Energy Audit Summary Report

AEE INTEC

Audit no. 29 – AUT09

Chocolat factory

30th of June 2012

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. 29 – AUT09

1. Data of the auditor

1.1. Contact data of the auditor

Jürgen Fluch

Number of audits preformed: 25

Date of the audit: 15.09.2011

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. Generally the company produces in several production lines that are all connected and linked. But within the audit only one production line was chosen to be audited to get an overview about the saving potentials.

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	Chocolat factory
Products	chocolats
No. of employees	n.a. (not available)

3.2. Flow sheet of the whole manufacturing side

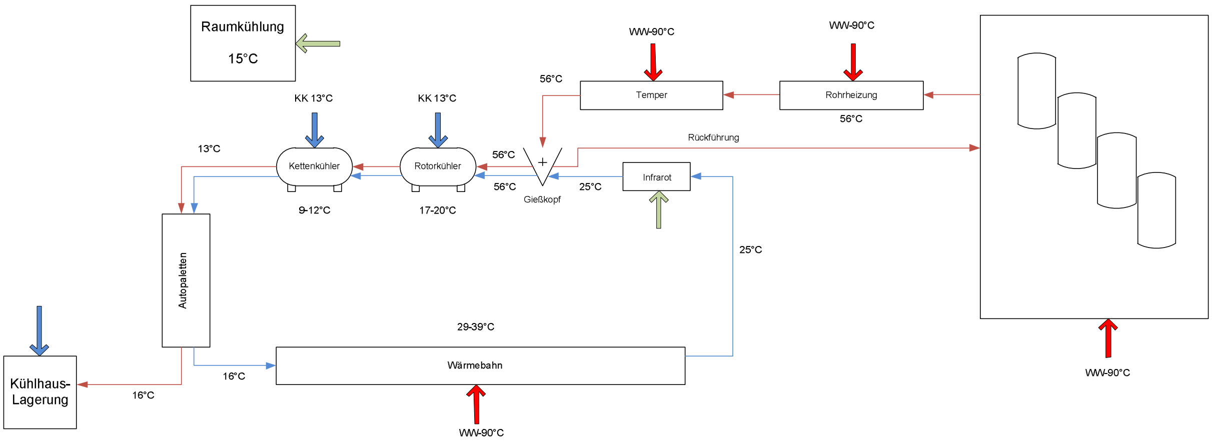

Figure 1: Flow sheet of the factory

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 hot water boiler and a chiller. The chocolate is delivered from the tanks and has to be heated during the distribution. Within the process the medium is filled into pre-heated forms, then cooled and separated from the forms. These are then heated once again.

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	346	32.71	346	56.86
Total electricity	713	67.29	263	43.14
Total (fuels + electricity)	**1,059**	**100.00**	**609**	**100.00**

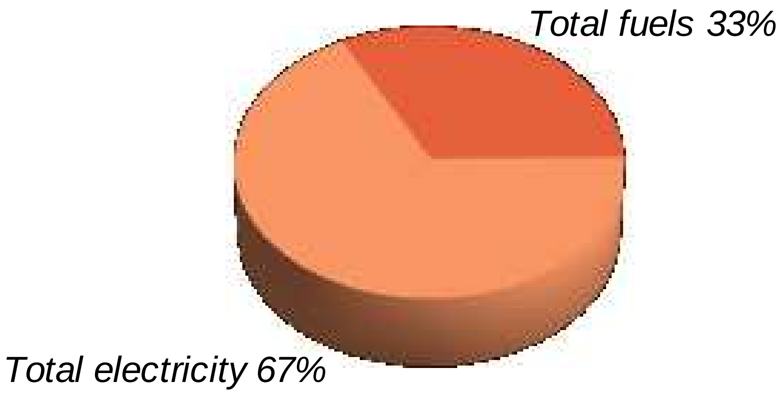

Figure 2: distribution of PEC by fuel type

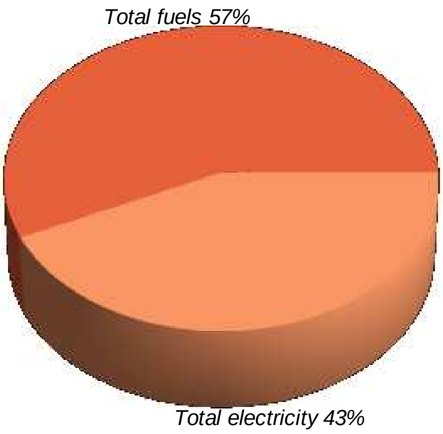

Figure 3: distribution of PET by fuel type

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	315	57.00	315	78.24
Electricity	238	43.00	88	21.76
Total	**553**	**100.00**	**403**	**100.00**

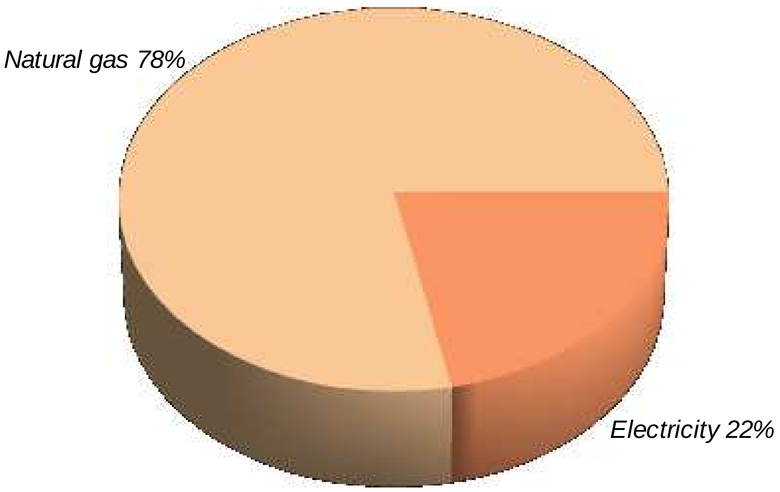

Figure 4: Total final energy consumption for thermal use (FET)

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

Equipment	Fuel type	FET by equipment	
		[MWh]	[% of Total]
Hot water boiler	Natural gas	315	78.24
Cold water chiller	Electricity	84	20.98
Chiller Kuehlung	Electricity	3	0.79
Total		**403**	**100.00**

