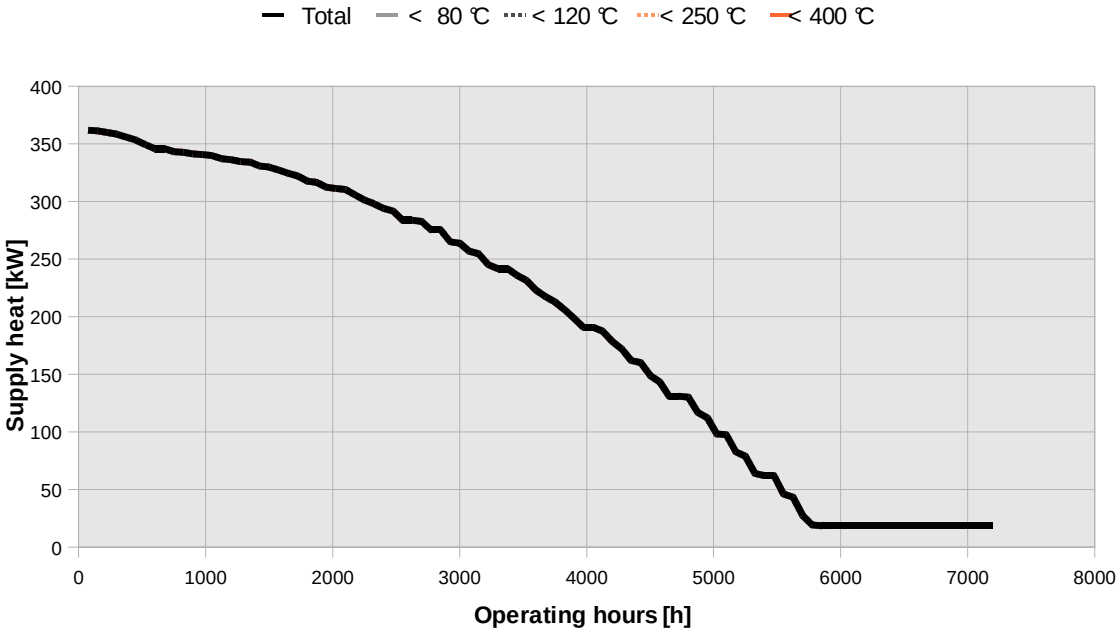

Figure 9: Distribution of supply heat by temperature levels and annual operating hours. Present state.

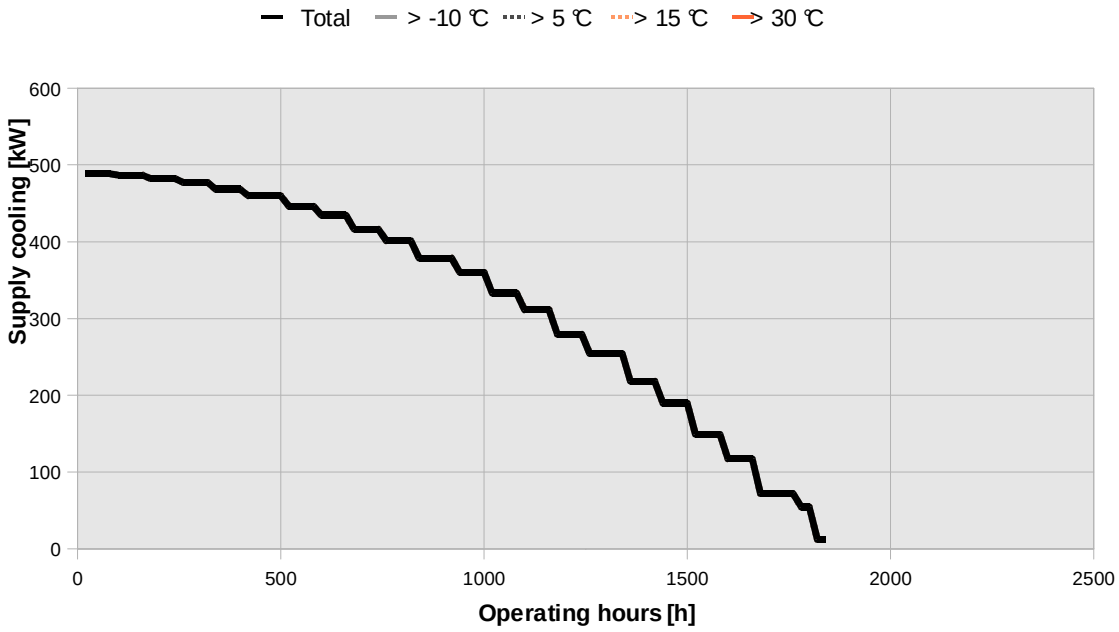

Figure 10: Distribution of supply cooling by temperature levels and annual operating hours. Present state.

