Energy Audit Summary Report

AEE INTEC

Audit no. 43– BUL05

Bakery

13th of February 2012

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. 43 - BUL05

1. Data of the auditor

1.1. Contact data of the auditor

Jürgen Fluch, Matthäus Hubmann

Number of audits preformed: 16

Date of the audit: 15.01.2012

Duration of the audit: 4 weeks

AEE INTEC, Gleisdorf, Austria

2. Introduction

2.1. Objectives

The main objectives of this audit were to verify and check the potential energy savings.

3. Status Quo: processes, distribution, energy supply

The reference data and information are taken of the year 2010.

3.1. General information of the company

Bakery in Bulgaria

Sector	Bakeries
Products	Bread and Bread Products
No. of employees	n.a. (not available)

Current primary electrical energy consumption 384 [MWh/a]

3.2. Flow sheet of the whole manufacturing side

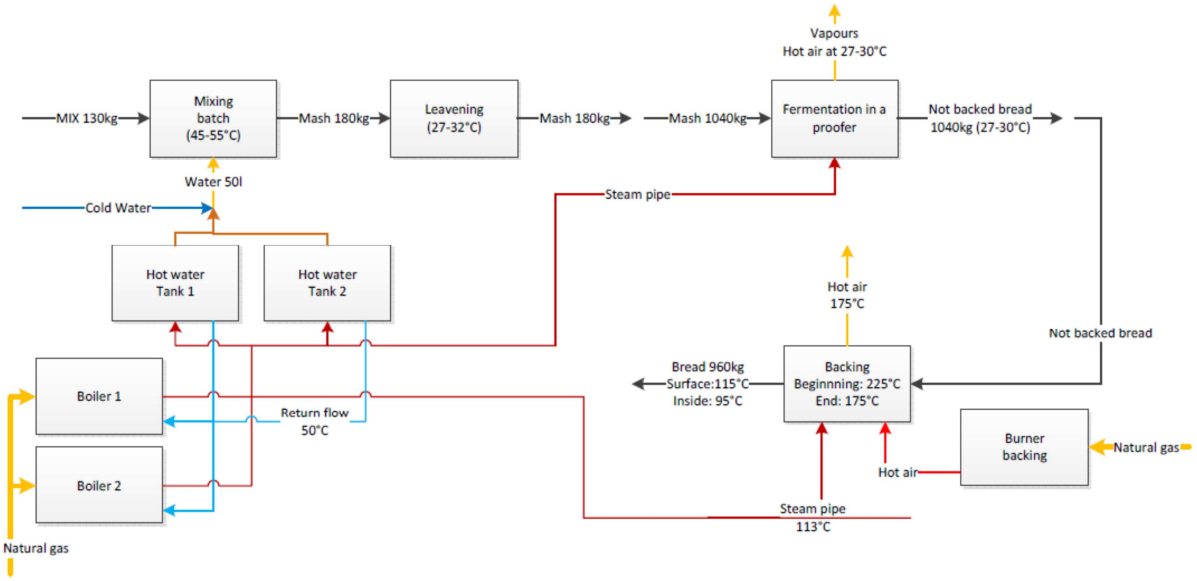

Figure 1: Flow sheet of school

3.3. Description of the existing system

- **Energy Supply:**

The bakery is mainly consuming energy for heating purposes especially the boilers and the burner have a high energy consumption. In addition it has electrical consumption for lighting and the electrical devices within the bakery.

Table 1: 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	4,240	78.64	4,240	100.00
Total electricity	1,152	21.36	0	0.00
Total (fuels + electricity)	**5,392**	**100.00**	**4,240**	**100.00**

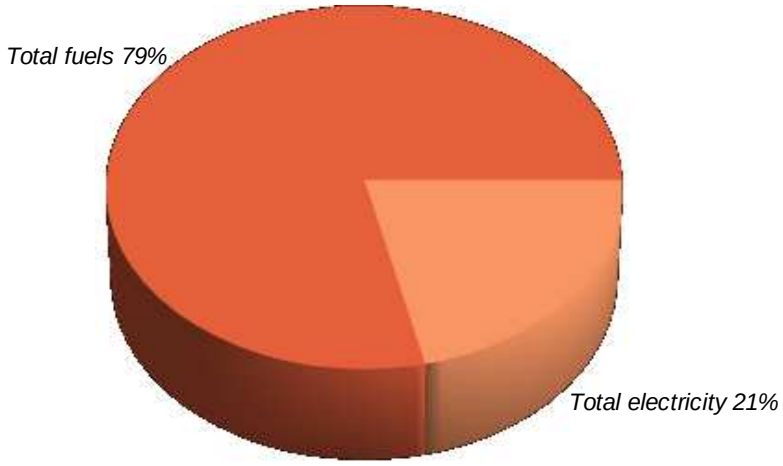

Figure 2: distribution of PEC by fuel type

Table 2: Final energy consumption (FEC) and Final energy consumption for thermal use (FET)

Fuel type	FEC		FET	
	[MWh]	[% of Total]	[MWh]	[% of Total]
Natural gas	3,855	90.94	3,855	100.00
Electricity	384	9.06	0	0.00
Total	**4,239**	**100.00**	**3,855**	**100.00**

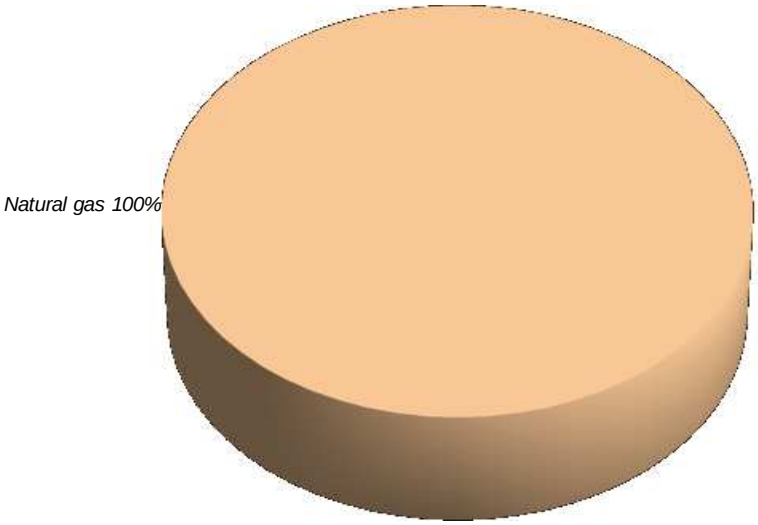

Figure 3: Total final energy consumption for thermal use (FET)

Table 3: Final energy consumption for thermal use (FET) by equipment
Explanation: Boiler 1 has no energy consumption as it is only a reserve boiler.

Equipment	Fuel type	FET by equipment	
		[MWh]	[% of Total]
Boiler	Natural gas	980	25.43
Burner	Natural gas	791	20.51
Boiler 2	Natural gas	982	25.48
furnaces	Natural gas	1,102	28.58
Total		**3,855**	**100.00**

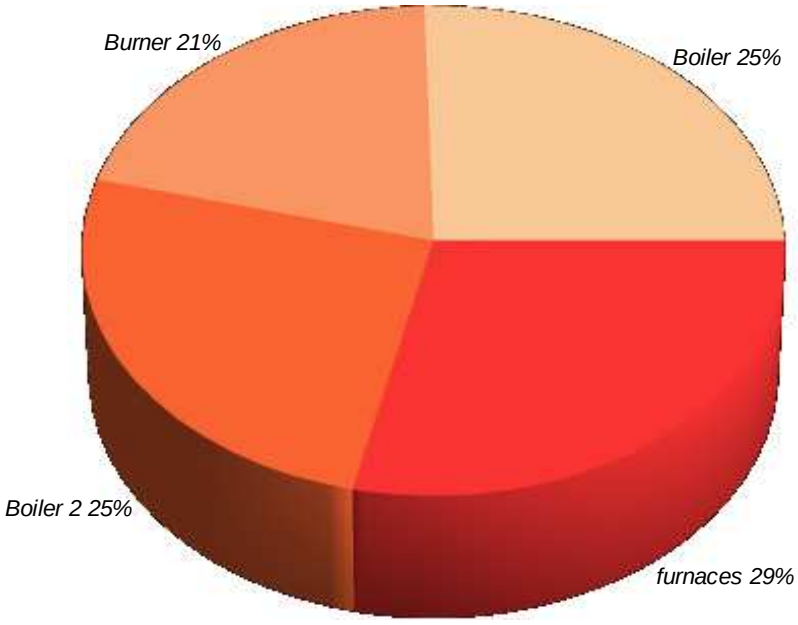

Figure 4: Final energy consumption for thermal use (FET) by equipment

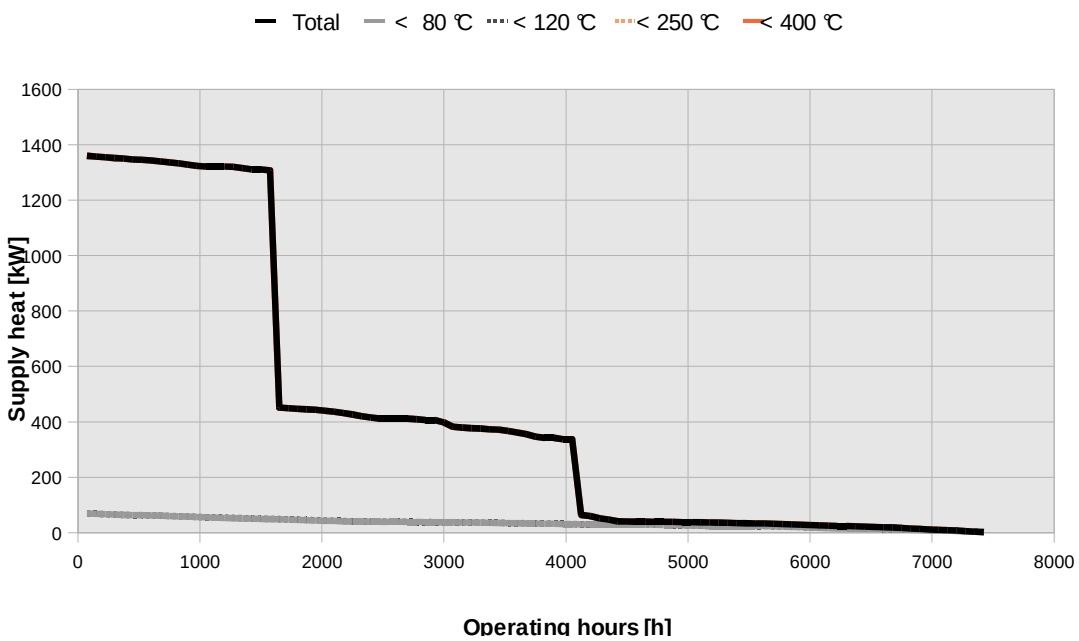

Figure 5: Distribution of supply heat by temperature levels and annual operating hours. Present state.