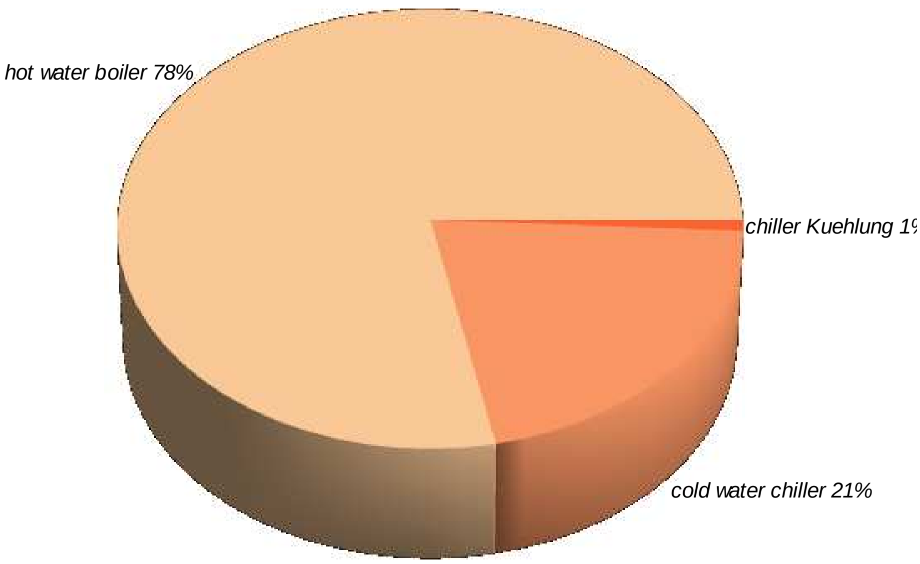

Figure 5: Final energy consumption for thermal use (FET) by equipment

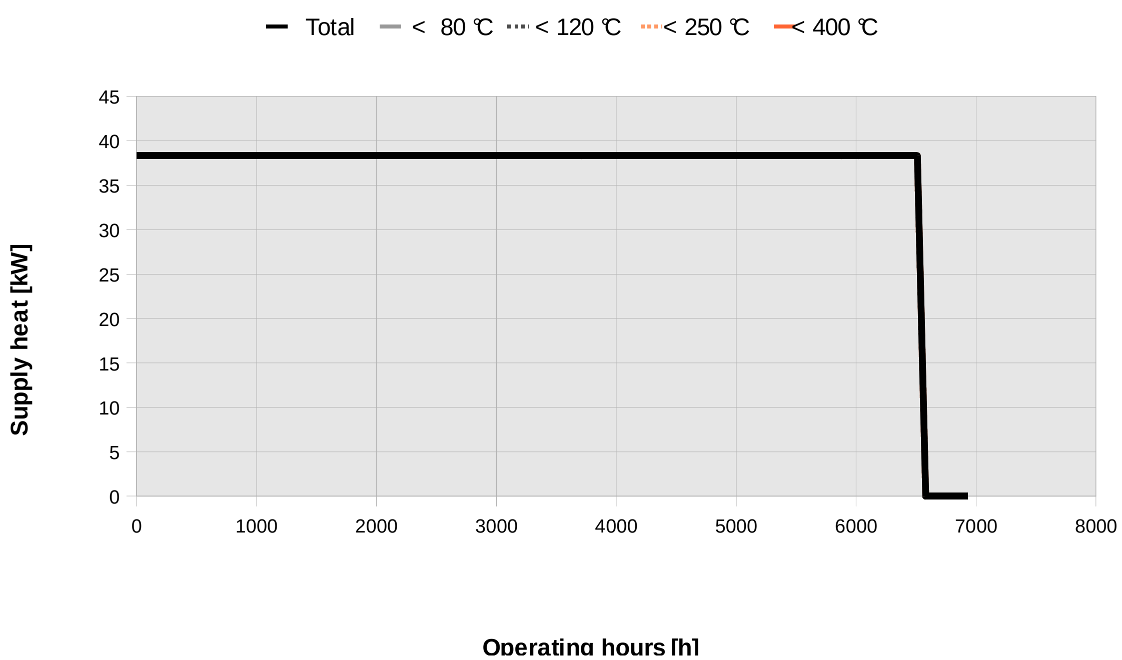

Figure 6: Distribution of supply heat by temperature levels and annual operating hours. Present state.

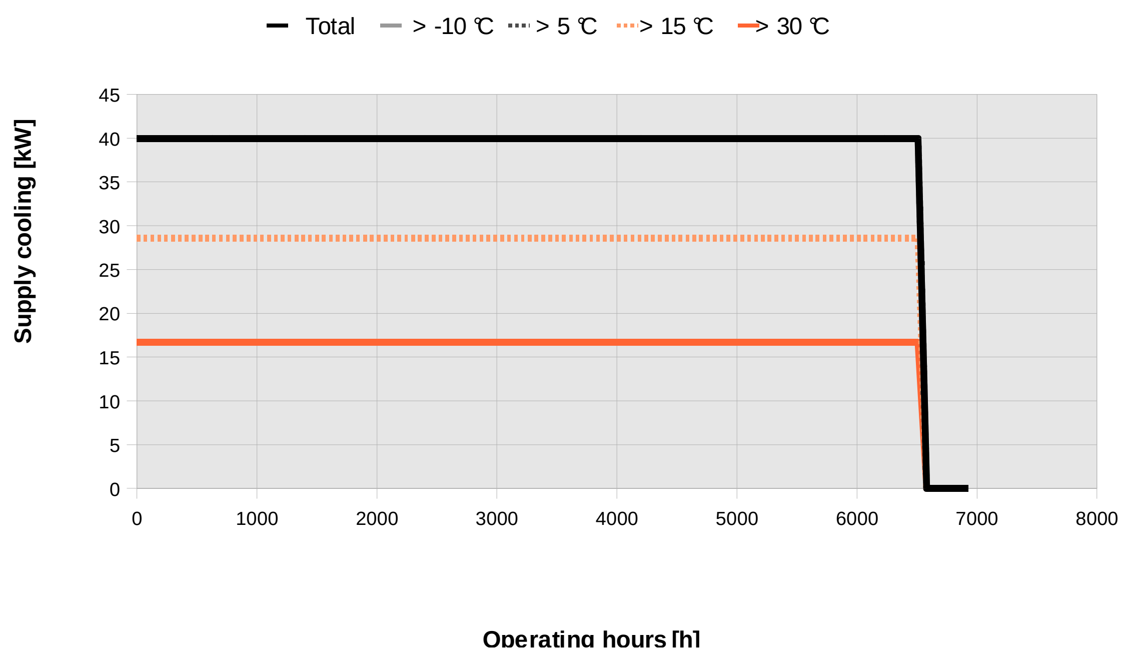

Figure 7: Distribution of supply cooling by temperature levels and annual operating hours. Present state.

