Energy Audit Summary Report
AEE INTEC
Audit no. 44 – BUL06
Dairy

14th of February 2012

Supported by INTELLIGENT ENERGY EUROPE

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AUDIT no. 44 - BUL06

1. Data of the auditor

1.1. Contact data of the auditor

Jürgen Fluch, Matthäus Hubmann

Number of audits preformed: 17

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

Sector	Dairy
Products	Milk and Dairy Products
No. of employees	n.a. (not available)

Current primary electrical energy consumption 378 [MWh/a]

3.2. Flow sheet of the whole manufacturing side

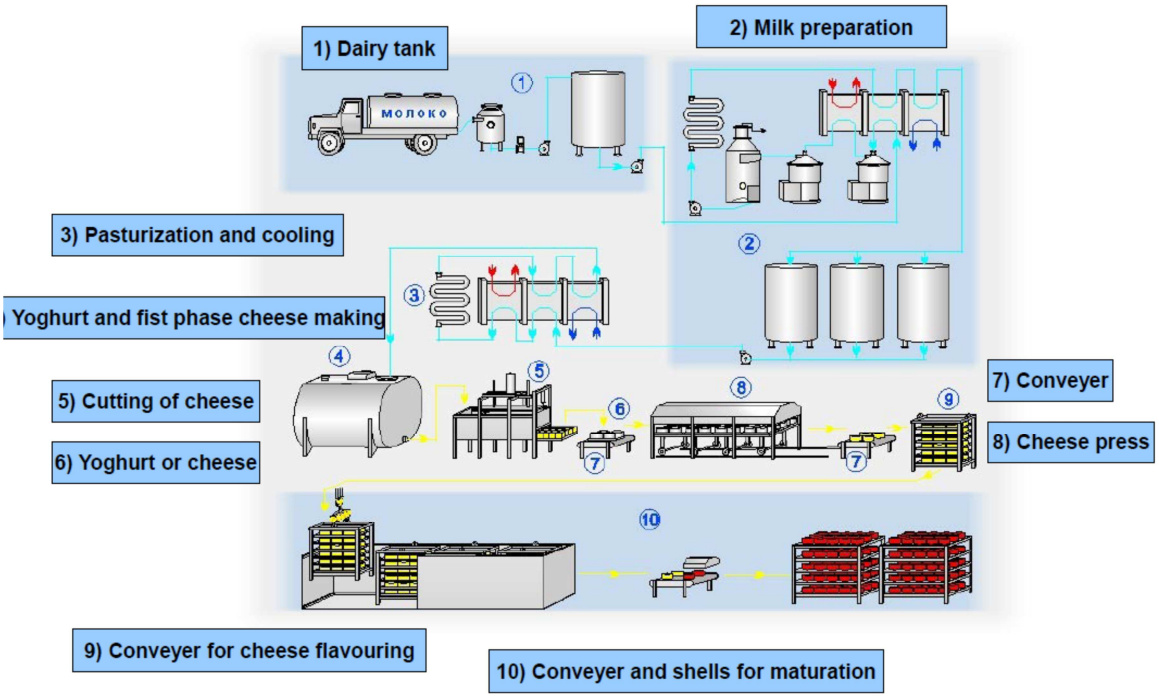

Figure 1: Flow sheet of the dairy

3.3. Description of the existing system

- **Energy Supply:**

The dairy is mainly consuming energy for heating purposes during the production. In addition it has electrical consumption for cooling and heating in winter.

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	157	41.61	157	44.60
Total electricity	221	58.39	195	55.40
Total (fuels + electricity)	**378**	**100.00**	**352**	**100.00**

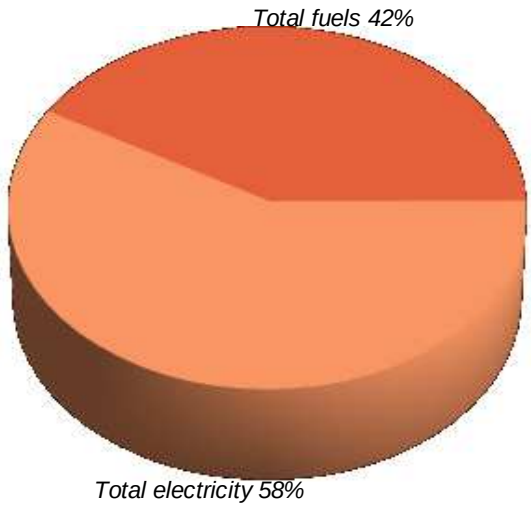

Figure 2: distribution of PEC by fuel type

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

Fuel type	FEC		FET	
	[MWh]	[% of Total]	[MWh]	[% of Total]
black coal	131	64.05	131	66.81
Electricity	74	35.95	65	33.19
Total	**205**	**100.00**	**196**	**100.00**

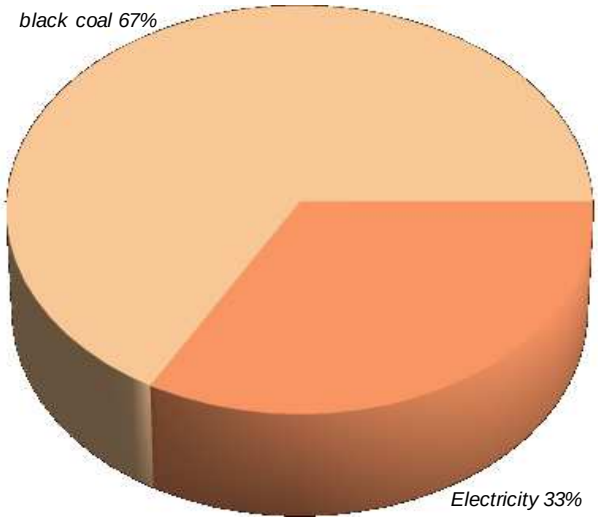

Figure 3: Total final energy consumption for thermal use (FET)

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]
steam boiler	black coal	133	68.22
cooling	Electricity	22	11.37
refrigeration system	Electricity	36	18.22
electric heaters	Electricity	4	2.19
Total		**195**	**100.00**

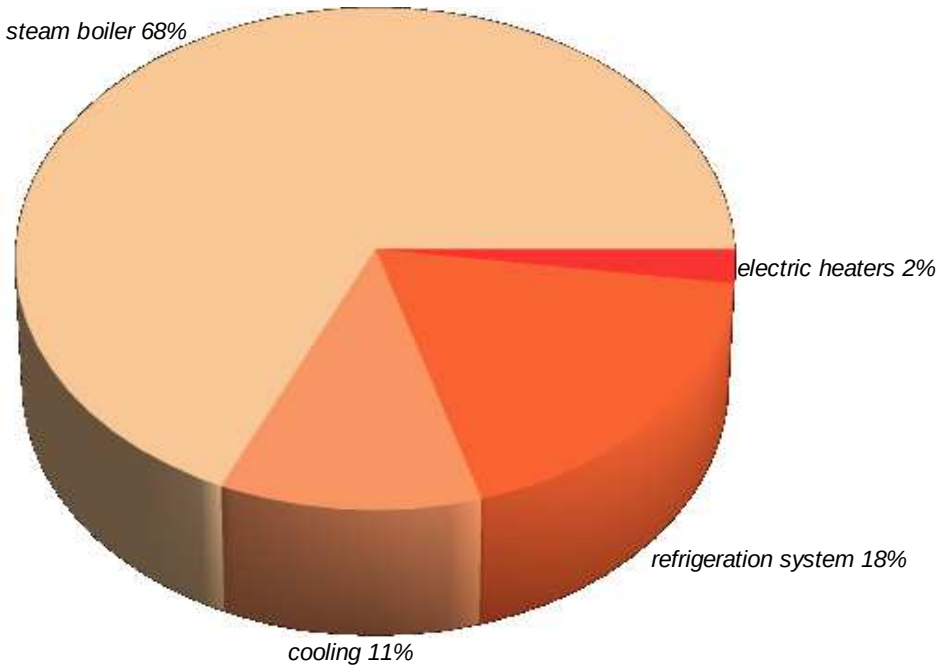

Figure 4: Final energy consumption for thermal use (FET) by equipment

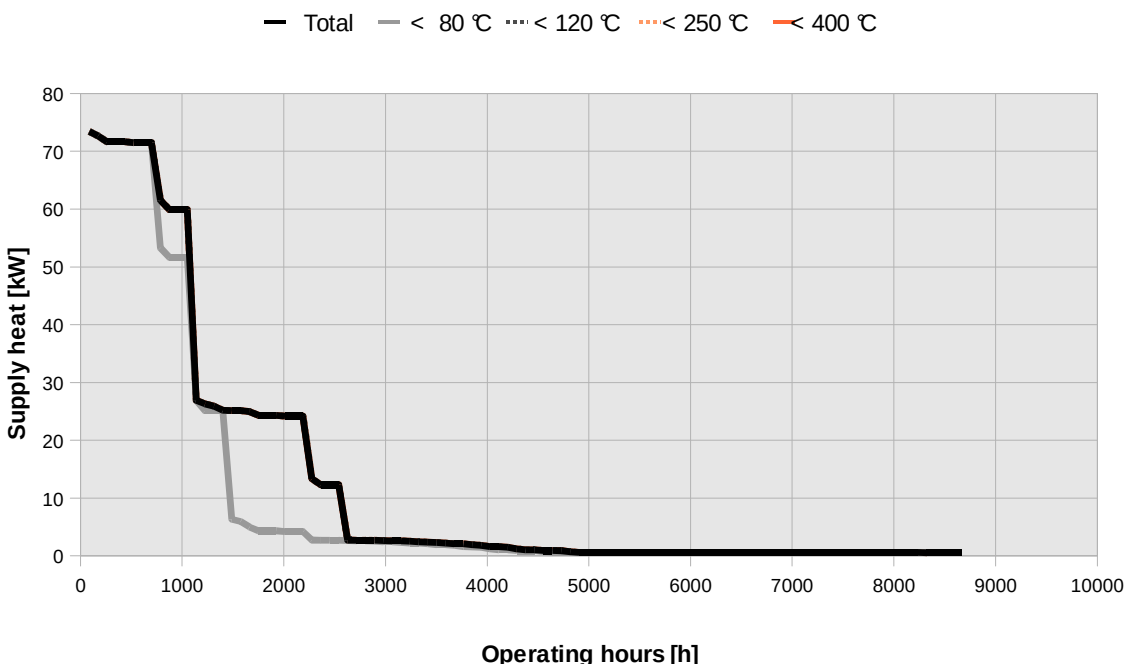

Figure 5: Distribution of supply heat by temperature levels and annual operating hours. Present state.

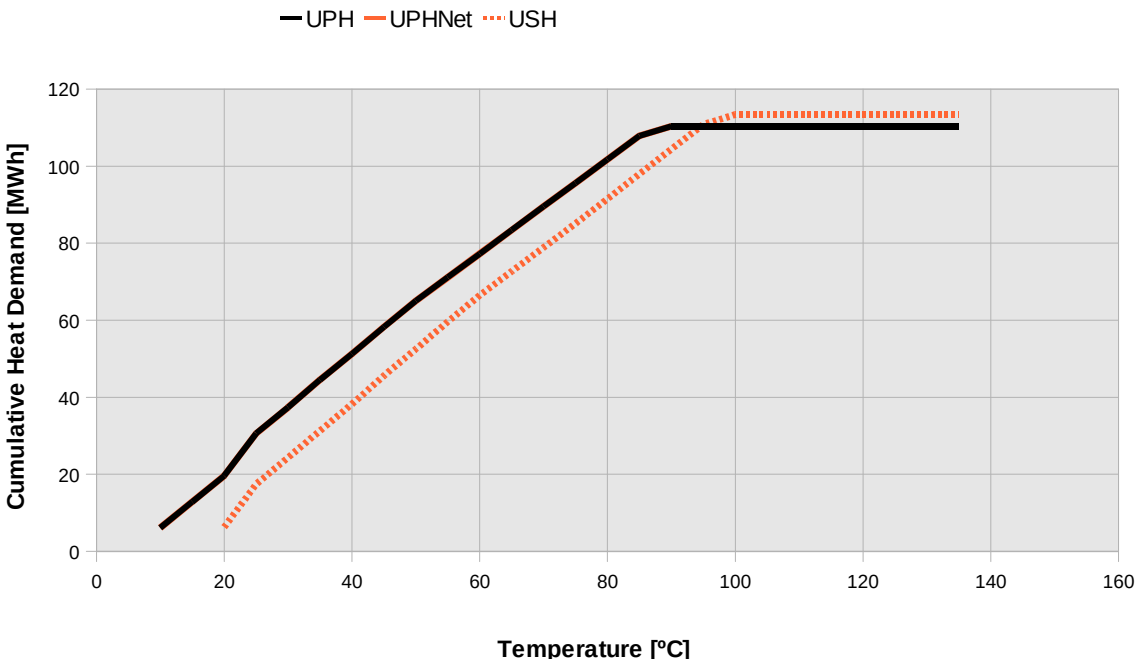

Figure 6: Distribution of the heat demand by temperature levels

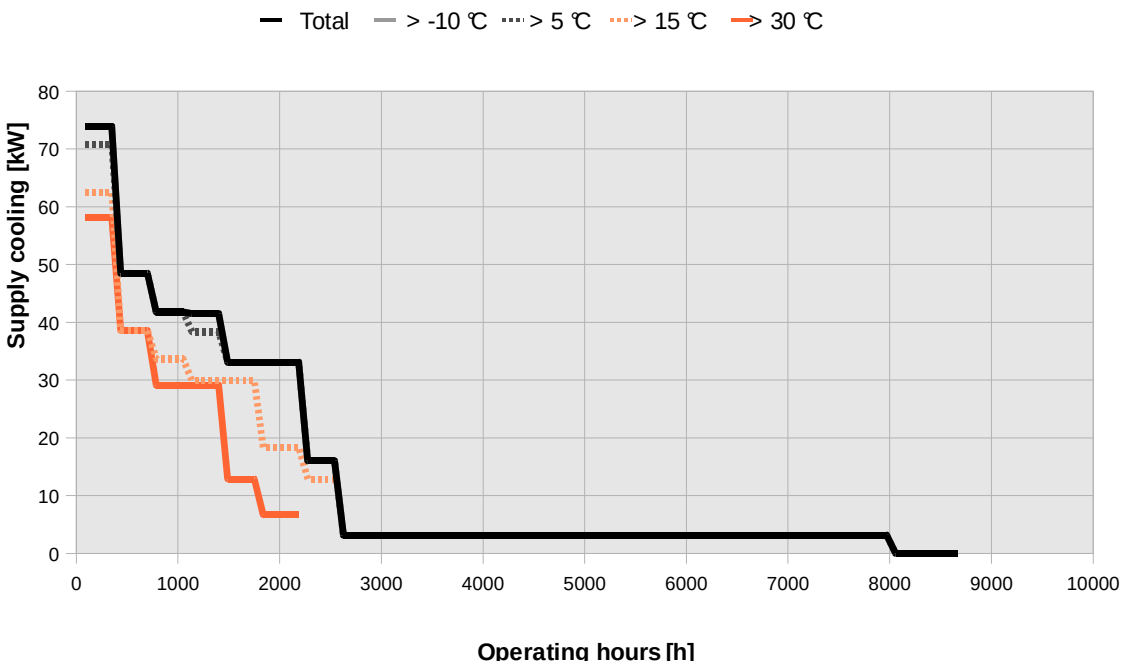

Figure 7: Distribution of supply cooling by temperature levels and annual operating hours. Present state.

