Energy Audit Summary Report

AEE INTEC

Audit no. *13* – UK03

Health Care

Hospital

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. 13 – UK03

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: 5
Date of the audit: 10/11/2011
Duration of the audit: 4 weeks

2. Introduction

2.1. Objectives

Main objective of this audit was to determine the potential of integrating solar thermal power into the heat generation system of the company.

3. Status Quo: processes, distribution, energy supply

3.1. General info of company

Sector: healthcare, hospital
Number of employees: 7,000

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

in form of a block diagram

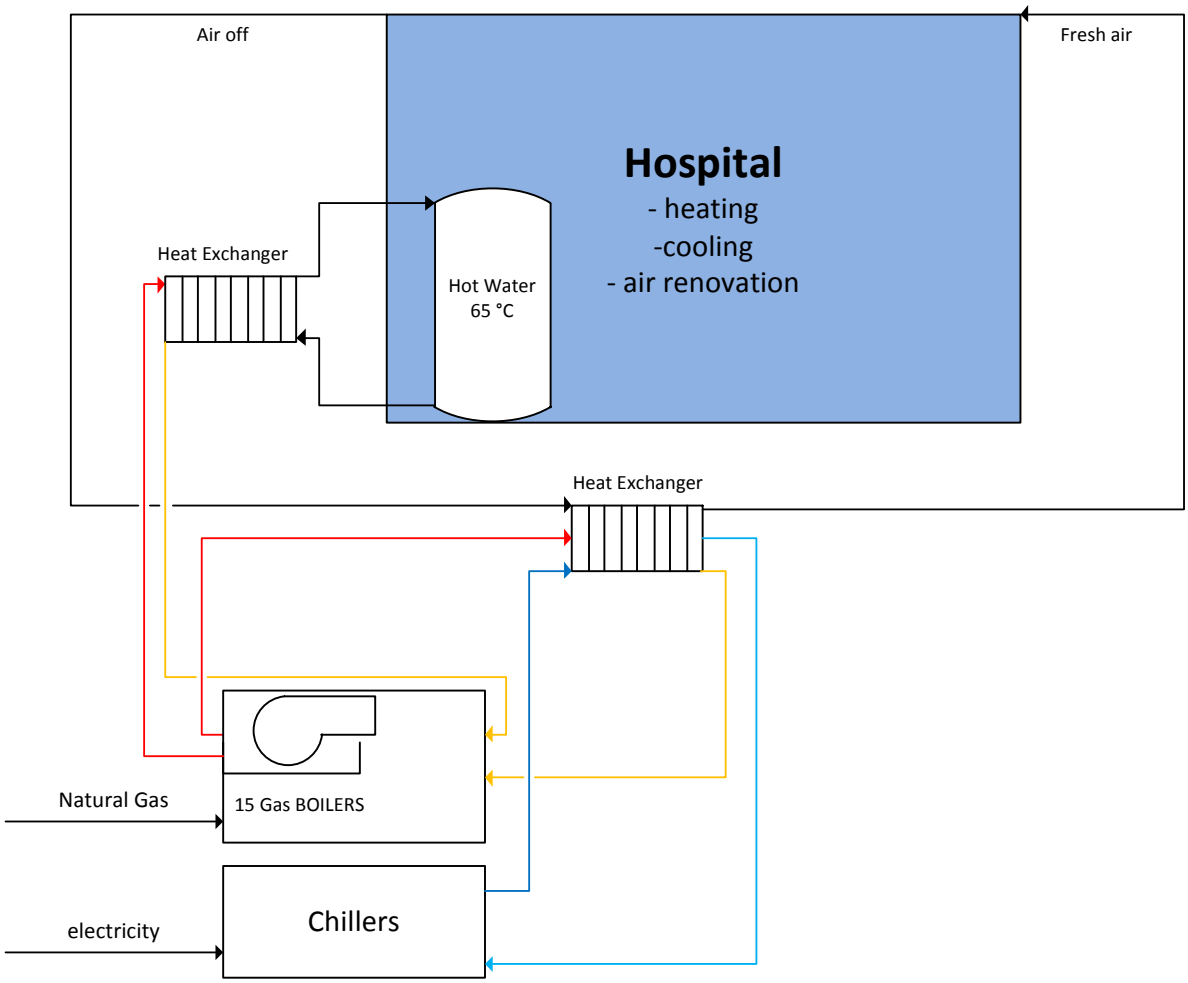

Figure 1: Flow sheet

3.3. Description of the existing system

The hospital has 15 gas boilers generating the needed heat for hot water (25,990 MWh) and building heating (10,336 MWh), ranging from 1,320 kW to 1570 kW of nominal power. The cooling demand for the hospital is as high as 13,577 MWh per year. In the following calculations and simulations the building and the building management were disregarded and the focus was on the energy supply.

- **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	47,197	23.98	47,197	76.22
Total electricity	149,616	76.02	14,723	23.78
Total (fuels + electricity)	**196,813**	**100.00**	**61,920**	**100.00**

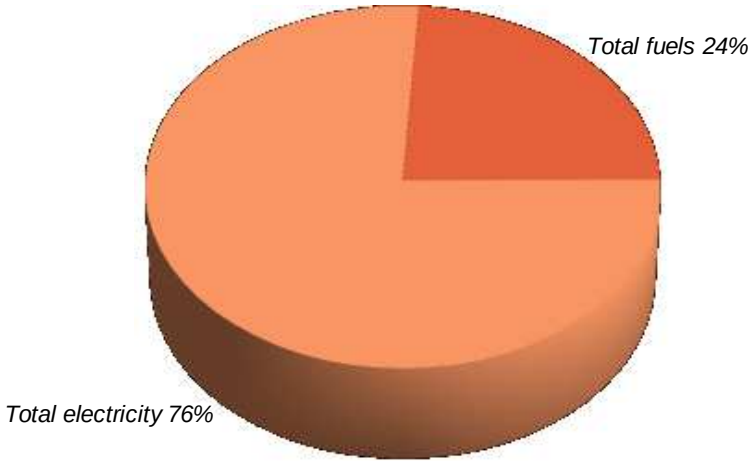

Figure 2: Distribution of PEC by fuel type

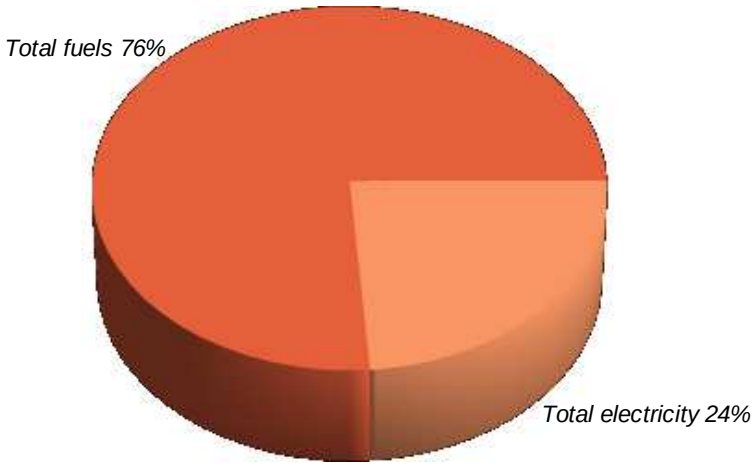

Figure 3: Distribution of PET by fuel type

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

Table 2: Total primary energy consumption (PEC) and primary energy consumption for thermal use (PET)