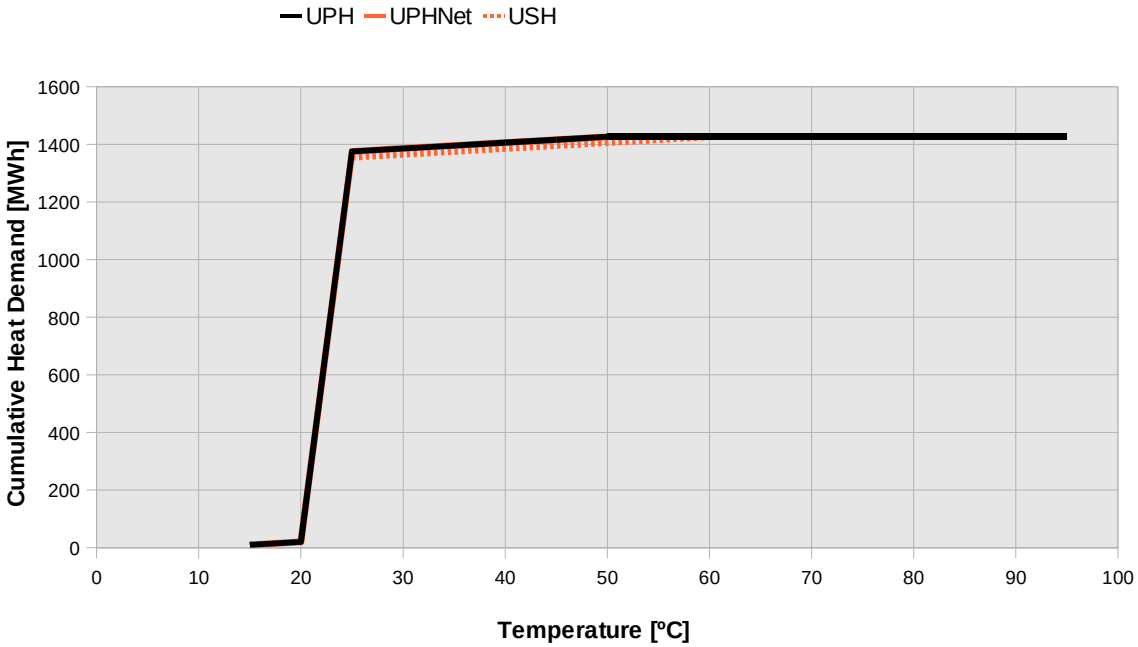

Figure 11: Distribution of the heat demand by temperature levels

- **Main energy consuming energy processes and buildings**

  External energy delivered to process (UPHproc), Total energy demand (UPH) per process

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

Process	Total [MWh]	Circulation [MWh]	Maintenance [MWh]	Start-up [MWh]
The_HW	82	82	0	0
The_heating	1.345	0	1.345	0
Total	**1.427**			

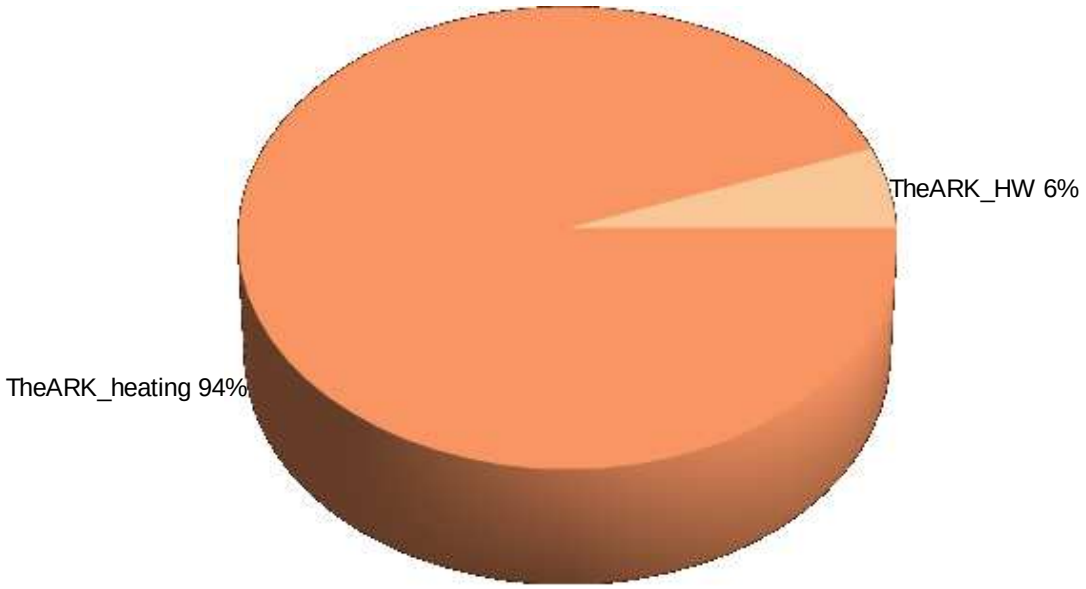

Figure 12: Useful process heat (UPH) by process

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

Process	Total [MWh]	Circulation [MWh]	Maintenance [MWh]	Start-up [MWh]
The_cooling	610	0	610	0
Total	**610**			

