Energy Audit Summary Report

AEE INTEC

Audit no. 64 – UK08

food factory

30th of June 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. 64 – UK09

1. Data of the auditor

1.1. Contact data of the auditor

Jürgen Fluch

Number of audits preformed: 25

Date of the audit: 15.05.2012

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 2011.

3.1. General information of the company

Sector	food sector
Products	food sector
No. of employees	n.a. (not available)

3.2. Flow sheet of the whole manufacturing side

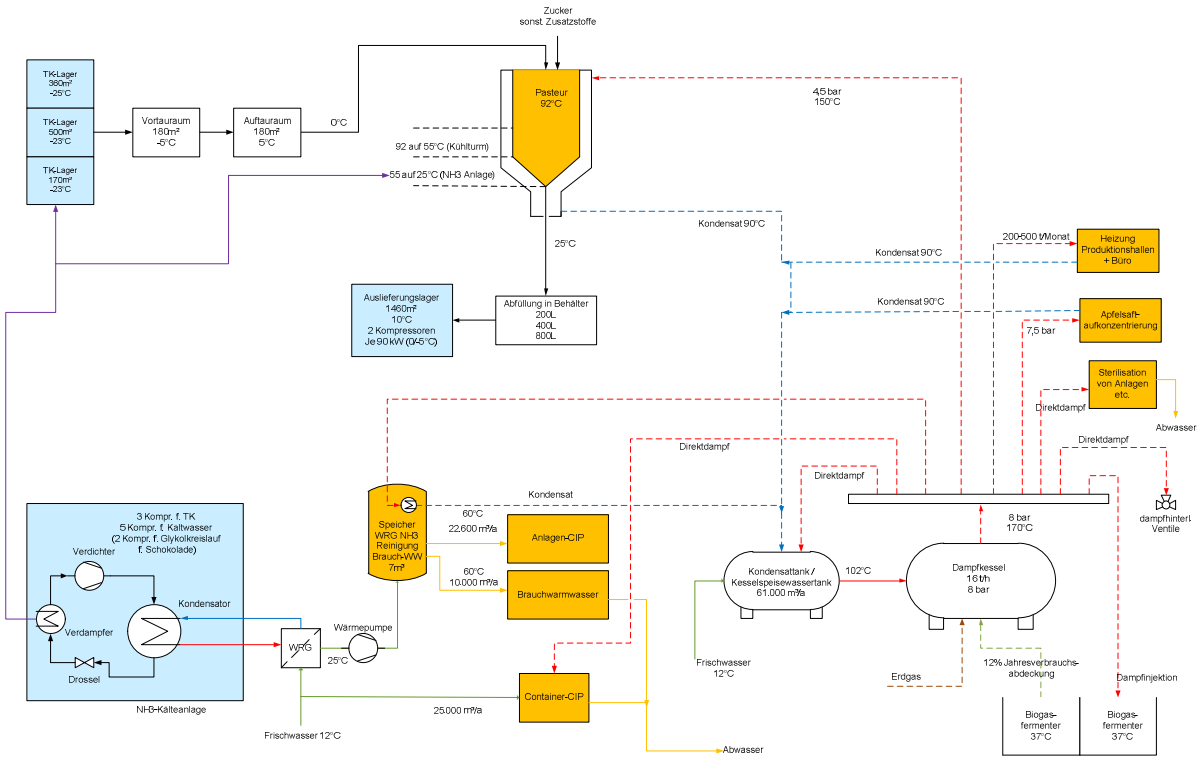

Figure 1: Flow sheet of the factory

3.3. Description of the existing system

The production line has a heating and cooling demand at different temperature levels that are supplied by a steam boiler and two chillers.

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	32,465	54.05	32,465	89.04
Total electricity	27,601	45.95	3,994	10.96
Total (fuels + electricity)	**60,066**	**100.00**	**36,459**	**100.00**

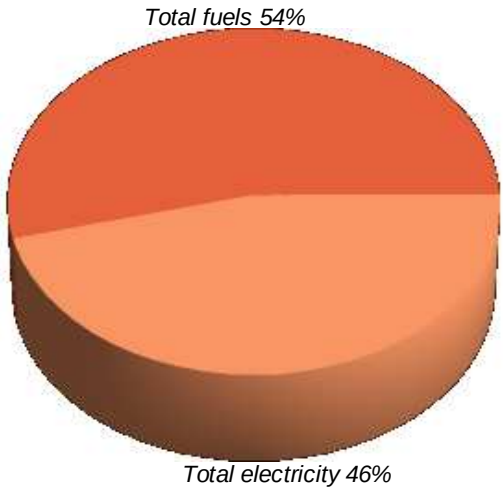

Figure 2: distribution of PEC by fuel type

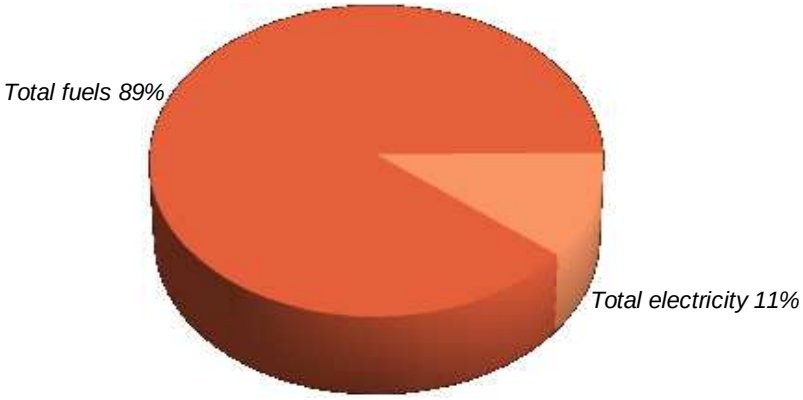

Figure 3: distribution of PET by fuel type

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	29,513	76.23	29,513	95.68
Electricity	9,200	23.77	1,331	4.32
Total	**38,714**	**100.00**	**30,845**	**100.00**

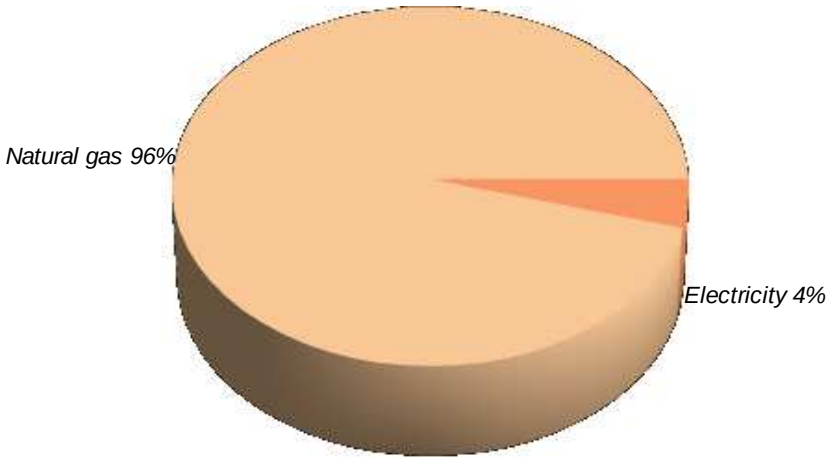

Figure 4: Total final energy consumption for thermal use (FET)

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

Equipment	Fuel type	FET by equipment	
		[MWh]	[% of Total]
Dampfkessel	Natural gas	29,513	95.68
Wasserkuehler	Electricity	735	2.38
Kaltwasserkuehler	Electricity	596	1.93
Total		**30,845**	**100.00**