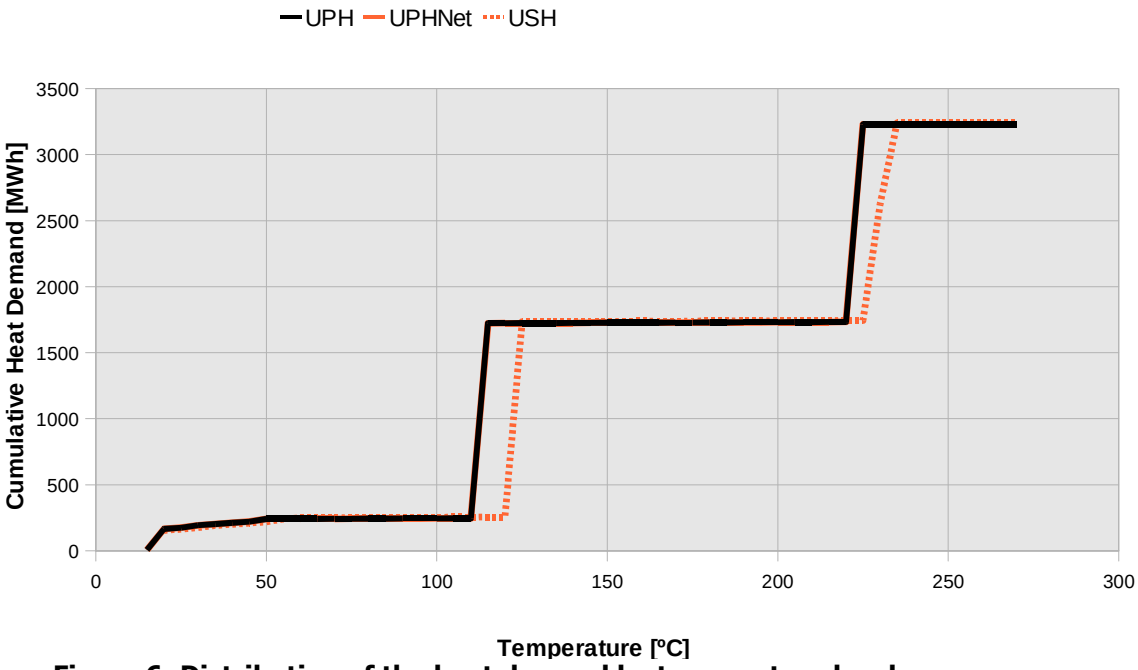

Figure 6: Distribution of the heat demand by temperature levels

Table 4: Useful supply heat (USH) by equipment. Present state.

Equipment	USH by equipment	
	[MWh]	[% of Total]
Boiler	863	26.62
Burner	633	19.52
Boiler 2	864	26.67
furnaces	881	27.19
Total	**3,241**	**100.00**

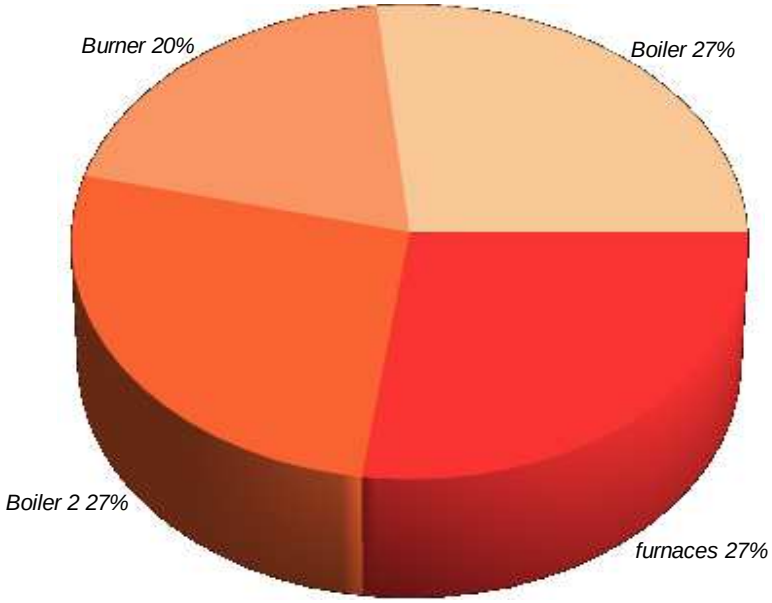

Figure 7: Useful supply heat (USH) by equipment. Present state.

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

Process	Total	Circulation	Maintenance	Start-up
	[MWh]	[MWh]	[MWh]	[MWh]
fermentation	3	0	3	0
backing	633	18	614	0
steam for backing	1,476	0	1,476	0
hand made bread	881	0	881	0
premixing	11	0	11	0
bakery_heating	150	0	150	0
heating room	7	0	7	0
bakery_HW	68	68	0	0
Total	**3,229**	**86**	**3,142**	**0**

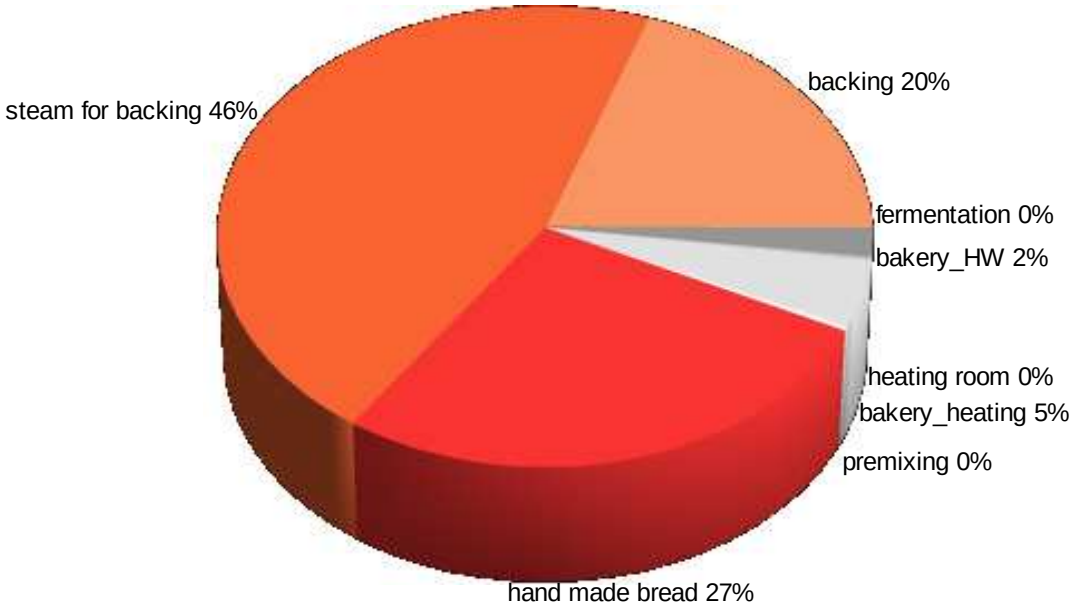

Figure 8: Useful process heat (UPH) by process

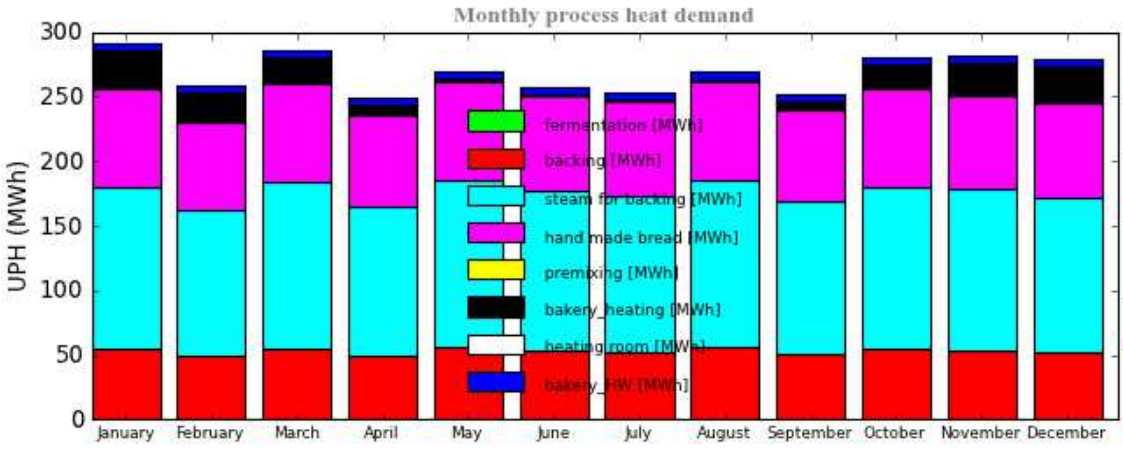

Figure 9: Distribution of useful process heat demand per month

3.4. General

- The target room temperature during winter is 20 °C.
- The hot water demand was estimated to be 4 m³ per day.
- The specific energy demand for baking the bread was estimated to be 1.32 kWh/kg.