Fuel type	FEC		FET	
	[MWh]	[% of Total]	[MWh]	[% of Total]
Natural gas	42,906	46.25	42,906	89.74
Electricity	49,872	53.75	4,908	10.26
Total	92,778	100.00	47,814	100.00

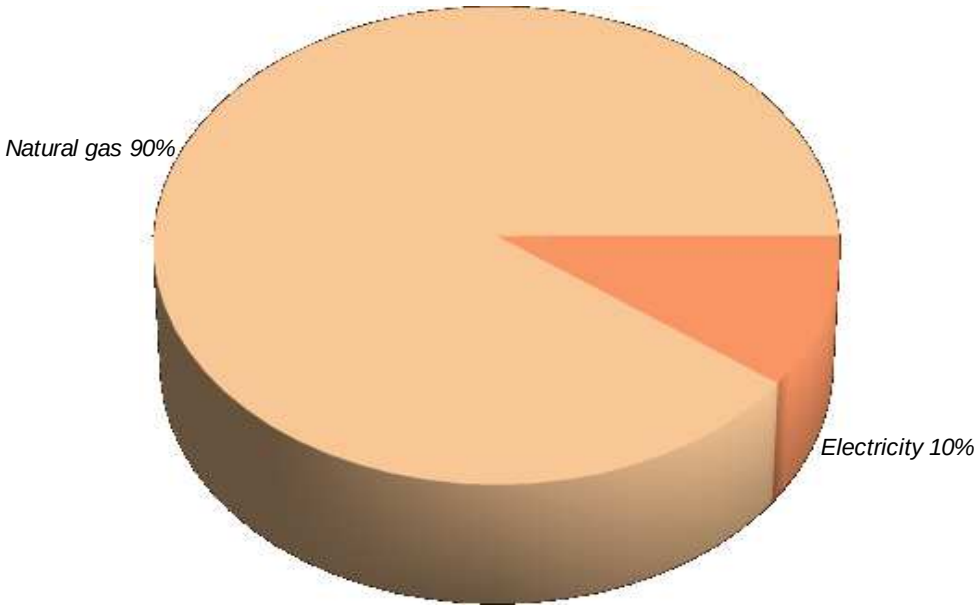

Figure 4: Total final energy consumption for thermal use (FET); present state.

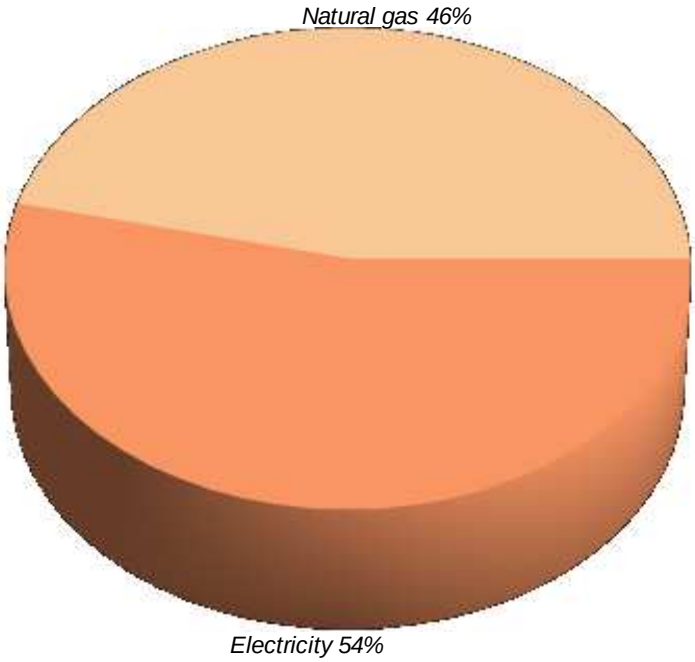

Figure 5: Total final energy consumption (FEC); present state.

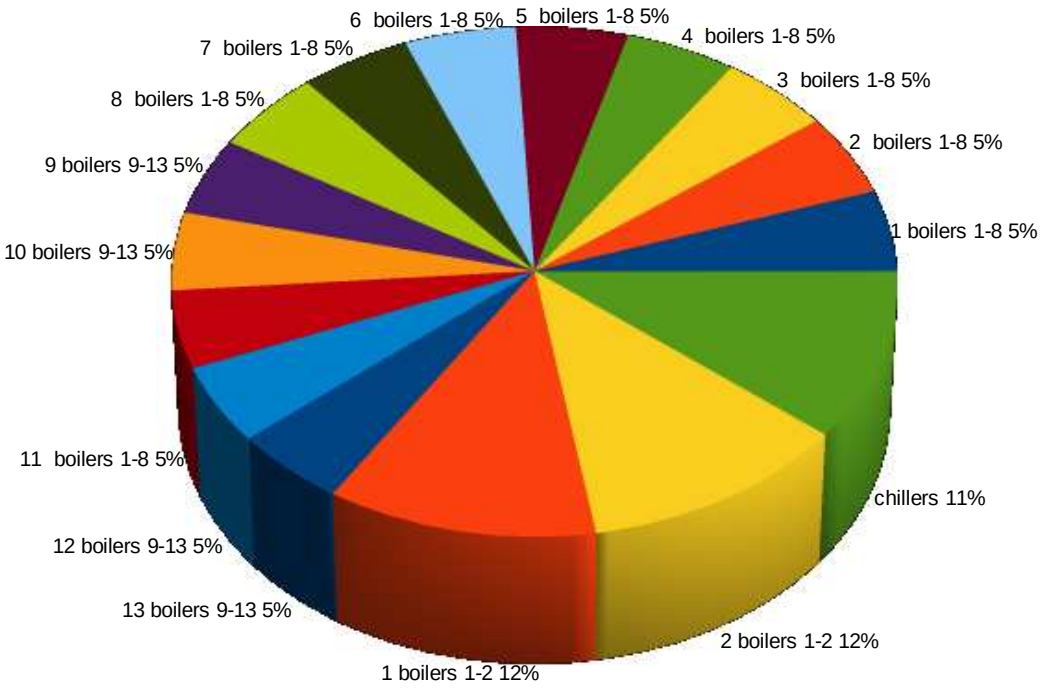

Figure 6: Final energy consumption for thermal use (FET) by equipment

Table 3: Final energy consumption for thermal use (FET) by equipment (present state). (not complete not all the equipment is shown)