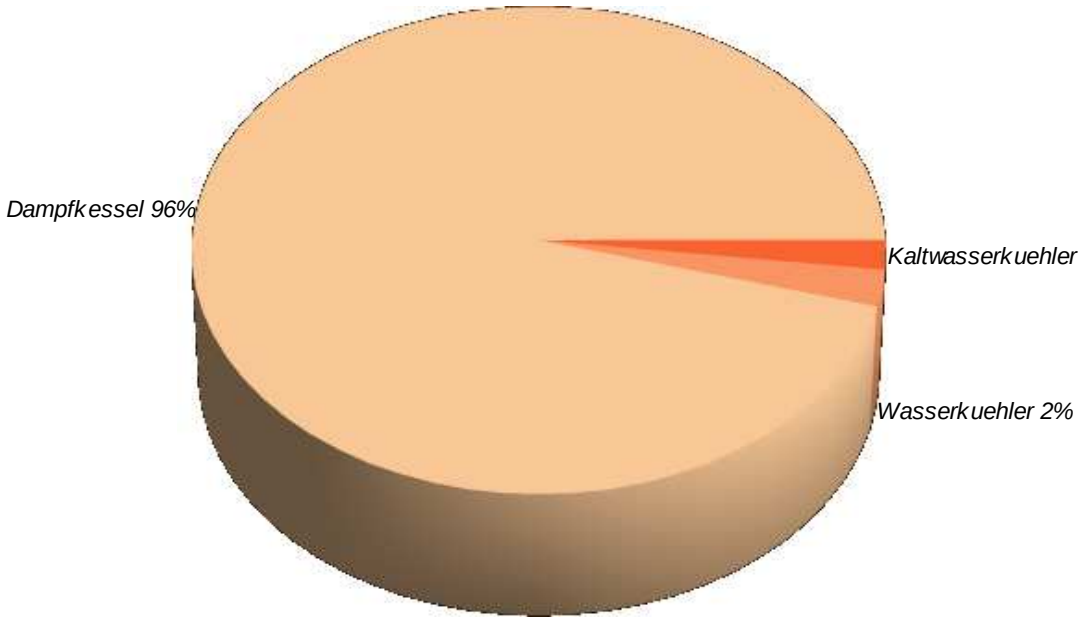

Figure 5: Final energy consumption for thermal use (FET) by equipment

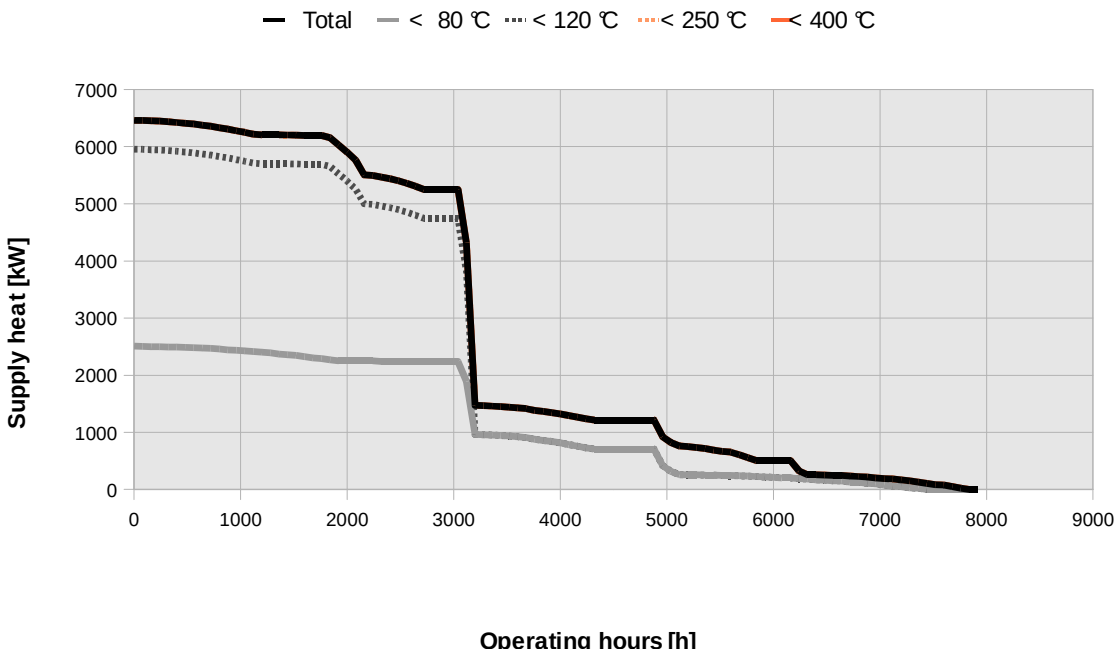

Figure 6: Distribution of supply heat by temperature levels and annual operating hours. Present state.

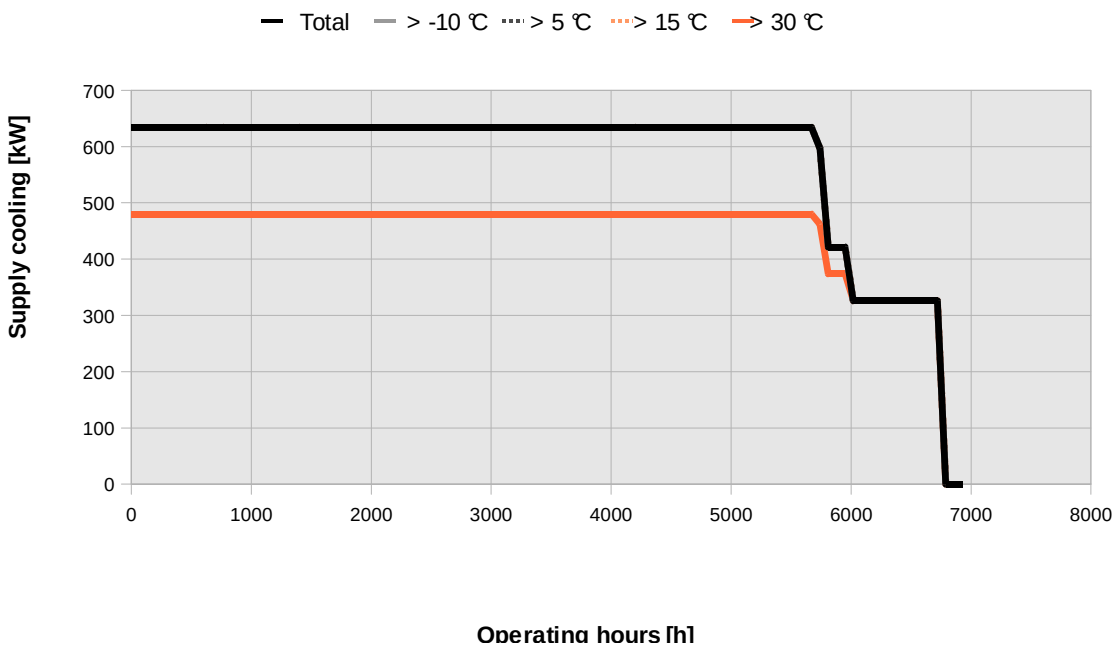

Figure 7: Distribution of supply cooling by temperature levels and annual operating hours. Present state.

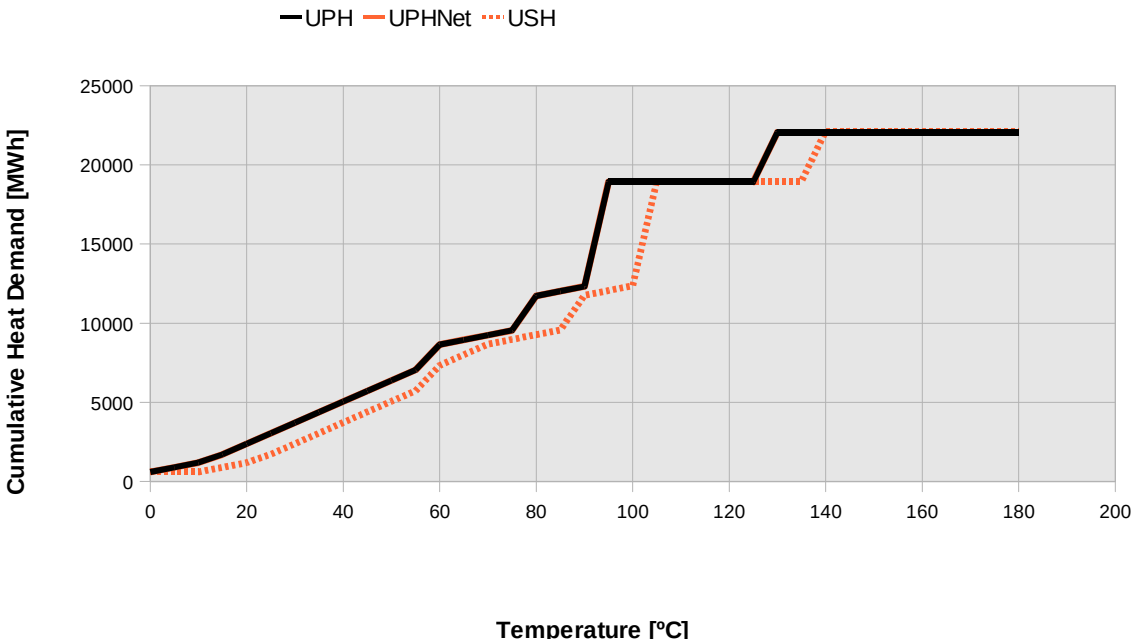

Figure 8: Distribution of the heat demand by temperature levels

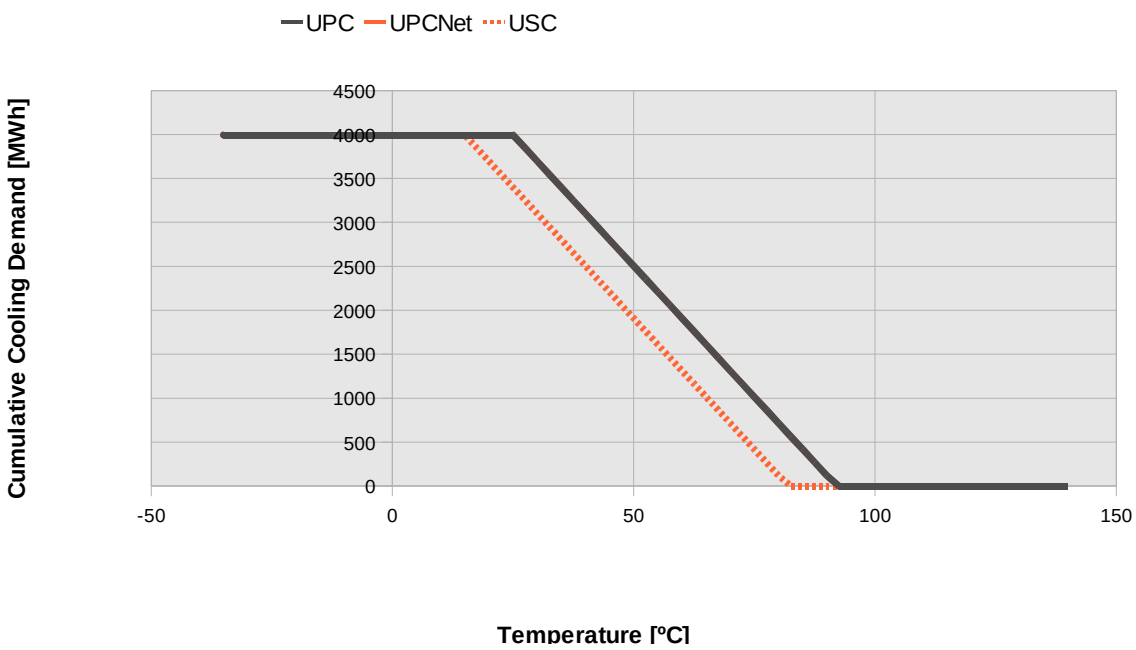

Figure 9: Distribution of the cooling demand by temperature levels

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

Equipment	USH by equipment	
	[MWh]	[% of Total]
Dampfkessel	22,135	100.00
Total	**22,135**	**100.00**