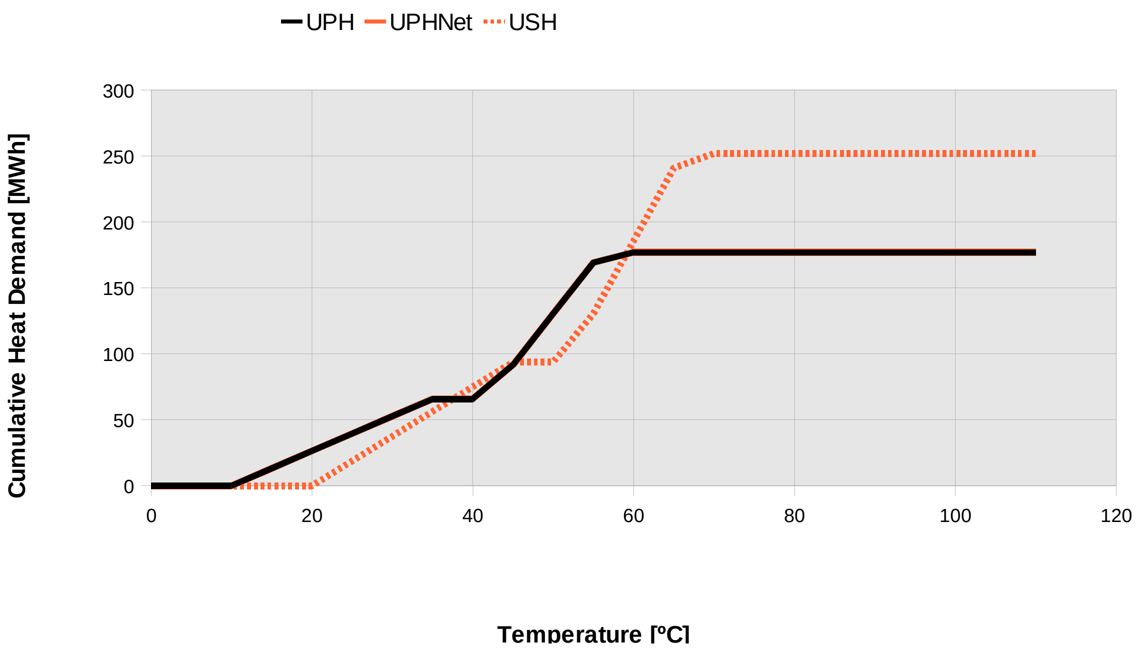

Figure 8: Distribution of the heat demand by temperature levels

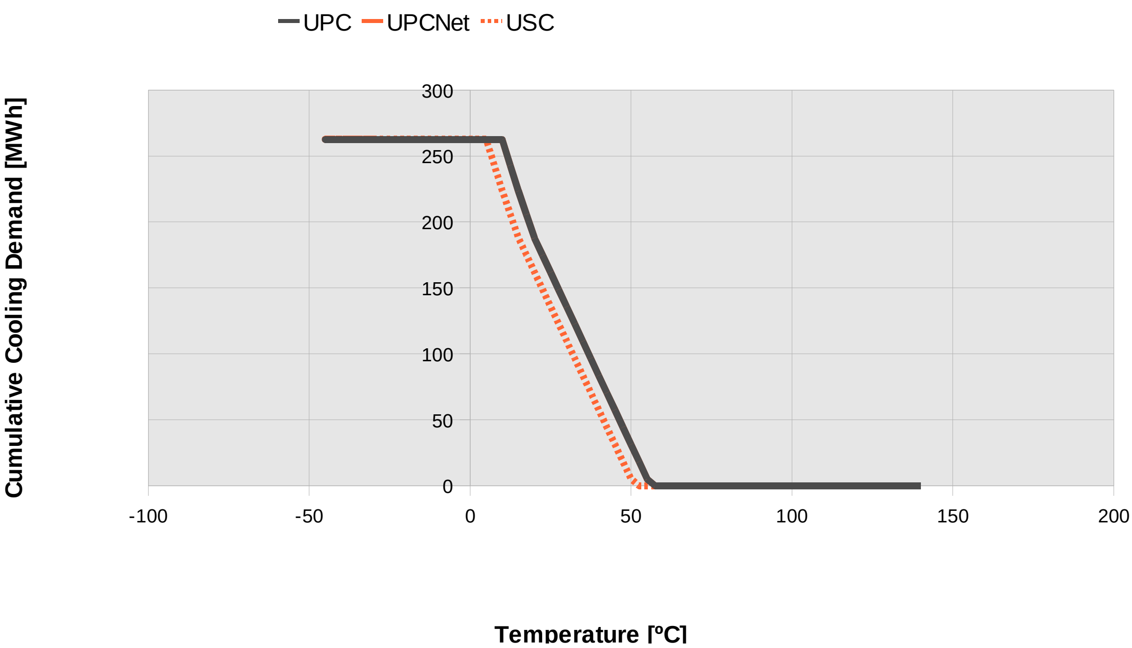

Figure 9: Distribution of the cooling demand by temperature levels

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

Equipment	USH by equipment	
	[MWh]	[% of Total]
Hot water boiler	252	100.00
Total	**252**	**100.00**

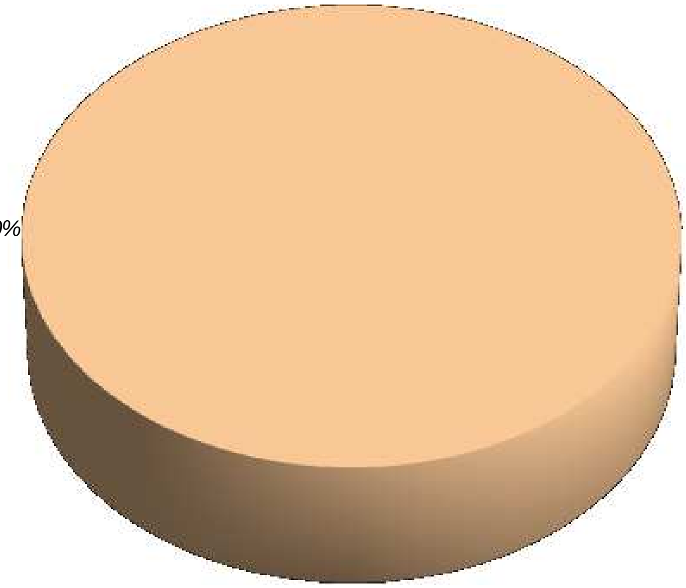

Figure 10: Useful supply heat (USH) by equipment. Present state

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

Equipment	USC by equipment	
	[MWh]	[% of Total]
Cold water chiller	253	96.38
Chiller Kuehlung	10	3.62
Total	**263**	**100.00**

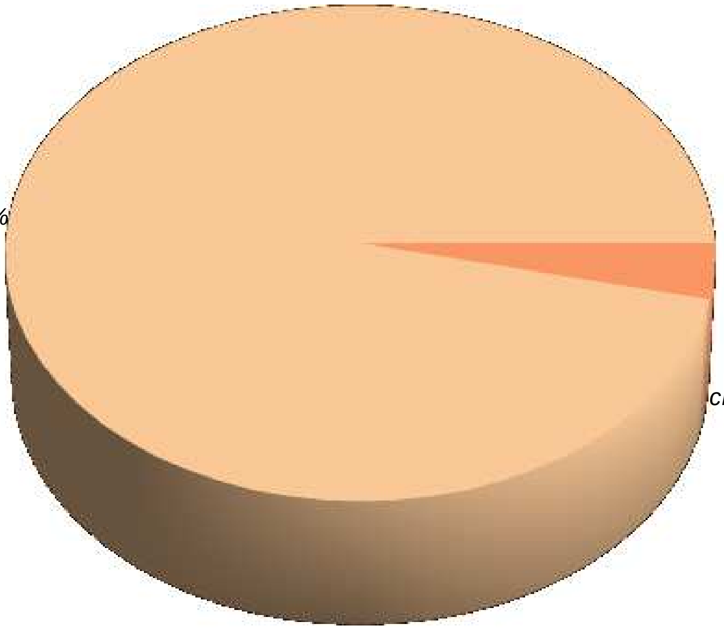

Figure 11: Useful supply cold (USC) by equipment. Present state

Table 6: Useful process heat (UPH) by process

Process	Total	Circulation	Maintenance	Start-up
	[MWh]	[MWh]	[MWh]	[MWh]
Tankheizung	28	28	0	0
Rohrheizung	41	41	0	0
Temper	41	41	0	0
Waermebahn	66	66	0	0
Total	**177**			

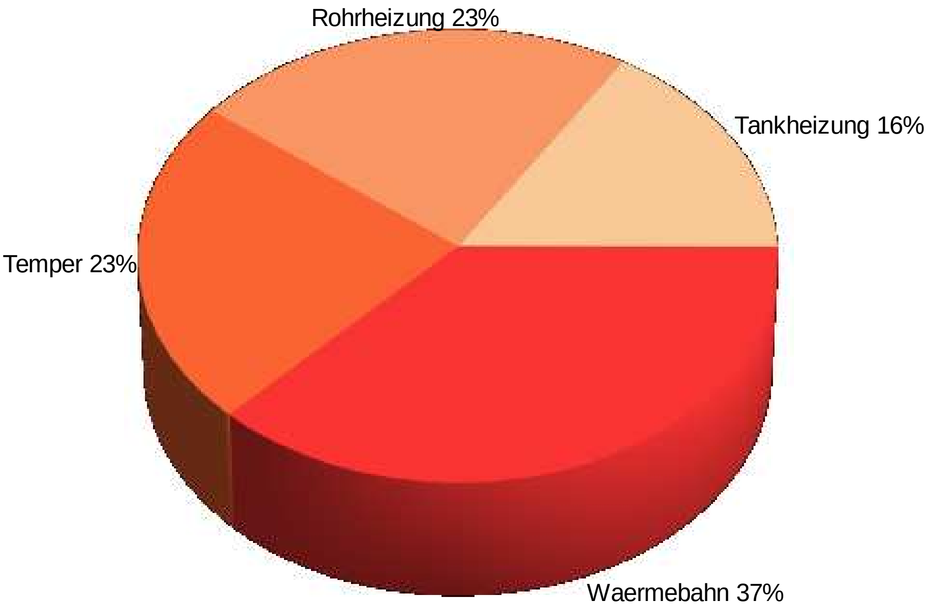

Figure 12: Useful process heat (UPH) by process

Table 7: Useful process cold (UPC) by process

Process	Total	Circulation	Maintenance	Start-up
	[MWh]	[MWh]	[MWh]	[MWh]
Rotorkuehler	188	188	0	0
Kettenkuehler	52	52	0	0
Kuehlhaus	13	13	0	0
Kuehlung Halle	10	10	0	0
Total	**262**			