Equipment	Fuel type	FET by equipment	
		[MWh]	[% of Total]
1 boilers 1-8	Natural gas	2,359	5.17
2 boilers 1-8	Natural gas	2,359	5.17
3 boilers 1-8	Natural gas	2,359	5.17
4 boilers 1-8	Natural gas	2,359	5.17
5 boilers 1-8	Natural gas	2,359	5.17
6 boilers 1-8	Natural gas	2,359	5.17
7 boilers 1-8	Natural gas	2,359	5.17
8 boilers 1-8	Natural gas	2,359	5.17
9 boilers 9-13	Natural gas	2,248	4.92
10 boilers 9-13	Natural gas	2,248	4.92
11 boilers 1-8	Natural gas	2,248	4.92
12 boilers 9-13	Natural gas	2,248	4.92
13 boilers 9-13	Natural gas	2,248	4.92
1 boilers 1-2	Natural gas	5,311	11.64
2 boilers 1-2	Natural gas	5,311	11.64
chillers	Electricity	4,908	10.75
Total		**45,641**	**100.00**

Tabelle 1: Useful supply heat (USH) by equipment; present state

Equipment	USH by equipment	
	[MWh]	[% of Total]
1 boilers 1-8	2,110	5.81
2 boilers 1-8	2,110	5.81
3 boilers 1-8	2,110	5.81
4 boilers 1-8	2,110	5.81
5 boilers 1-8	2,110	5.81
6 boilers 1-8	2,110	5.81
7 boilers 1-8	2,110	5.81
8 boilers 1-8	2,110	5.81
9 boilers 9-13	2,010	5.54
10 boilers 9-13	2,010	5.54
11 boilers 9-13	2,010	5.54
12 boilers 9-13	2,010	5.54
13 boilers 9-13	2,010	5.54
1 variation boilers 9-13	4,683	12.90
2 variation boilers 9-13	4,683	12.90
Total	**36,298**	**100.00**

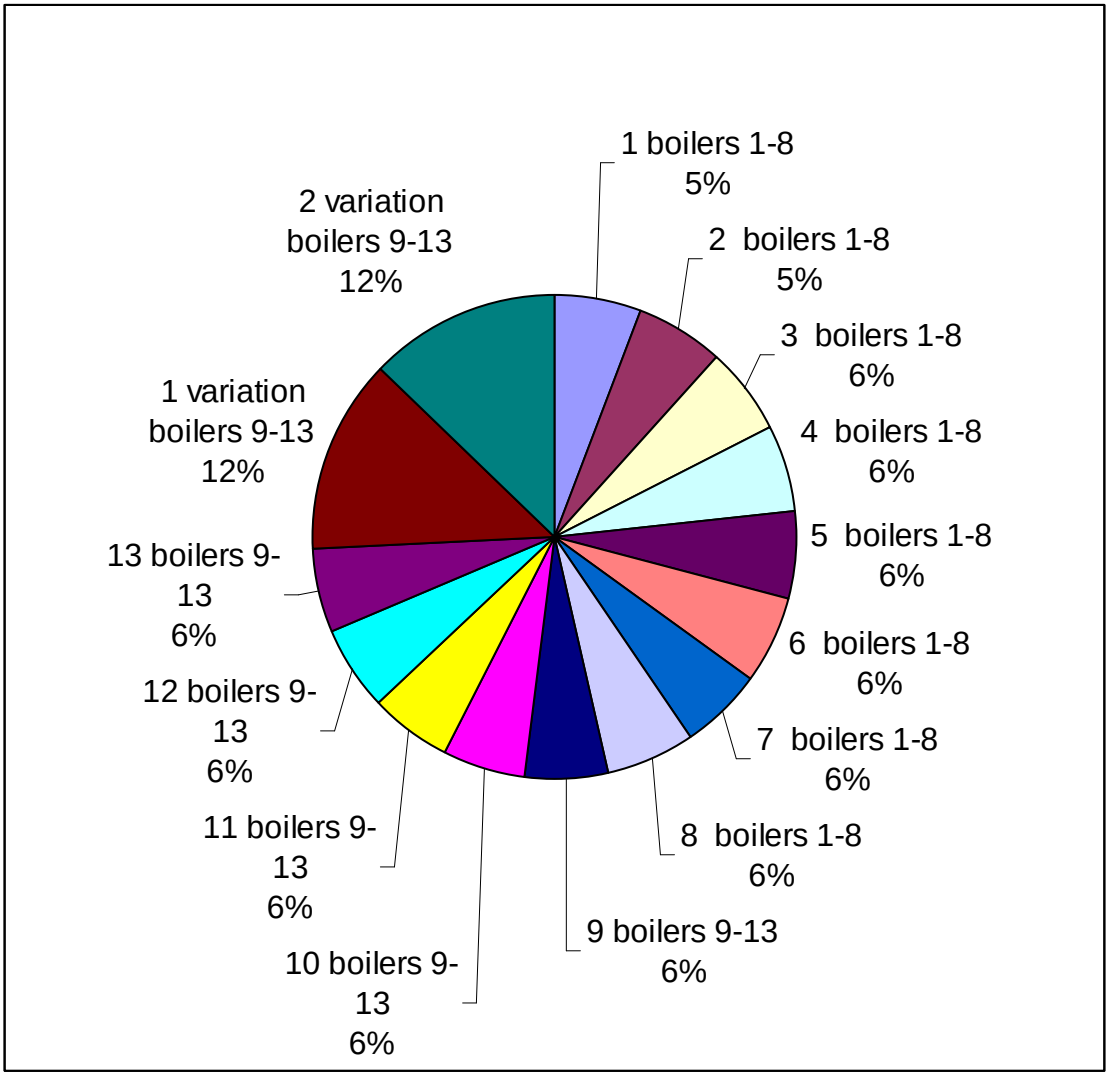

Figure 7: Final energy consumption for thermal use (FET) by equipment

Table 4: Useful supply cooling (USC) by equipment; present state.

Equipment	**USC by equipment**	
	[MWh]	[% of Total]
chillers	13,577	100.00
Total	**13,577**	**100.00**