4. Comparative study

4.1. Proposed alternatives

There are five proposals made in this study. In the first one proposes a heat exchanger network to save energy. In the second proposal a solar thermal system is installed and in the third one a combination of the first and the second proposal. In the fourth proposal a new combined heat and power generation system (CHP) is proposed. In the last proposal a combination of the first and the forth proposal is made.

Table 6: Overview of the alternative proposals studied

Short Name	Description
HX	based on present state two heat exchangers are installed
solar	based on present state a solar thermal system is installed
HX + solar	based on present state two heat exchangers are installed and additionally a solar thermal system is installed
CHP	based on present state a solar CHP is installed
HX + CHP	based on present state two heat exchangers are installed and additionally a CHP is installed

4.1.1. Heat Supply

- **Heat Exchanger (HX):**

In this alternative two heat exchangers are proposed. The first heat exchanger HX_AbovePinch_0 uses the waste heat of the boilers to produce hot water for the bakery. By installing this heat exchanger energy savings of 66 MWh can be achieved.

The second heat exchanger uses the waste heat of the burner and is used during the winter for heating the production hall, 46 MWh per year can be saved by the use for space heating.

Table 7: Heat exchangers and amount of recovered energy

Heat Exchanger	Power	Heat Source	Heat Sink	Amount of recovered energy	
	[kW]			[MWh]	[%]
HX_AbovePinch_0	23	Boiler	bakery_HW	66	58,64
HX_AbovePinch_1	27	Burner	bakery_heating	46	41,36
	50			**112,06**	**100**

Table 8: Overview of contribution to total heat supply by equipment

Equipment	Nominal capacity	Contribution to total heat and cooling supply	
	[kW]	[MWh]	[%]
Boiler	800	1,430	45.08
Burner	489	633	19.94
Boiler 2	800	229	7.21
furnaces	488	881	27.78
Total	**2,577**	**3,173**	**200**

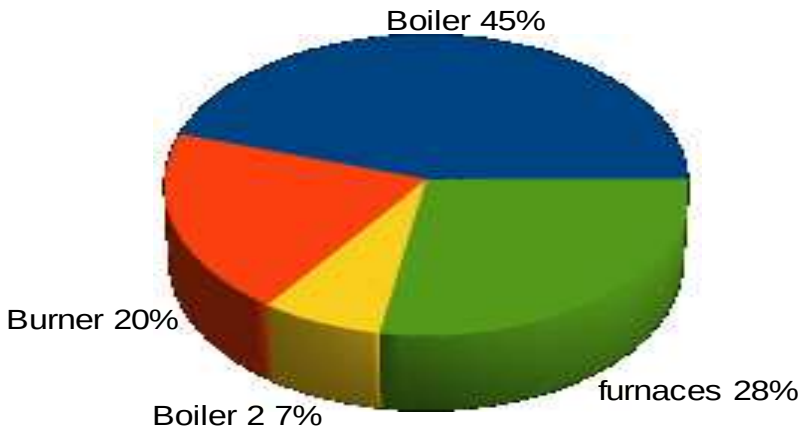

Figure 10: Contribution of each equipment to the total useful heat supply (USH).

- **Solar:**

Collector type:	FPC (flat plate collectors)
Installed capacity:	736 kW
Installed collector area:	1052 m²
Solar buffer storage volume:	52.6 m³
Solar fraction:	12.7 %
Annual energy yield:	300.5 kWh/kWa

Table 9: Overview of contribution to total heat supply by equipment

Equipment	Nominal capacity	Contribution to total heat and cooling supply	
	[kW]	[MWh]	[%]
Solar thermal system	736	221	6.83
Boiler	800	1,399	43.16
Burner	489	621	19.15
Boiler 2	800	200	6.17
furnaces	488	800	24.69
Total	**3,313**	**3,241**	**200**

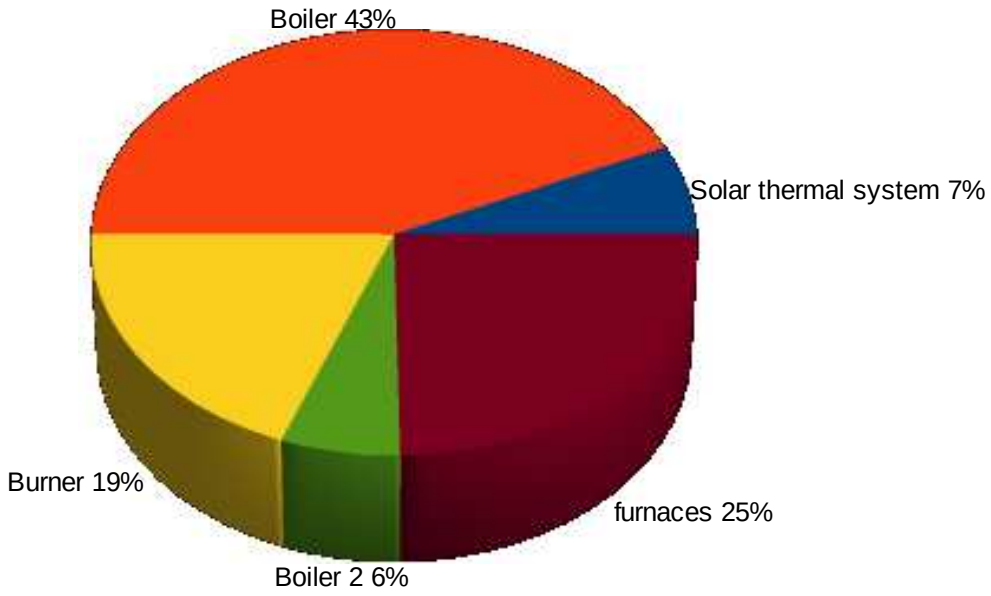

Figure 11: Contribution of each equipment to the total useful heat supply (USH).

- graphic: heat demand covered by solar thermal system

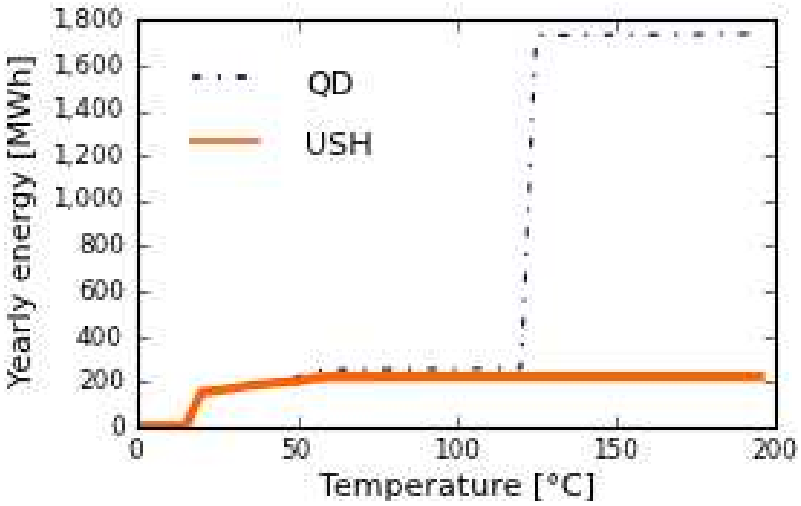

Figure 12: Heat demand and solar contribution

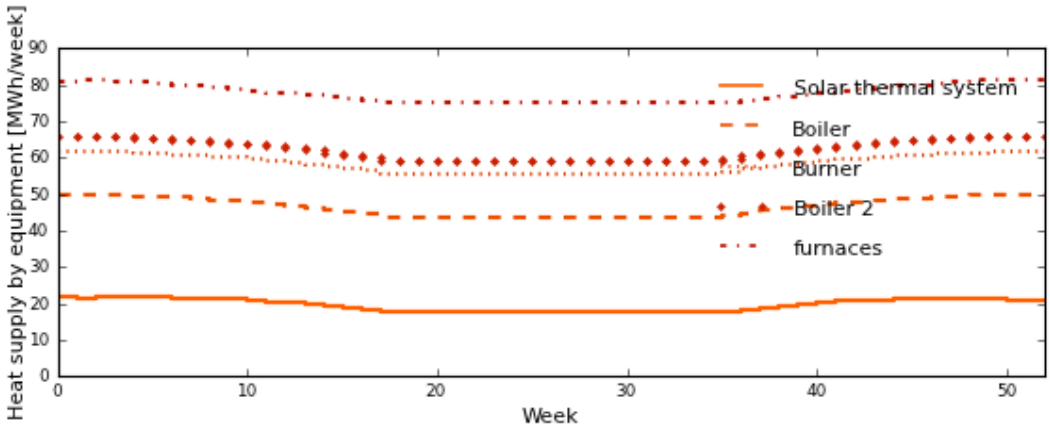

Figure 13: Daily heat supply by equipment

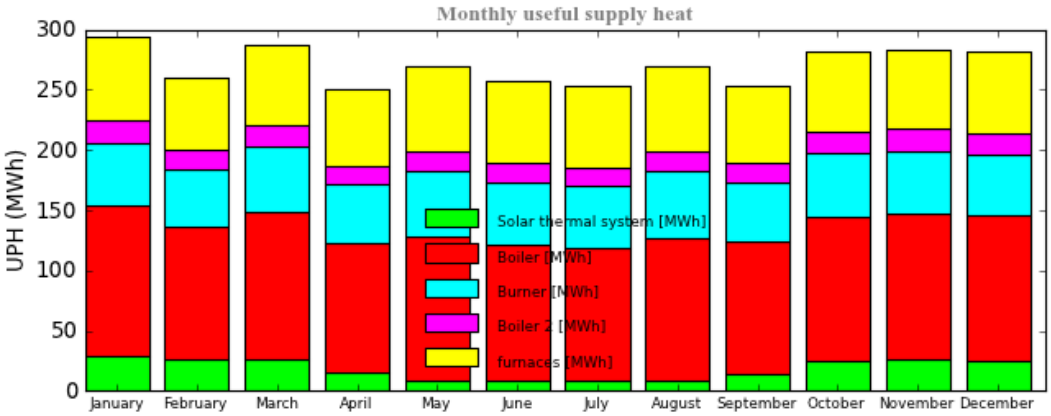

Figure 14: Distribution of useful supply heat per month

- **HX + Solar**

Collector type:	FPC (flat plate collectors)
Installed capacity:	508.2 kW
Installed collector area:	726 m²
Solar buffer storage volume:	36.3 m³
Solar fraction:	14.58 %
Annual energy yield:	305.47 kWh/kWa