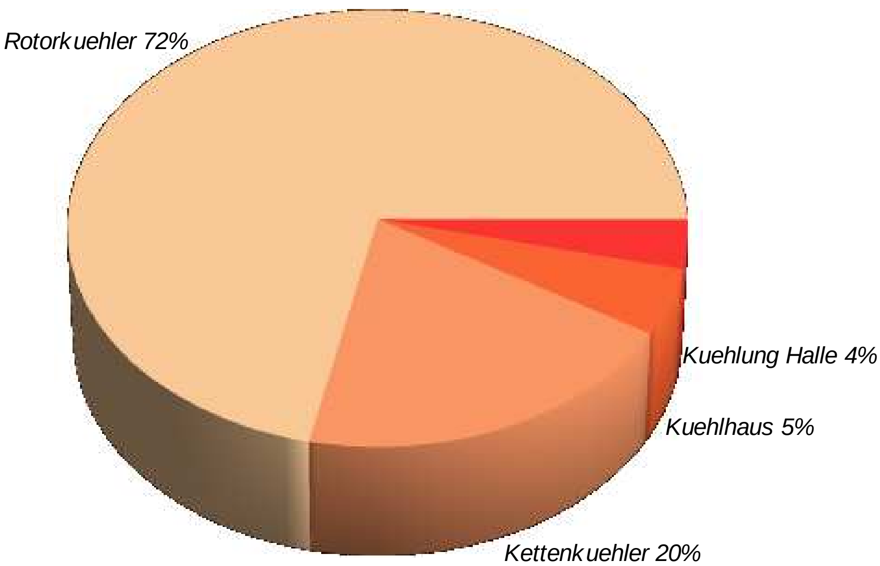

Figure 13: Useful process cold (UPC) by process

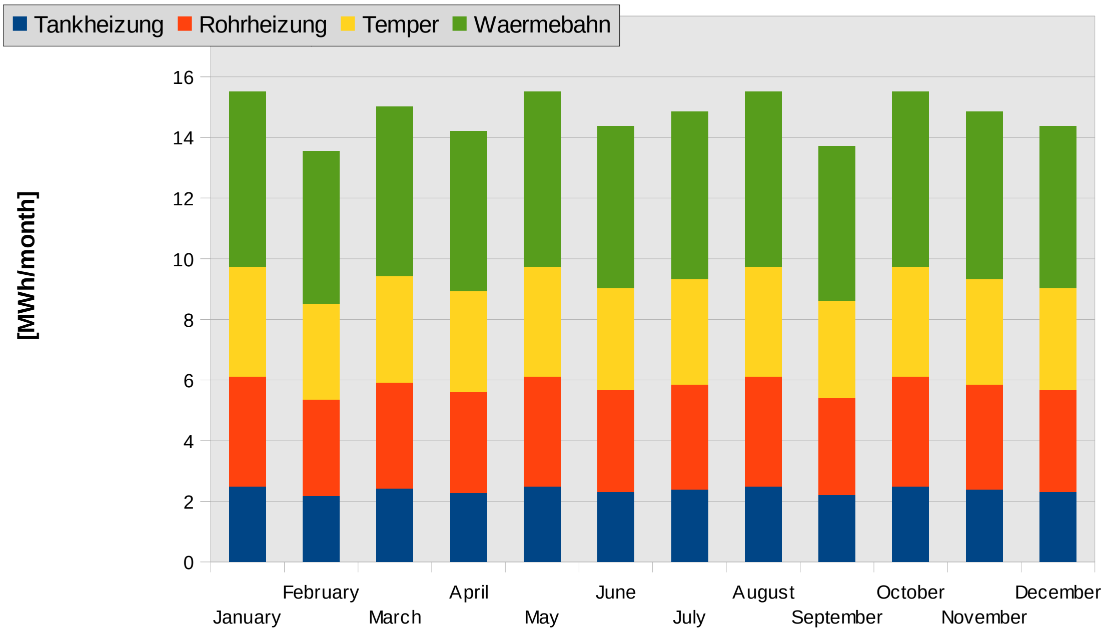

Figure 14: Distribution of useful process heat demand per month

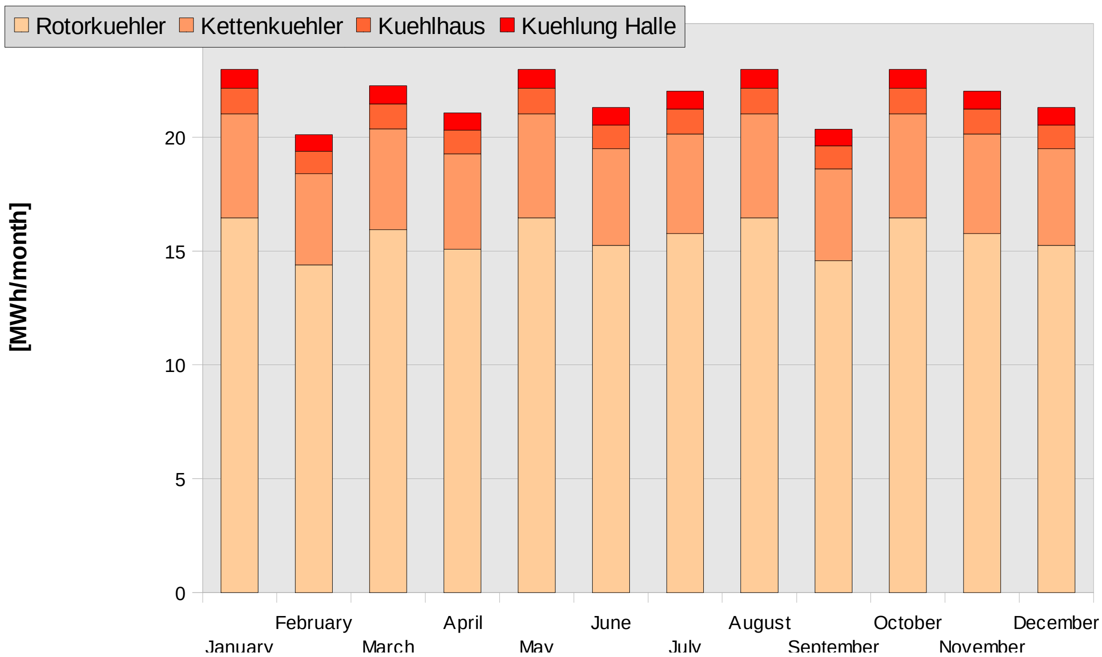

Figure 15: Distribution of useful process cooling demand per month

4. Comparative study

4.1. Proposed alternatives

There are four 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 heat pump 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.