- **Distribution system:**

  Media and temperatures

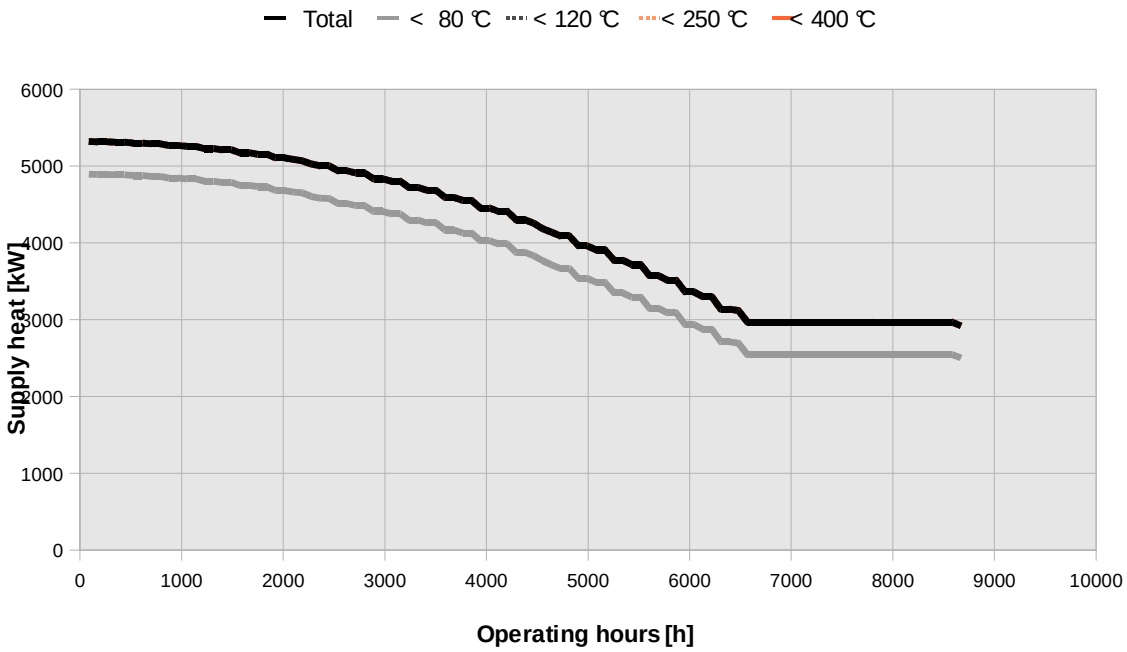

Figure 8: Distribution of supply heat by temperature levels and annual operating hours. Present state.

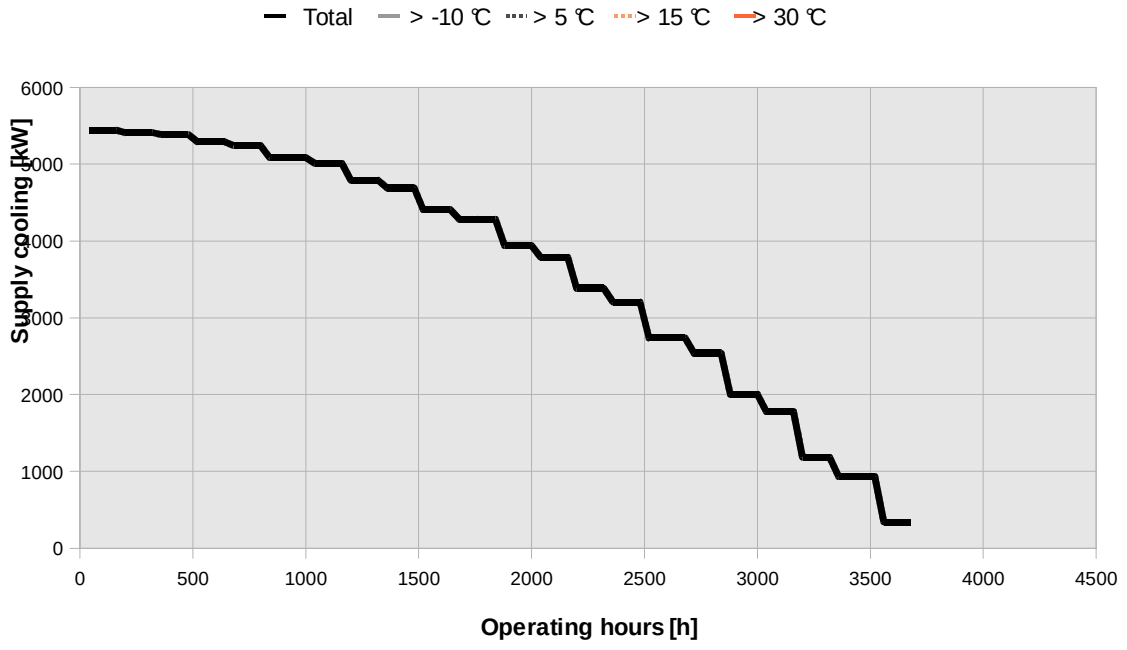

Figure 9: Distribution of supply cooling by temperature levels and annual operating hours. Present state.

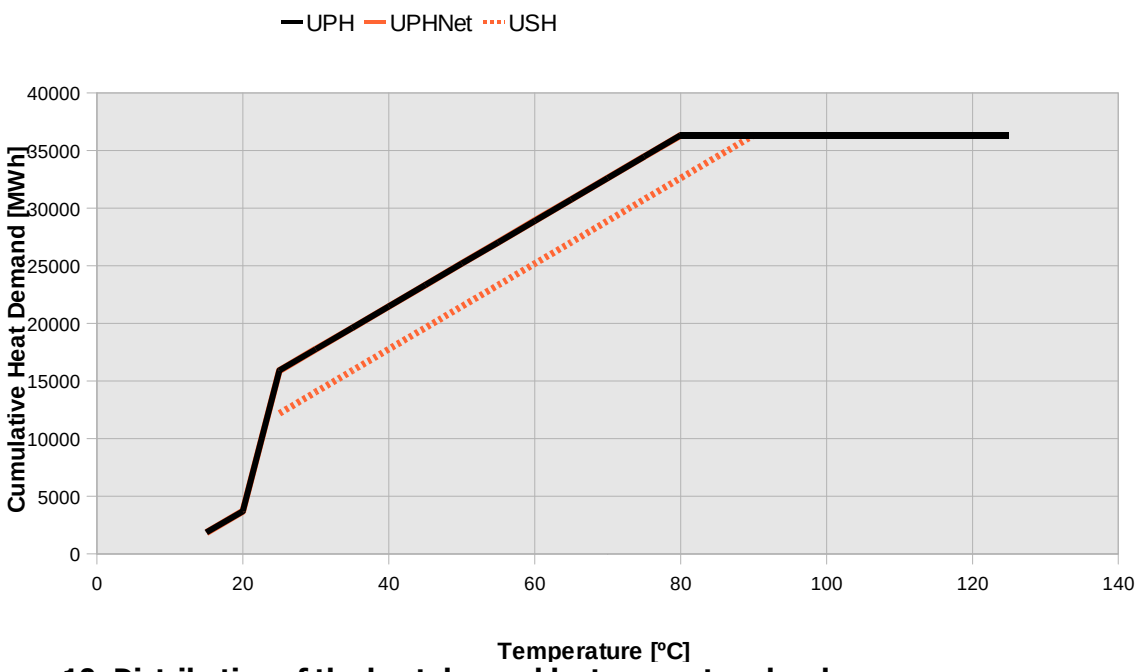

Figure 10: Distribution of the heat demand by temperature levels

- Main energy consuming energy processes and buildings
  External energy delivered to process (UPHproc), Total energy demand (UPH) per process

Table 5: Useful process heat demand (UPH) by process. Present state.