Table 10: Overview of contribution to total heat supply by equipment

Equipment	Nominal capacity	Contribution to total heat and cooling supply	
	[kW]	[MWh]	[%]
Solar thermal system	508	155	4.87
Boiler	800	1,359	42.76
Burner	489	622	19.58
Boiler 2	800	203	6.40
furnaces	488	838	26.39
Total	**3,085**	**3,177**	**200**

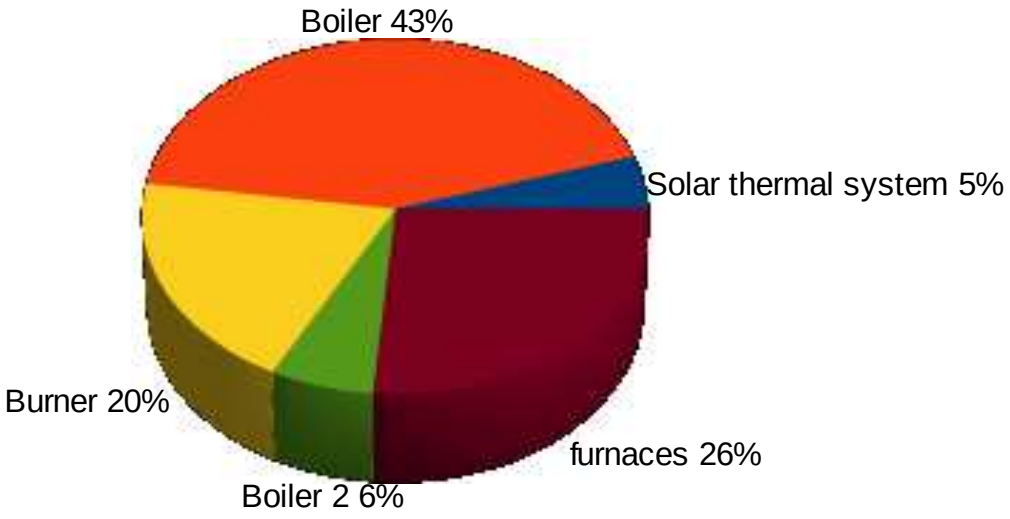

Figure 15: Contribution of each equipment to the total useful heat supply (USH).

- graphic: heat demand covered by the solar thermal system:

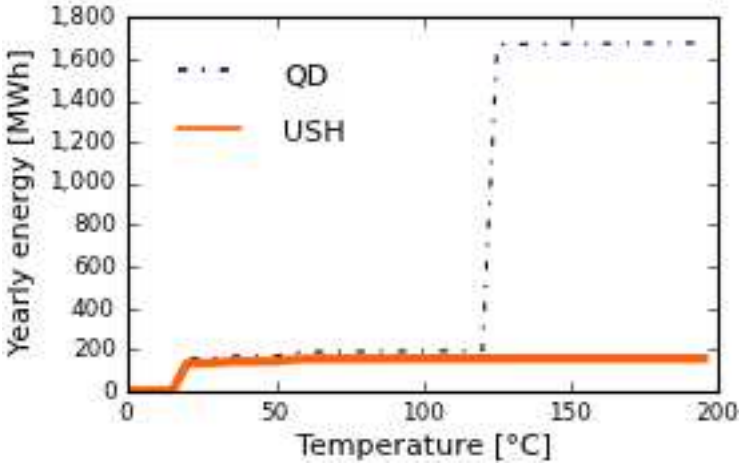

Figure 16: Heat demand and solar contribution

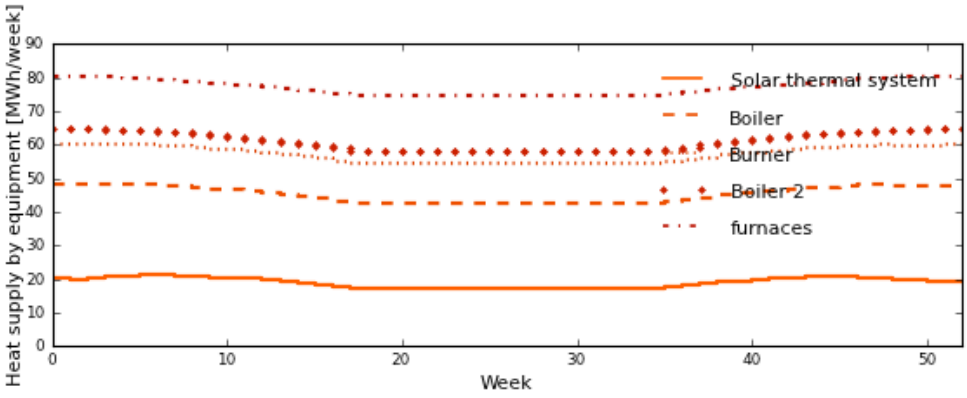

Figure 17: Daily heat supply by equipment

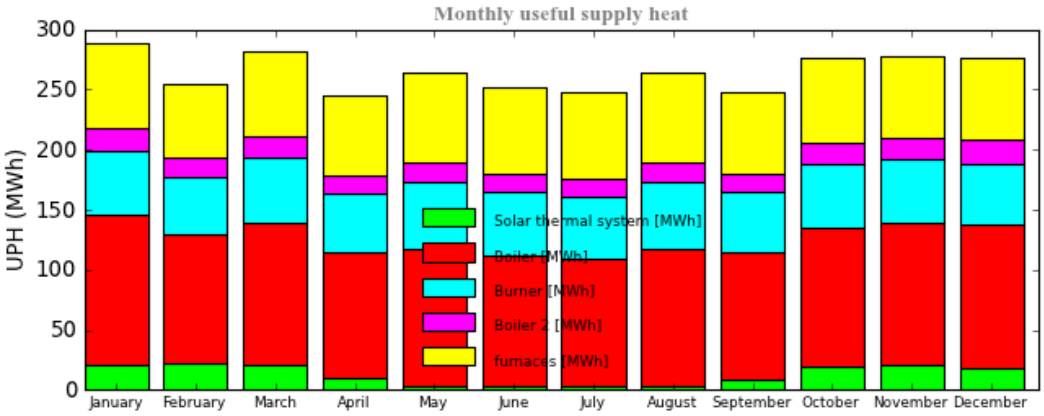

Figure 18: Distribution of useful process heat supply per month

- **CHP:**

Type	CHP engine
Nominal thermal power	50 kW
Nominal electric power	29 kW
Thermal efficiency	0.6
Operating hours	6,408 h

Table 11: Overview of contribution to total heat supply by equipment

Equipment	Nominal capacity	Contribution to total heat and cooling supply	
	[kW]	[MWh]	[%]
New CHP 1	50	217	6.71
Boiler	800	1,309	40.39
Burner	489	633	19.52
Boiler 2	800	201	6.19
furnaces	488	881	27.19
Total	**2,627**	**3,241**	**200**

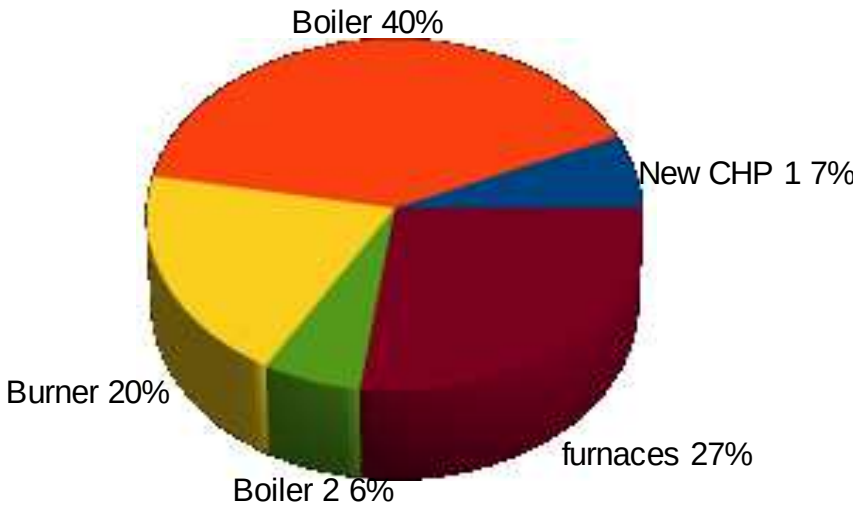

Figure 19: Contribution of each equipment to the total useful heat supply (USH).