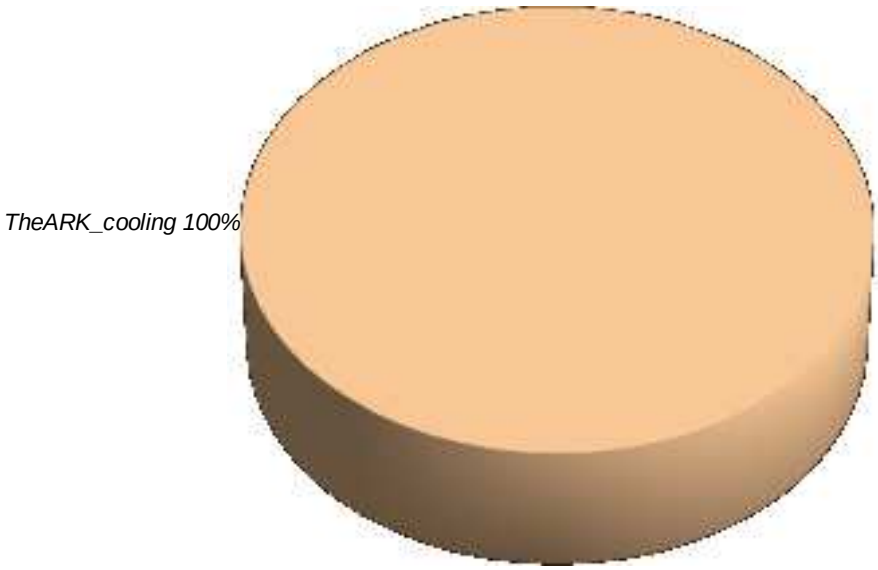

Figure 13: Useful process cooling (UPC) by process

3.4. General

- The hot water consumption per day of the building was calculated from the average water consumption of 4.8 m³/day. Taking the benchmark of hot water consumption for offices of 22 litres per day and person in account this leads to an average occupation of 220 persons per day.
- The heating demand was then calculated subtracting the hot water heating demand from the total gas consumption, regarding an average efficiency of the gas boilers of 94%. (heating demand: 1,344 MWh/a; 89 kWh/m²a)
- The cooling demand of the building was calculated from the difference of the electrical power consumption between summer and winter months and a COP (coefficient of performance) of the electrical chillers of 2.97. (cooling demand: 610 MWh/a)

4. Comparative study

Table 8: Overview of the alternative proposals studied

Short Name	Description
solar	based on present state + max. 1,400 m² solar thermal
CHP	based on present state + CHP (combined heat and power)

4.1. Proposed alternatives: **solar**

- solar

Collector type:	FPC (flat plate collector)
Collector area:	431 m²
Installed capacity:	302 kW
Solar buffer storage volume:	22 m³
Solar fraction:	6.36 %
Annual energy yield:	300 kWh/kWa

A solar thermal system with an collector area of 431 m² is installed and delivers 91 MWh of thermal energy per year to the heat supply system. The installed flat plate collectors have a capacity of 302 kW and the needed solar buffer storage has a volume of 22 m³.