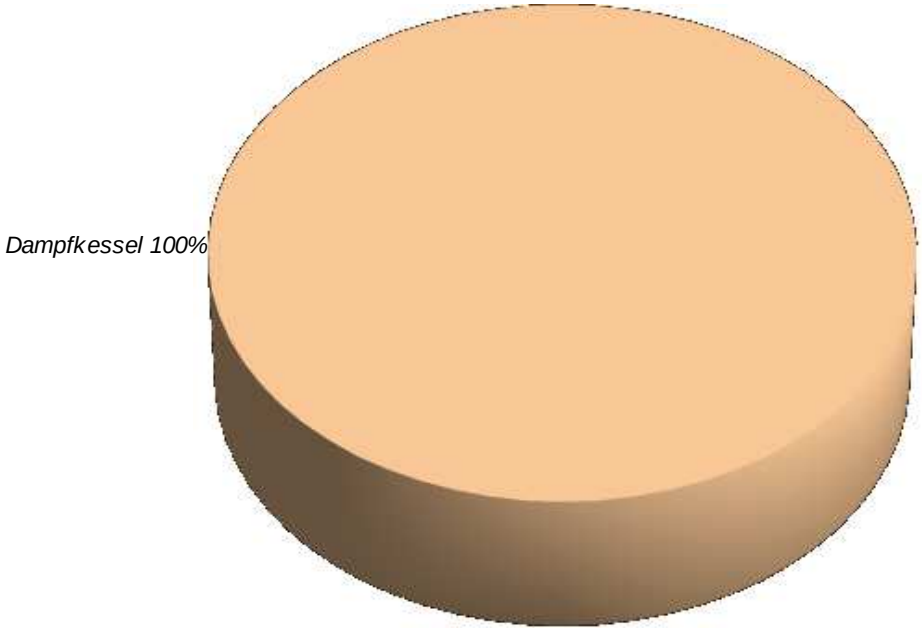

Figure 10: Useful supply heat (USH) by equipment. Present state

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

Equipment	USC by equipment	
	[MWh]	[% of Total]
Wasserkuehler	2,206	55.22
Kaltwasserkuehler	1,789	44.78
Total	**3,994**	**100.00**

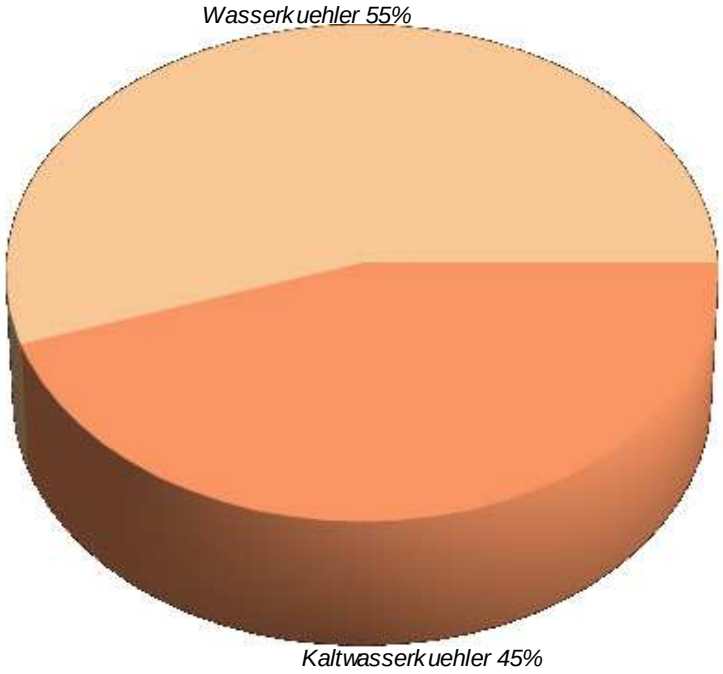

Figure 11: Useful supply cold (USC) by equipment. Present state

Table 6: Useful process heat (UPH) by process

Process	Total	Circulation	Maintenance	Start-up
	[MWh]	[MWh]	[MWh]	[MWh]
Erwaermung fruits	6,876	6,080	796	0
Halten fruits	5,685	0	5,685	0
Heisswasser	3,530	3,530	0	0
WW_San	10	10	0	0
Schoko	1,881	0	1,881	0
Buero_heating	937	0	937	0
Regelung	3,145	0	3,145	0
Total	**22,064**			

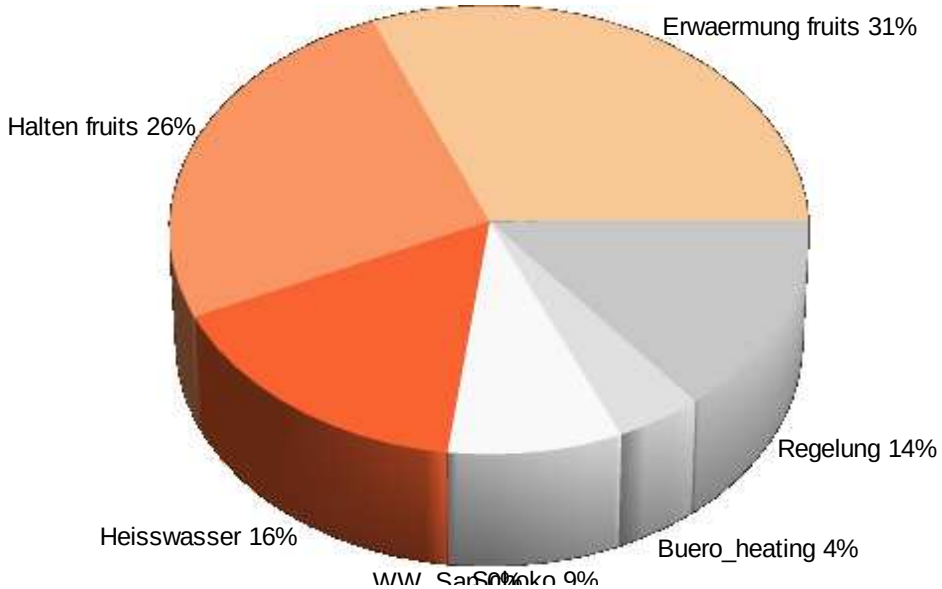

Figure 12: Useful process heat (UPH) by process

Table 7: Useful process cold (UPC) by process

Process	Total	Circulation	Maintenance	Start-up
	[MWh]	[MWh]	[MWh]	[MWh]
Wasserkuehlung	2,206	2,206	0	0
Kaltkuehlung	1,789	1,789	0	0
Total	**3,994**			