- graphic: heat demand covered by CHP

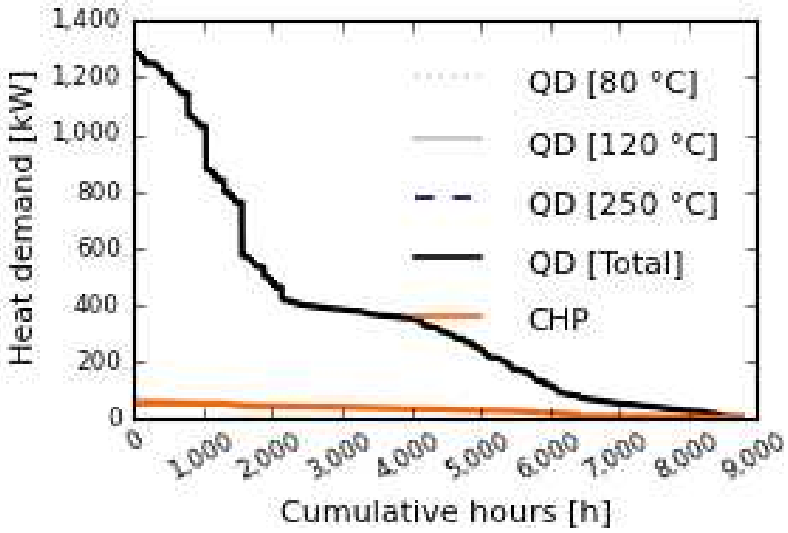

Figure 20: Cumulative heat demand to be covered by CHP

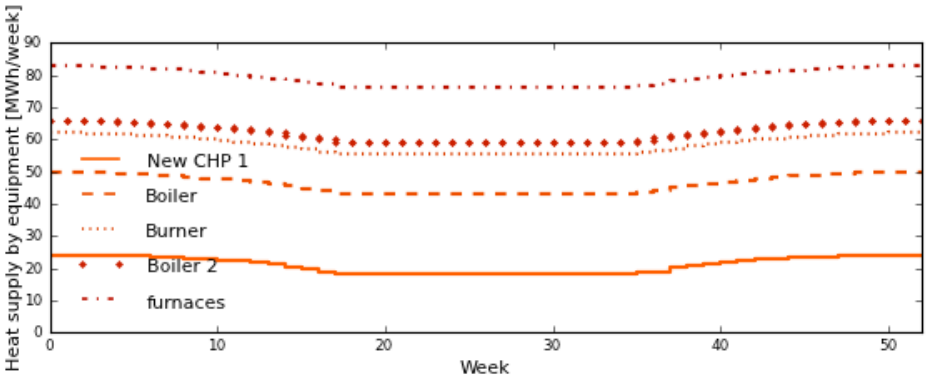

Figure 21: Daily heat supply by equipment

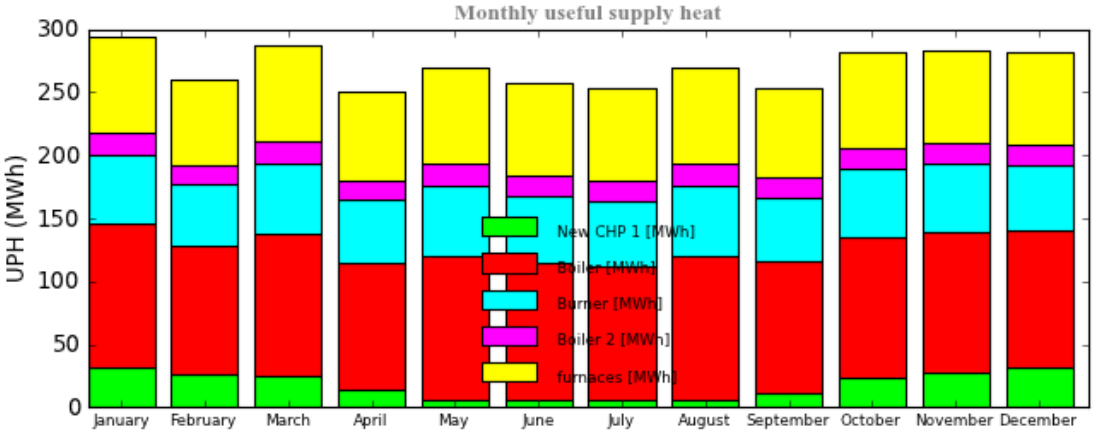

Figure 22: Distribution of useful process heat supply per month

- **HX + CHP:**

Type	CHP engine	
Nominal thermal power	50 kW	
Nominal electric power	29 KW	
Thermal efficiency	0.5	
Operating hours	6,258 h	

Table 12: Overview of contribution to total heat supply by equipment

Equipment	Nominal capacity	Contribution to total heat and cooling supply	
	[kW]	[MWh]	[%]
New CHP 2	50	196	6.18
Boiler	800	1,347	42.39
Burner	489	616	19.38
Boiler 2	800	188	5.91
furnaces	488	830	26.13
Total	**2,627**	**3,177**	**200**

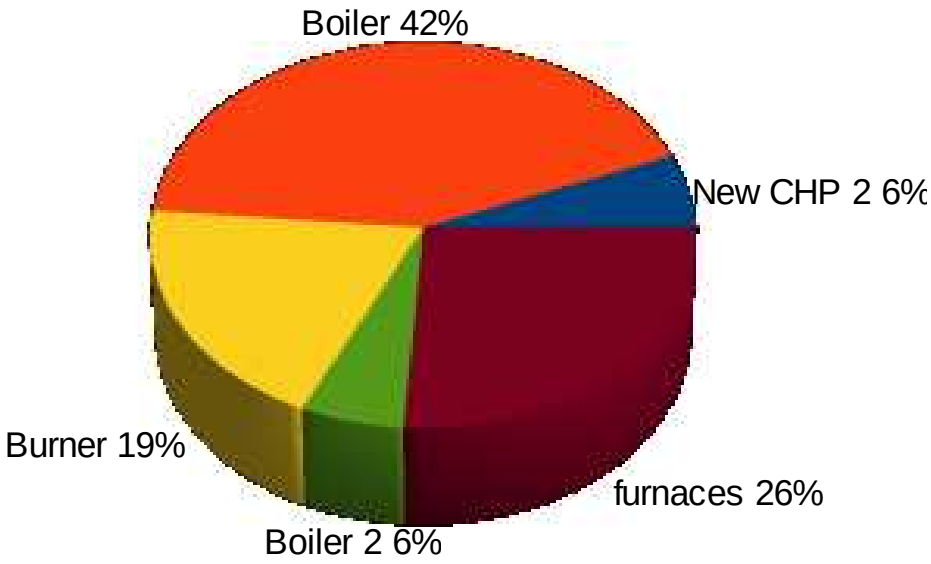

Figure 23: Contribution of each equipment to the total useful heat supply (USH).