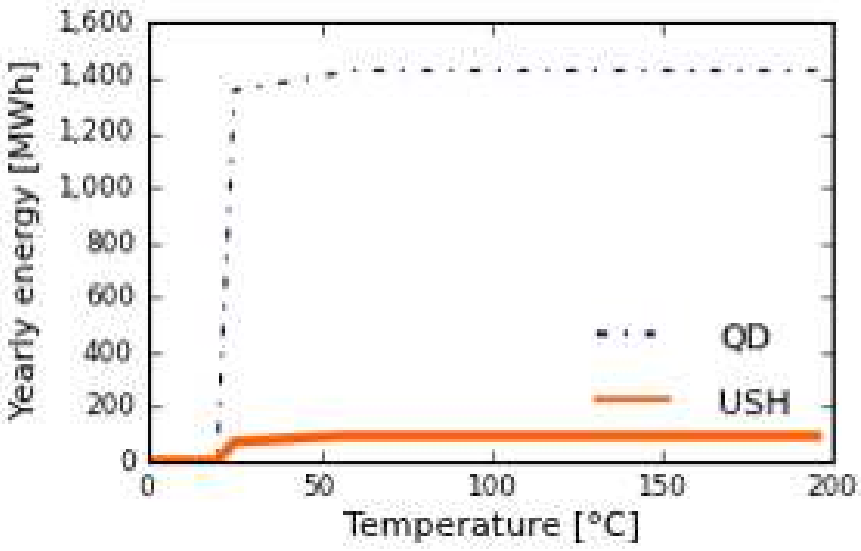

Figure 14: Heat demand and solar contribution

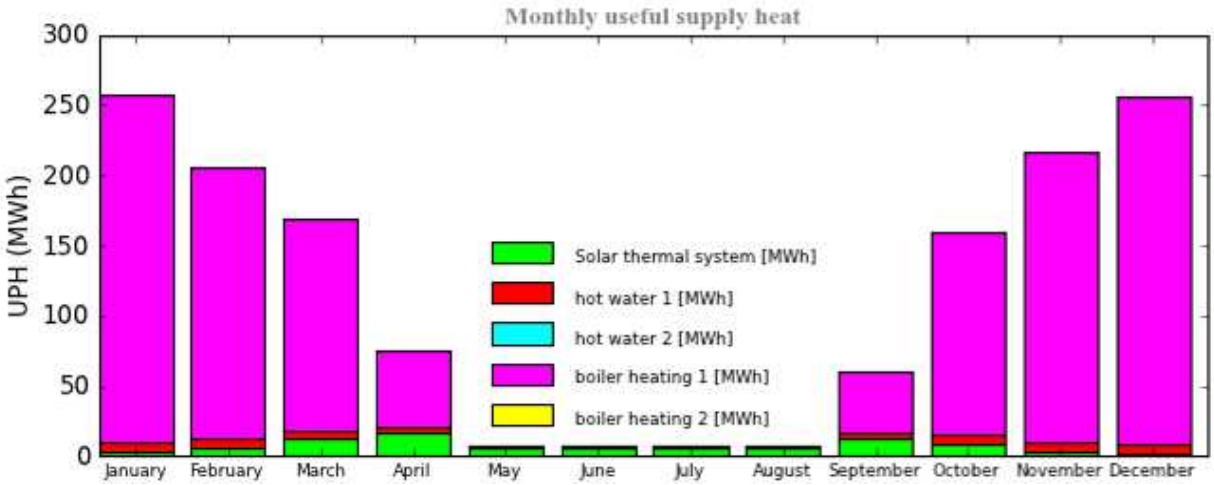

Figure 15: Distribution of useful supply heat per months

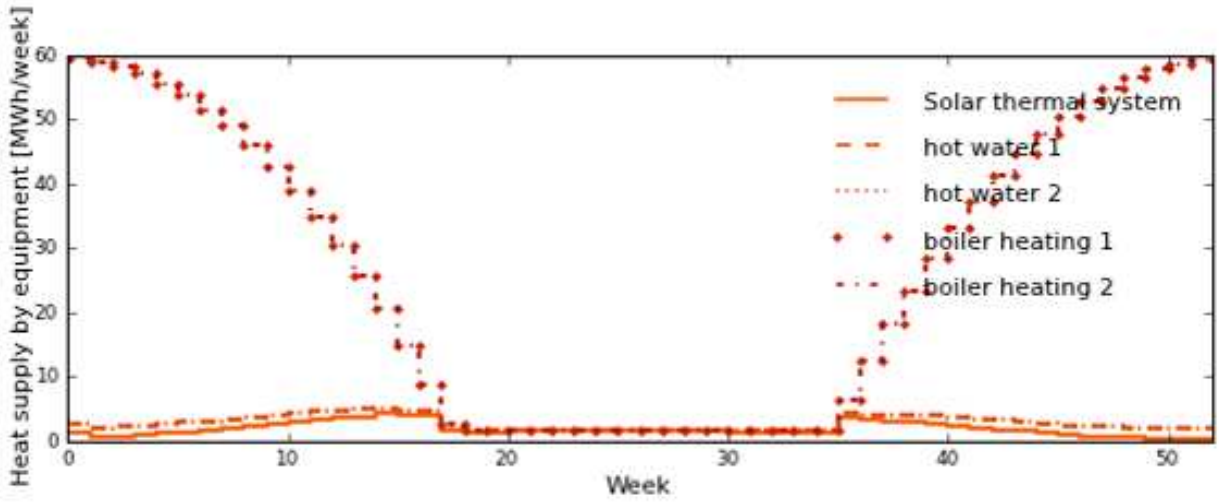

Figure 16: weekly heat supply by equipment

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]	[%]
Solar thermal system	solar thermal (flat-plate)	o==heating==o o==HW distribution==o	302	91	4,46
hot water 1	hot water boiler	o==HW distribution==o	20	49	2,42
hot water 2	hot water boiler	o==HW distribution==o	20	0	0,00
boiler heating 1	hot water boiler	o==heating==o	800	1.287	63,17
boiler heating 2	hot water boiler	o==heating==o	800	0	0,00
chiller 1	compression chiller (air cooled)	o==cooling==o	589	610	29,95
chiller 2	compression chiller (air cooled)	o==cooling==o	589	0	0,00
chiller 3	compression chiller (air cooled)	o==cooling==o	589	0	0,00
Total			**3.709**	**2.037**	**100**

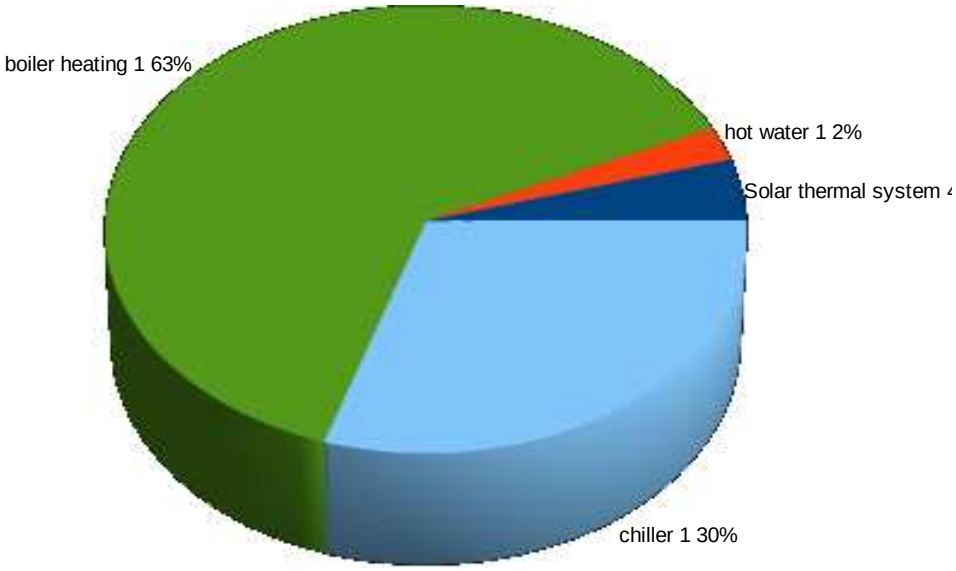

Figure 17: Contribution of each equipment to the total useful heat and useful cooling supply (USH & USC).

4.2. Proposed alternatives: **CHP**

- CHP (combined heat and power)

Type:	gas turbine
Installed electrical capacity:	100 kW
Installed thermal capacity:	176 kW
Electrical efficiency:	0.29
Thermal efficiency:	0.51
Operating hours:	6,460

The installed CHP gas turbine supplies the heat supply system with 929 MWh of thermal energy per year with 6,460 operating hours per year. During the whole year the gas turbine also generates 528 MWh of electrical energy.