Process	Total	Circulation	Maintenance	Start-up
	[MWh]	[MWh]	[MWh]	[MWh]
BHM hospital_HW	25,990	25,990	0	0
BHM hospital_heating	10,336	0	10,336	0
Total	**36,326**			

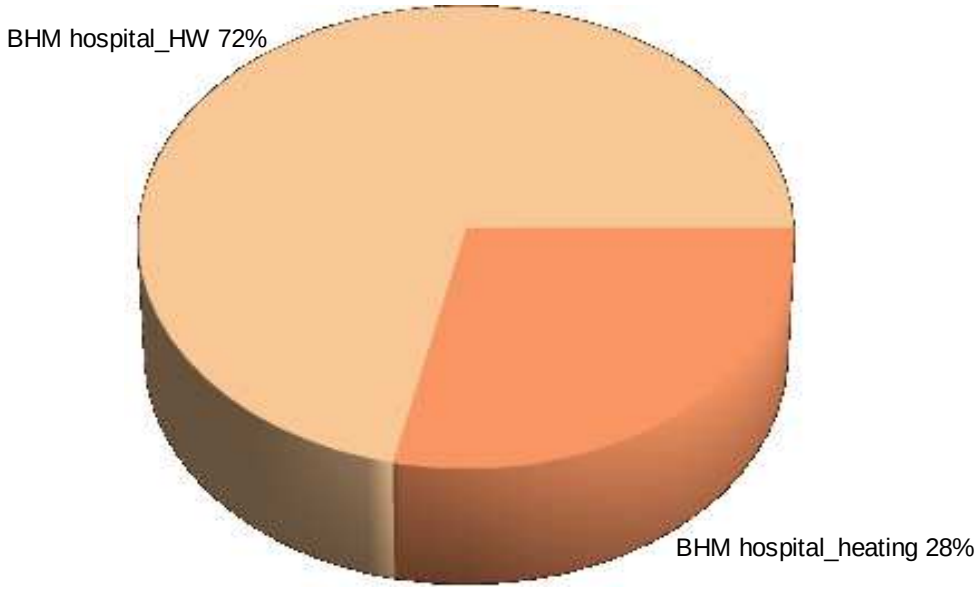

Figure 11: Useful process heat (UPH) by process

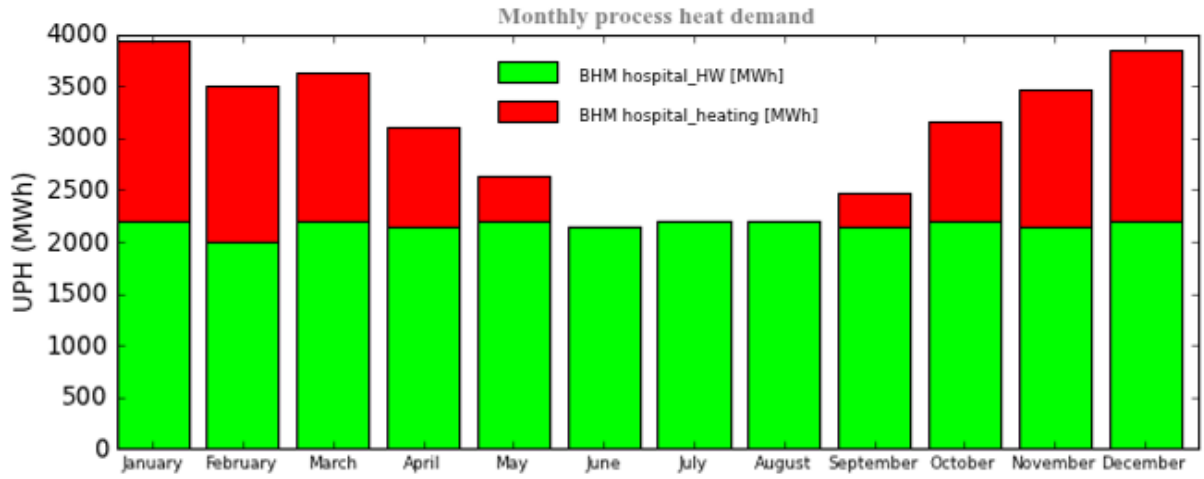

Figure 12: Monthly process heat demand; HW (hot water)

3.4. General

- As the electricity consumption of the chiller was only available for one month (approx. 770 MWh) an assumption of the average electric consumption of non thermal use was made based on this month (Sept).
- The cooling demand was than calculated taking the average non thermal consumption of electricity in account, using a COP (coefficient of performance) for the chiller of 3.
- The consumption of the hot water (HW) demand was calculated from the average gas consumption during the period of April until September, as the gas consumption data showed that the heating period starts at the end of September

and ends at the beginning of April. Taking an approximate hot water demand of 160 litres per day and person leads this to an around 5,500 persons per day.

- The heating demand was calculated than from the total gas consumption minus the gas consumption for HW, this led to a heating demand of 10,336 MWh per year taking the conversion efficiency of the different boilers in account.

4. Comparative study

Table 6: Overview of the alternative proposals studied

Short Name	Description
2 CHP	based on present state + two CHP plants
solar 9,000m²	based on present state + 9,000 m² solar collectors on the roof
solar 9,000m² no boiler mod.	based on present state + solar 9.000m²; no modification of the equipment cascade

4.1. Proposed alternative: 2 CHP

- 2 CHP

Two CHP (combined heat and power) plants with a nominal capacity of 1,500 kW are installed.

Type:	CHP, gas turbine
Installed thermal capacity:	1,500 kW
Installed electrical capacity:	800 kW
Electrical efficiency:	0.32
Thermal efficiency:	0.60
Operating hours:	8,500

Table 7: 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 5	CHP gas turbine	o==heating==o	1.500	13.141	36,18
New CHP 4	CHP gas turbine	o==heating==o	1.500	13.066	35,97
1 variation boilers 1-2	hot water boiler	o==heating==o	1.450	7.808	21,49
2 variation boilers 1-2	hot water boiler	o==heating==o	1.450	2.311	6,36
Boilers 1-8	hot water boiler	o==heating==o	10.560	0	0,00
Boilers 9-13	hot water boiler	o==heating==o	7.850	0	0,00
Total			**24.310**	**36.326**	**100**