- graphic: heat demand covered by CHP

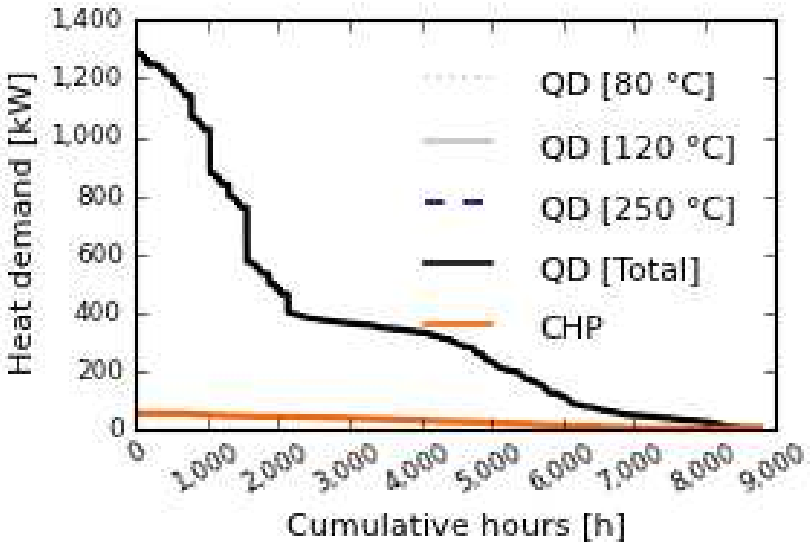

Figure 24: Cumulative heat demand to be covered by CHP

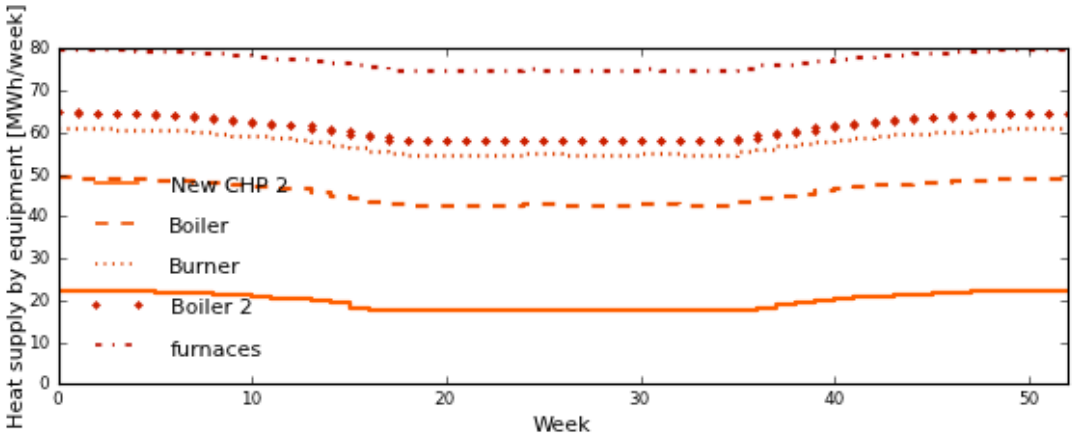

Figure 25: Daily heat supply by equipment

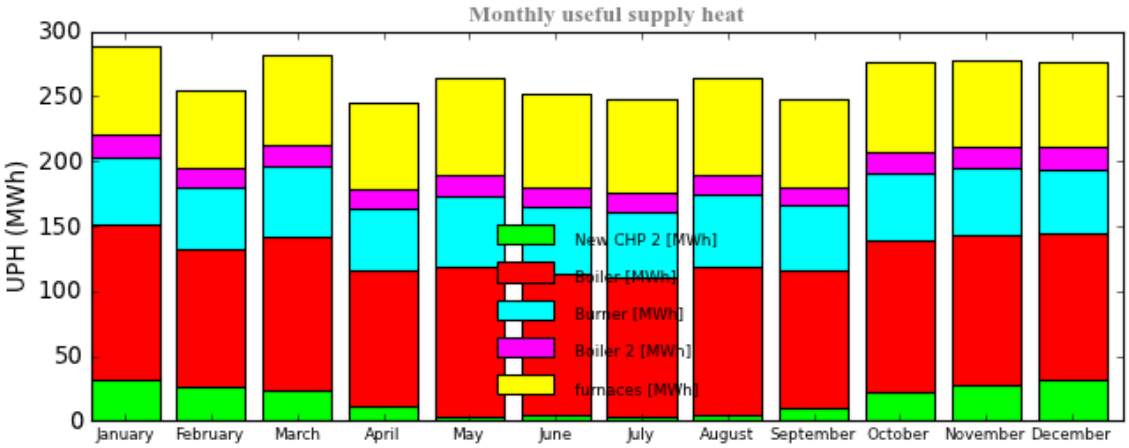

Figure 26: Distribution of useful process heat supply per month

- Primary energy consumption (PEC)

Table 13: primary energy consumption and savings

Alternative	Primary energy consumption	Savings	
	[MWh]	[MWh]	[%]
Present State (checked)	5,392	---	---
HX	5,307	85	1.57
solar	5,111	281	5.21
HX + solar	5,117	275	5.10
CHP	5,220	172	3.19
HX + CHP	5,154	238	4.42

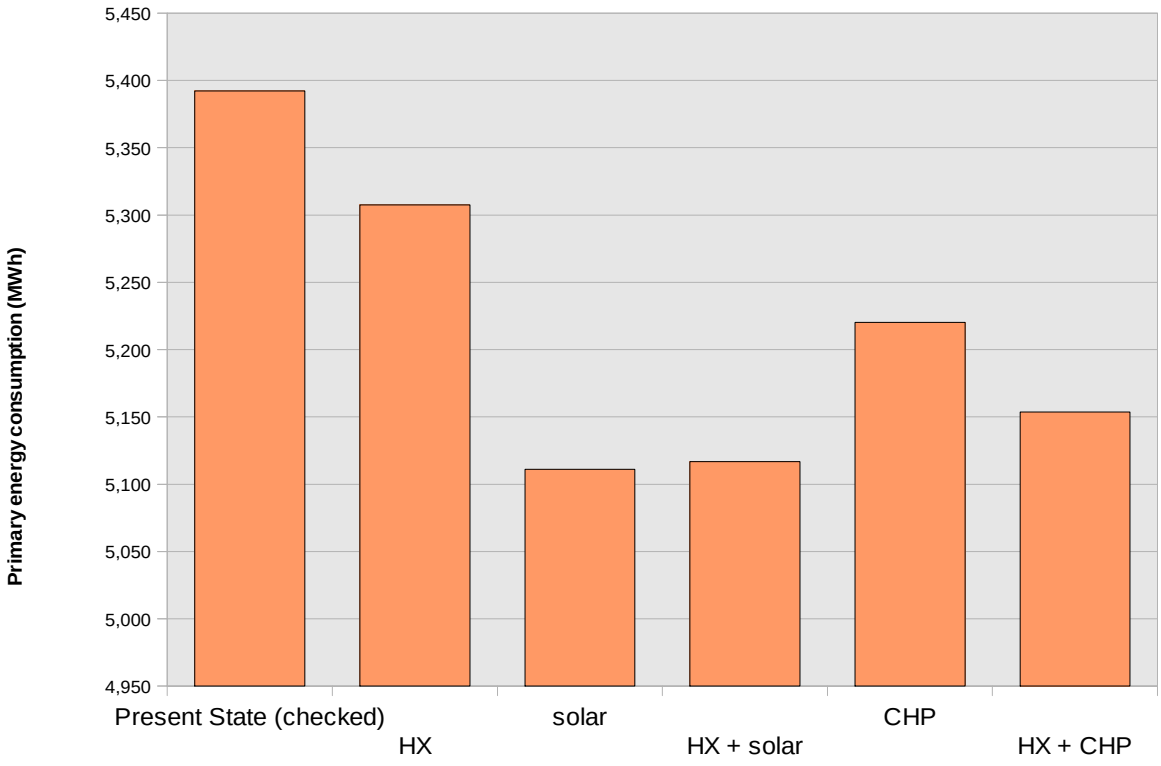

Figure 27: Comparison of alternatives: primary energy consumption

- Useful process and supply heat (UPH and USH)

  Due to the fact that the processes were not changed, the useful process heat and the supply heat stayed the same.

Table 14: Useful process and supply heat: present state and alternative proposals.

Alternative	Useful process heat (UPH)	Savings UPH	Useful supply heat (USH)	Savings USH
	[MWh]	[MWh]	[MWh]	[MWh]
Present State (checked)	648	---	648	---
solar	648	0	648	0
HW by boiler	648	0	648	0
new boiler	648	0	648	0
HW by new boiler	648	0	648	0

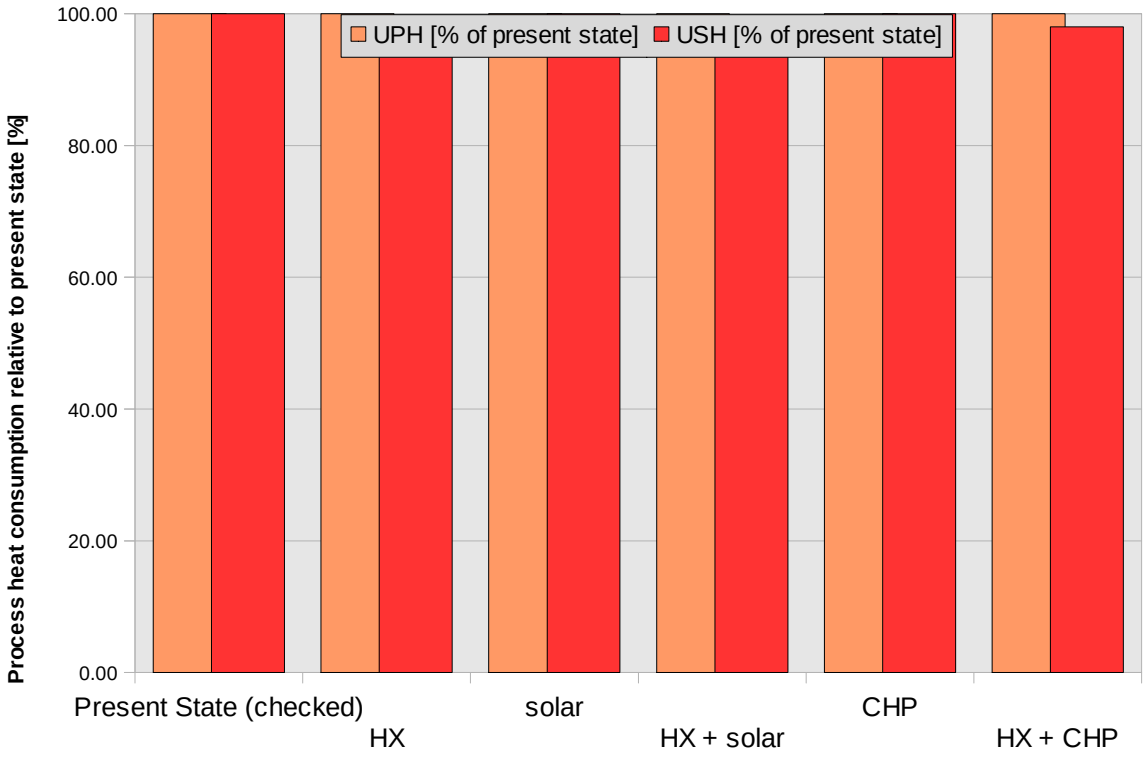

Figure 28: Comparison of alternatives: useful process heat supply

- Environmental impact

Table 15: CO2 production and CO2 savings per year

Alternative	Production of CO2	Water consumption
	[t]	[m3]
Present State (checked)	1155.65	0.00
HX	1136.42	0.00
solar	1091.38	0.00
HX + solar	1092.83	0.00
CHP	1139.35	0.00
HX + CHP	1123.45	0.00