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+WP	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)

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 chiller	4	cold water chiller	Waermebahn	26	45.21
HX Kessel	5	hot water boiler	Rohrheizung	32	54.79
Total	9			**58**	**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]	[%]
Hot water boiler	hot water boiler	o==hot water==o	50	169	39.15
Cold water chiller	compression chiller (water cooled)	o==cold water==o	40	253	58.65
Chiller Kuehlung	compression chiller (water cooled)	o==cold air==o	3	10	2.20
Total			**93**	**432**	**100**

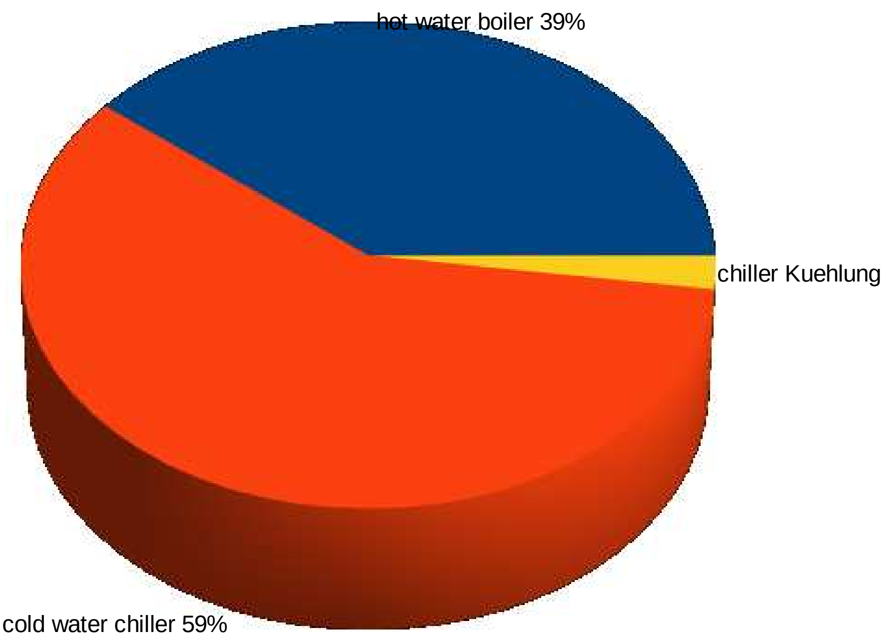

Figure 16: Final energy consumption for thermal use (FET) by equipment

4.1.2. HX + Solar:

Collector type:	FPC (flat plate collectors)
Installed capacity:	120.8 kW
Installed collector area:	188 m²
Solar buffer storage volume:	8.63 m³
Solar fraction:	45.72 %
Annual energy yield:	709 kWh/kWa

Table 11: Heat exchangers and amount of recovered energy

Heat Exchanger	Power	Heat Source	Heat Sink	Savings	
	[kW]			[MWh]	[%]
HX chiller	4	cold water chiller	Waermebahn	26	45.21
HX Kessel	5	hot water boiler	Rohrheizung	32	54.79
Total	9			**58**	**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 (evacuated tubes)	o==hot water==o	121	87	19.29
hot water boiler	hot water boiler	o==hot water==o	50	101	22.40
cold water chiller	compression chiller (water cooled)	o==cold water==o	40	253	56.21
chiller Kuehlung	compression chiller (water cooled)	o==cold air==o	3	10	2.11
Total			**213**	**451**	**100**

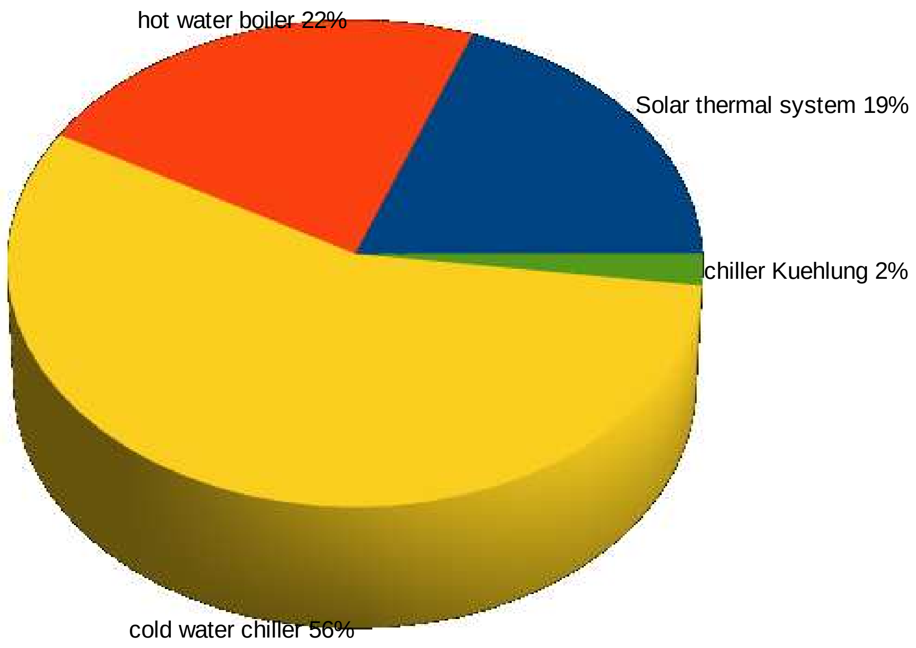

Figure 17: Final energy consumption for thermal use (FET) by equipment

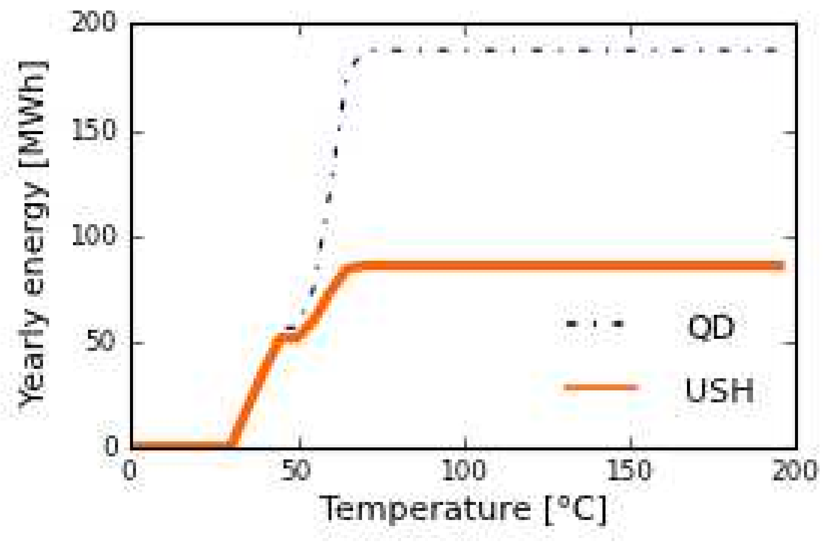

Figure 18: Heat demand and solar contribution

4.1.3. HX + WP:

Heat pump type:	compression heat pump
Installed capacity:	30 kW
Operating hours:	6576

Table 13: Heat exchangers and amount of recovered energy

Heat Exchanger	Power	Heat Source	Heat Sink	Savings	
	[kW]			[MWh]	[%]
HX chiller	4	cold water chiller	Waermebahn	26	45.21
HX Kessel	5	hot water boiler	Rohrheizung	32	54.79
Total	9			**58**	**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 heat pump 1	compression heat pump	o==hot water==o	30	61	13.63
Hot water boiler	hot water boiler	o==hot water==o	50	122	27.34
Cold water chiller	compression chiller (water cooled)	o==cold water==o	40	253	56.89
Chiller Kuehlung	compression chiller (water cooled)	o==cold air==o	3	10	2.13
Total			**123**	**445**	**100**