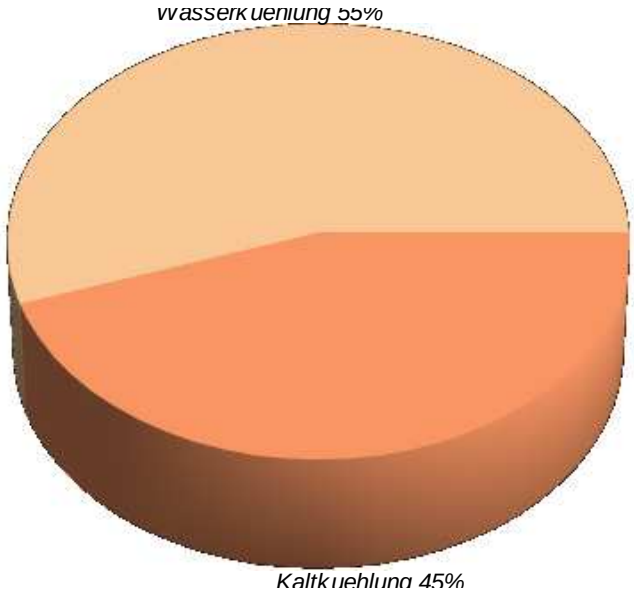

Figure 13: Useful process cold (UPC) by process

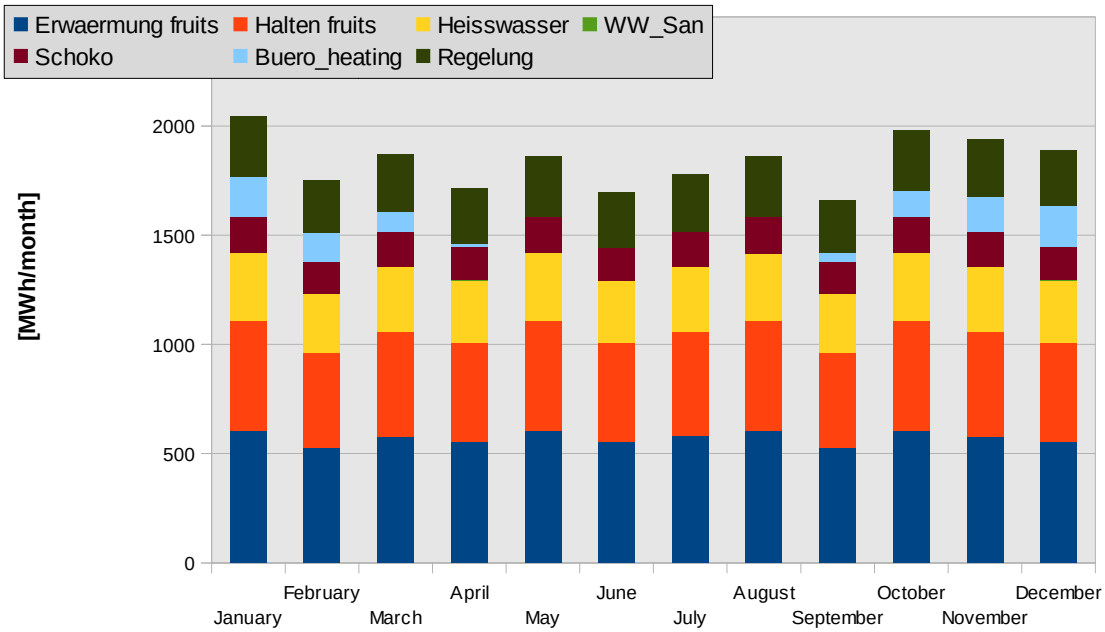

Figure 14: Distribution of useful process heat demand per month

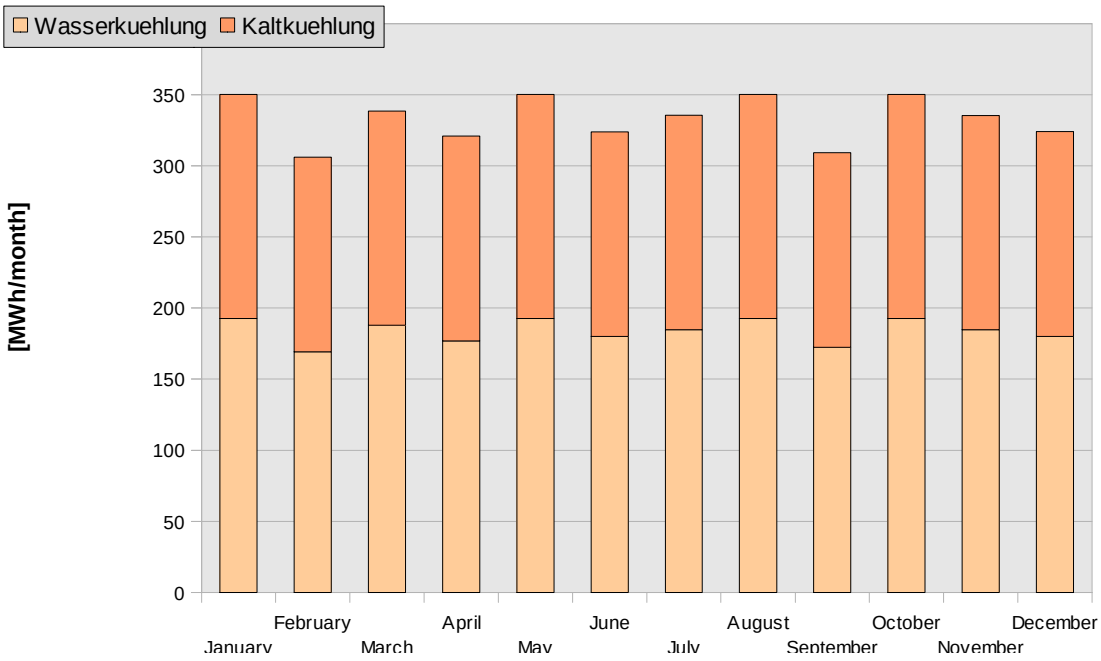

Figure 15: Distribution of useful process cooling demand per month

4. Comparative study

4.1. Proposed alternatives

There are five proposals made in this study. In the first proposal additional heat exchangers are proposed to be installed. The second proposal is a solar thermal system using flat plate collectors including the heat exchangers from proposal no.1. The third proposal focuses on the installation of a CHP plus the heat exchangers from proposal no.1. In the fourth proposal a new boiler is installed including the heat exchangers from proposal no.1. Proposal no.5 is a combination of the HX, the solar thermal and the new boiler proposal.

Table 8: Overview of the alternative proposals studied

Short Name	Description
PSSim	based on present state
HX	based on present state(modified alternative based on PSSim)
HX+solar	based on present state(modified alternative based on PSSim)(modified alternative based on HX)
HX+CHP	based on present state(modified alternative based on PSSim)(modified alternative based on HX)
HX+boiler	based on present state(modified alternative based on PSSim)(modified alternative based on HX)
HX+boiler+solar	based on present state(modified alternative based on PSSim)(modified alternative based on HX)(modified alternative based on HX+boiler)

4.1.1. HX:

Heat exchanger type: finned tubes; plate heat exchangers

In the following the heat exchanger network design of this alternative is presented. These are also part of all following proposals except proposal 4!

Table 9: Heat exchangers and amount of recovered energy

Heat Exchanger	Power	Heat Source	Heat Sink	Savings	
	[kW]			[MWh]	[%]
HX Kaelte	8	Kaelteanlage	WW_San	8	082
HX Wasser	186	Heisswasser	Heisswasser	961	99.18
Total	194			**969**	**100**

Table 10: Final energy consumption for thermal use (FET) by equipment

Equipment	Type	Heat and cooling supplied to pipe/duct	Nominal capacity	Contribution to total heat and cooling supply	
			[kW]	[MWh]	[%]
Dampfkessel	steam boiler	o==Dampf==o	7,500	21,163	84.12
Wasserkuehler	cooling tower (wet)	o==wasser==o	340	2,206	8.77
Kaltwasserkuehler	compression chiller (water cooled)	o==kaltwasser==o	310	1,789	7.11
Total			**8,150**	**25,157**	**100**

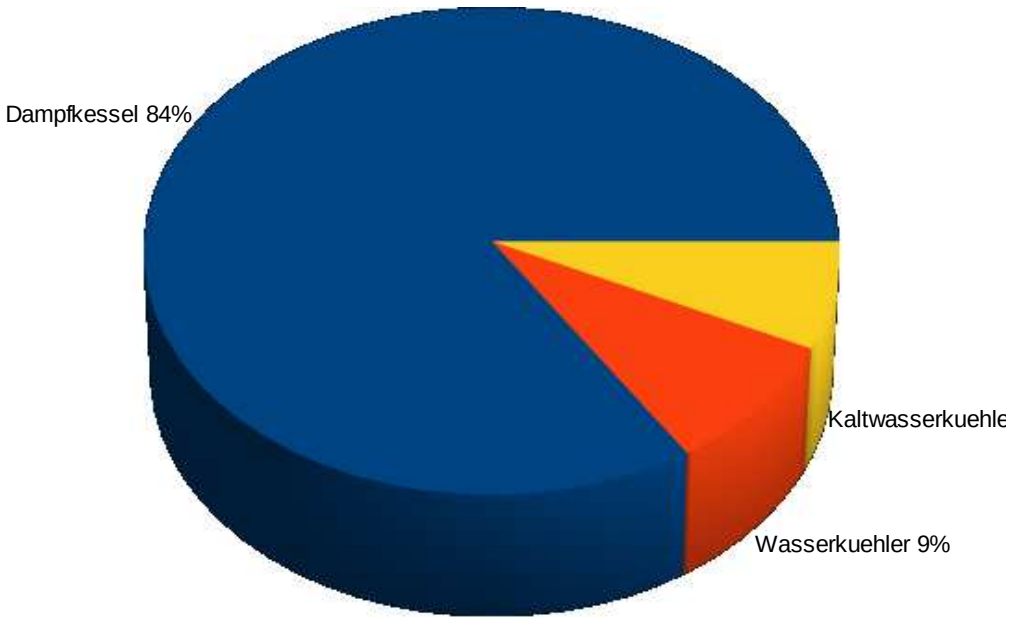

Figure 16: Final energy consumption for thermal use (FET) by equipment

4.1.2. HX + Solar:

Collector type:	FPC (flat plate collectors)
Installed capacity:	3,000 kW
Installed collector area:	4,500 m²
Solar buffer storage volume:	200 m³
Solar fraction:	7.35 %
Annual energy yield:	490 kWh/kWa

Table 11: Heat exchangers and amount of recovered energy

Heat Exchanger	Power	Heat Source	Heat Sink	Savings	
	[kW]			[MWh]	[%]
HX Kaelte	8	Kaelteanlage	WW_San	8	0.82
HX Wasser	186	Heisswasser	Heisswasser	961	99.18
Total	194			**969**	**100**

Table 12: Final energy consumption for thermal use (FET) by equipment

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==Dampf==o	3,182	1,556	6.18
Dampfkessel	steam boiler	o==Dampf==o	7,500	19,607	77.94
Wasserkuehler	cooling tower (wet)	o==wasser==o	340	2,206	8.77
Kaltwasserkuehler	compression chiller (water cooled)	o==kaltwasser==o	310	1,789	7.11
Total			**11,332**	**25,157**	**100**