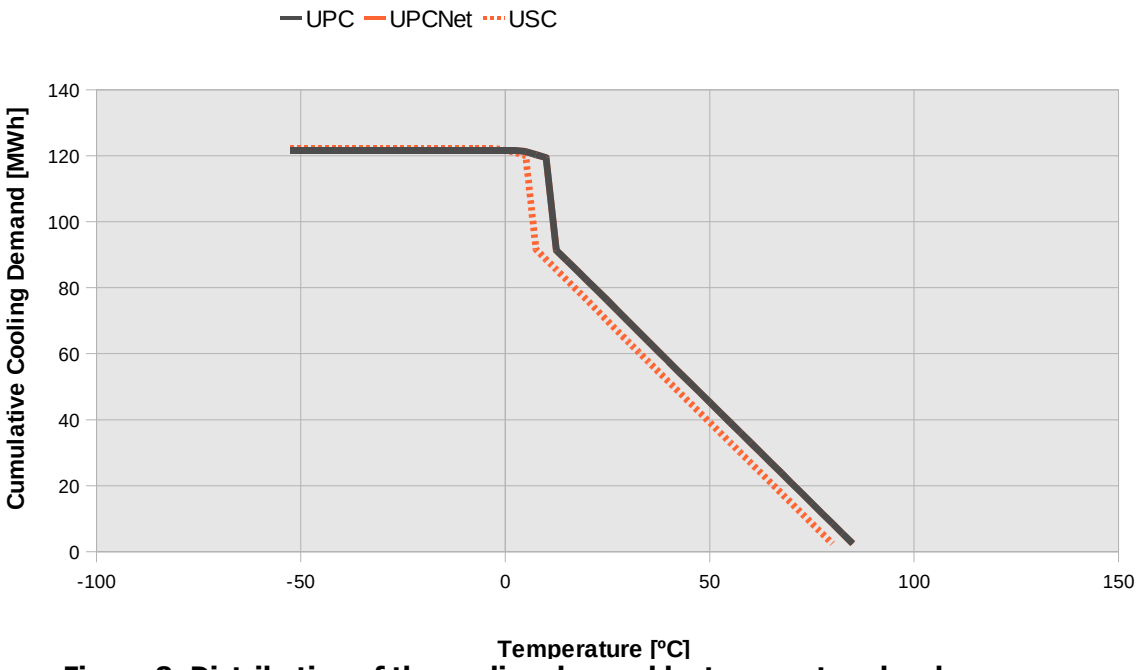

Figure 8: Distribution of the cooling demand by temperature levels

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

Equipment	USH by equipment	
	[MWh]	[% of Total]
steam boiler	109	96.28
electric heaters	4	3.72
Total	**113**	**100.00**

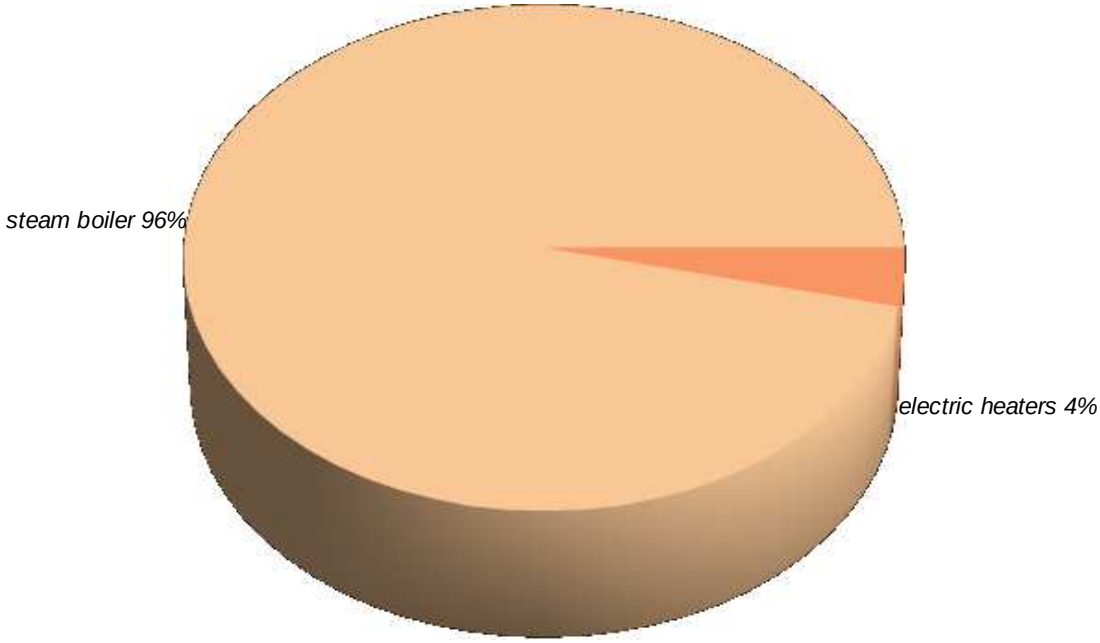

Figure 9: Useful supply heat (USH) by equipment. Present state

Table 5: Useful supply cooling (USC) by equipment. Present state.

Equipment	USC by equipment	
	[MWh]	[% of Total]
cooling	69	56.43
refrigeration system	53	43.57
Total	**122**	**100**

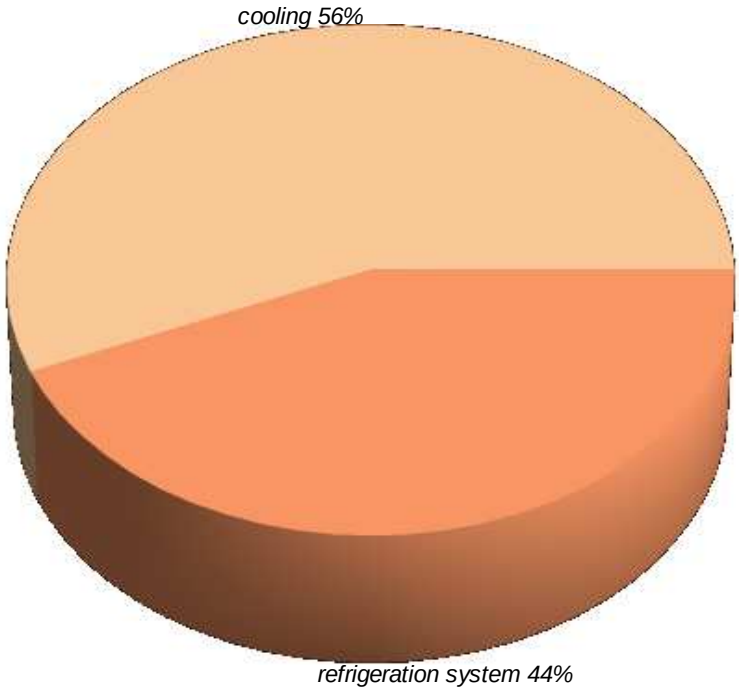

Figure 10: Useful supply cooling (USC) by equipment. Present state.

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

Process	Total	Circulation	Maintenance	Start-up
	[MWh]	[MWh]	[MWh]	[MWh]
yoghurt - fermentation	0	0	0	0
cheese - fermentation	0	0	0	0
production_HW	5	5	0	0
production_heating	4	0	4	0
milk preheating	45	45	0	0
milk normalization	31	31	0	0
milk homogenisation	6	6	0	0
milk heating	18	18	0	0
Total	**110**	**105**	**4**	**0**

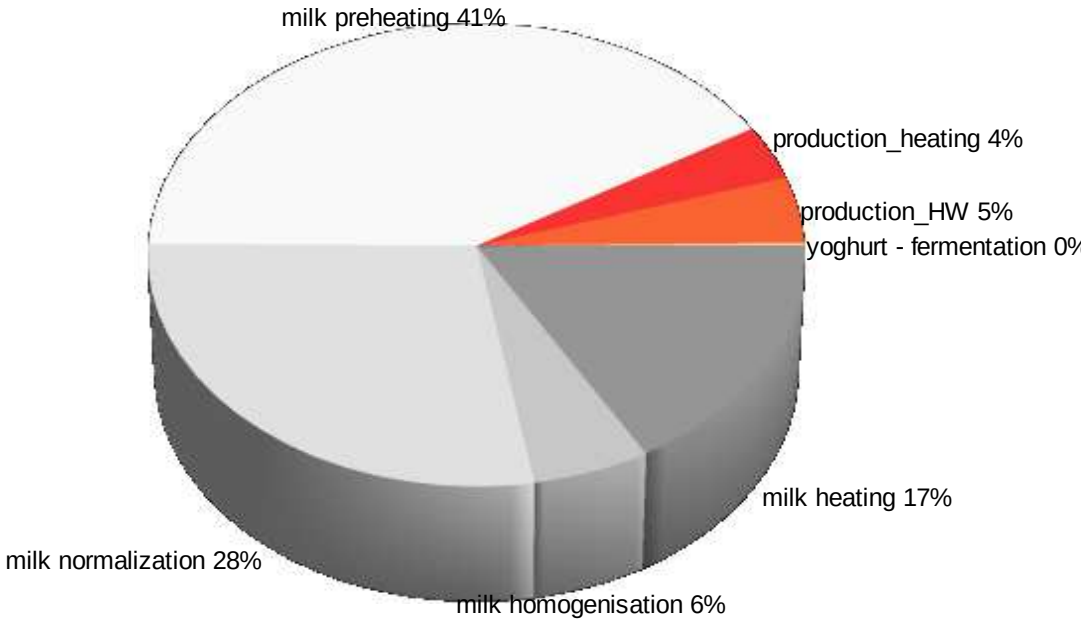

Figure 11: Useful process heat (UPH) by process

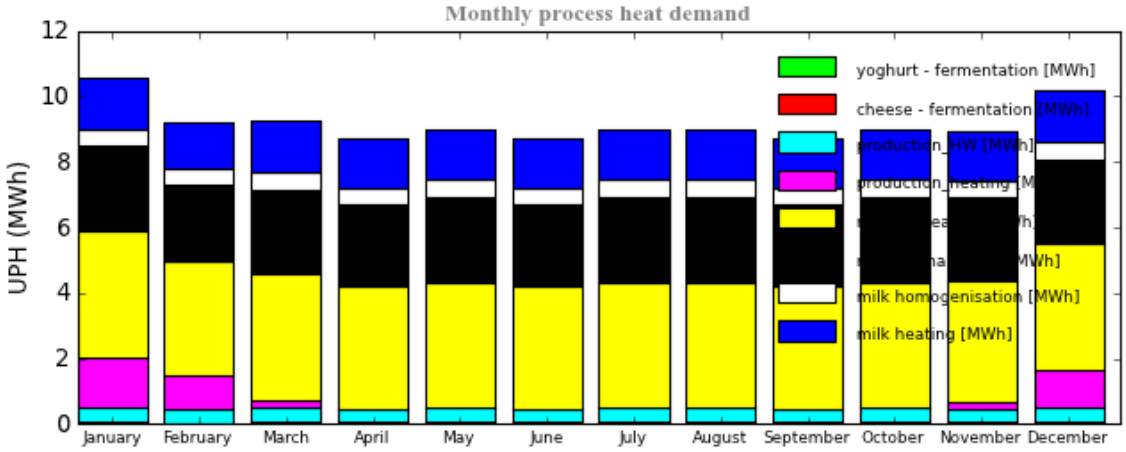

Figure 12: Distribution of useful process heat demand per month

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

Process	Total	Circulation	Maintenance	Start-up
	[MWh]	[MWh]	[MWh]	[MWh]
yoghurt - cooling enter starters	19	19	0	0
cheese - cooling enter starters	44	44	0	0
yoghurt - cooling	7	7	0	0
yoghurt - yoghurt cooling	8	8	0	0
cheese - cutting cooling	20	20	0	0
cheese - maturation	0	0	0	0
refrigerant storage_cooling	25	0	25	0
Total	**122**	**98**	**25**	**0**