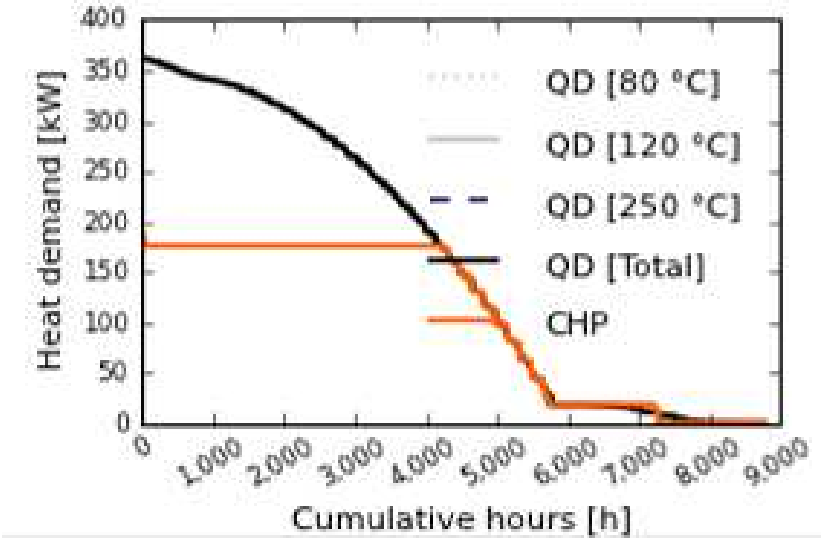

Figure 18: Cumulative heat demand to be covered by CHP

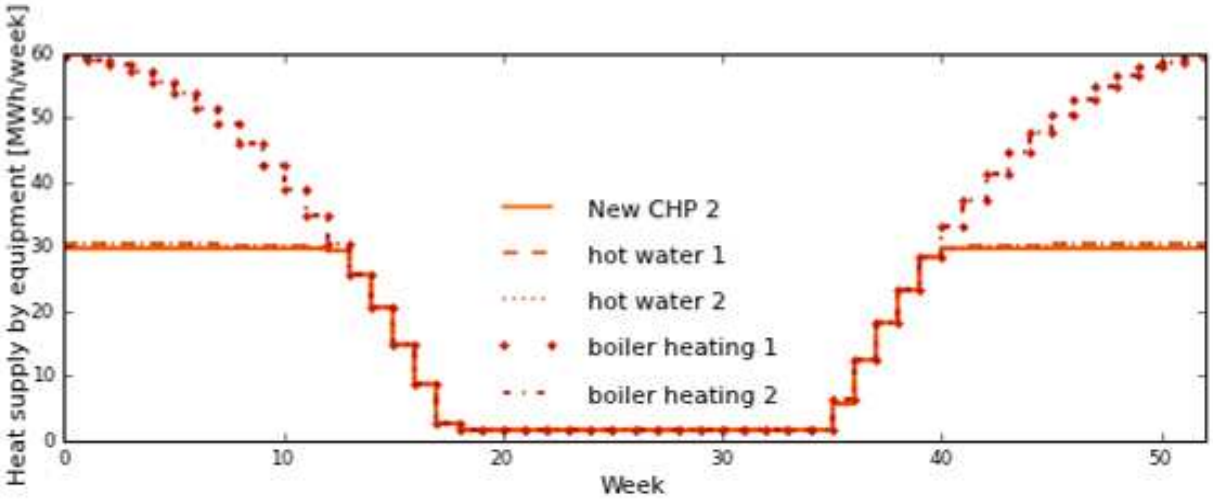

Figure 19: weekly heat supply by equipment

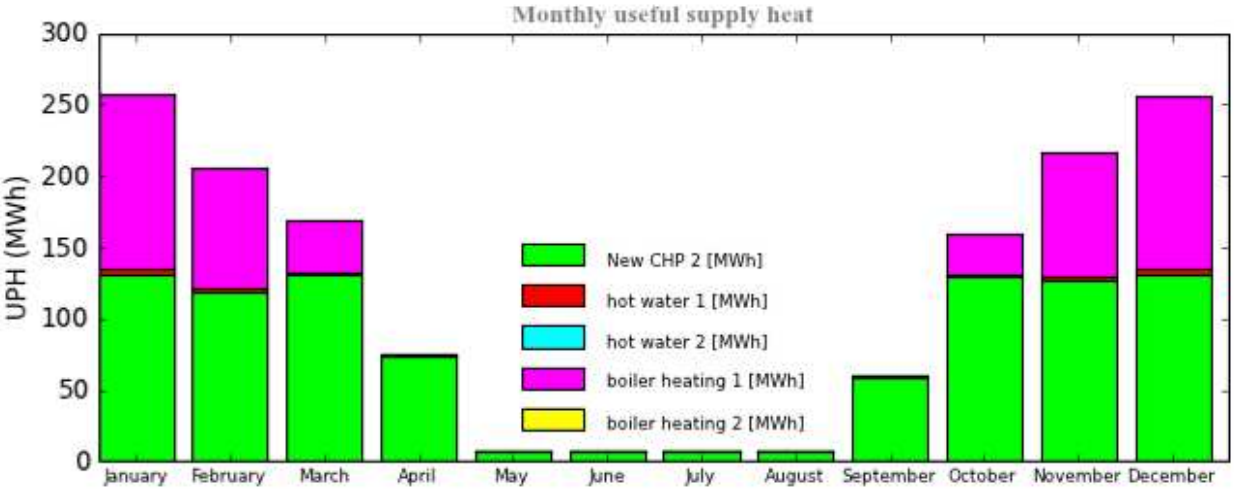

Figure 20: Distribution of useful supply heat per months

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]	[%]
New CHP 2	CHP engine	o==heating==o o==HW distribution==o	176	929	45,64
hot water 1	hot water boiler	o==HW distribution==o	20	16	0,77
hot water 2	hot water boiler	o==HW distribution==o	20	0	0,00
boiler heating 1	hot water boiler	o==heating==o	800	482	23,64
boiler heating 2	hot water boiler	o==heating==o	800	0	0,00
chiller 1	compression chiller (air cooled)	o==cooling==o	589	610	29,95
chiller 2	compression chiller (air cooled)	o==cooling==o	589	0	0,00
chiller 3	compression chiller (air cooled)	o==cooling==o	589	0	0,00