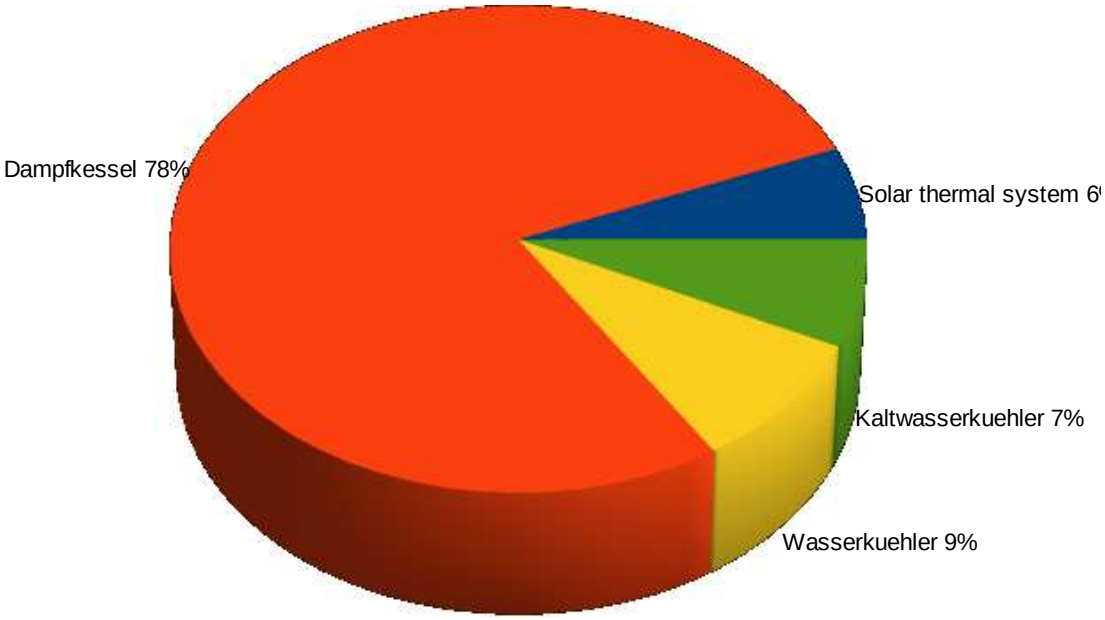

Figure 17: Final energy consumption for thermal use (FET) by equipment

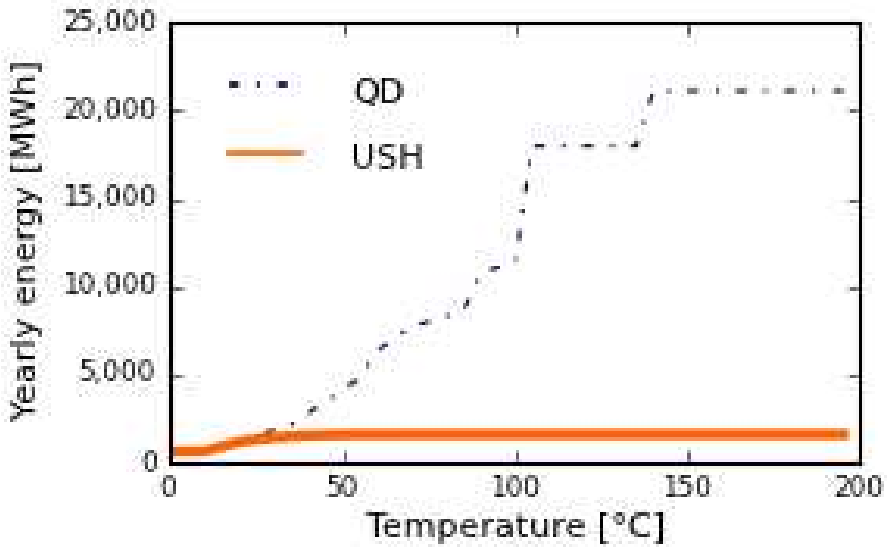

Figure 18: Heat demand and solar contribution

4.1.3. HX + CHP:

CHP:	CHP engine
Installed capacity thermal:	923 kW
Produced electricity	800 kW

Table 13: Heat exchangers and amount of recovered energy

Heat Exchanger	Power	Heat Source	Heat Sink	Savings	
	[kW]			[MWh]	[%]
HX Kaelte	8	Kaelteanlage	WW_San	8	0.82
HX Wasser	186	Heisswasser	Heisswasser	961	99.18
Total	194			**969**	**100**

Table 14: Final energy consumption for thermal use (FET) by equipment

Equipment	Type	Heat and cooling supplied to pipe/duct	Nominal capacity	Contribution to total heat and cooling supply	
			[kW]	[MWh]	[%]
New CHP 1	CHP engine	o==Dampf==o	923	4,661	18.53
Dampfkessel	steam boiler	o==Dampf==o	7,500	16,502	65.59
Wasserkuehler	cooling tower (wet)	o==wasser==o	340	2,206	8.77
Kaltwasserkuehler	compression chiller (water cooled)	o==kaltwasser==o	310	1,789	7.11
Total			**9,073**	**25,157**	**100**

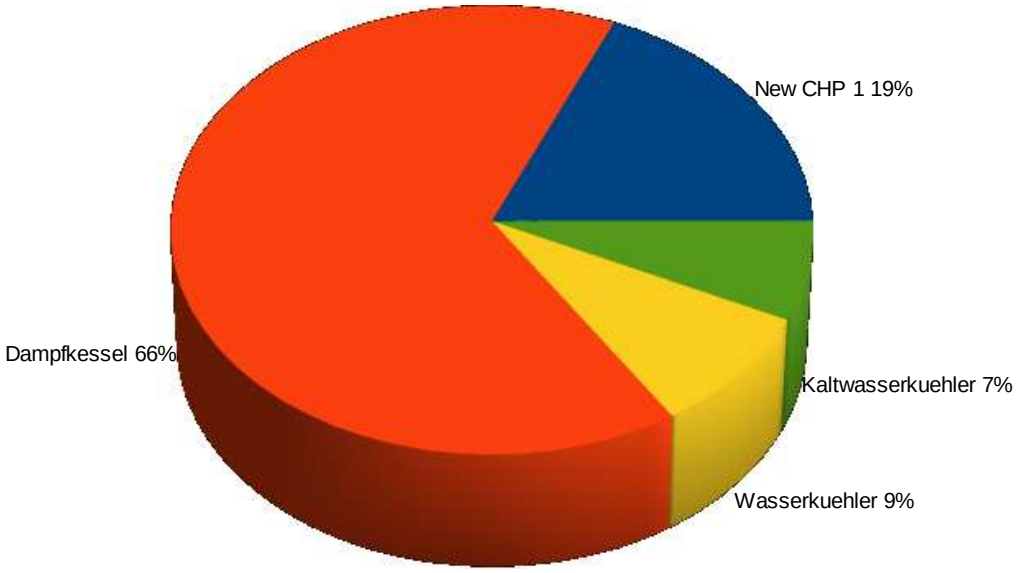

Figure 19: Final energy consumption for thermal use (FET) by equipment

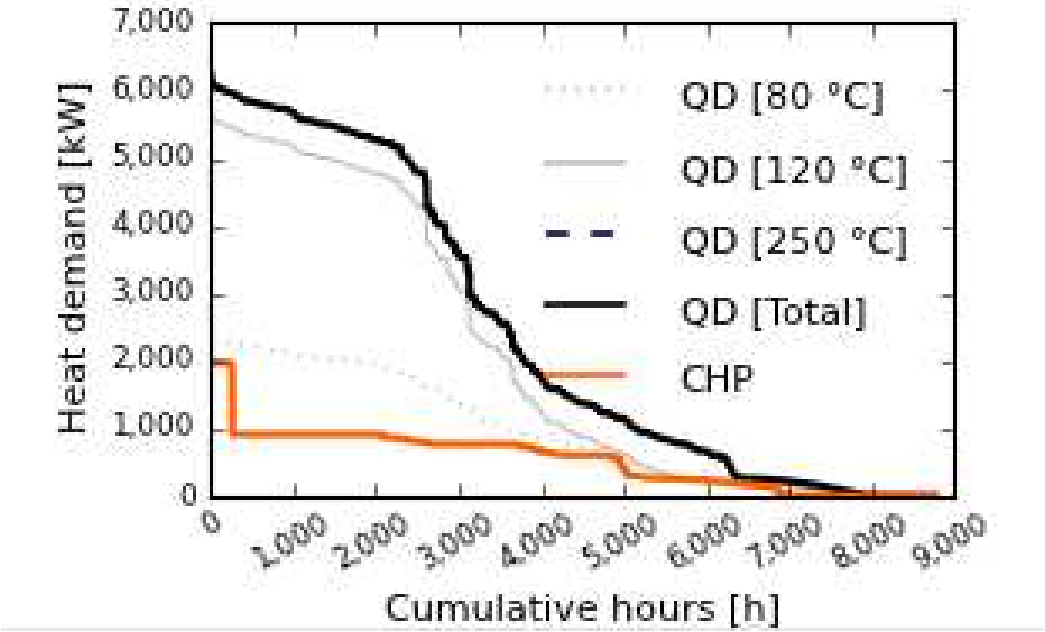

Figure 20: Heat demand and solar contribution

4.1.4. HX + boiler:

Type	condensing boiler
Nominal thermal power	5,000 kW
Efficiency	1.10

Table 15: Heat exchangers and amount of recovered energy

Heat Exchanger	Power	Heat Source	Heat Sink	Savings	
	[kW]			[MWh]	[%]
HX Kaelte	8	Kaelteanlage	WW_San	8	0.82
HX Wasser	186	Heisswasser	Heisswasser	961	99.18
Total	194			**969**	**100**

Table 16: Final energy consumption for thermal use (FET) by equipment

Equipment	Type	Heat and cooling supplied to pipe/duct	Nominal capacity	Contribution to total heat and cooling supply	
			[kW]	[MWh]	[%]
New boiler 3	condensing boiler	o==Dampf==o	5,000	8,303	33.01
Wasserkuehler	cooling tower (wet)	o==wasser==o	340	2,206	8.77
Kaltwasserkuehler	compression chiller (water cooled)	o==kaltwasser==o	310	1,789	7.11
Dampfkessel	steam boiler	o==Dampf==o	7,500	12,860	51.12
Total			**13,150**	**25,157**	**100**