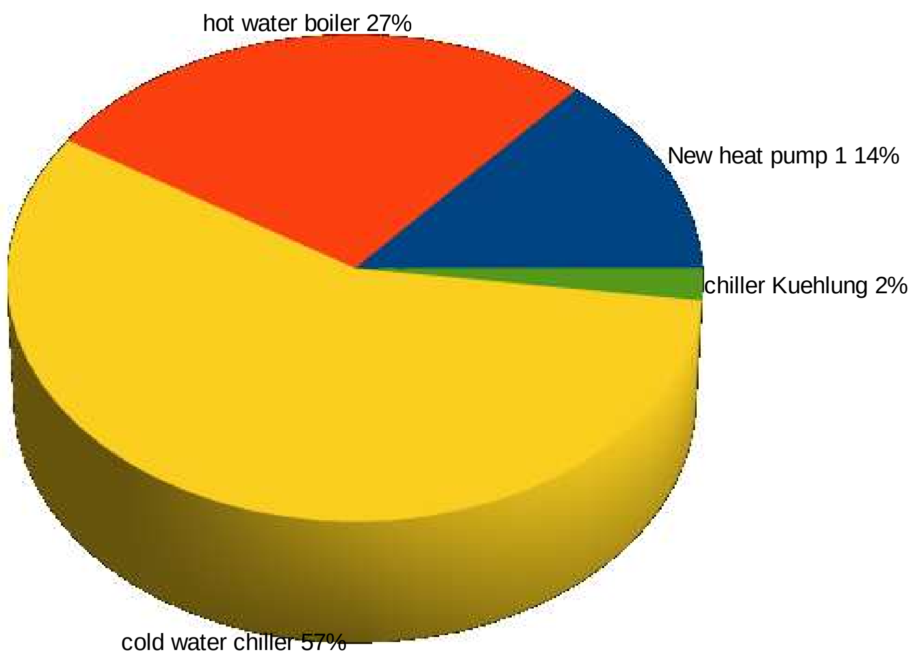

Figure 19: Final energy consumption for thermal use (FET) by equipment

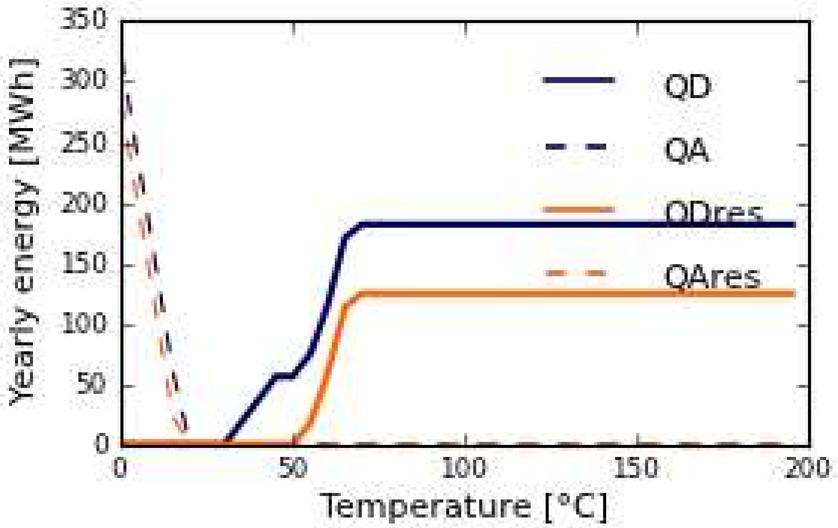

Figure 20: Heat demand and solar contribution

4.1.4. HX + boiler:

Type	condensing boiler
Nominal thermal power	81 kW
Efficiency	1.13

Table 15: Heat exchangers and amount of recovered energy

Heat Exchanger	Power	Heat Source	Heat Sink	Savings	
	[kW]			[MWh]	[%]
HX chiller	4	cold water chiller	Waermebahn	26	45.21
Total *	9			**58**	**100**

* Only one heat exchanger could have been installed as the boiler that supplied the second HX was substituted by the new one.

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]	[%]
Cold water chiller	compression chiller (water cooled)	o==cold water==o	40	253	53.08
Chiller Kuehlung	compression chiller (water cooled)	o==cold air==o	3	10	1.99
New boiler 4	condensing boiler	o==hot water==o	80	214	44.93
Total			**123**	**477**	**100**

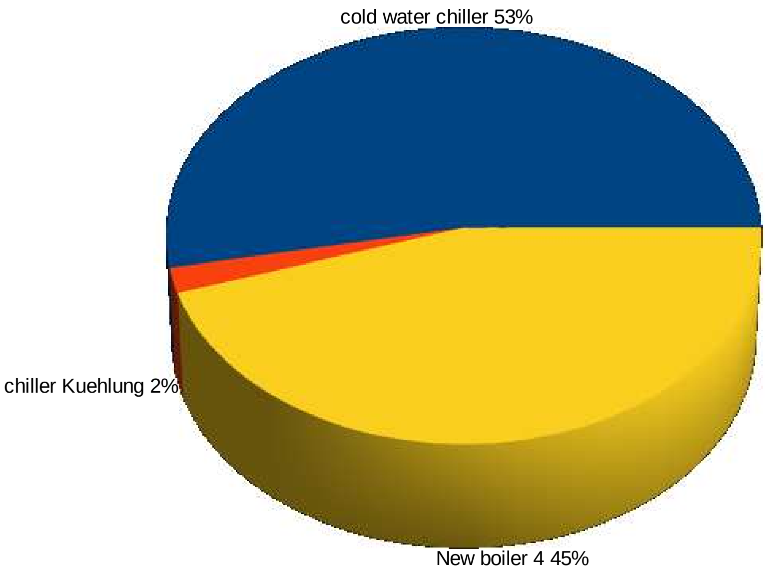

Figure 21: Final energy consumption for thermal use (FET) by equipment

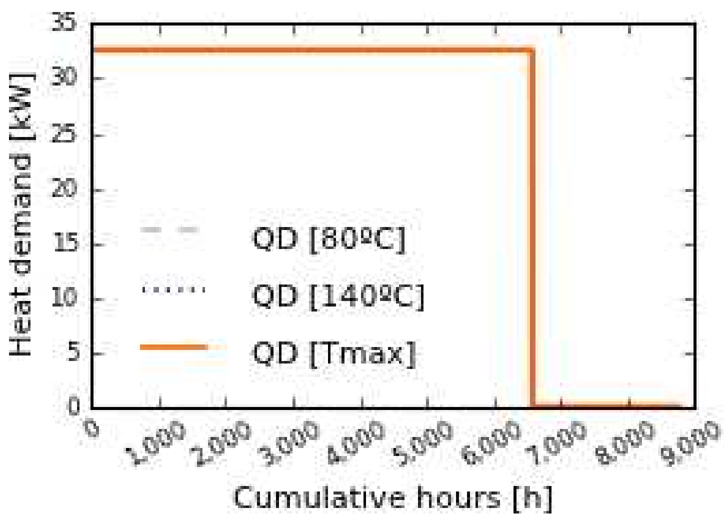

Figure 22: Cumulative heat supply to be covered by CHP

- Primary energy consumption (PEC)

Table 17: primary energy consumption and savings

Alternative	Primary energy consumption	Savings	
	[MWh]	[MWh]	[%]
Present State (checked)	1,059	---	---
PSSim	960	99	9.33
HX	846	213	20.09
HX+solar	755	304	28.69
HX+WP	839	221	20.83
HX+boiler	828	231	21.79