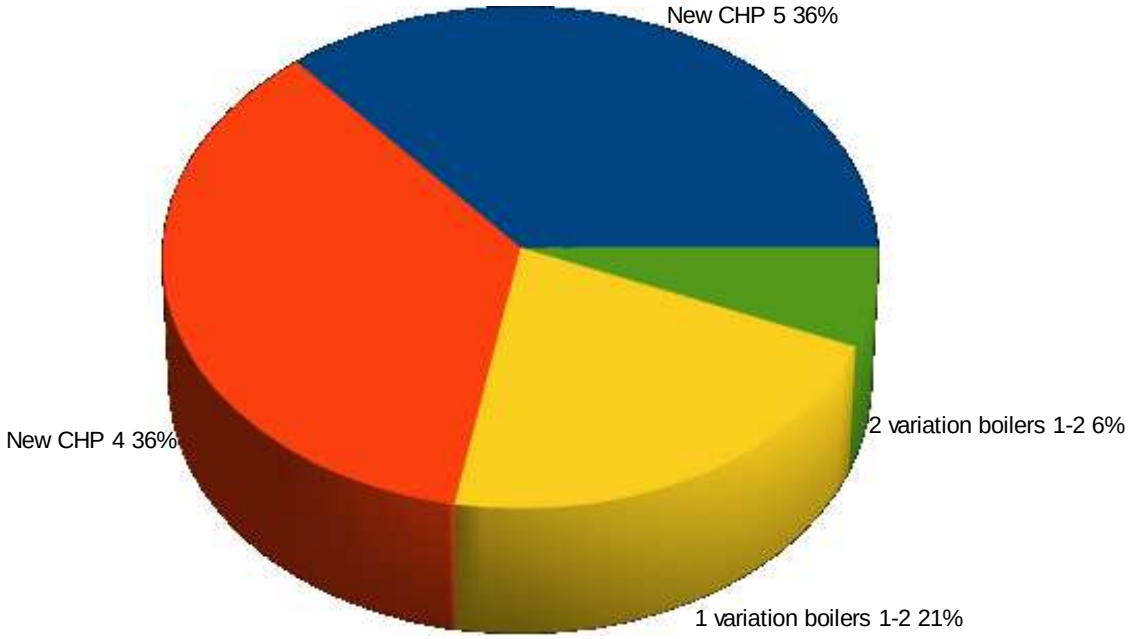

Figure 13: Contribution of each equipment to the total useful heat and useful cooling supply (USH & USC).

4.2. Proposed alternative: solar 9,000 m²

- Solar 9,000 m²

By installing 3,805 m² of flat plat collectors on the roof of the hospital it supplies the system with 1,451 MWh of thermal energy. Additionally the variation boilers with an efficiency of 90% are in first order in the heat generation cascade.

Collector type:	FPC (flat plate collector)
Installed collector area:	3,805 m²
Installed capacity:	2,664 kW
Solar buffer storage volume:	211 m³
Solar fraction:	3.99 %
Annual energy yield:	545 kWh/kWa