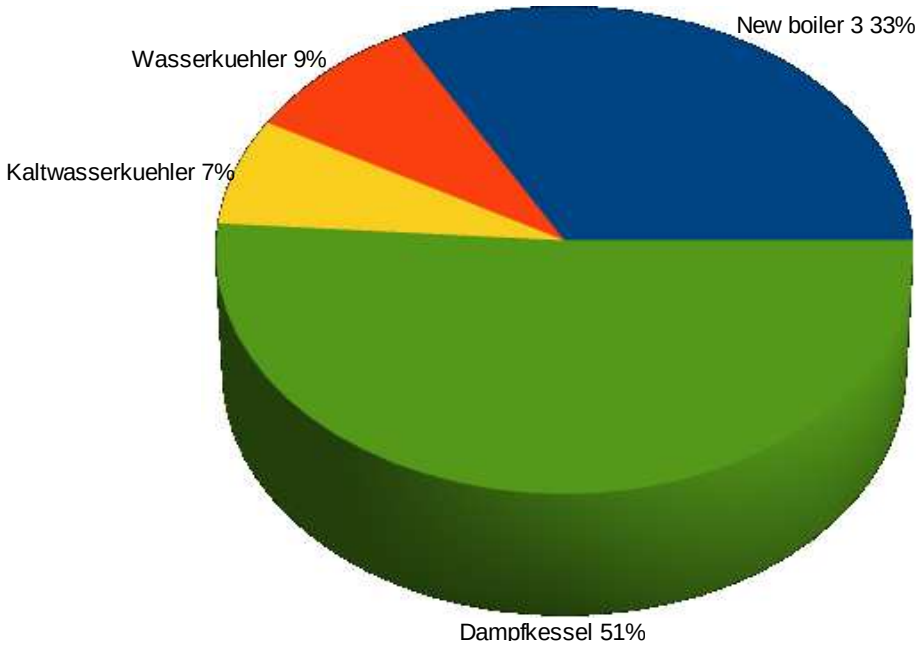

Figure 21: Final energy consumption for thermal use (FET) by equipment

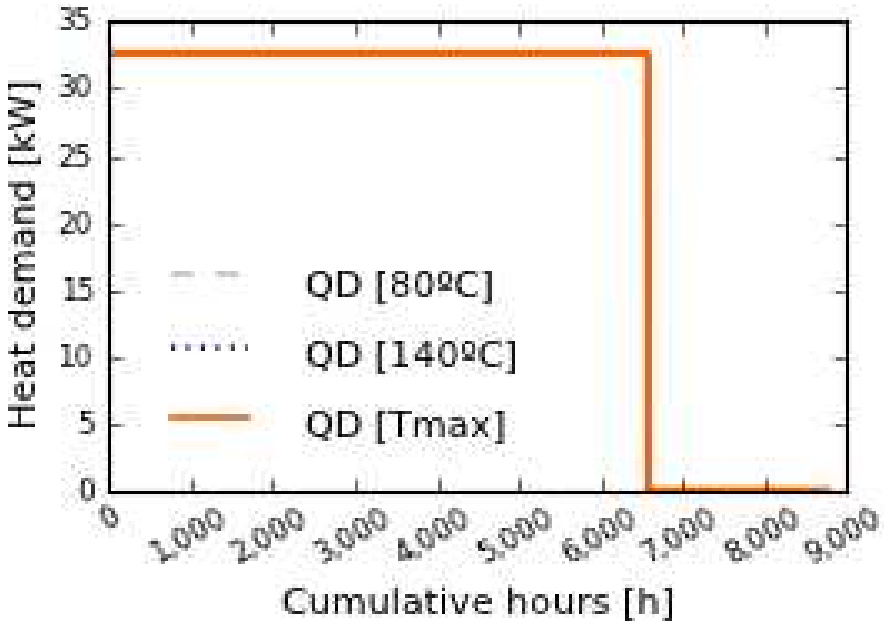

Figure 22: Cumulative heat supply to be covered by CHP

4.1.5. HX + boiler + solar

- Primary energy consumption (PEC)

Table 17: primary energy consumption and savings

Alternative	Primary energy consumption	Savings	
	[MWh]	[MWh]	[%]
Present State (checked)	60,066	---	---
PSSim	59,051	1,016	1.69
HX	57,625	2,442	4.06
HX+solar	55,389	4,677	7.79
HX+CHP	49,988	10,079	16.78
HX+boiler	53,976	6,090	10.14
HX+boiler+solar	52,424	7,642	12.72

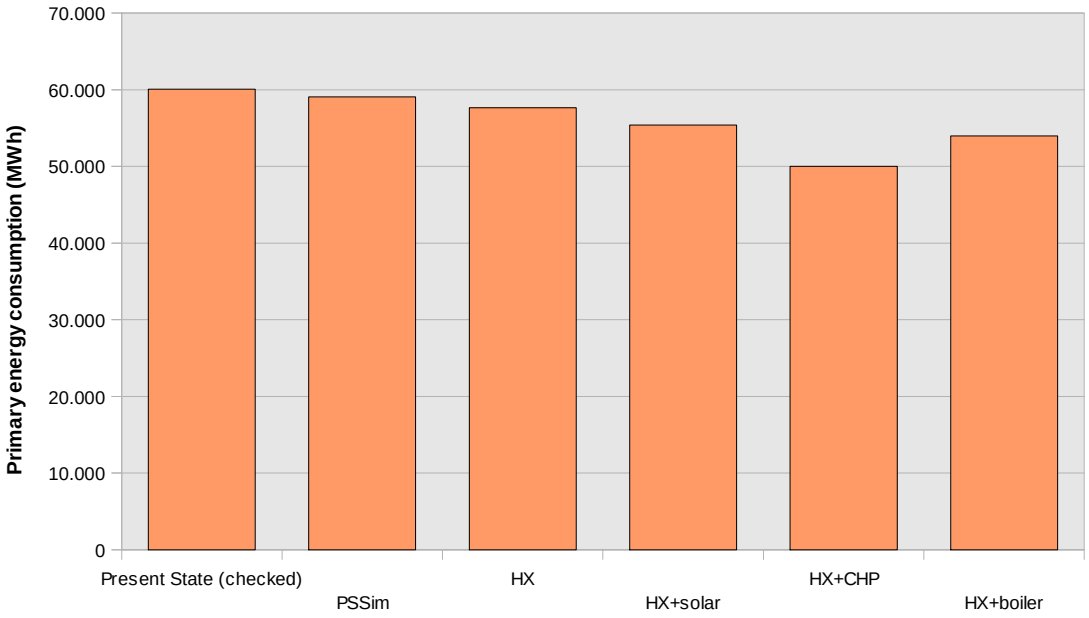

Figure 23: Comparison of alternatives: primary energy consumption

- Useful process and supply heat (UPH and USH)

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

Table 18: 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)	22,064	---	22,135	---
PSSim	22,064	0	22,135	0
HX	22,064	0	21,163	972
HX+solar	22,064	0	21,163	972
HX+CHP	22,064	0	21,163	972
HX+boiler	22,064	0	21,163	972
HX+boiler+solar	22,064	0	21,163	972

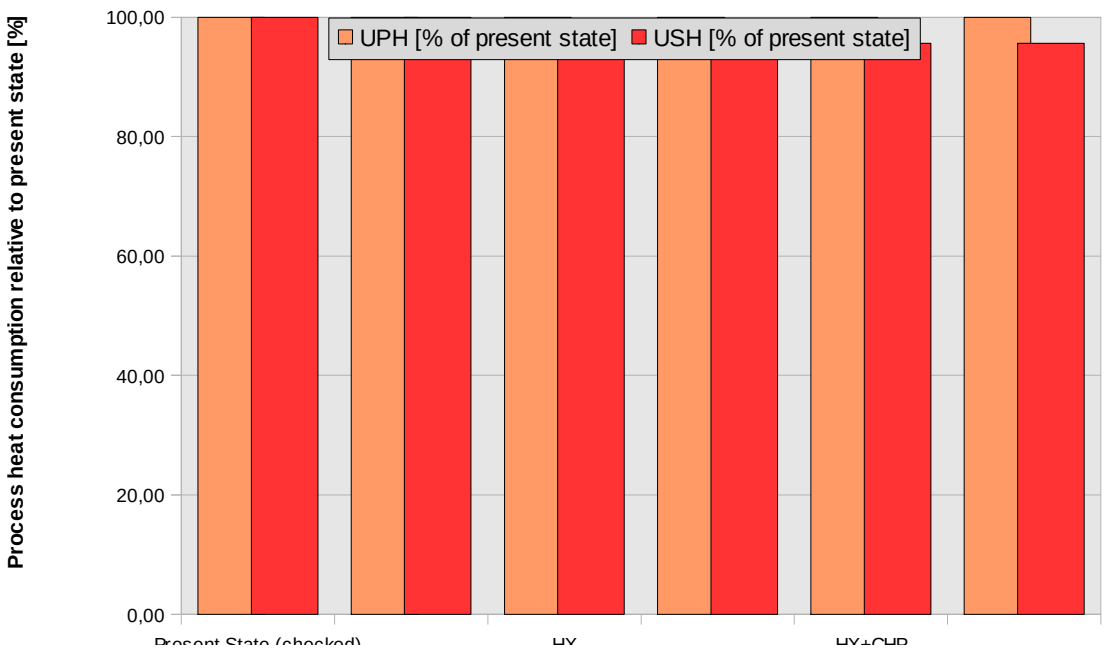

Figure 24: Comparison of alternatives: useful process heat supply

Table 19: Useful process and supply cold: 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)	3,994	---	3,994	---
PSSim	3,994	0	3,994	0
HX	3,994	0	3,994	0
HX+solar	3,994	0	3,994	0
HX+CHP	3,994	0	3,994	0
HX+boiler	3,994	0	3,994	0
HX+boiler+solar	3,994	0	3,994	0

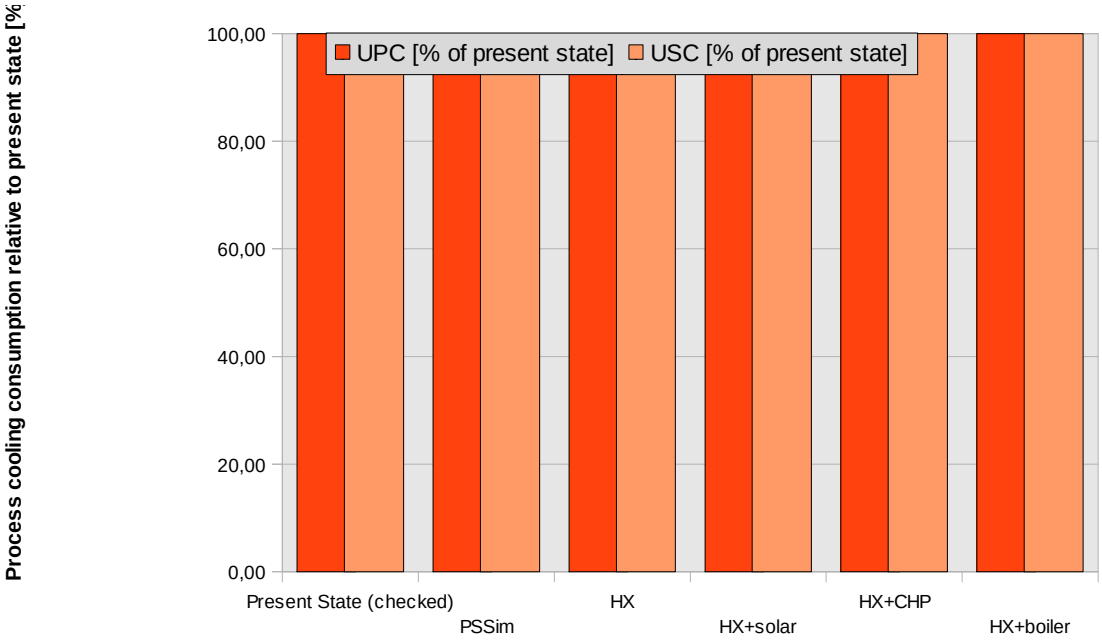

Figure 25: Comparison of alternatives: useful process heat supply

- Environmental impact

Table 20: CO_2 production and CO_2 savings per year

Alternative	Production of CO_2	Highly Radioactive Nuclear Waste	Water consumption
	[t]	[kg]	[m3]
Present State (checked)	11978.60	0.00	9085.09
PSSim	11809.33	0.00	0.00
HX	11485.24	0.00	0.00
HX+solar	10974.36	0.00	0.00
HX+CHP	10561.01	0.00	0.00
HX+boiler	10642.34	0.00	0.00
HX+boiler+solar	10289.41	0.00	0.00