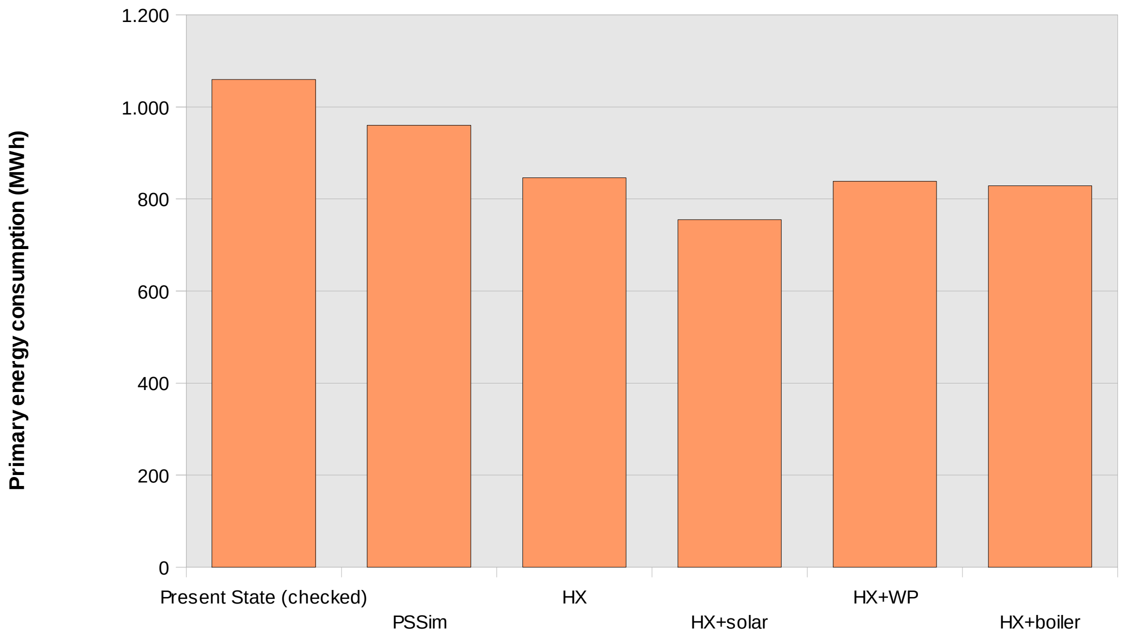

Figure 23: Comparison of alternatives: primary energy consumption

- 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. By the changed equipment and its changed efficiencies the supply heat changed.

Table 18: Useful process and supply heat: present state and alternative proposals.

Alternative	Useful process heat (UPH) [MWh]	Savings UPH [MWh]	Useful supply heat (USH) [MWh]	Savings USH [MWh]
Present State (checked)	177	---	252	---
PSSim	177	0	252	0
HX	177	0	169	83
HX+solar	177	0	188	64
HX+WP	177	0	182	70
HX+boiler	177	0	214	37

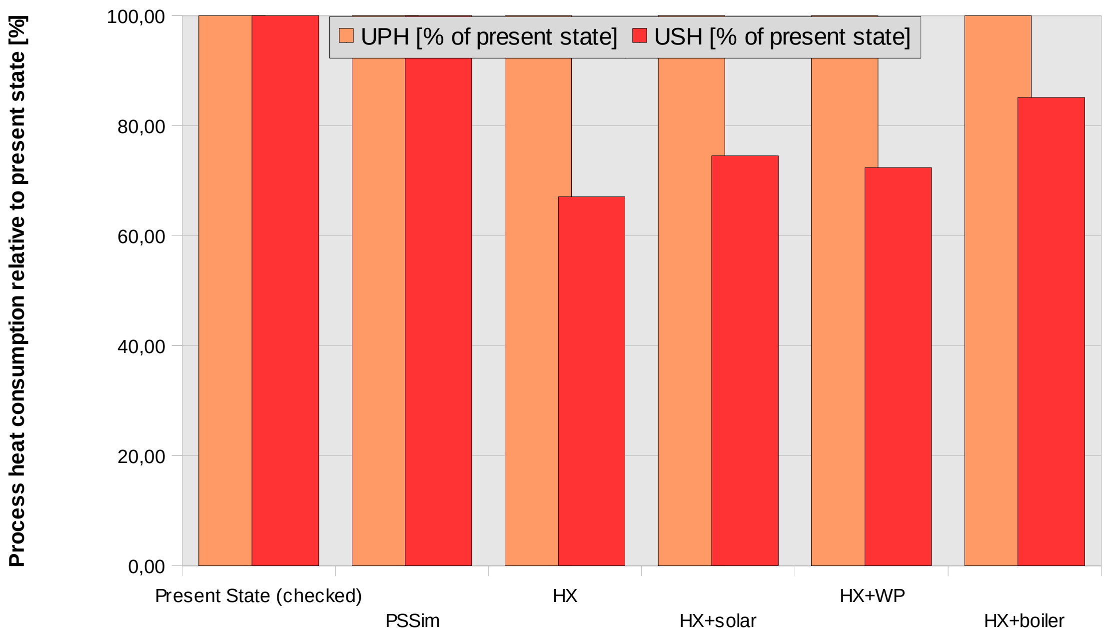

Figure 24: Comparison of alternatives: useful process heat supply

Table 19: Useful process and supply cold: present state and alternative proposals.

Alternative	Useful process cooling (UPC) [MWh]	Savings UPC [MWh]	Useful supply cooling (USC) [MWh]	Savings USC [MWh]
Present State (checked)	262	---	263	---
PSSim	262	0	263	0
HX	262	0	263	0
HX+solar	262	0	263	0
HX+WP	262	0	263	0
HX+boiler	262	0	263	0

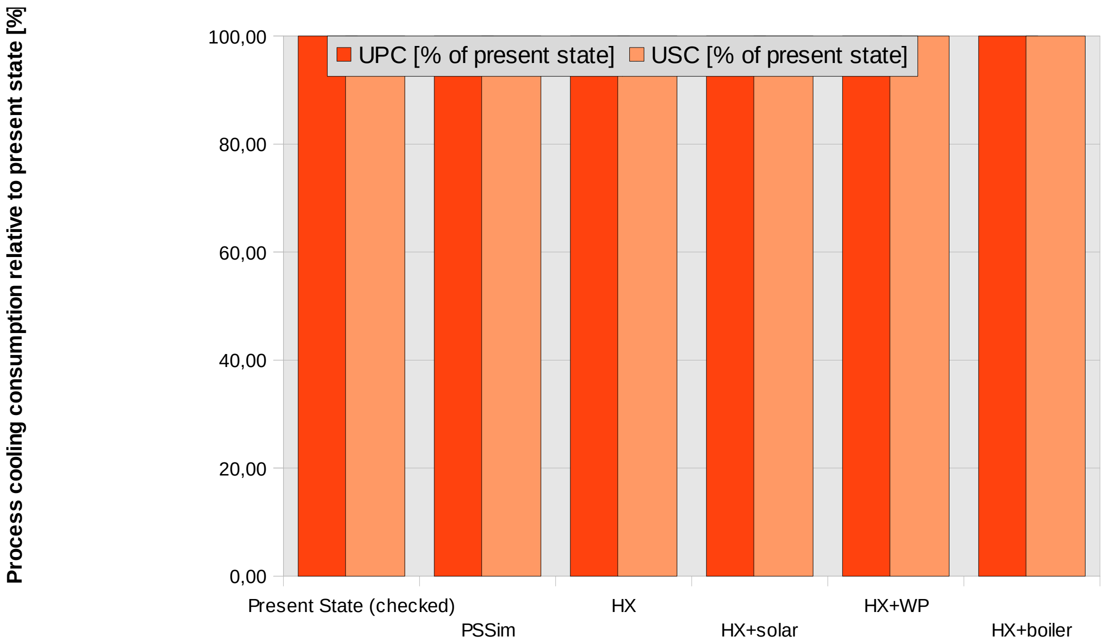

Figure 25: Comparison of alternatives: useful process heat supply

- Environmental impact

Table 20: CO2 production and CO2 savings per year

Alternative	Production of CO2	Highly Radioactive Nuclear Waste	Water consumption
	[t]	[kg]	[m3]
Present State (checked)	197.54	0.00	689.67
PSSim	181.06	0.00	0.00
HX	155.16	0.00	0.00
HX+solar	134.30	0.00	0.00
HX+WP	149.91	0.00	0.00
HX+boiler	150.73	0.00	0.00