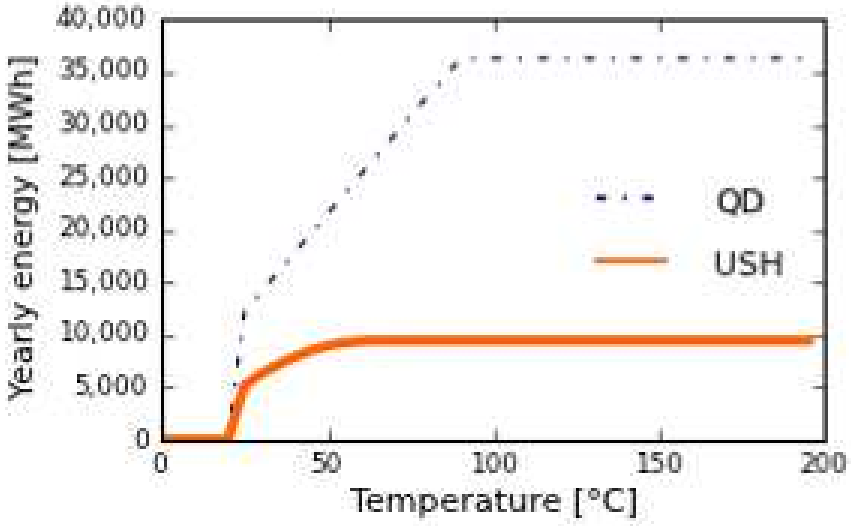

Figure 14: Heat demand and solar contribution

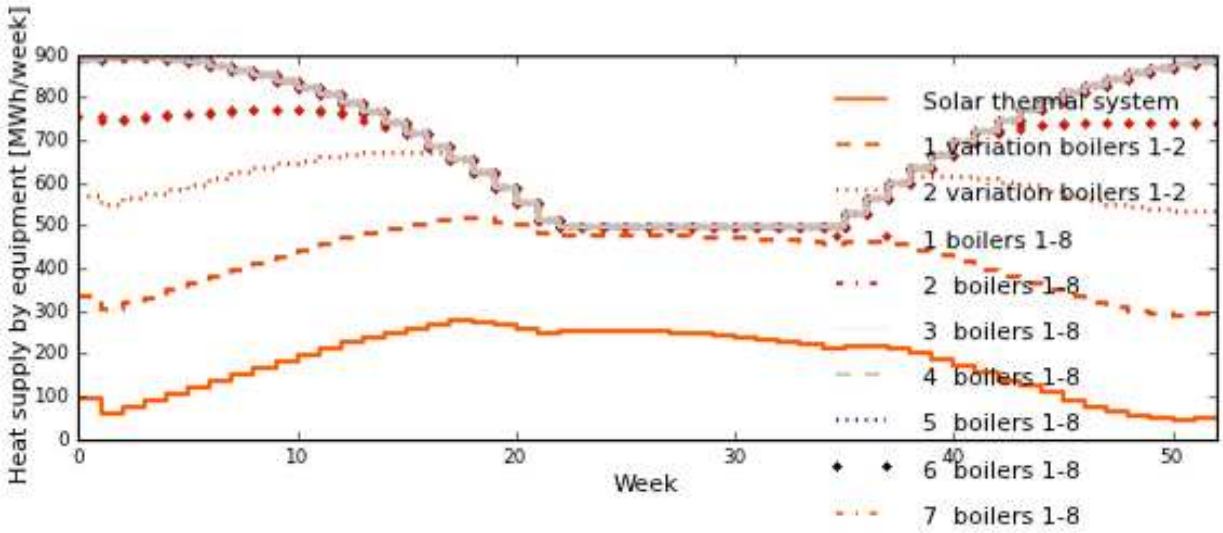

Figure 15: Weekly heat supply by equipment

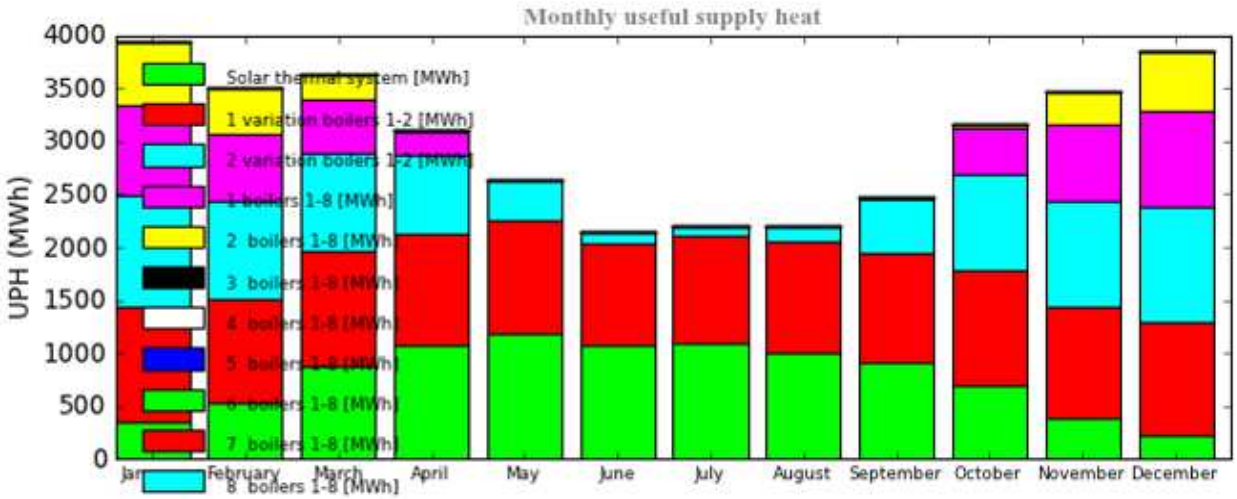

Figure 16: Monthly useful supply heat

Table 8: 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	2,664	1,451	3.99
1 variation boilers 1-2	hot water boiler	o==heating==o	1,450	12,702	34.97
2 variation boilers 1-2	hot water boiler	o==heating==o	1,450	12,177	33.52
1 boilers 1-8	hot water boiler	o==heating==o	1,320	7,053	19.41
2 boilers 1-8	hot water boiler	o==heating==o	1,320	2,944	8.10
boilers 3-8	hot water boiler	o==heating==o	7,920	0	0.00
boilers 9-13	hot water boiler	o==heating==o	7,850	0	0.00
Total			**23,974**	**36,326**	**100**

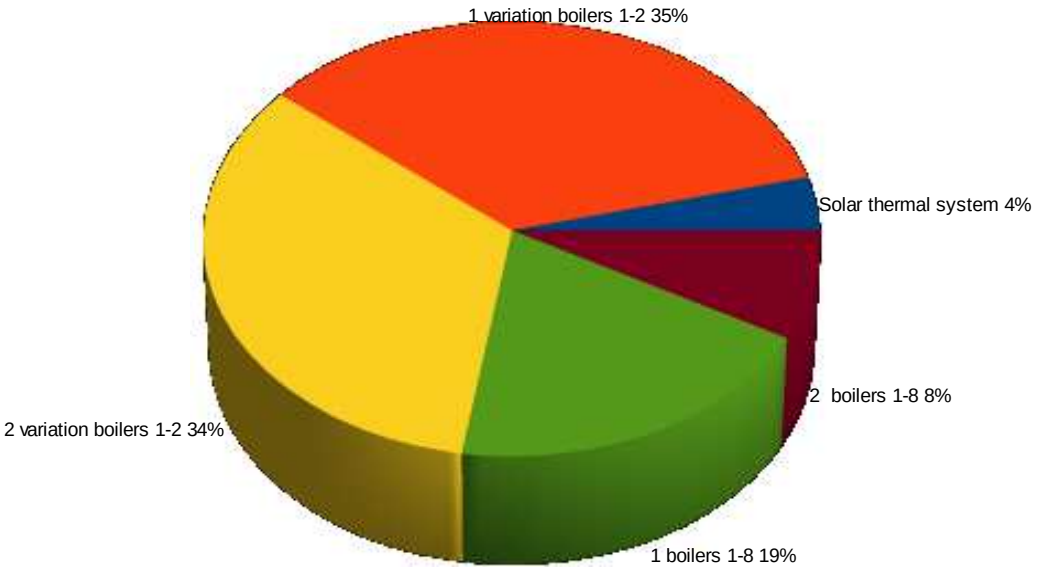

Figure 17: Contribution of each equipment to the total useful heat and useful cooling supply (USH & USC).

4.3. Proposed alternative: solar 9,000 m² no boiler mod.

- Solar 9,000 m² no boiler mod.

By installing 3,805 m² of flat plat collectors on the roof of the hospital it supplies the system with 1,451 MWh of thermal energy. Additionally the boilers with an efficiency of 83% are in first order in the heat generation cascade.

Collector type:	FPC (flat plate collector)
Installed collector area:	3,805 m²
Installed capacity:	2,664 kW
Solar buffer storage volume:	211 m³
Solar fraction:	3.99 %
Annual energy yield:	545 kWh/kWa

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	2,664	1,451	3.99
1 boilers 1-8	hot water boiler	o==heating==o	1,320	11,563	31.83
2 boilers 1-8	hot water boiler	o==heating==o	1,320	11,372	31.31
3 boilers 1-8	hot water boiler	o==heating==o	1,320	7,856	21.63
4 boilers 1-8	hot water boiler	o==heating==o	1,320	4,066	11.19
5 boilers 1-8	hot water boiler	o==heating==o	1,320	17	0.05
boilers 6-8	hot water boiler	o==heating==o	3,960	0	0.00
boilers 9-13	hot water boiler	o==heating==o	7,850	0	0.00
variation boilers 1-2	hot water boiler	o==heating==o	2,900	0	0.00
Total			**23,974**	**36,326**	**100**

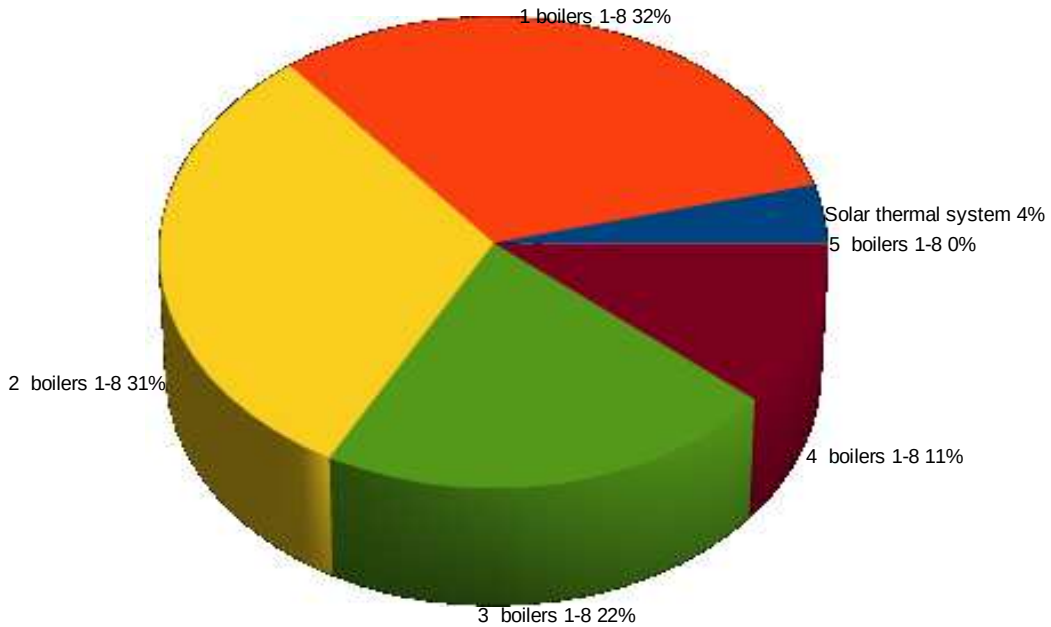

Figure 18: Contribution of each equipment to the total useful heat and useful cooling supply (USH & USC).