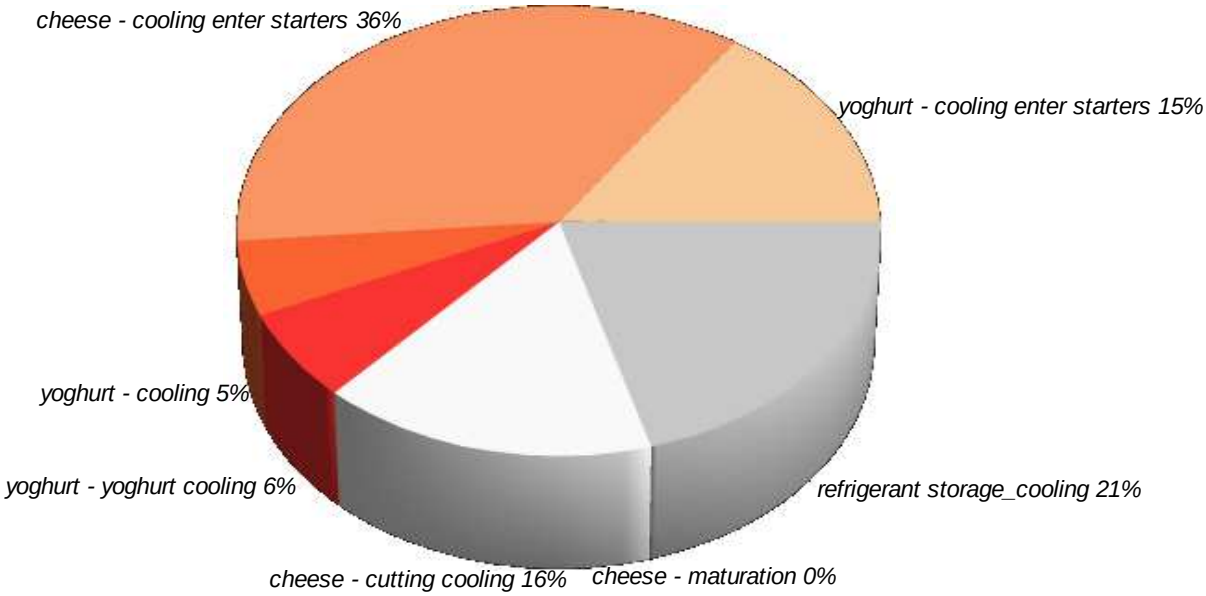

Figure 13: Useful process cooling (UPC) by process

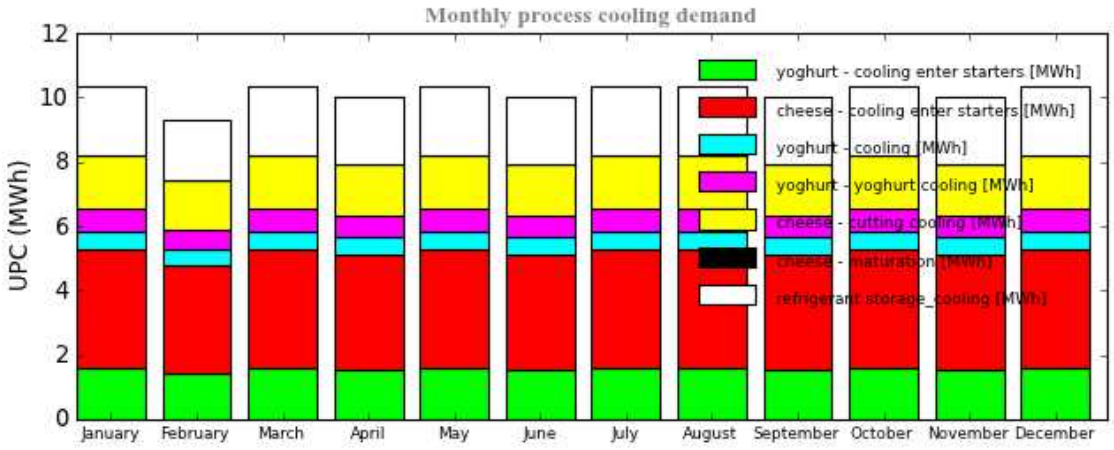

Figure 14: Distribution of useful process cooling demand per month

3.4. General

- The target room temperature during winter is 25 °C for the production hall and 15 °C for the storage room.
- The hot water demand was estimated to be 0.3 m³ per day.

4. Comparative study

4.1. Proposed alternatives

There are five proposals made in this study. In the first one four new heat exchangers are implemented into the existing system. In the second proposal a solar thermal system is installed additionally to the heat exchangers. The third proposal focuses on the installation of a new CHP (combined heat and power plant) in combination with the heat exchangers. The fourth and fifth proposal "HX + new boiler" and "New boiler" take a closer look at the additional installation of a new boiler with or without the heat exchangers.

Table 8: Overview of the alternative proposals studied

Short Name	Description
heat exchanger	based on present state four new heat exchangers are installed
HX + solar	based on present state four new heat exchangers are installed and additionally a solar thermal system is implemented
HX + CHP	based on present state four new heat exchangers are installed and additionally a combined heat and power plant (CHP) is implemented
HX + new boiler	based on present state four new heat exchangers are installed and additionally a new boiler is implemented
New boiler	based on present state a new boiler is implemented

4.1.1. Heat Supply

- **Heat Exchanger (HX):**

In Table 9 the proposed heat exchangers are listed. The heat exchangers use the "milk preheating", "milk heating" "cheese-cooling enter starters" and the "yoghurt-cooling enter starters" as heat sources and the following streams as heat sinks: "production_HW (hot water)", "milk normalization", "milk homogenization" and "milk heating". By installing these four heat exchangers up to 43.48 MWh of energy can be recovered. In Figure 15 the assumed time schedule of the production can be found. The heat exchanger network was based on this schedule and has to be adopted if the production times differ.

Table 9: Heat exchangers and amount of recovered energy

Heat Exchanger	Power	Heat Source	Heat Sink	Amount of recovered energy	
	[kW]			[MWh]	[%]
HX_BelowPinch_2	0	milk preheating	production_HW	3	6,30
HX_BelowPinch_3	28	milk heating	milk normalization	31	70,29
HX_BelowPinch_4	6	cheese - cooling enter starters	milk homogenisation	6	14,06
HX_BelowPinch_7	4	yoghurt - cooling enter starters	milk heating	4	9,35
	38			**43,48**	**100**

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

Equipment	Nominal capacity	Contribution to total heat and cooling supply	
	[kW]	[MWh]	[%]
steam boiler	75	65	93.90
cooling	60	55	50.67
refrigeration system	55	53	49.33
electric heaters	16	4	6.10
Total	**206**	**177**	**200**

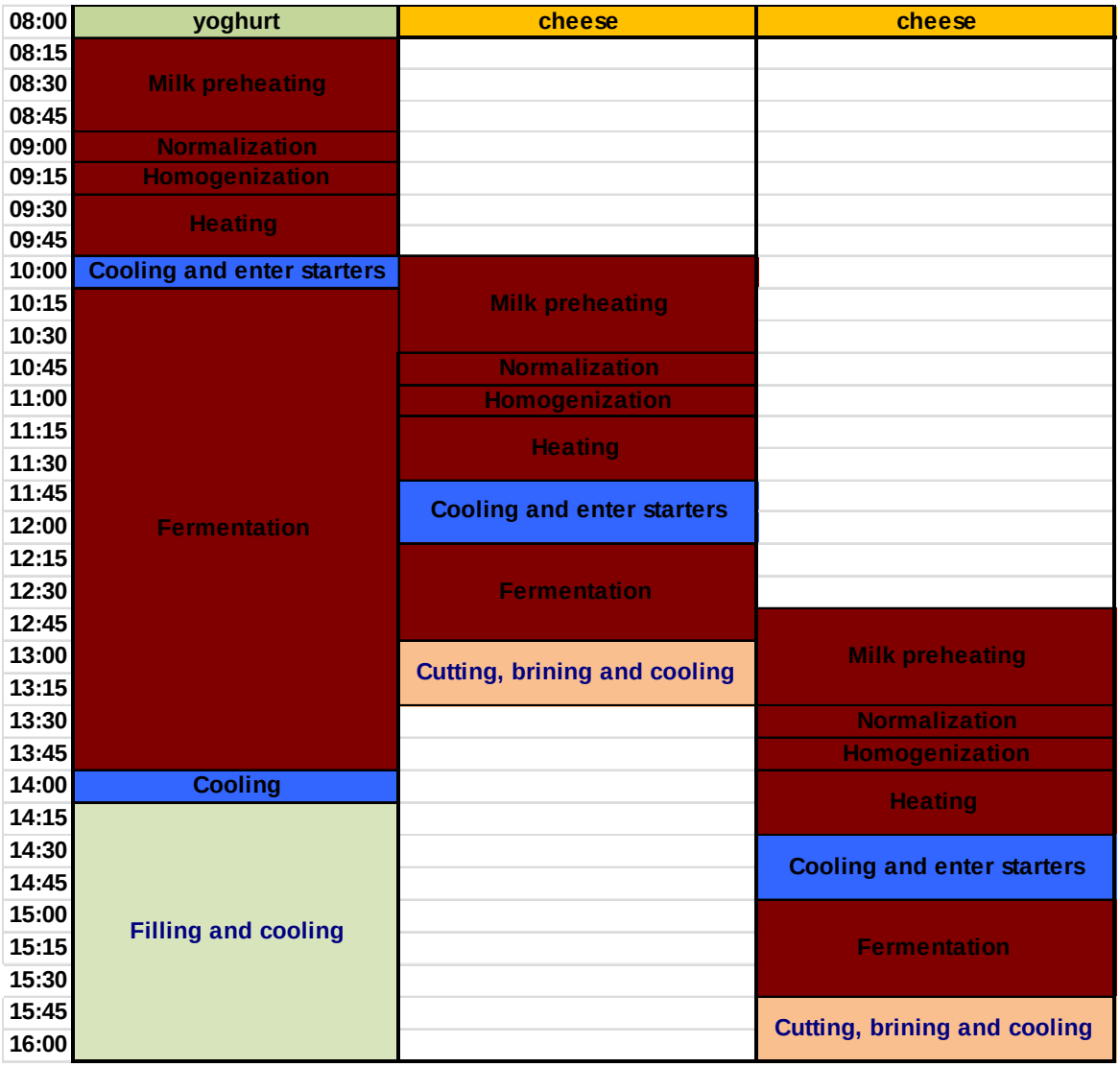

Figure 15: Assumed time schedule

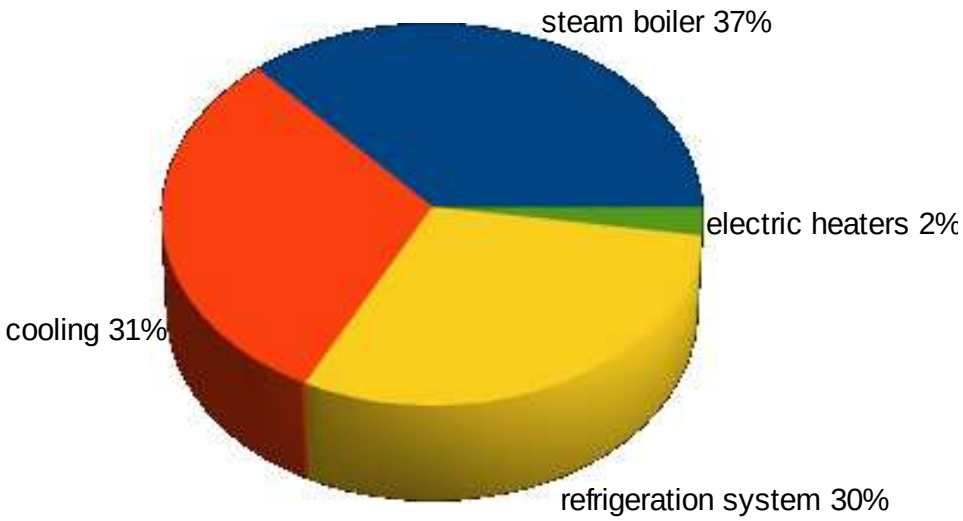

Figure 16: Contribution of each equipment to the total useful heat and useful cooling supply (USH & USC).

- graphic: heat demand covered by boiler:

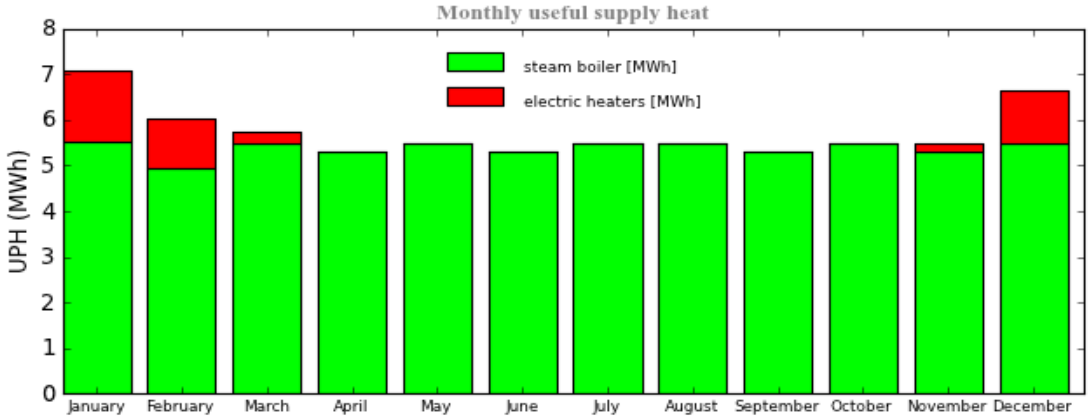

Figure 17: Distribution of useful process heat supply per month

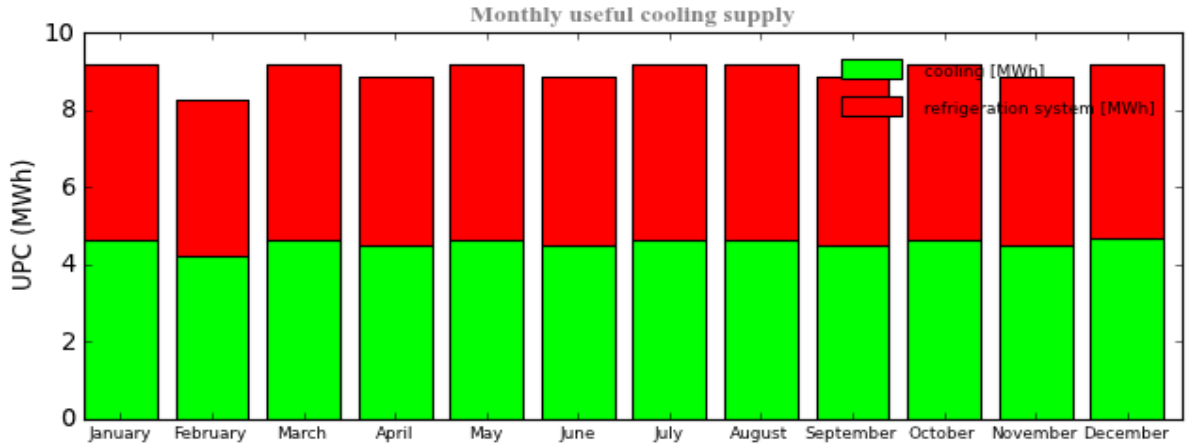

Figure 18: Distribution of useful cooling supply per month

- **HX + Solar:**

Collector type:	FPC (flat plate collectors)
Installed capacity:	46.2 kW
Installed collector area:	66 m²
Solar buffer storage volume:	3.3 m³
Solar fraction:	50.41 %
Annual energy yield:	751.24 kWh/kWa