Total			**3.583**	**2.037**	**100**

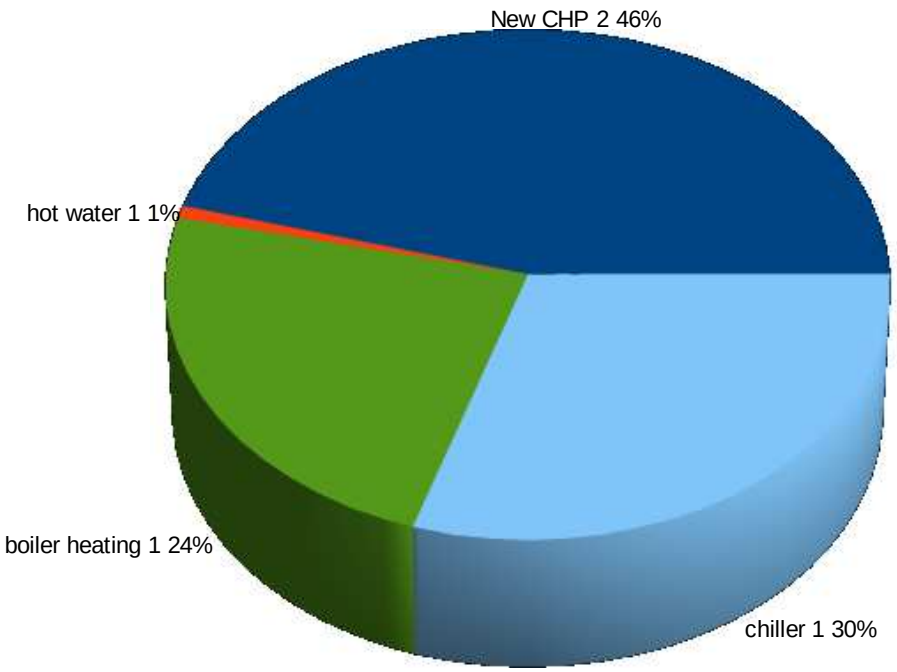

Figure 21: Contribution of each equipment to the total useful heat and useful cooling supply (USH & USC).

5. Selected alternative(s) and conclusions

The alternative "CHP" was chosen due to the fact that this alternative has one of the highest primary energy consumption savings and has a lower payback period.

5.1. Selected alternative: **CHP**

Table 11: Primary energy consumption: present state and alternative proposals

Alternative	Primary energy consumption	Savings	
	[MWh]	[MWh]	[%]
Present State (checked)	10,736	---	---
solar	10,495	242	2.25
CHP	9,980	756	7.04

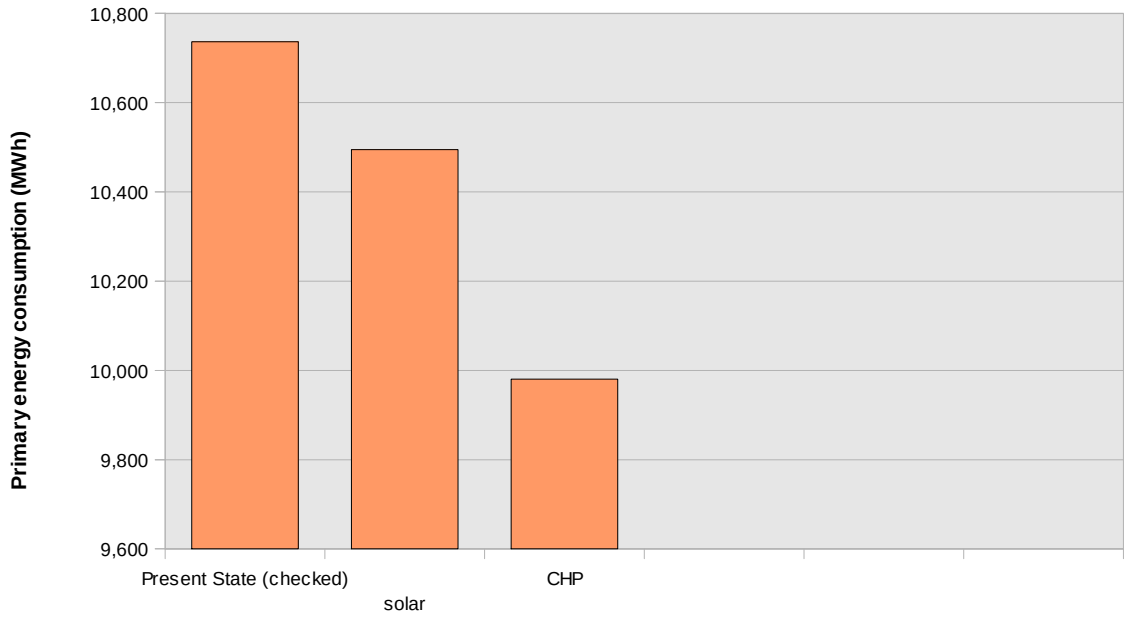

Figure 22: Comparison of alternatives: primary energy consumption

5.1.1. Process optimisation (written proposals)

Based on the available data no process optimisation was proposed.