5. Selected alternative(s) and conclusions

5.1. Selected alternative: "solar 9,000 m²"

The alternative solar 9,000 m² was chosen because it offered a high primary energy saving potential and a short payback period in comparison to the other solar thermal alternatives.

Table 10: Primary energy consumption: present state and alternative proposals

Alternative	Primary energy consumption	Savings	
	[MWh]	[MWh]	[%]
Present State (checked)	196,813	---	---
2 CHP	168,122	28,691	14.58
solar 9.000m²	193,483	3,329	1.69
solar 9.000m² no boiler mod.	196,450	363	0.18

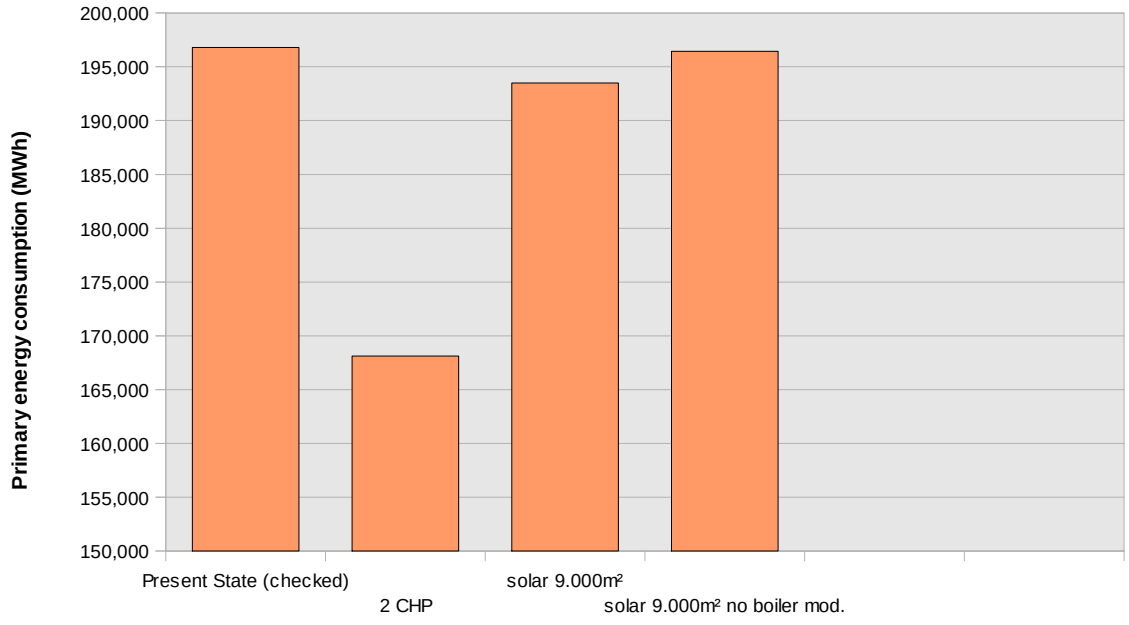

Figure 19: Comparison of alternatives: primary energy consumption

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

The description (type, nominal power, efficiencies, other relevant technical data) can be found in 4.2 "Proposed alternative: solar 9,000 m²"

5.2. Comparative study and conclusions

Table 11: Comparative study

		Present state	**Alternative**	**Saving**
Total primary energy consumption (1)		196,813	193,483	3,330
- total	[MWh]			
- fuels	[MWh]	47,197	43,817	3,380
- electricity	[MWh]	149,616	149,666	- 50
Primary energy saving due to renewable energy	[MWh]		1	
CO_2 emissions	[t/a]	35,663	34,118	1,544
Annual energy system cost (2)	[EUR]	5,485,615	5,415,713	69,902
Total investment costs	[EUR]		1,522,300	
Payback period (3)	[years]		20	

(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 12: Environmental impact: present state and alternative proposals

Alternative	Production of CO2	Water consumption
	[t]	[m3]
Present State (checked)	35662.50	0.00
2 CHP	31689.84	0.00
solar 9.000m²	34902.79	0.00
solar 9.000m² no boiler mod.	35577.00	0.00

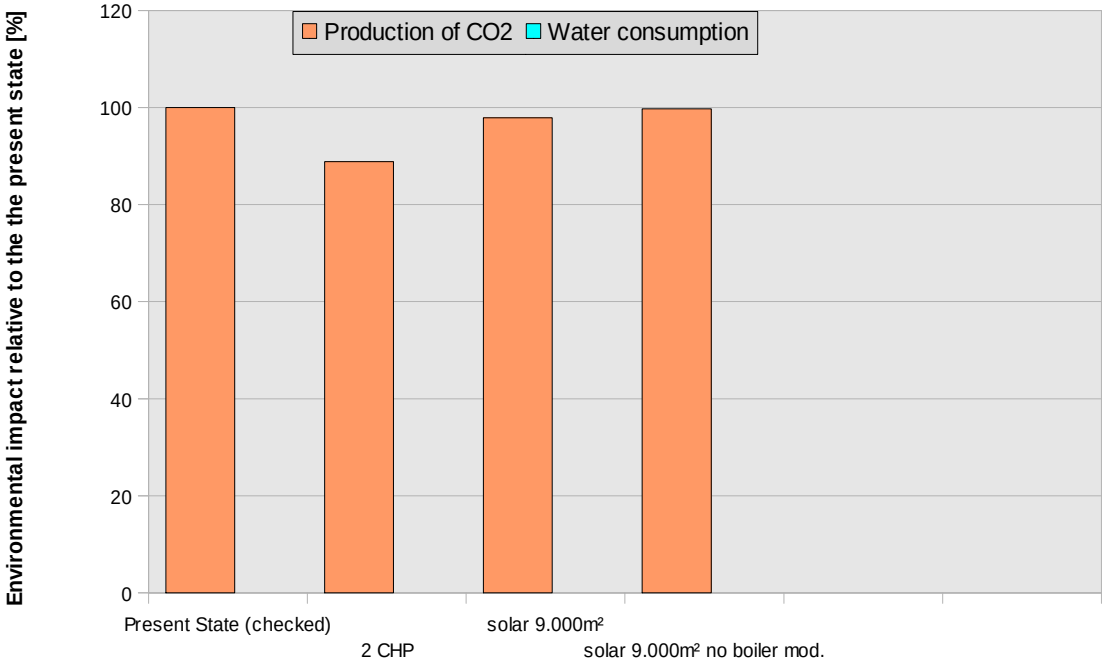

Figure 20: Comparison of alternatives: environmental impact

5.2.1. Energy and environmental analysis

Primary energy savings as high as 3,330 lead to a reduction of CO2 emissions of 1,544 tons per year compared to the present state.

5.2.2. Economic analysis

The investment costs for flat plate collectors are assumed by € 1,064,000. The calculated payback period is therefore 20 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.