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

Equipment	Nominal capacity	Contribution to total heat and cooling supply	
	[kW]	[MWh]	[%]
Solar thermal system	46	35	50.41
steam boiler	75	32	46.17
cooling	60	55	50.67
refrigeration system	55	53	49.33
electric heaters	16	2	3.42
Total	**252**	**177**	**200**

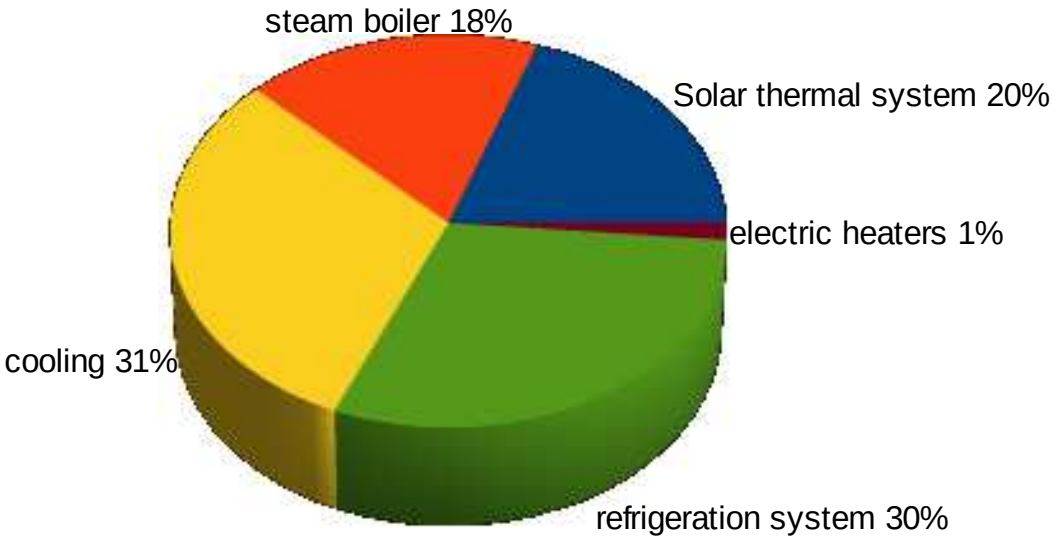

Figure 19: Contribution of each equipment to the total useful heat and useful cooling supply (USH & USC).

- graphic: heat demand covered by solar thermal system:

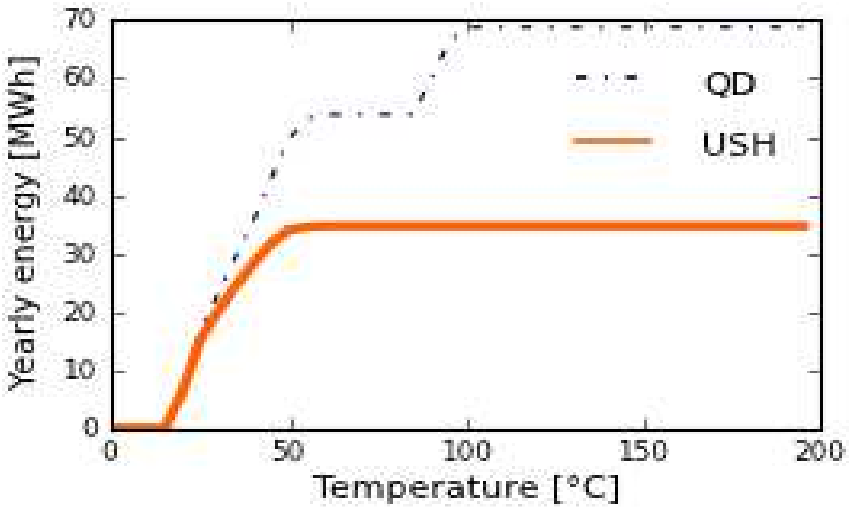

Figure 20: Heat demand and solar contribution

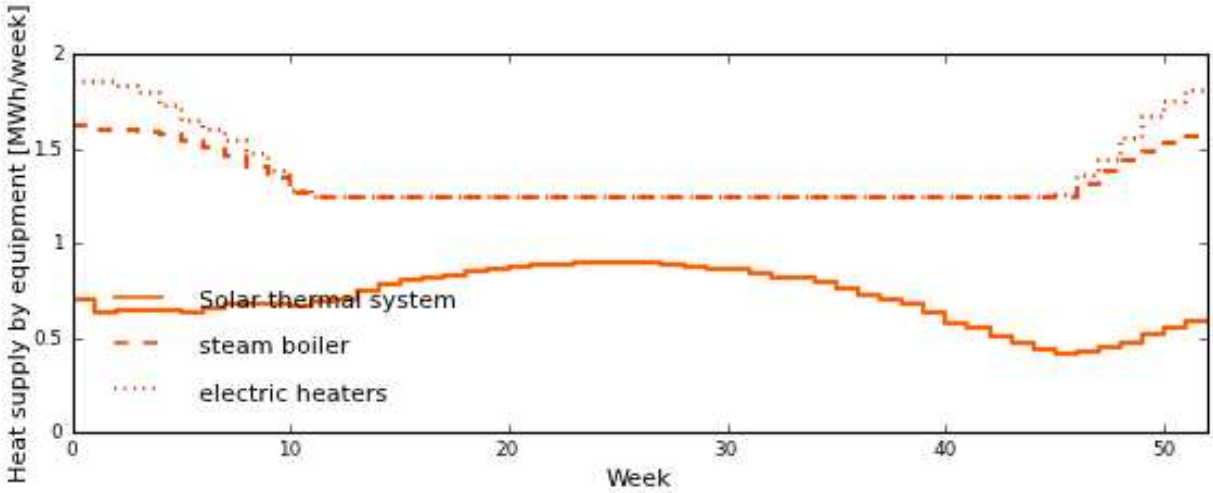

Figure 21: Daily heat supply by equipment

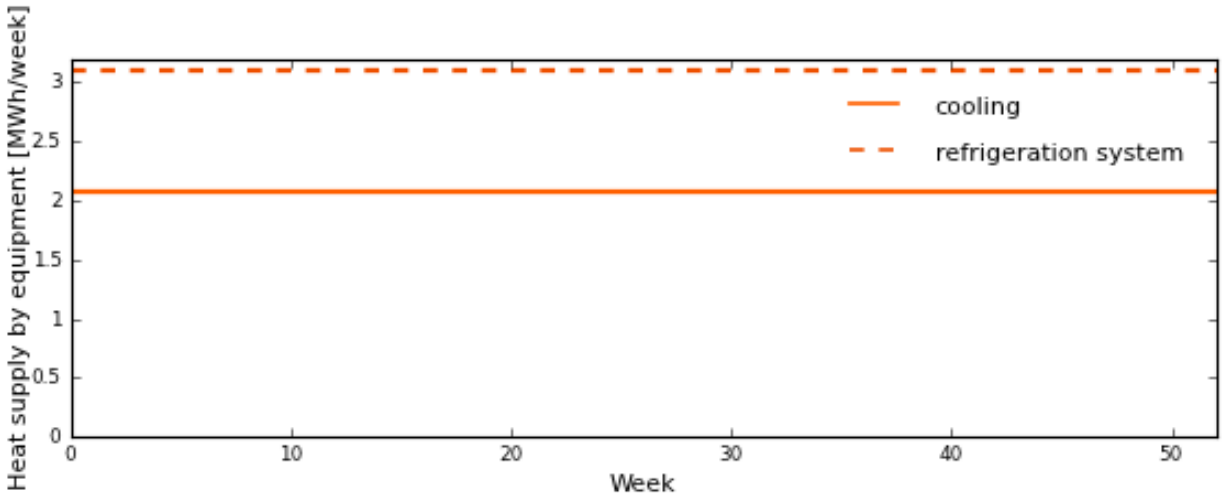

Figure 22: Daily cold supply by equipment

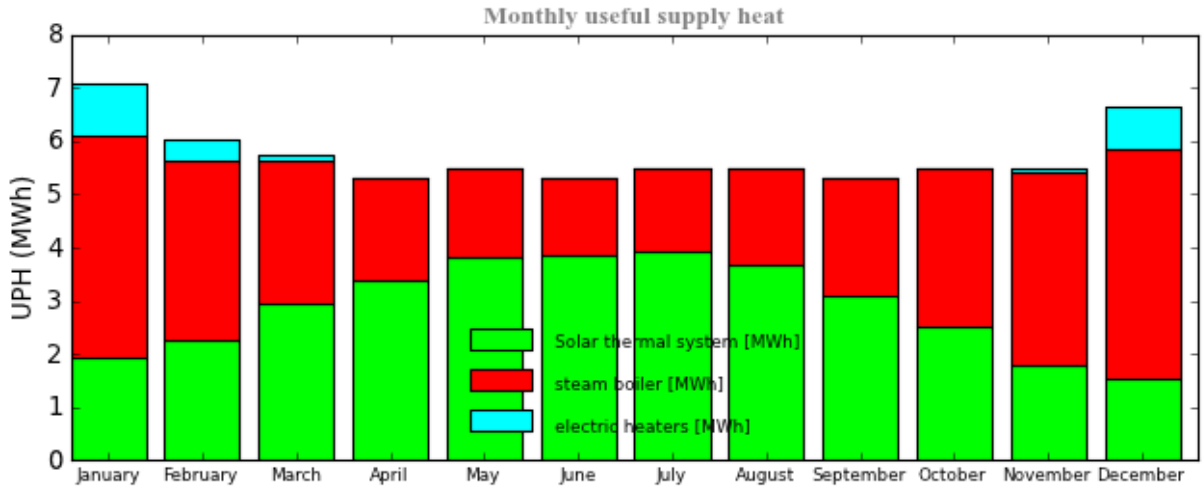

Figure 23: Distribution of useful process heat supply per month

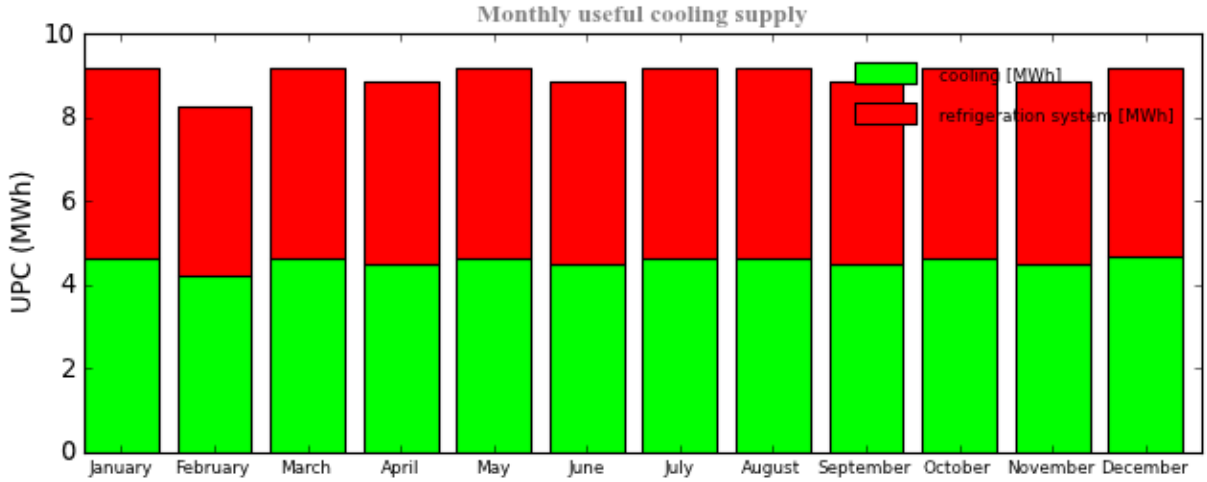

Figure 24: Distribution of useful cooling supply per month

- **HX + CHP**

Type	CHP gas engine
Nominal thermal power	93 kW
Nominal electrical power	50 kW
Thermal efficiency	0.52
Electrical efficiency	0.28
Operating hours	1,940 h

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

Equipment	Nominal capacity	Contribution to total heat and cooling supply	
	[kW]	[MWh]	[%]
New CHP 4	93	67	97.73
steam boiler	75	0	0.35
cooling	60	55	50.67
refrigeration system	55	53	49.33
electric heaters	16	1	1.91
Total	**299**	**177**	**200**

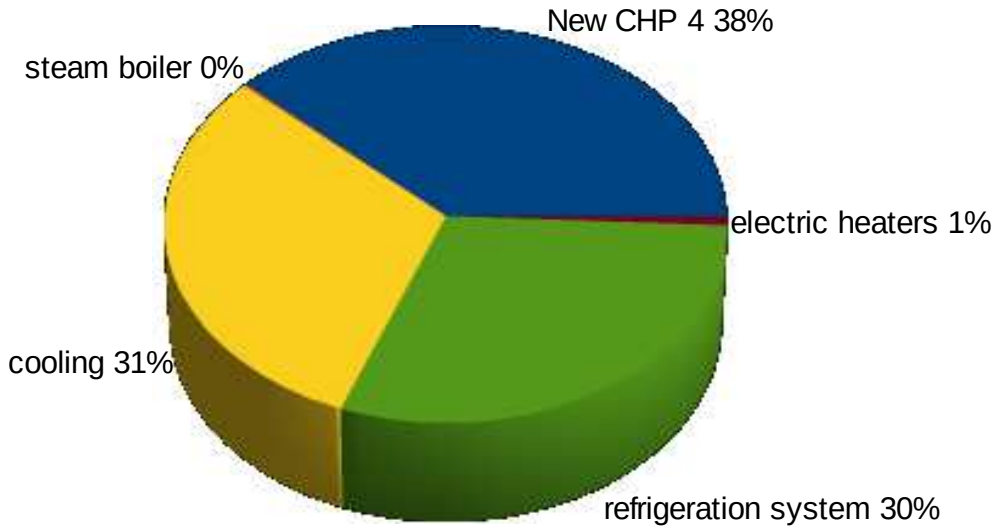

Figure 25: Contribution of each equipment to the total useful heat and useful cooling supply (USH & USC).