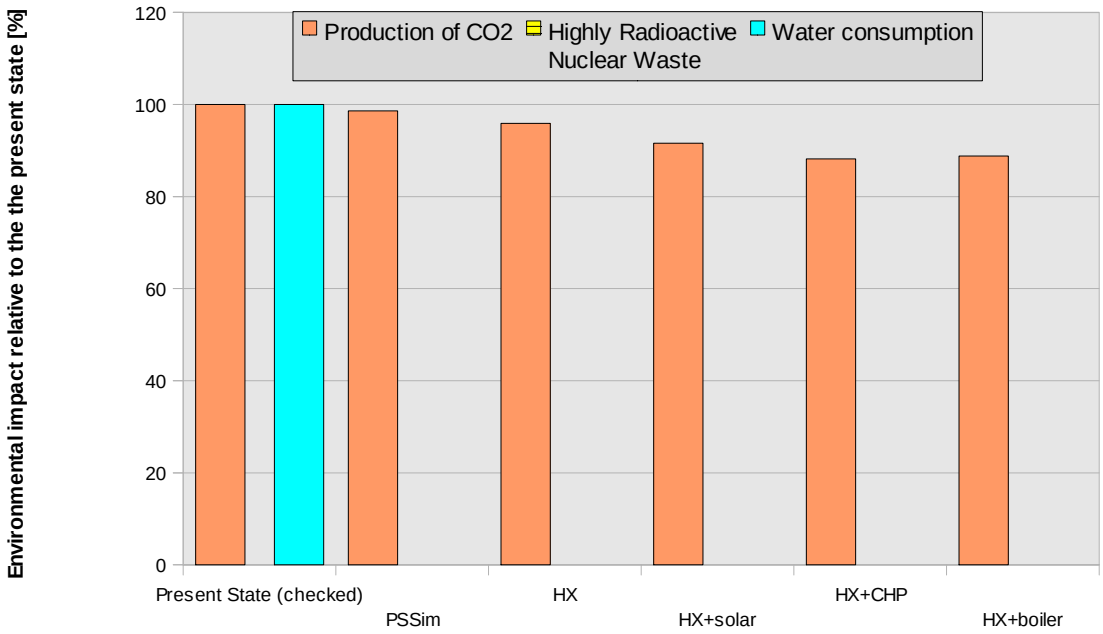

Figure 26: Comparison of alternatives: environmental impact

Table 21: Investment costs and subsidies of the proposals

Alternative	Total investment [€]	Own investment [€]	Subsidies [€]
Present State (checked)	---	---	---
PSSim	0	0	0
HX	15,000	15,000	0
HX+solar	1,446,630	873,978	572,652
HX+CHP	765,000	540,000	225,000
HX+boiler	765,000	540,000	225,000
HX+boiler+solar	2,181,630	1,527,141	654,489

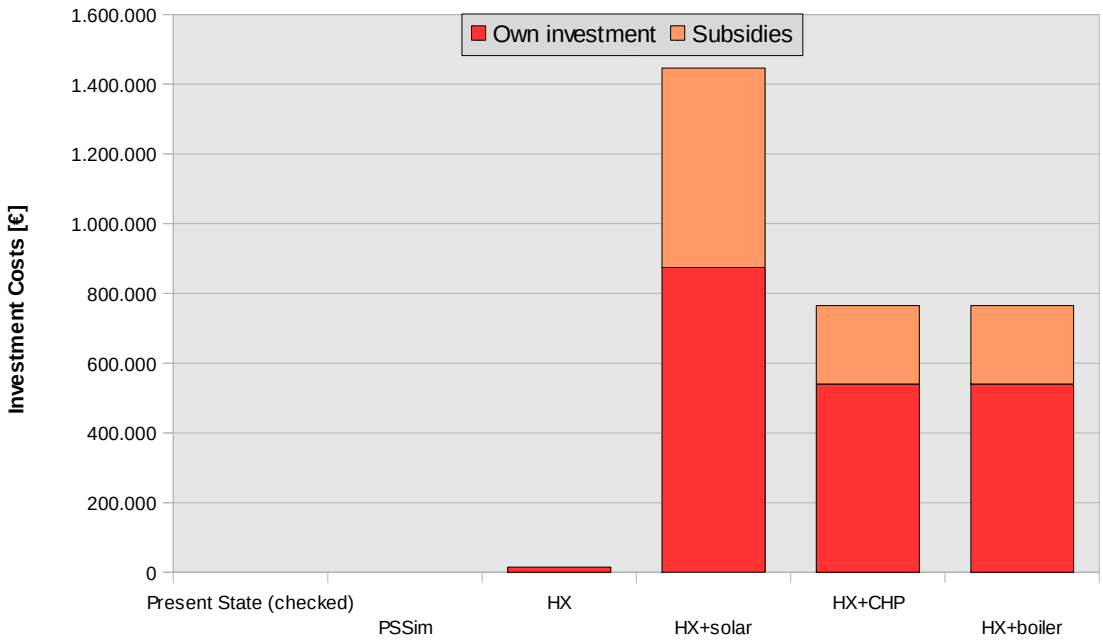

Figure 27: Comparison of alternatives investment cost

Table 22: 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)	1,815,012	---	---
PSSim	1,786,234	-28,778	-28.33
HX	1,741,967	-73,044	-29.92
HX+solar	1,787,375	-27,636	-5.91
HX+CHP	1,621,195	-193,816	-19.23
HX+boiler	1,680,278	-134,733	-22.12
HX+boiler+solar	1,746,488	-68,524	-8.97

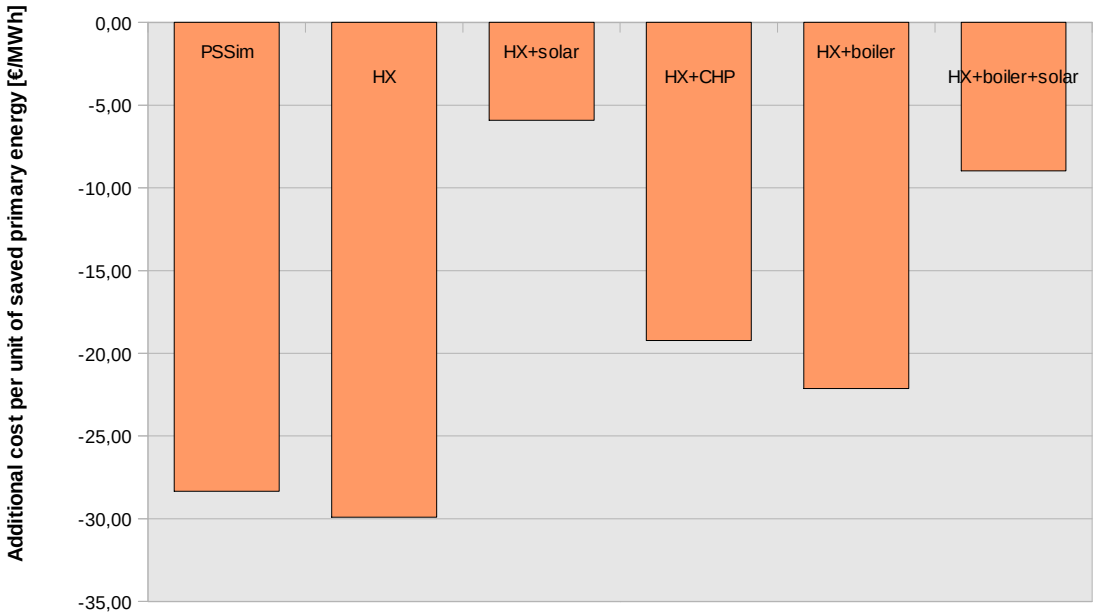

Figure 28: Comparison of alternatives: Total additional cost per saved primary energy.

1. Selected alternative(s) and conclusions

1.1. Selected alternative

As selected alternative the "HX + solar" proposal has been chosen, because of the short payback period and the high CO_2 savings per year.