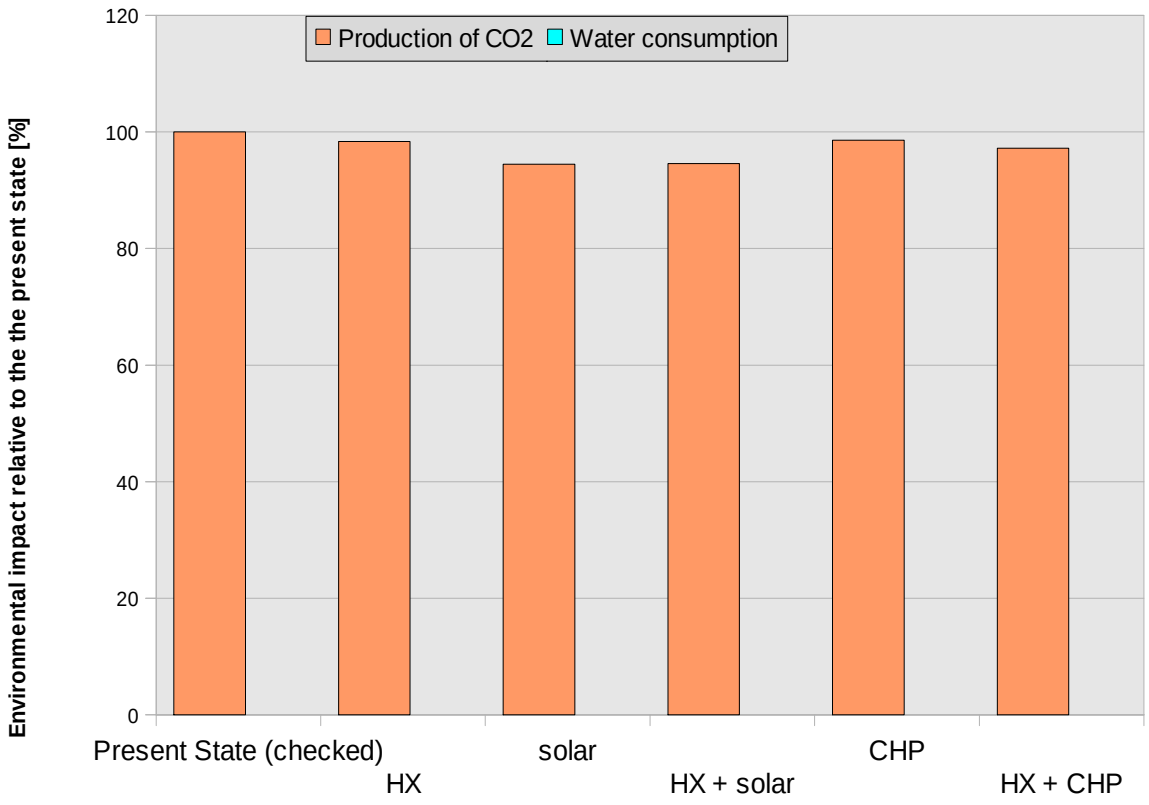

Figure 29: Comparison of alternatives: environmental impact

Table 16: Investment costs and subsidies of the proposals

Alternative	Total investment	Own investment	Subsidies
	[€]	[€]	[€]
Present State (checked)	---	---	---
HX	4,000	4,000	0
solar	473,400	331,380	142,020
HX + solar	330,700	232,690	98,010
CHP	43,500	30,450	13,050
HX + CHP	46,500	33,750	12,750

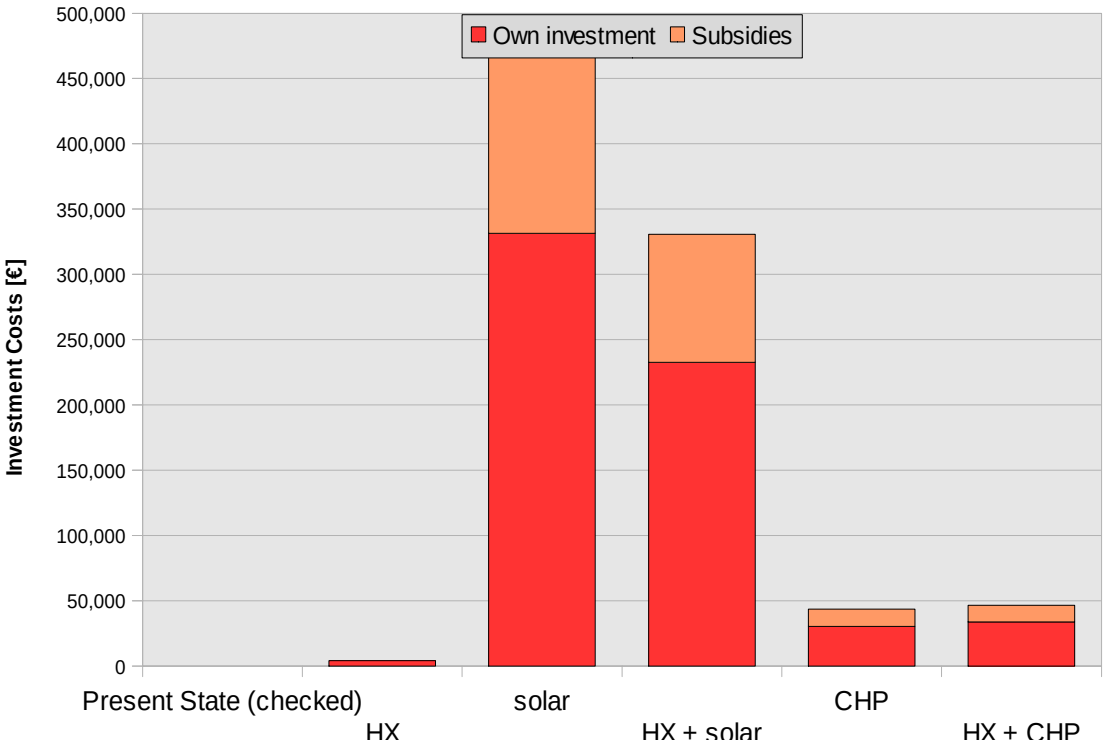

Figure 30: Comparison of alternatives investment cost

5. Selected alternative(s) and conclusions

5.1. Selected alternative

As selected alternative the "Heat Exchanger (HX)" proposal has been chosen because of the short payback period and the high CO_2 savings per year.

5.1.1. Process optimisation (written proposals)

None

5.1.2. Heat Supply

- **Heat Exchanger (HX):**

The following table shows the heat exchanger network in the system and the amount of recovered energy.

Table 17: Heat exchanger network and amount of recovered energy

Heat Exchanger	Power	Heat Source	Heat Sink	Heat transferred	
	[kW]			[MWh]	[%]
HX_AbovePinch_0	23	Boiler	bakery_HW	66	58,64
HX_AbovePinch_1	27	Burner	bakery_heating	46	41,36
	50			**112,06**	**100**

Table 18: Overview of contribution to total heat supply by equipment

Equipment	Nominal capacity	Contribution to total heat and cooling supply	
	[kW]	[MWh]	[%]
Boiler	800	1,430	45.08
Burner	489	633	19.94
Boiler 2	800	229	7.21
furnaces	488	881	27.78
Total	**2,577**	**3,173**	**200**

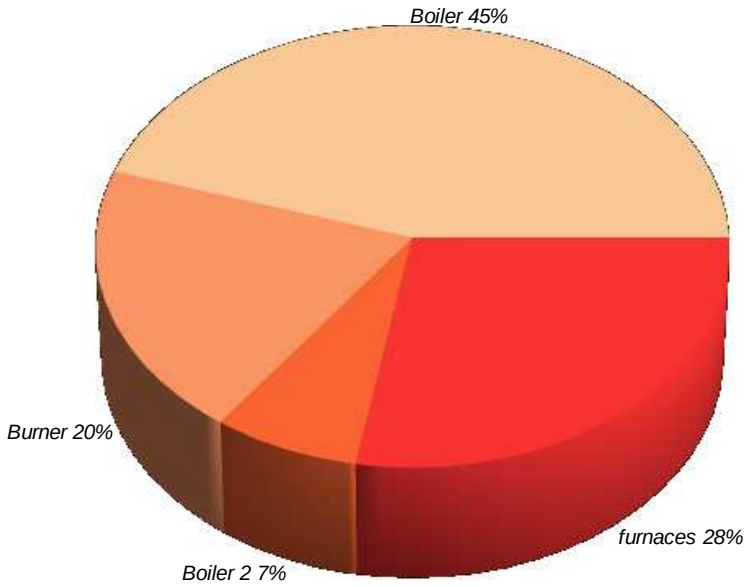

Figure 31: Contribution of each equipment to the total useful heat supply (USH).

5.1.3. Energy Consumption

Table 19: 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	4,156	78.30	4,156	100.00
Total electricity	1,152	21.70	0	0.00
Total (fuels + electricity)	**5,307**	**100.00**	**4,156**	**100.00**

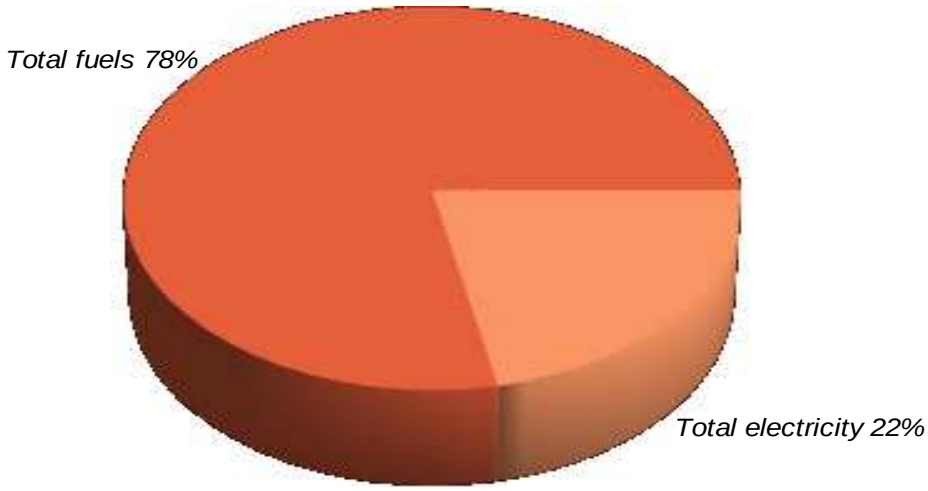

Figure 32: Distribution of PEC by fuel type

Table 20: Total final energy consumption (FEC) and final energy for thermal use (FET). Proposed final solution.