- graphic: heat demand covered by CHP:

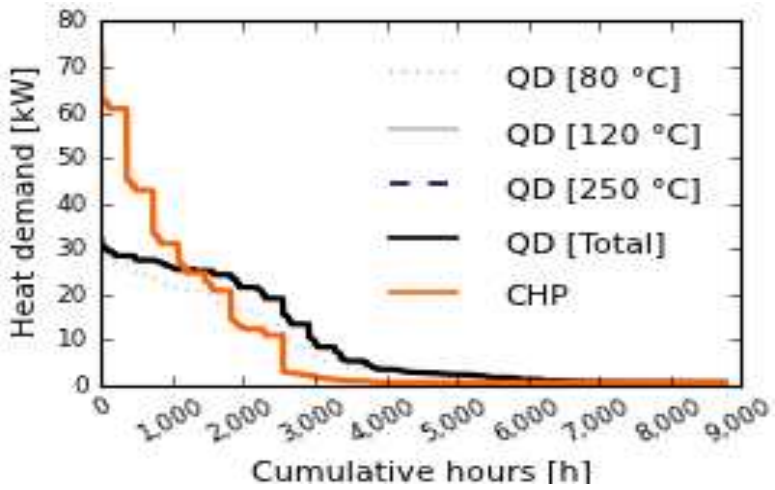

Figure 26: Cumulative heat supply to be covered by CHP

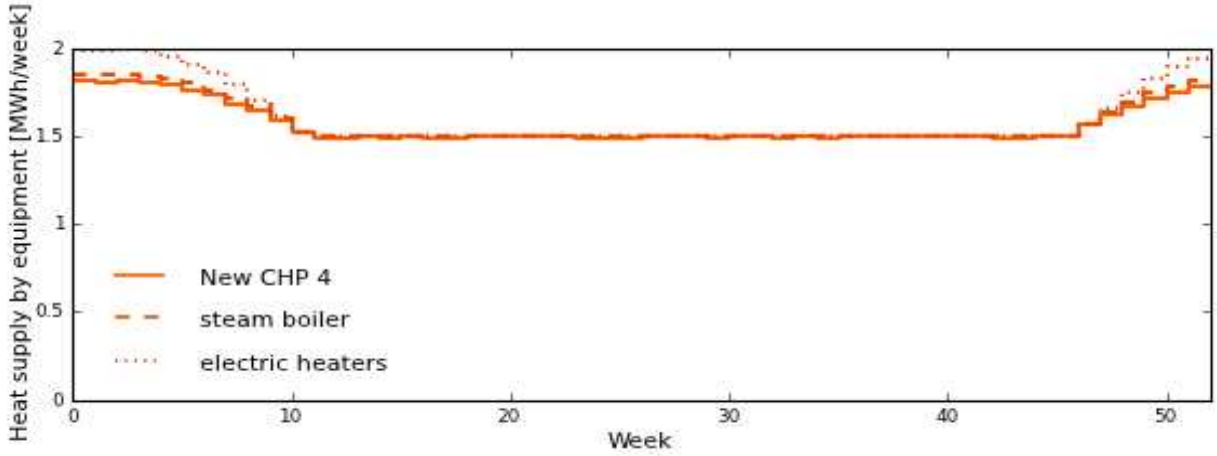

Figure 27: Daily heat supply by equipment

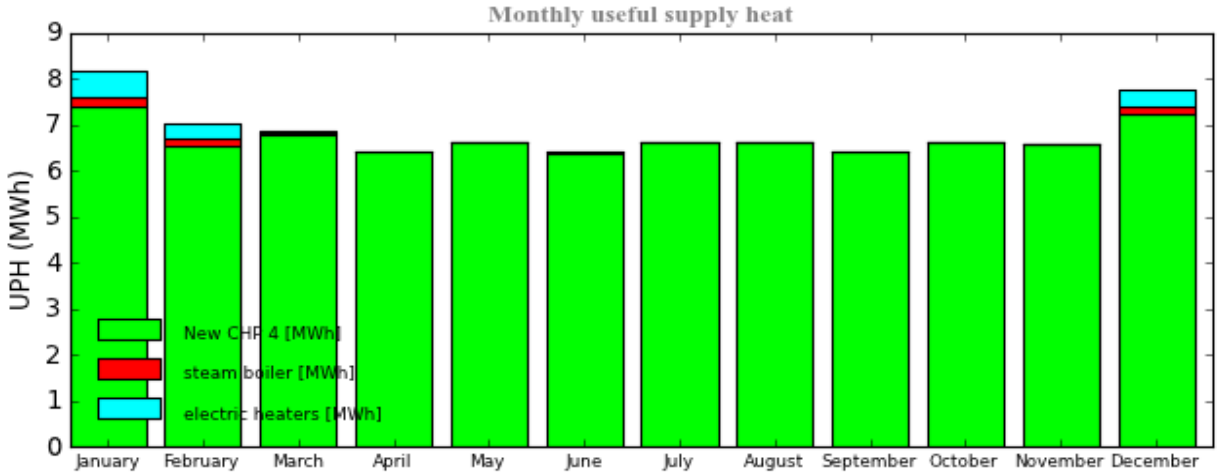

Figure 28: Distribution of useful process heat supply per month

- **HX + New Boiler:**

Type of boiler	gas boiler
Nominal power	50 kW
Thermal efficiency	1.1
Operating hours	8,760 h

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

Equipment	Nominal capacity	Contribution to total heat and cooling supply	
	[kW]	[MWh]	[%]
cooling	60	55	50.67
refrigeration system	55	53	49.33
electric heaters	16	4	6.10
new boiler	50	65	93.90
Total	**181**	**177**	**200**

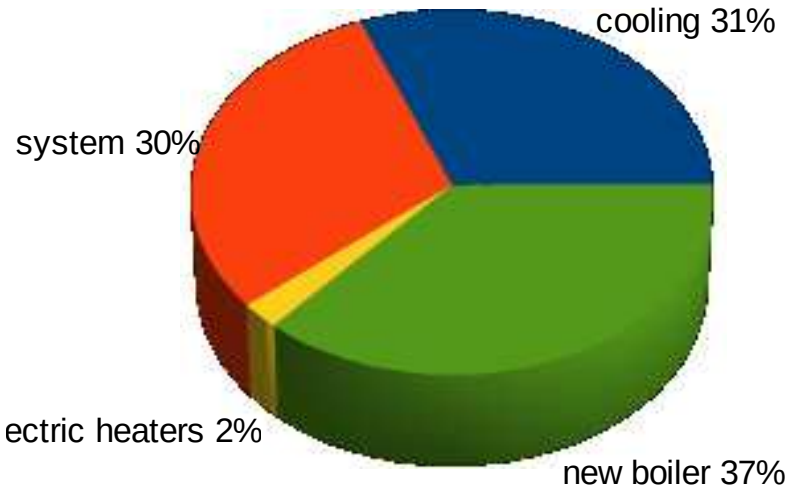

Figure 29: Contribution of each equipment to the total useful heat and useful cooling supply (USH & USC).

- graphic: heat demand covered by boilers

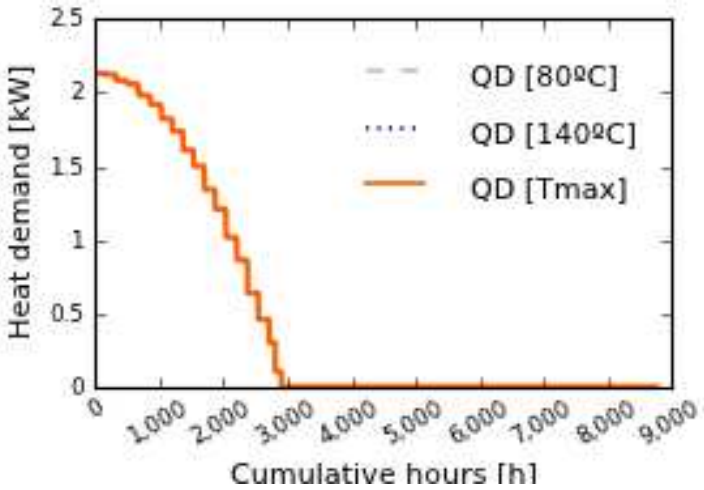

Figure 30: Cumulative heat demand to be covered by boilers

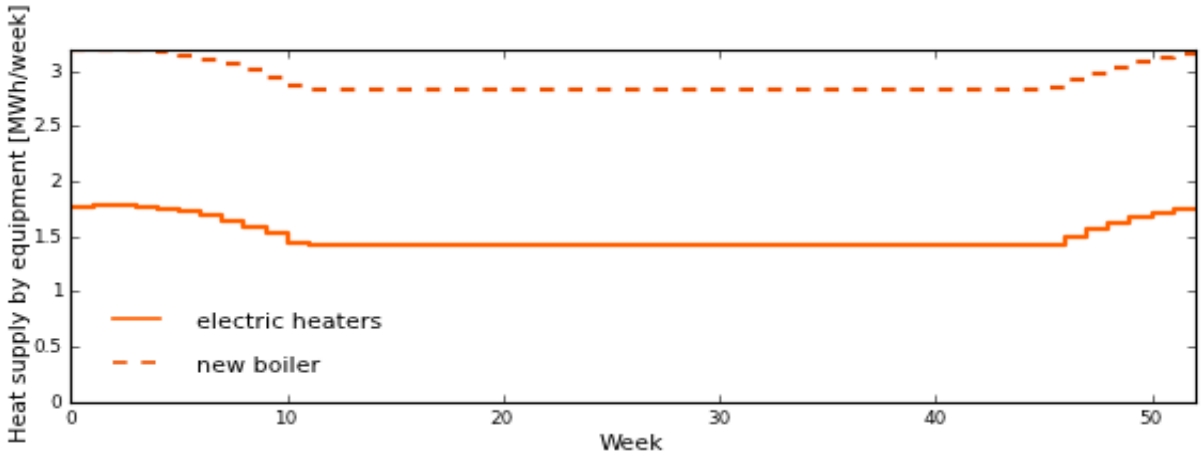

Figure 31: Daily heat supply by equipment

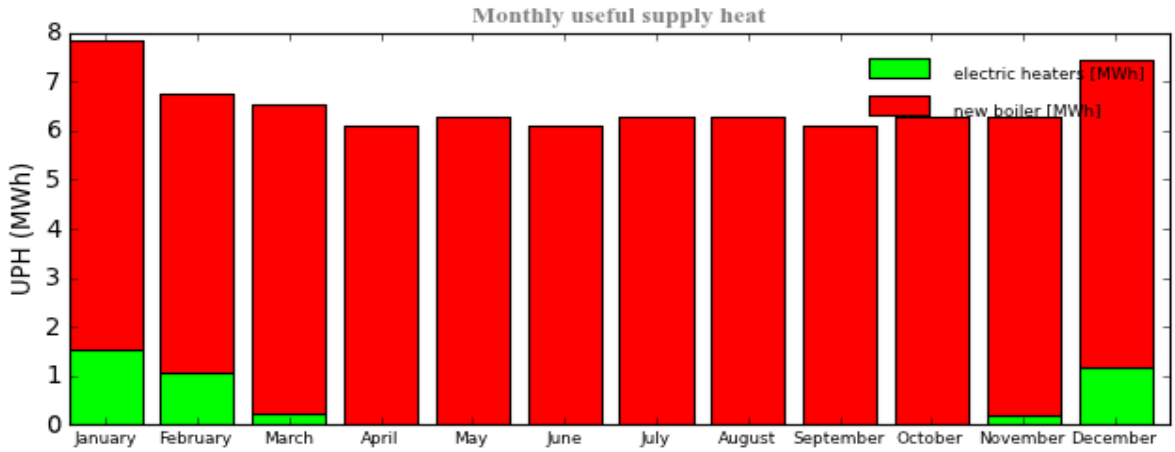

Figure 32: Distribution of useful process heat supply per month

- **New Boiler:**

Type of boiler	gas boiler
Nominal power	75 kW
Thermal efficiency	1.1
Operating hours	8,760 h

Table 14: Heat and cooling supply equipment and contribution to total heat and cooling supply

Equipment	Nominal capacity	Contribution to total heat and cooling supply	
	[kW]	[MWh]	[%]
cooling	60	69	56.43
refrigeration system	55	53	43.57
electric heaters	16	4	3.70
new boiler	75	109	96.30
Total	**206**	**236**	**200**

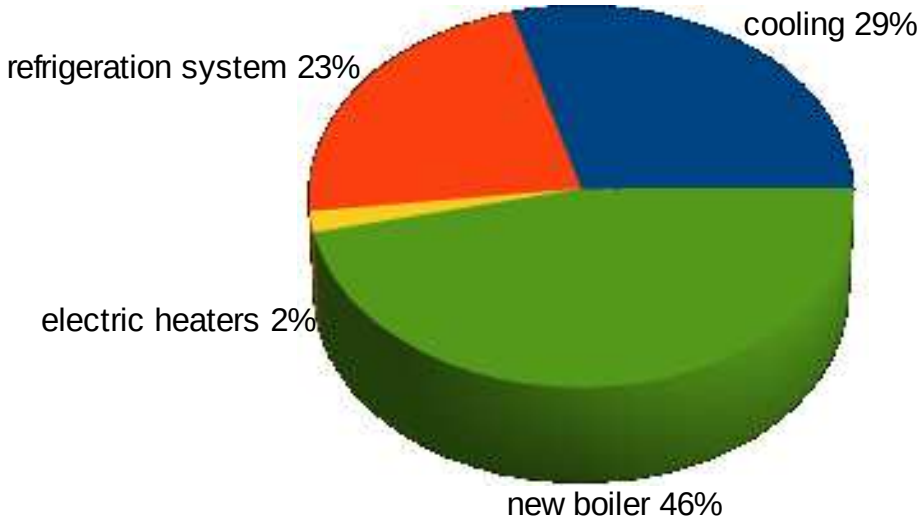

Figure 33: Contribution of each equipment to the total useful heat and useful cooling supply (USH & USC).