1.1.1. Process optimisation (written proposals)

None

1.1.2. Heat Supply

HX + Solar (FPC):

Collector type:	FPC (flat plate collectors)
Installed capacity:	3,000 kW
Installed collector area:	4,500 m²
Solar buffer storage volume:	200 m³
Solar fraction:	7.35 %
Annual energy yield:	490 kWh/kWa

Table 23: Heat exchangers and amount of recovered energy

Heat Exchanger	Power	Heat Source	Heat Sink	Heat transferred	
	[kW]			[MWh]	[%]
HX Kaelte	8	Kaelteanlage	WW_San	8	0.82
HX Wasser	186	Heisswasser	Heisswasser	961	99.18

Table 24: Final energy consumption for thermal use (FET) by equipment

Equipment	Type	Heat / cooling supplied to pipe/duct	Nominal capacity	Contribution to total heat / cooling supply	
			[kW]	[MWh]	[%]
Solar thermal system	solar thermal (flat-plate)	o==Dampf==o	3,182	1,556	6.18
Dampfkessel	steam boiler	o==Dampf==o	7,500	19,607	77.94
Wasserkuehler	cooling tower (wet)	o==wasser==o	340	2,206	8.77
Kaltwasserkuehler	compression chiller (water cooled)	o==kaltwasser==o	310	1,789	7.11
Total			**11,332**	**25,157**	**100**

1.1.3. Energy Consumption

Table 25: 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	28,757	51.92	28,757	90.48
Total electricity	26,632	48.08	3,025	9.52
Total (fuels + electricity)	**55,389**	**100.00**	**31,782**	**100.00**

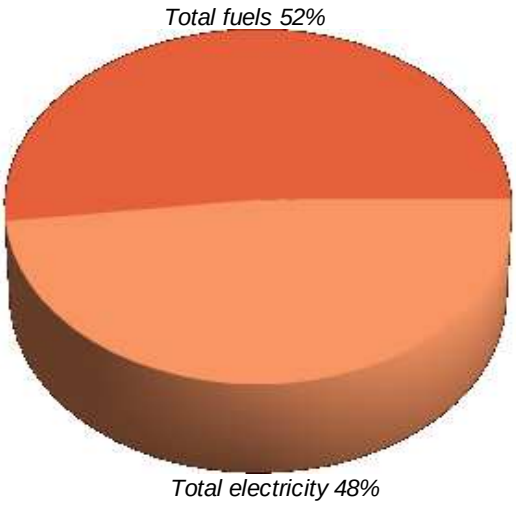

Figure 29: Distribution of PEC by fuel type

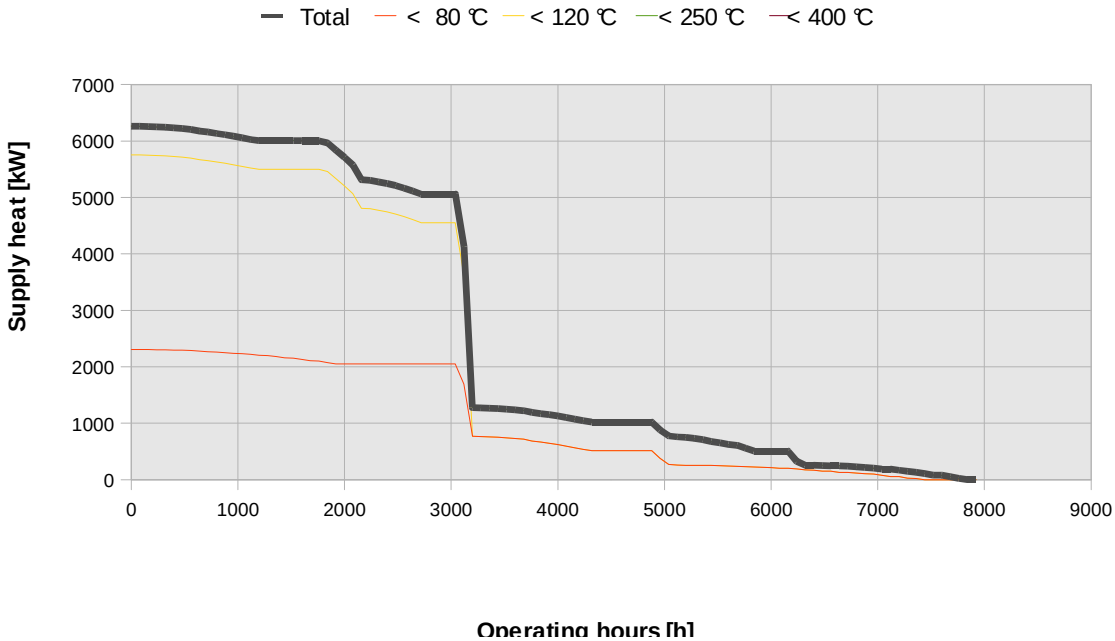

Figure 30: Distribution of supply heat by temperature levels and annual operating hours. Proposed final solution.

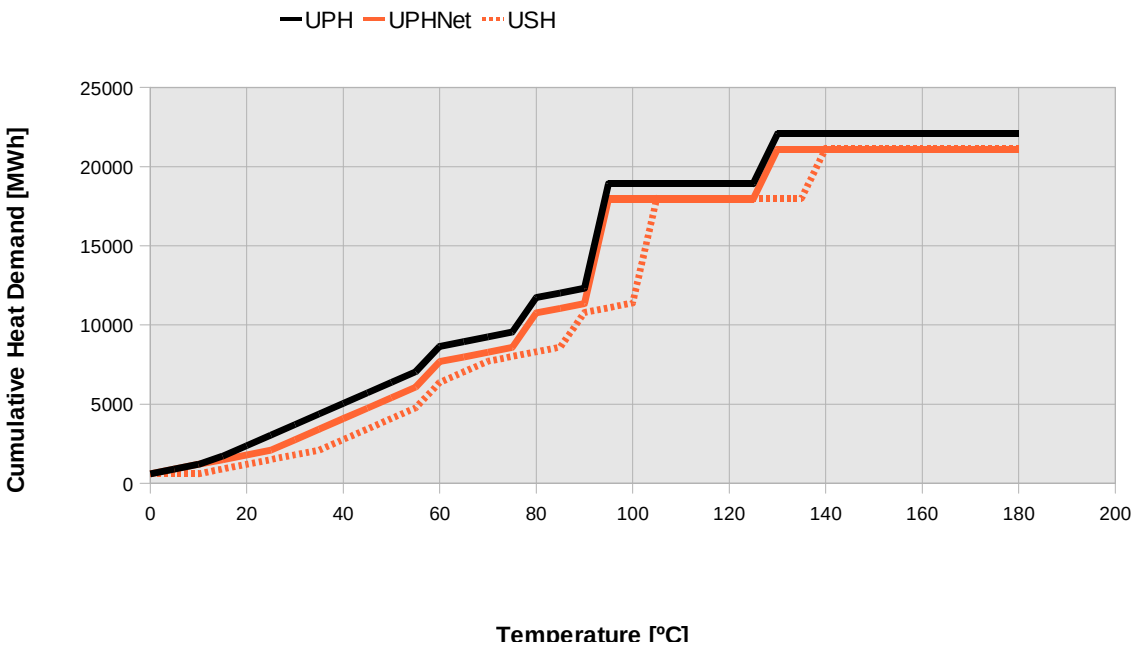

Figure 31: Distribution of the heat demand by temperature levels

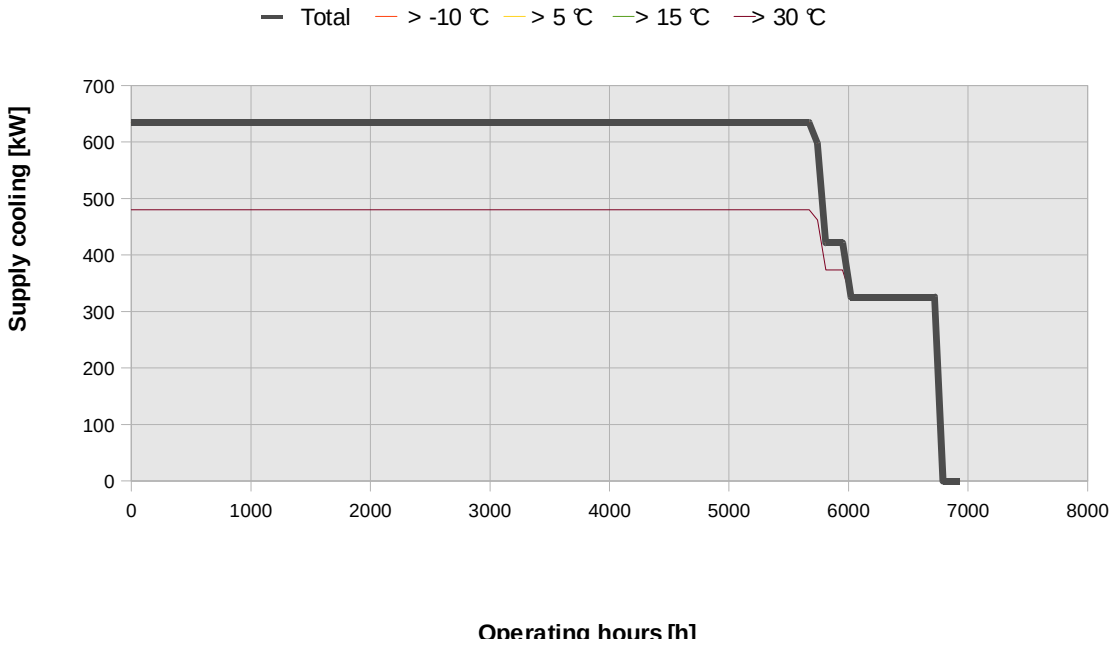

Figure 32: Distribution of supply cooling by temperature levels and annual operating hours. Proposed final solution.

1.2. Comparative study and conclusions

1.2.1. Energy and environmental analysis

In the proposed alternative around 25 % of the CO_2 pollution can be saved.

1.2.2. Economic analysis

The payback period of about 6.9 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 40% for the solar thermal plant of the investment costs and have to be revised.

Table 26: Savings of the proposed alternative in comparison to the present state

		Present state	Alternative	Saving	[% savings]
Total primary energy consumption (1)					
- total	[MWh]	59,051	55,389	3,662	6%
- fuels	[MWh]	32,465	28,757	3,708	11%
- electricity	[MWh]	26,586	26,586	0	0%
Primary energy saving due to renewable energy	[MWh]		2,235		
CO_2 emissions	[t/a]	11,809	10,974	835	7%
Annual energy system cost (2)	[EUR]	1,815,012	1,787,375	7,252	1.5%
Total investment costs	[EUR]		1,446,630		
Payback period (3)	[years]		6.9		

(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)

1.2.3. Conclusions and outlook

- 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.