5.1.2. Heat recovery

Based on the available data no heat recovery was proposed.

5.1.3. Heat and Cold Supply:

CHP (combined heat and power)

Type:	gas turbine
Installed electrical capacity:	100 kW
Installed thermal capacity:	176 kW
Electrical efficiency:	0.29
Thermal efficiency:	0.51
Operating hours:	6,460

5.2. Comparative study and conclusions

Table 12: Comparative Study

		Present state	Alternative	Saving
Total primary energy consumption (1)	[MWh]	10,736	9,980	756
Allocation of energy consumption	[-]			
Total Fuels	[MWh]	1,574	2,602	- 1,028
Total Electricity	[MWh]	9,162	7,378	1,784
Share of renewable energy	[%]		-	
CO_2 emissions	[tons/a]	1,885	1,821	64
Annual energy system cost (2)	[EUR]	330,997	301,187	29,810
Investment costs	[EUR]		123,200	
Payback period (3)	[years]		7	

(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:

Table 13: Environmental impact: present state and alternative proposals

Alternative	Production of CO2	Highly Radioactive Nuclear Waste	Water consumption
	[t]	[kg]	[m3]
Present State (checked)	1884.75	15.27	0.00
solar	1839.94	14.99	0.00
CHP	1821.11	12.30	0.00

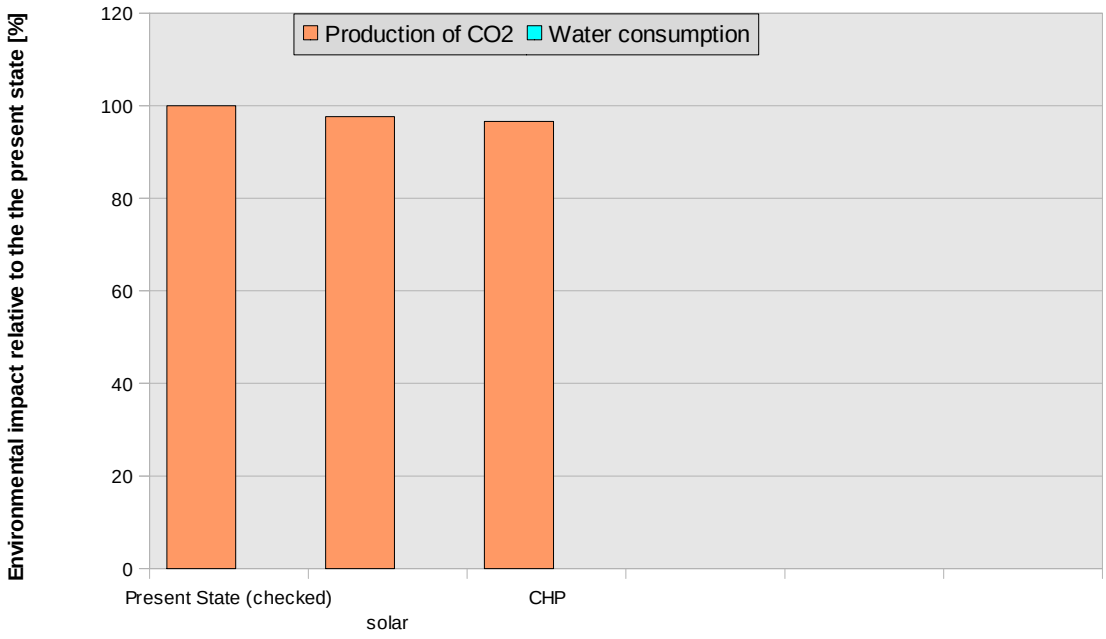

Figure 23: Comparison of alternatives: environmental impact

5.2.1. Energy and environmental analysis

By installing the CHP the primary energy demand for thermal use can be reduced and saves 64 tons of CO2.

5.2.2. Economic analysis

The investment costs for the CHP plant are assumed by £ 108,070 (conversion rate of 1:1.14 was assumed according to yahoo-finance on 02/09/2011). The calculated payback period is therefore 6.5 years.

Table 14: Investment cost: alternative proposals

Alternative	Total investment	Own investment	Subsidies
	[£]	[£]	[£]
Present State (checked)	---	---	---
solar	151,228	105,860	45,368
CHP	108,070	108,070	0