- graphic: heat demand covered by boiler

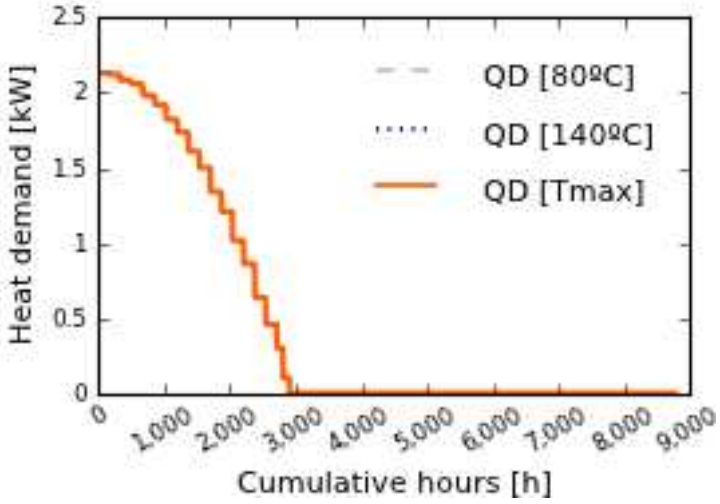

Figure 34: Cumulative heat demand to be covered by boilers

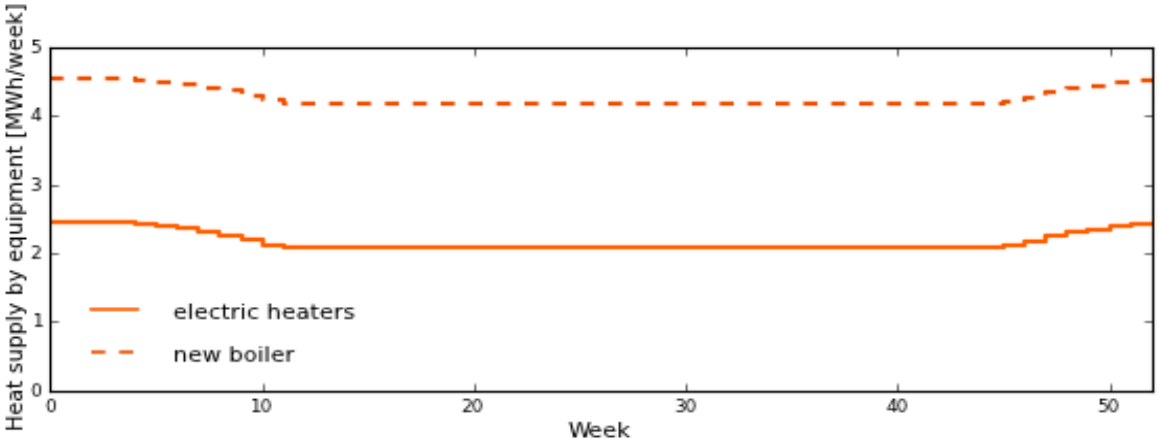

Figure 35: Daily heat supply by equipment

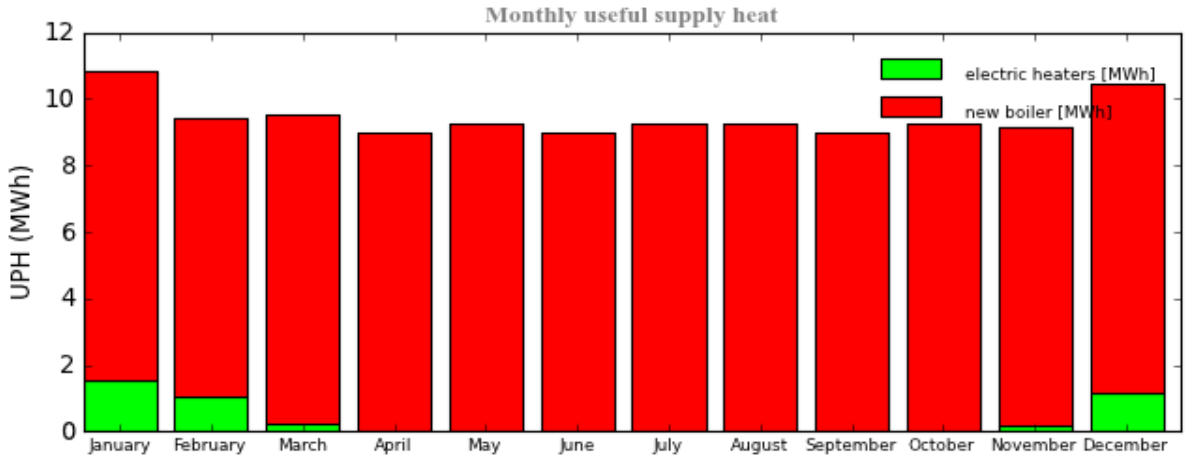

Figure 36: Distribution of useful process heat supply per month

- Primary energy consumption (PEC)

Table 15: primary energy consumption and savings

Alternative	Primary energy consumption	Savings	
	[MWh]	[MWh]	[%]
Present State (checked)	378	---	---
heat exchanger	301	77	20.42
HX + solar	246	131	34.80
HX + CHP	231	147	38.90
HX + new boiler	279	99	26.25
New boiler	339	39	10.36

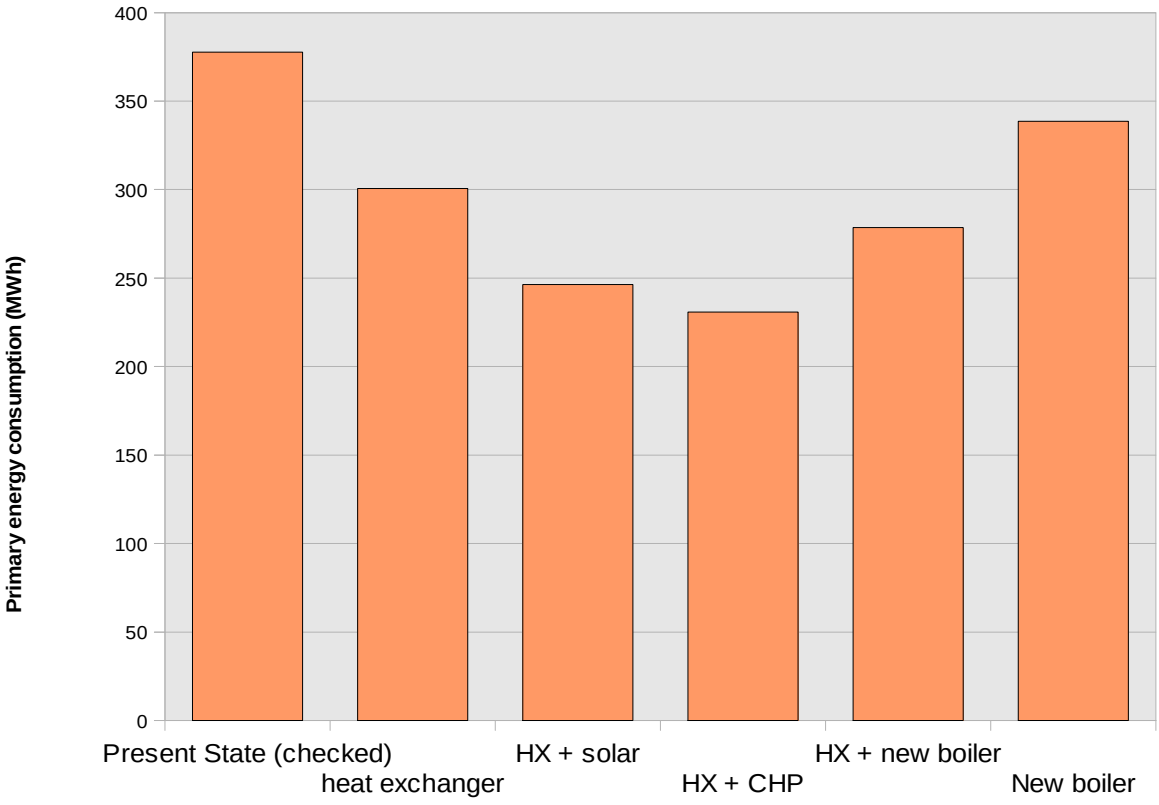

Figure 37: Comparison of alternatives: primary energy consumption

- 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 16: 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)	110	---	113	---
heat exchanger	110	0	69	44
HX + solar	110	0	69	44
HX + CHP	110	0	69	44
HX + new boiler	110	0	69	44
New boiler	110	0	113	0

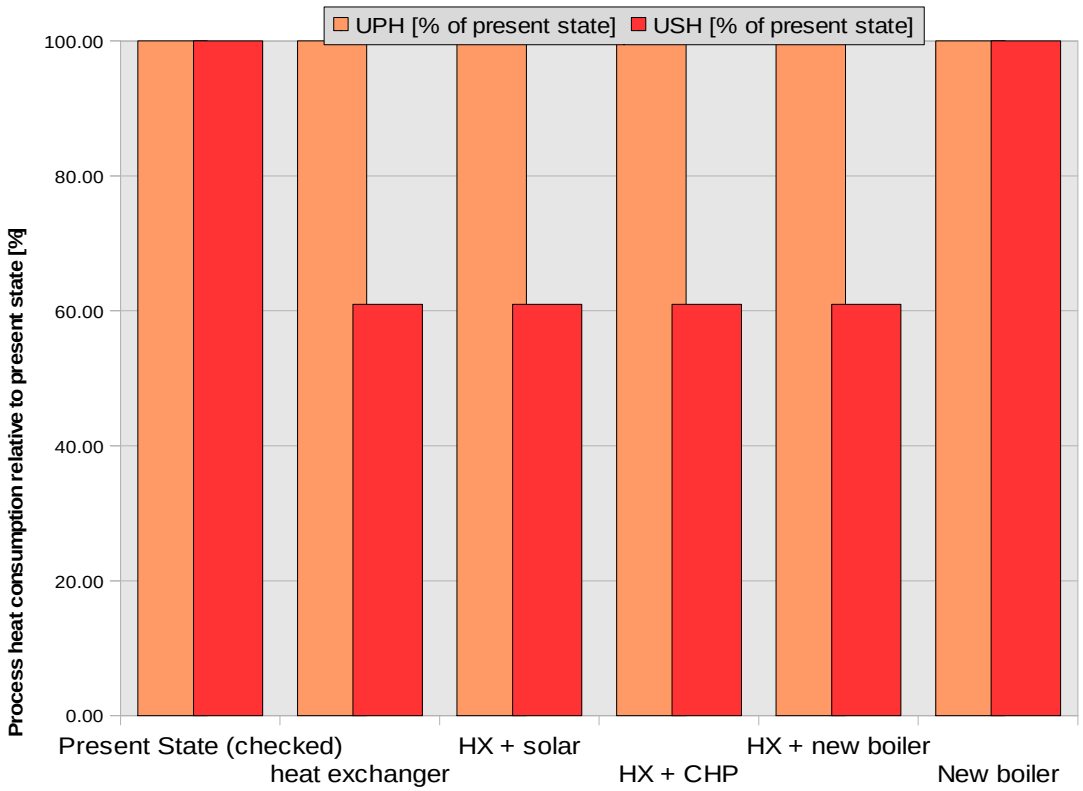

Figure 38: Comparison of alternatives: useful process heat supply

- Useful process and supply cooling (UPC and USC)

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

Table 17: Useful process and supply cooling: present state and alternative proposals.

Alternative	Useful process cooling (UPC)	Savings UPC	Useful supply cooling (USC)	Savings USC
	[MWh]	[MWh]	[MWh]	[MWh]
Present State (checked)	122	---	122	---
heat exchanger	122	0	108	14
HX + solar	122	0	108	14
HX + CHP	122	0	108	14
HX + new boiler	122	0	108	14
New boiler	122	0	122	0

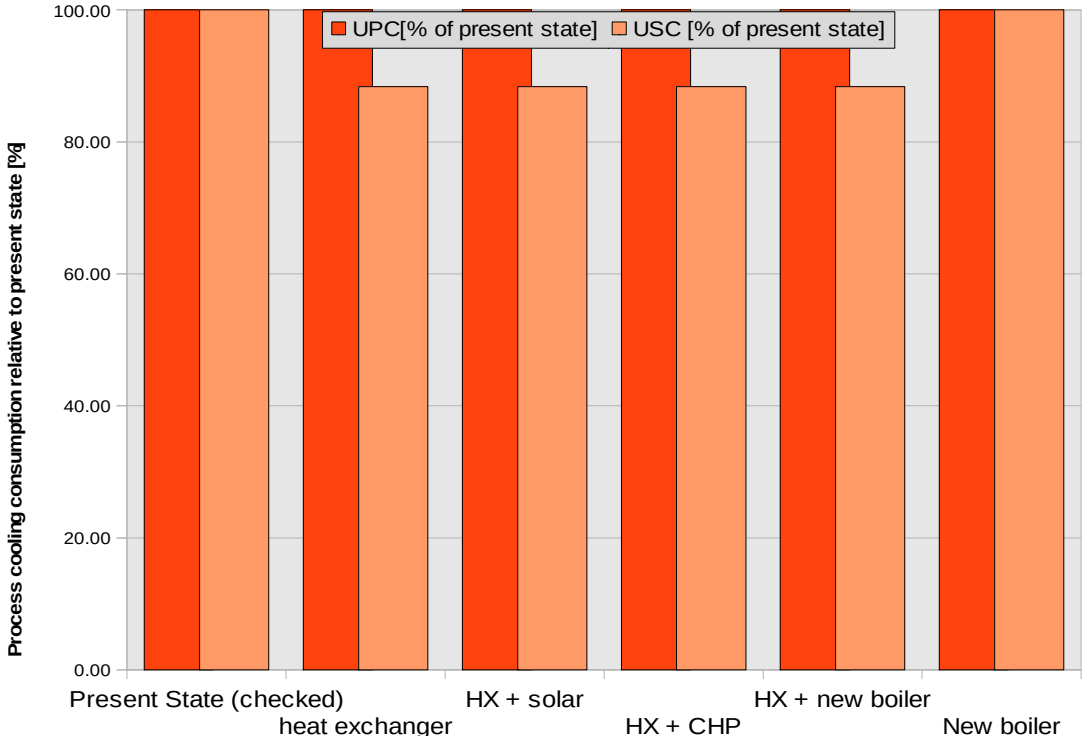

Figure 39: Comparison of alternatives: useful process cooling supply

- Environmental impact

Table 18: CO2 production and CO2 savings per year

Alternative	Production of CO2	Water consumption
	[t]	[m3]
Present State (checked)	85.23	0.00
heat exchanger	63.30	0.00
HX + solar	47.54	0.00
HX + CHP	47.87	0.00
HX + new boiler	56.43	0.00
New boiler	73.32	0.00