Fuel type	FEC		FET	
	[MWh]	[% of Total]	[MWh]	[% of Total]
Natural gas	3,778	90.77	3,778	100.00
Electricity	384	9.23	0	0.00

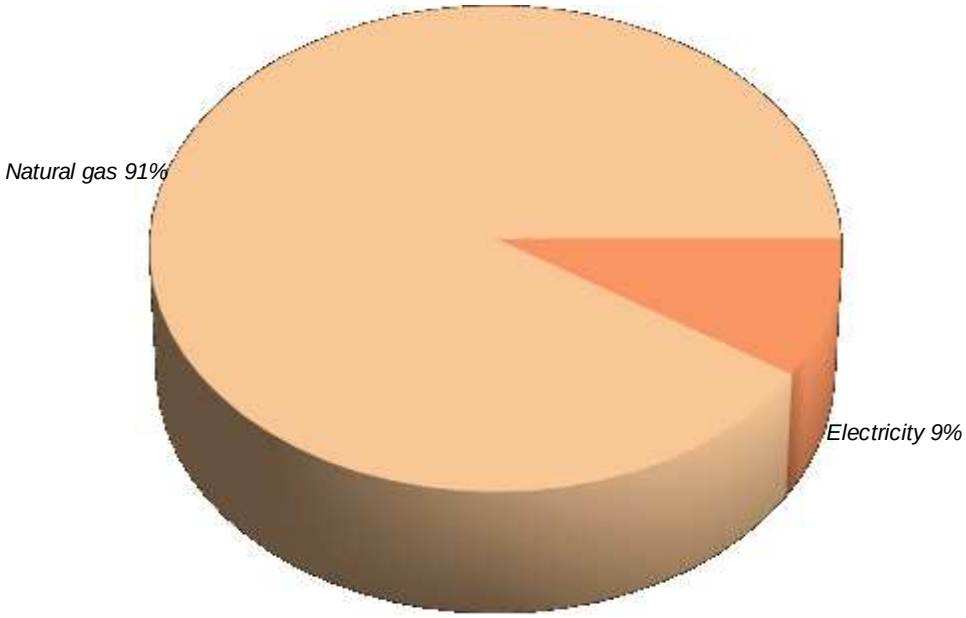

Figure 33: Total final energy consumption (FEC). Proposed final solution.

Table 21 : Final energy consumption for thermal use (FET) by equipment. Proposed final solution.

Equipment	Fuel type	FET by equipment	
		[MWh]	[% of Total]
Boiler	Natural gas	1,625	43.03
Burner	Natural gas	791	20.93
Boiler 2	Natural gas	260	6.88
furnaces	Natural gas	1,102	29.16
Total		**3,778**	**100**

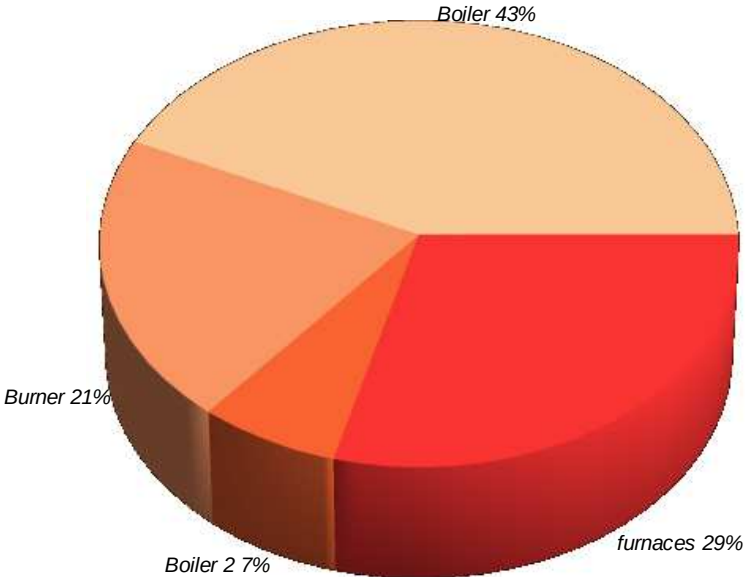

Figure 34: Final energy consumption for thermal use (FET) by equipment

Table 22 : Useful supply heat (USH) by equipment. Proposed final solution.

Equipment	USH by equipment	
	[MWh]	[% of Total]
Boiler	1,430	45.08
Burner	633	19.94
Boiler 2	229	7.21
furnaces	881	27.78
Total	**3,173**	**100**

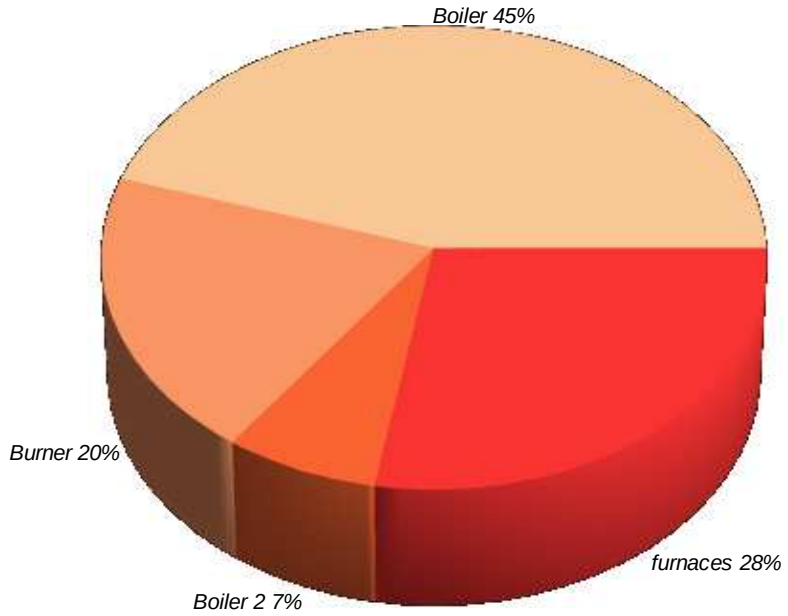

Figure 35: Useful supply heat (USH) by equipment. Proposed final solution

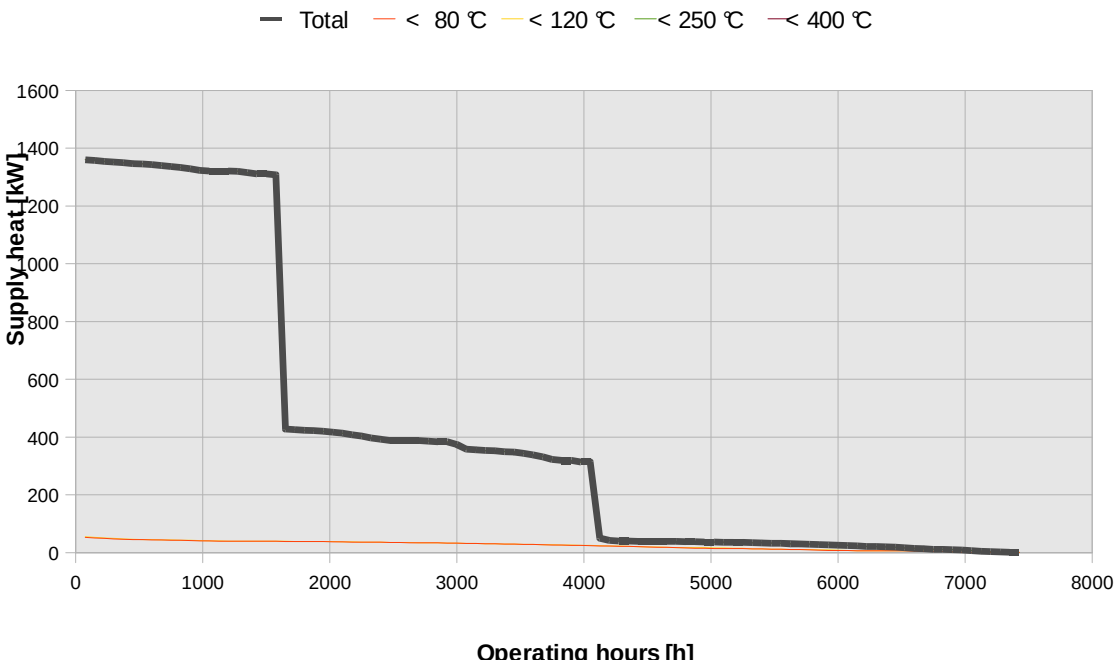

Figure 36: Distribution of supply heat by temperature levels and annual operating hours. Proposed final solution.

5.2. Comparative study and conclusions

5.2.1. Energy and environmental analysis

In the proposed alternative around 1.66 % of the CO2 pollution can be saved, which corresponds to 19.23 tons of CO2.

5.2.2. Economic analysis

The payback period of the proposed alternative of about 1.6 years has to be checked concerning the investment costs and due to the possible change of these figures the payback period will change in dependency.

The calculations for the solar thermal systems are based on estimated costs and subsidies of 30% of the investment costs and have to be revised. Investment and installing cost are based on actual cost in Austria and not Bulgaria.

Table 23: Savings of the proposed alternative in comparison to the present state

		Present state	Alternative	Saving	[% savings]
Total primary energy consumption (1)					
- total	[MWh]	5,392	5,307	85	2%
- fuels	[MWh]	4,240	4,156	84	2%
- electricity	[MWh]	1,152	1,152	-	0%
Primary energy saving due to renewable energy	[MWh]		-		
CO_2 emissions	[t/a]	1,156	1,136	19	2%
Annual energy system cost (2)	[EUR]	157,921	155,363	2,558	2%
Total investment costs	[EUR]		4,000		
Payback period (3)	[years]		2		

(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)

5.2.3. Conclusions and outlook

- As the calculations of the hot water consumption are based on assumptions and the yearly overall energy consumptions, these figures and data have to be revised and adapted to the actual figures.
- In order to gain savings as high as calculated, the calculations have to be adapted to the actual thermal efficiency of the new CHP as the computed savings are based on the highest number.

- Based on the available data and measurements performed the energy consumption split to the processes and equipments so that they could be 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 final investment costs are based on first estimations.