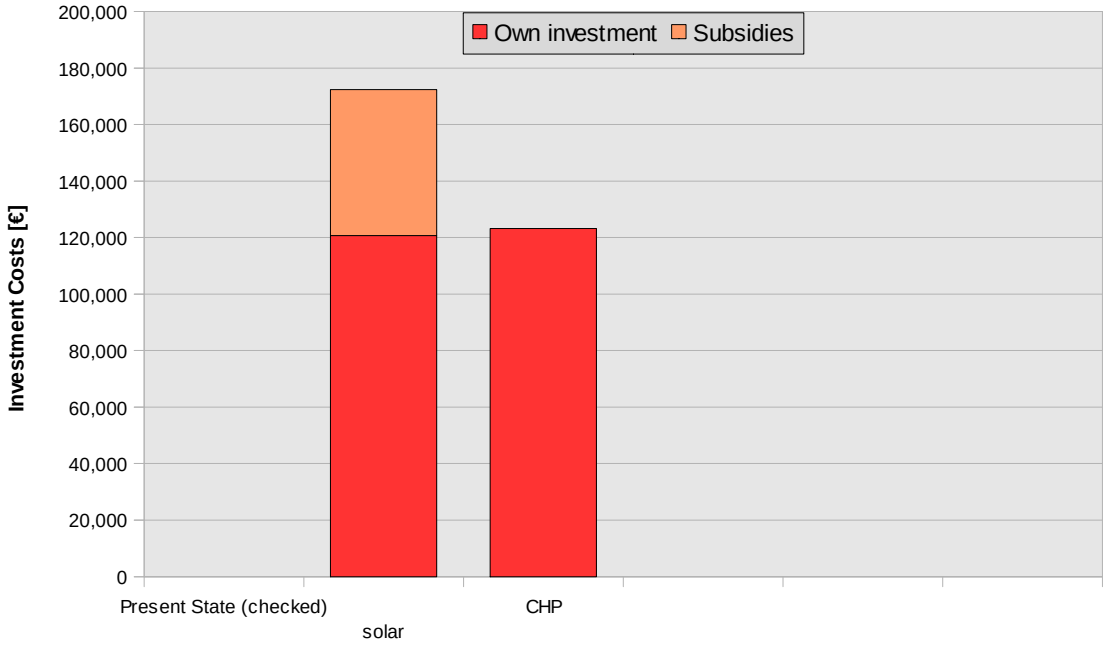

Figure 24: Comparison of alternatives: Investment cost*

Table 15: Total annual cost (fuels and electricity, O&M and annuity of investment): present state and alternative proposals

Economic parameters used in the analysis:

Real interest rate (*)	[%]	6,00	(*) Real interest rate = nominal interest rate – inflation rate
Economic depreciation period	[a]	15,00	
Annuity (**) of initial investment	[%]	10,30	(**) Annual payments for interest and depreciation

Alternative	Annuity	Energy Cost	O&M
	[£]	[£]	[£]
Present State (checked)	---	290,348	0
solar	6,052	288,709	947
CHP	4,325	264,199	9,030

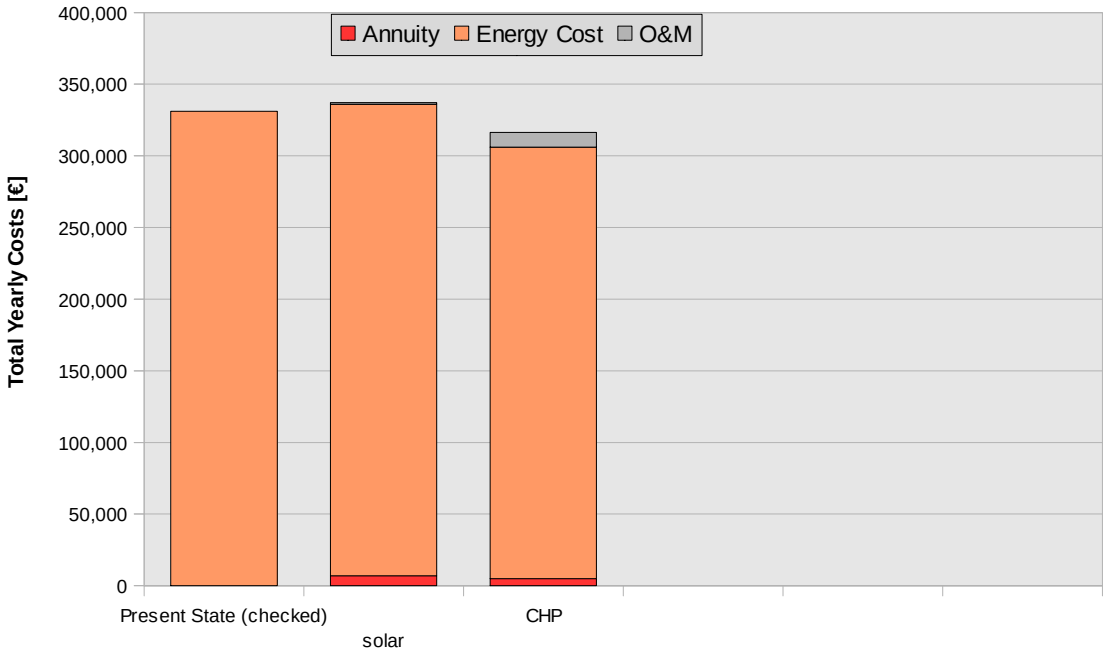

Figure 25: Comparison of alternatives: Total annual cost (fuels and electricity, O&M and annuity of investment)*

Table 16: Total additional cost (w/o subsidies) per saved primary energy (PE): comparison of alternative proposals

Alternative	Total energy cost (incl. O&M and invest.)	Additional cost	Additional cost per saved PE
	[£]	[£]	[£/MWh]
Present State (checked)	290,348	---	---
solar	295,707	5,359	22.9
CHP	277,554	-12,795	-16.7

Figure 26: Comparison of alternatives: Total additional cost per saved primary energy*.

5.2.3. Conclusions and outlook

Based on the available data and measurements performed 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.

* The figures are generated in [€] due to the software, yet the numbers in the tables are in [£]