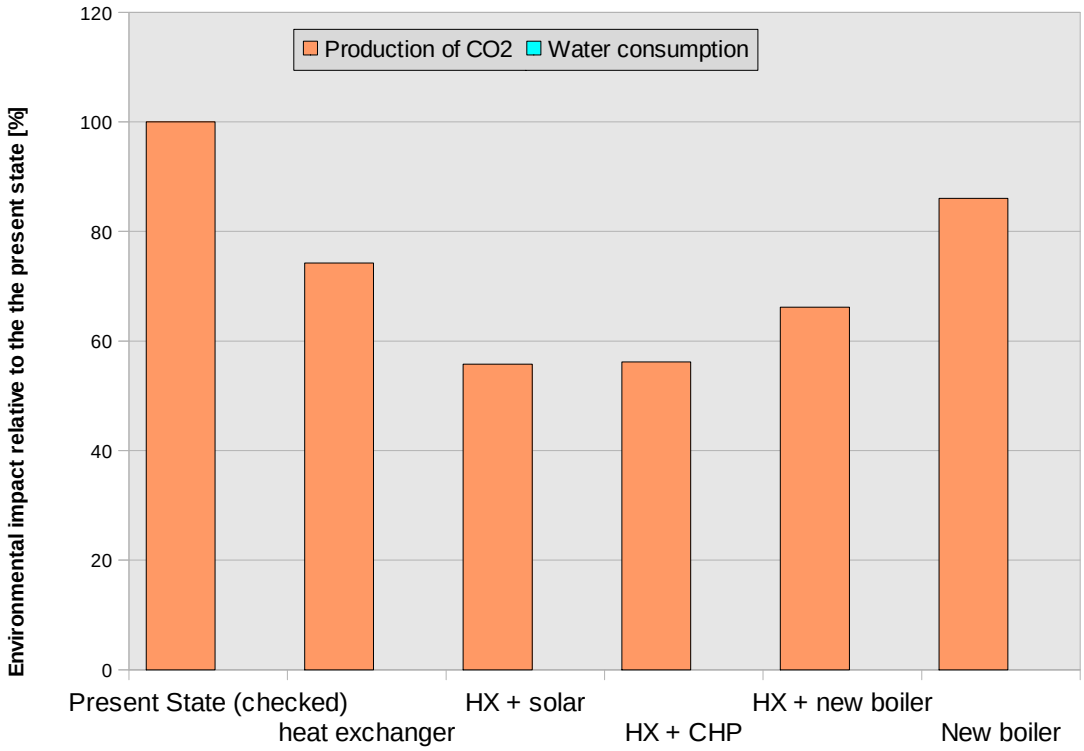

Figure 40: Comparison of alternatives: environmental impact

Table 19: Investment costs and subsidies of the proposals

Alternative	Total investment [€]	Own investment [€]	Subsidies [€]
Present State (checked)	---	---	---
heat exchanger	9,000	9,000	0
HX + solar	38,700	27,090	11,610
HX + CHP	84,000	84,000	0
HX + new boiler	16,500	16,500	0
New boiler	11,250	11,250	0

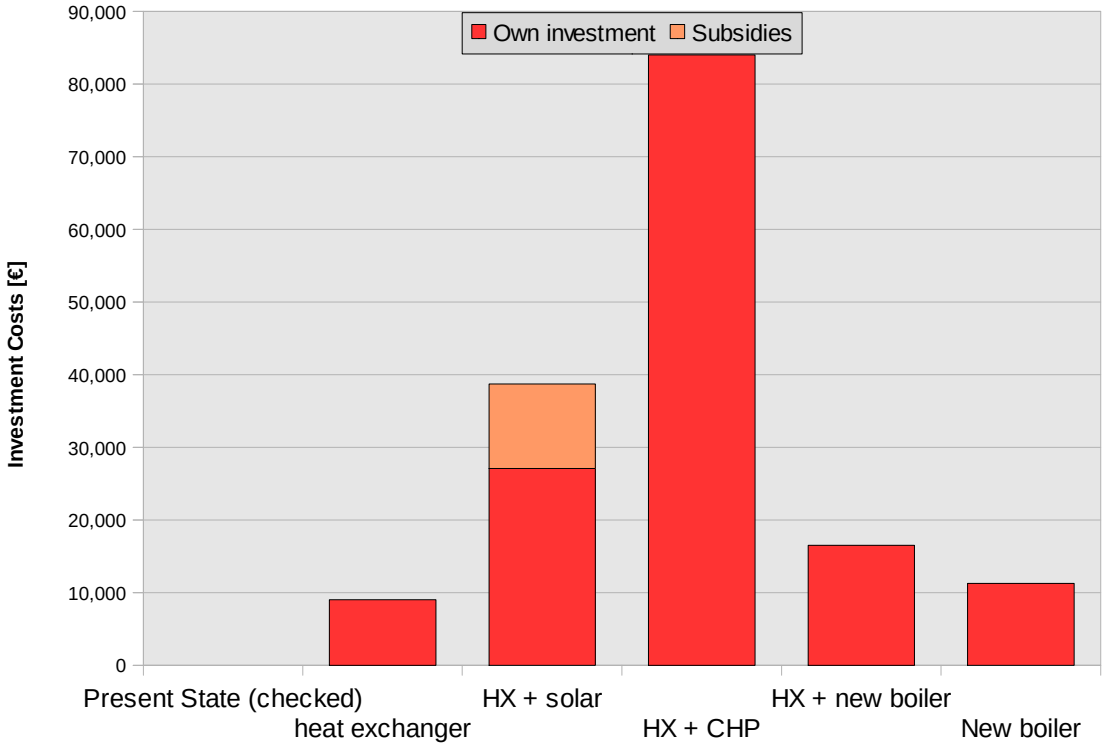

Figure 41: Comparison of alternatives investment cost

5. Selected alternative(s) and conclusions

5.1. Selected alternative

As selected alternative the "HX + New Boiler" 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

- **HX + New Boiler:**

Type of boiler gas boiler

Nominal power 75 kW

Thermal efficiency 1.1

Operating hours 8,760 h

In the following the Pinch Analysis is shown. The heat exchanger design of this alternative is presented and the remaining energy demand curve, as well as the remaining energy availability curves are displayed, in Table 20, Figure 42 and Figure 43.

Table 20: Heat exchangers and amount of recovered energy

Heat Exchanger	Power [kW]	Heat Source	Heat Sink	Amount of recovered energy [MWh]	[%]
HX_BelowPinch_2	0	milk preheating	production_HW	3	6,30
HX_BelowPinch_3	28	milk heating	milk normalization	31	70,29
HX_BelowPinch_4	6	cheese - cooling enter starters	milk homogenisation	6	14,06
HX_BelowPinch_7	4	yoghurt - cooling enter starters	milk heating	4	9,35
	38			**43,48**	**100**

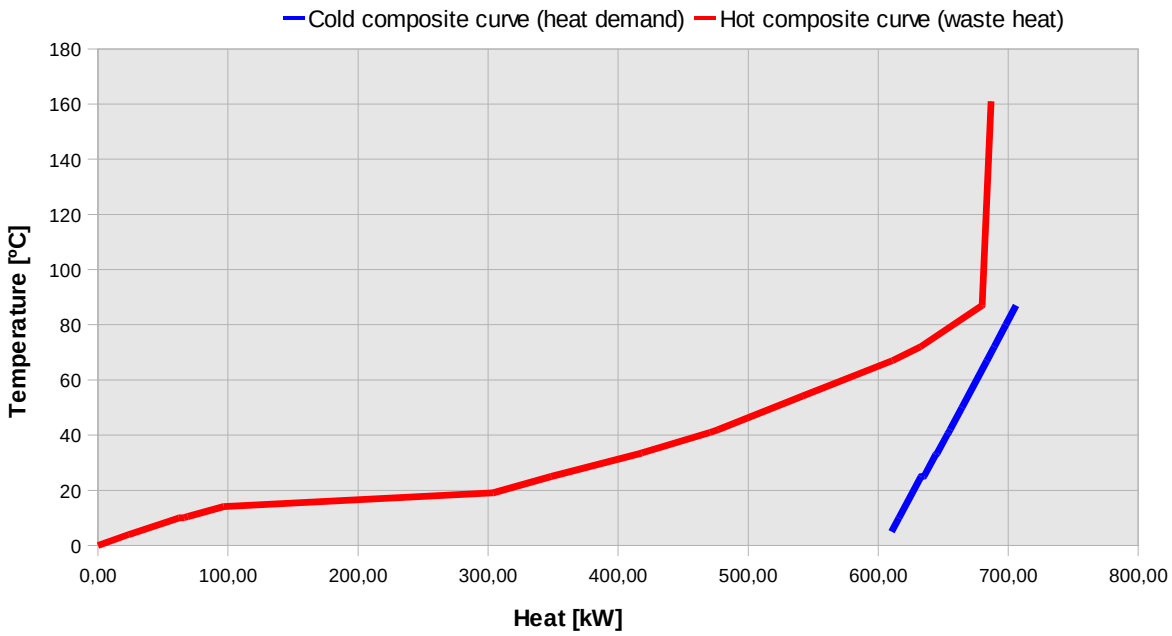

Figure 42: Pinch Analysis - Composite Curves

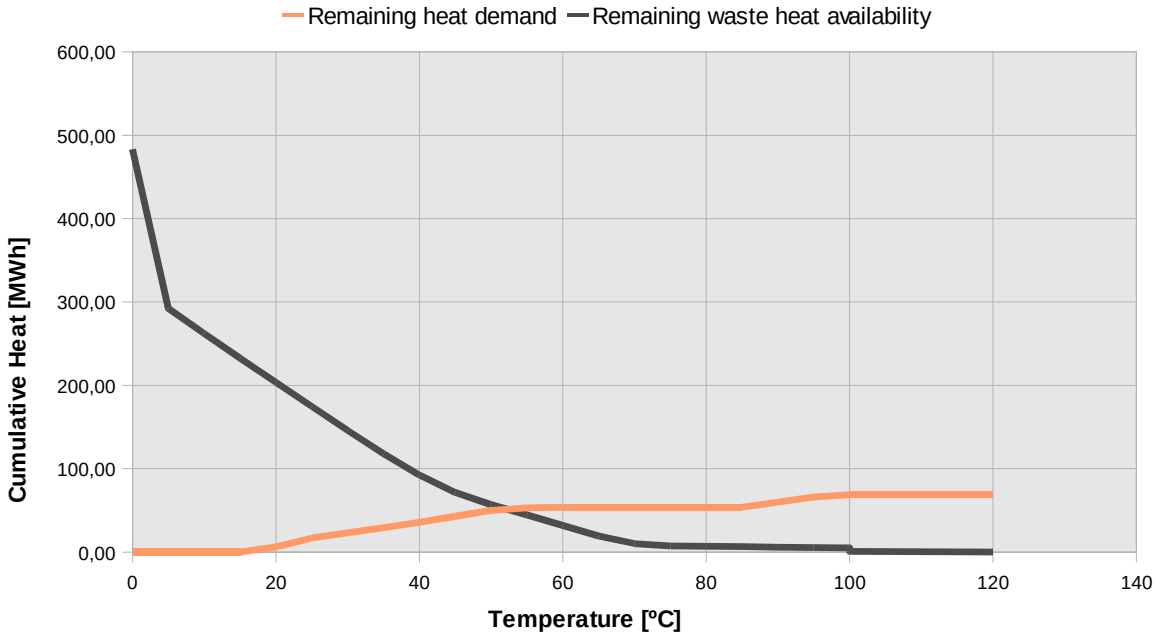

Figure 43: Pinch Analysis – Remaining yearly energy demand and energy availability

Table 21: Heat and cooling supply equipment and contribution to total heat and cooling supply

Equipment	Nominal capacity	Contribution to total heat and cooling supply	
	[kW]	[MWh]	[%]
cooling	60	55	50.67
refrigeration system	55	53	49.33
electric heaters	16	4	6.10
new boiler	50	65	93.90
Total	**181**	**177**	**200**

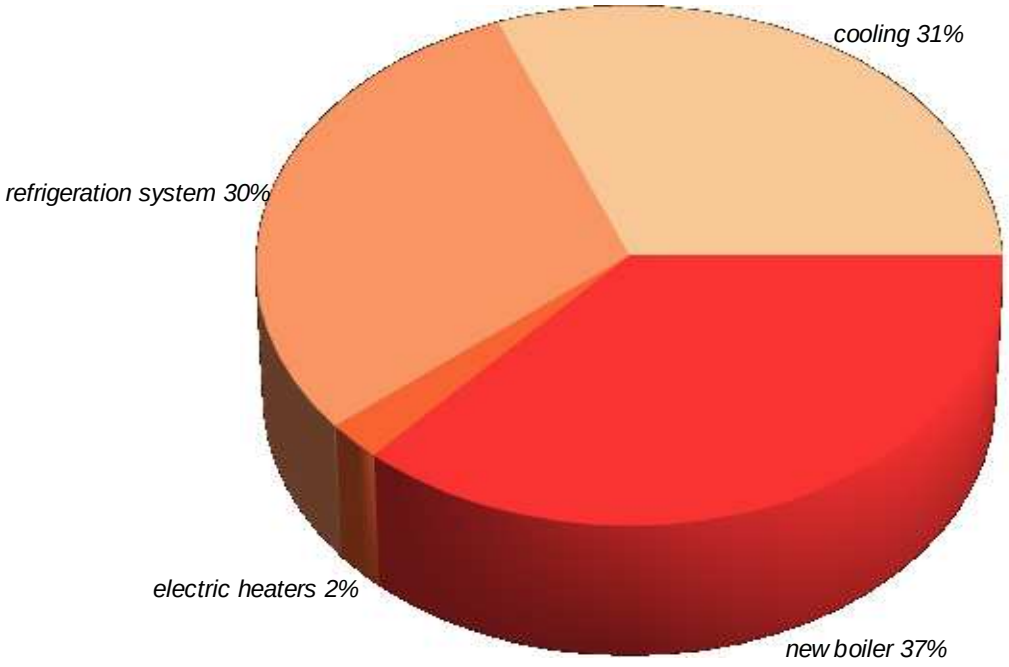

Figure 44: Contribution of each equipment to the total useful heat and useful cooling supply (USH & USC).

5.1.3. Energy Consumption

Table 22: 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	71	25.30	71	28.36
Total electricity	208	74.70	178	71.64
Total (fuels + electricity)	**279**	**100.00**	**249**	**100.00**

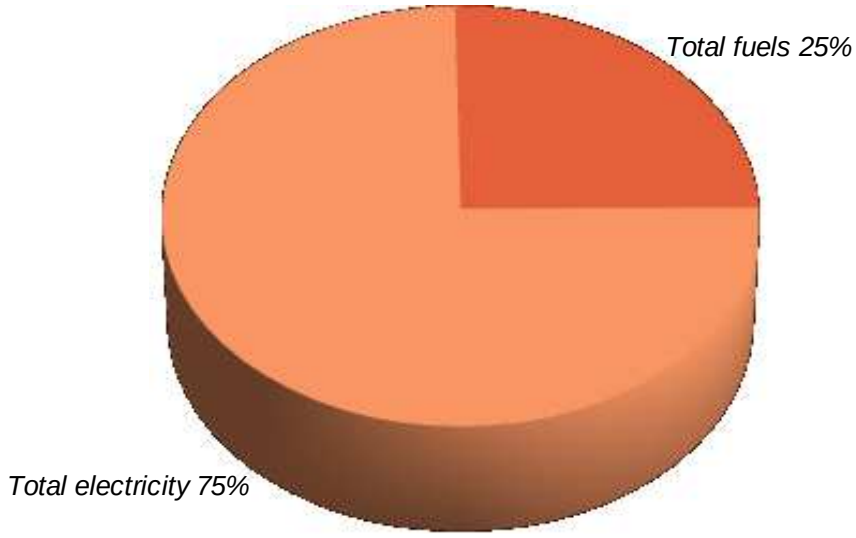

Figure 45: Distribution of PEC by fuel type

Table 23: 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]
black coal/natural gas	59	45.86	59	49.74
Electricity	69	54.14	59	50.26
Total	128	100.00	118	100.00

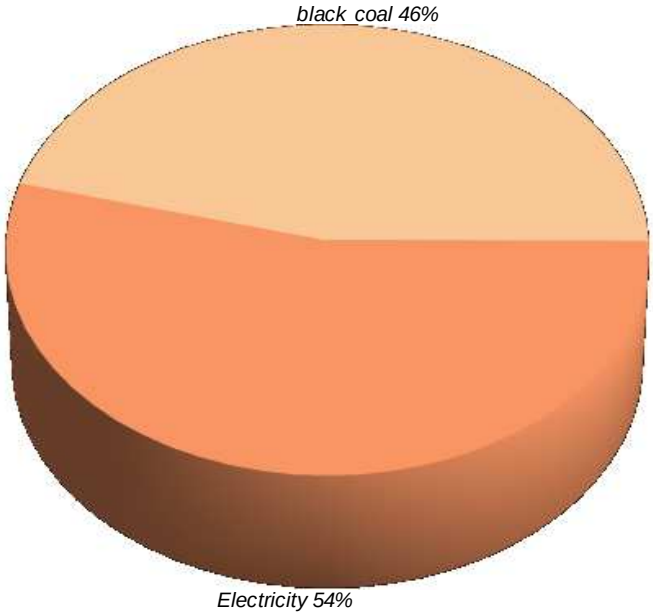

Figure 46: Total final energy consumption (FEC). Proposed final solution.

Table 24 : Final energy consumption for thermal use (FET) by equipment. Proposed final solution.

Equipment	Fuel type	FET by equipment	
		[MWh]	[% of Total]
cooling	Electricity	18	15.17
refrigeration system	Electricity	35	29.97
electric heaters	Electricity	4	3.63
new boiler	black coal/natural gas	61	51.23
Total		**118**	**100**

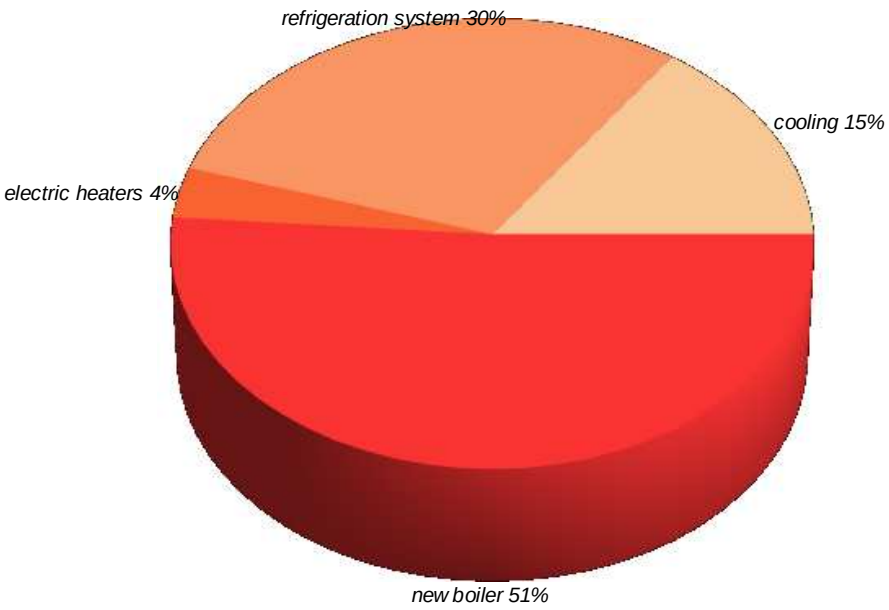

Figure 47: Final energy consumption for thermal use (FET) by equipment

Table 25 : Useful supply heat (USH) by equipment. Proposed final solution.

Equipment	USH by equipment	
	[MWh]	[% of Total]
electric heaters	4	6.10
new boiler	65	93.90
Total	**69**	**100**

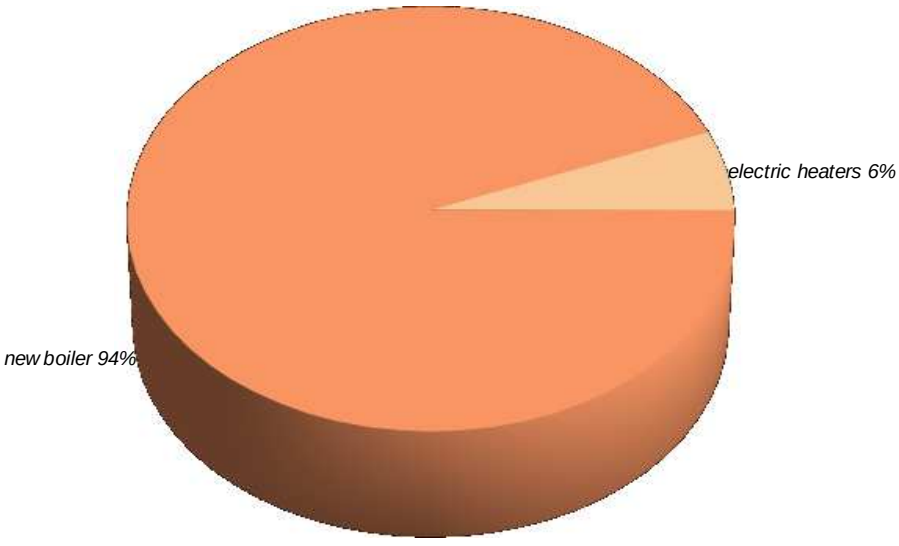

Figure 48: Useful supply heat (USH) by equipment. Proposed final solution

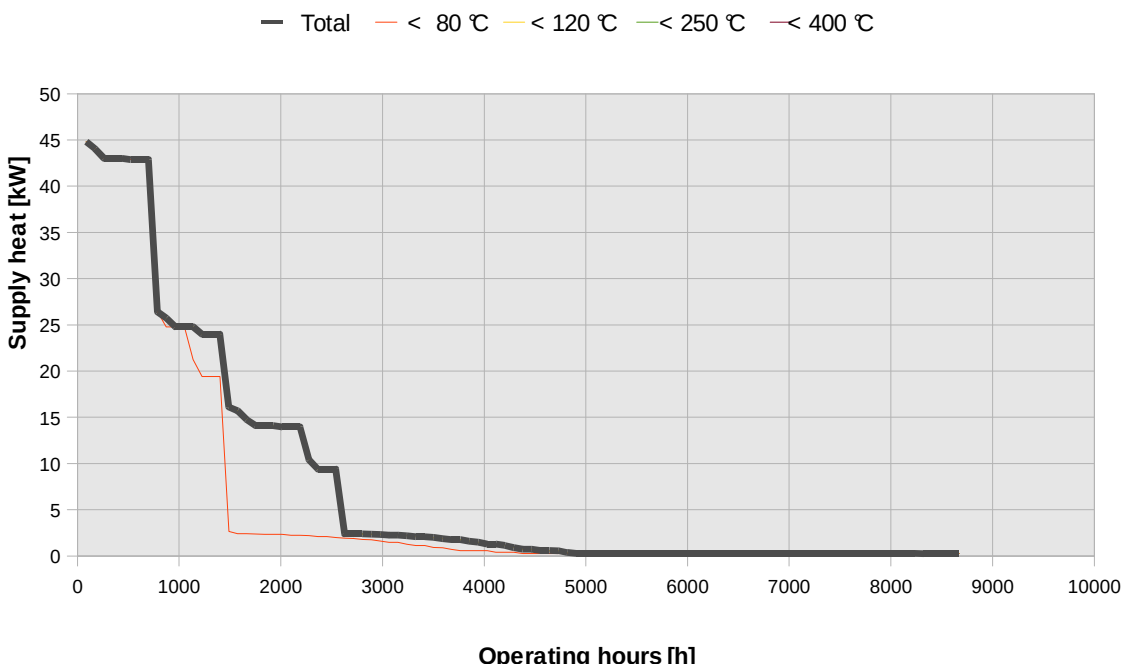

Figure 49: Distribution of supply heat by temperature levels and annual operating hours. Proposed final solution.

Table 26 : Useful supply cooling (USC) by equipment. Proposed final solution.

Equipment	USC by equipment	
	[MWh]	[% of Total]
cooling	55	50.67
refrigeration system	53	49.33
Total	**108**	**100**

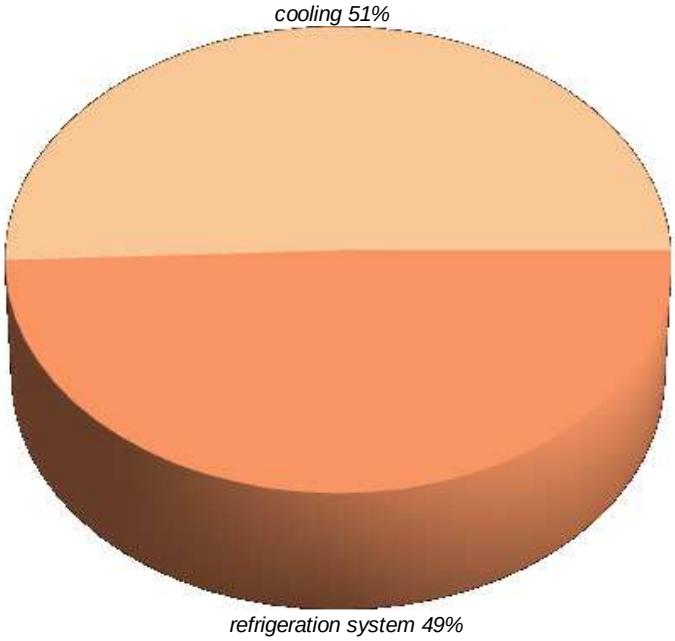

Figure 50: Useful supply cooling (USC) by equipment. Proposed final solution

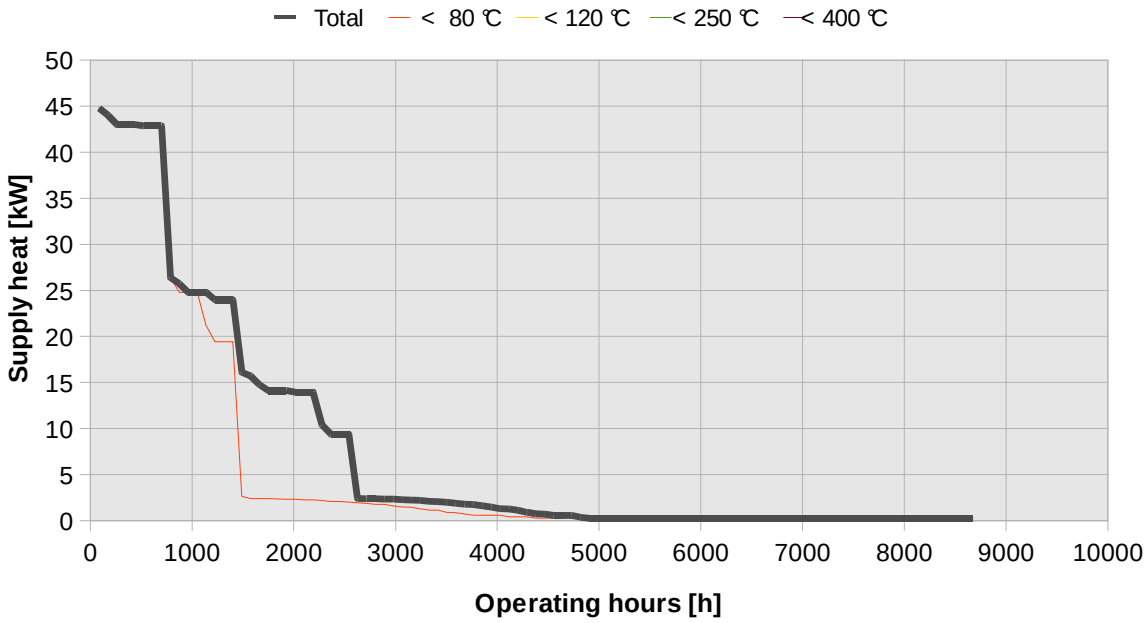

Figure 51: Distribution of supply heat by temperature levels and annual operating hours. Proposed final solution.

5.2. Comparative study and conclusions

5.2.1. Energy and environmental analysis

In the proposed alternative around 34 % of the CO_2 pollution can be saved.

5.2.2. Economic analysis

The payback period of about 18 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 are based on costs and subsidies of 30% for the solar thermal plant of the investment costs and have to be revised. Investment and installing cost are based on actual cost in Austria and not Bulgaria.

Table 27: Savings of the proposed alternative in comparison to the present state

		Present state	Alternative	Saving	[% savings]
Total primary energy consumption (1)					
- total	[MWh]	378	279	99	26%
- fuels	[MWh]	157	71	86	55%
- electricity	[MWh]	221	208	13	6%
Primary energy saving due to renewable energy	[MWh]		0		
CO_2 emissions	[t/a]	85.23	56.43	28.8	34%
Annual energy system cost (2)	[EUR]	4,411	3,501	910	21%
Total investment costs	[EUR]		16,500		
Payback period (3)	[years]		18		

(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 boiler 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.