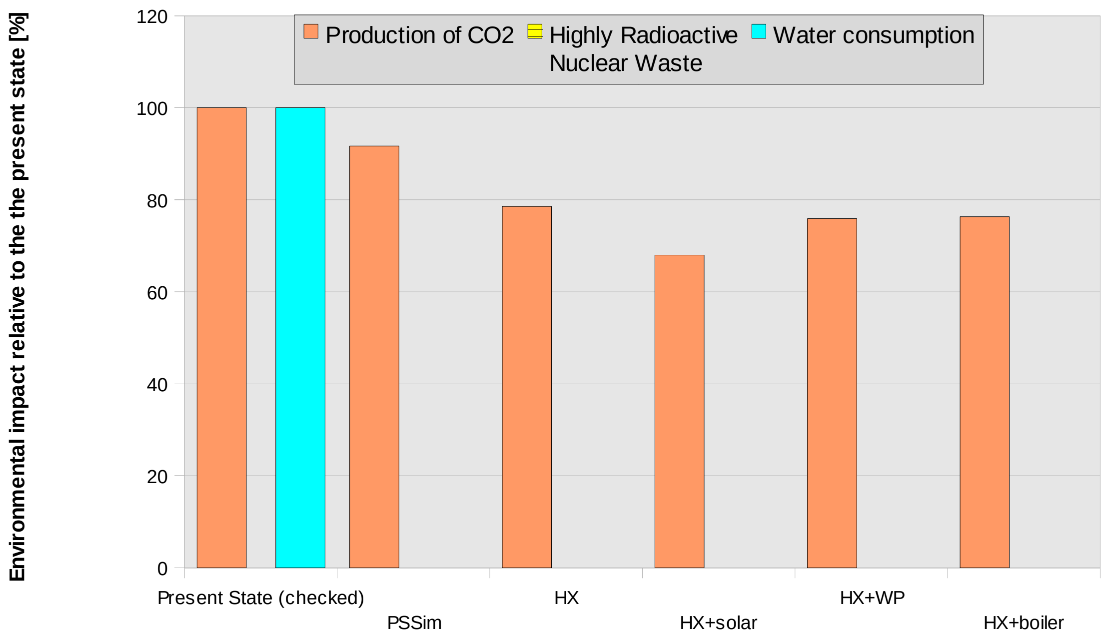

Figure 26: Comparison of alternatives: environmental impact

Table 21: Investment costs and subsidies of the proposals

Alternative	Total investment [€]	Own investment [€]	Subsidies [€]
Present State (checked)	---	---	---
PSSim	0	0	0
HX	10,000	10,000	0
HX+solar	120,000	76,000	44,000
HX+WP	19,000	16,300	2,700
HX+boiler	22,000	18,400	3,600

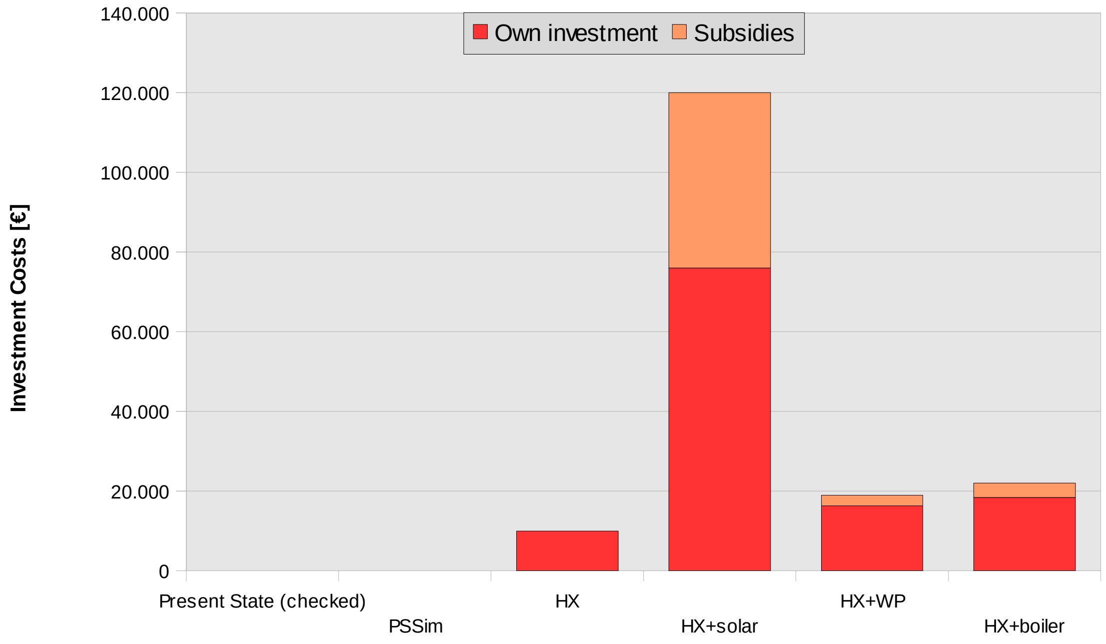

Figure 27: Comparison of alternatives investment cost

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)	31,220	---	---
PSSim	28,419	-2,801	-28.33
HX	25,485	-5,735	-26.95
HX+solar	30,427	-793	-2.61
HX+WP	25,162	-6,058	-27.45
HX+boiler	25,819	-5,401	-23.40

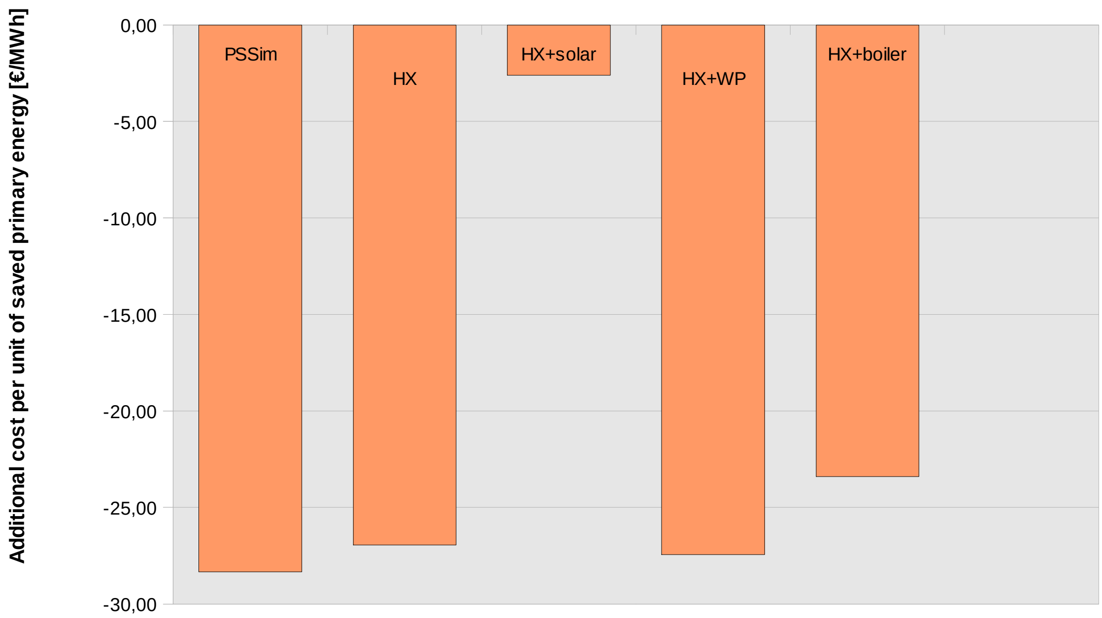

Figure 28: Comparison of alternatives: Total additional cost per saved primary energy.

5. Selected alternative(s) and conclusions

5.1. 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.

5.1.1. Process optimisation (written proposals)

None

5.1.2. Heat Supply

HX + Solar (FPC):

Collector type:	FPC (flat plate collectors)
Installed capacity:	120.8 kW
Installed collector area:	188 m²
Solar buffer storage volume:	8.63 m³
Solar fraction:	45.72 %
Annual energy yield:	709 kWh/kWa

Table 23: Heat exchangers and amount of recovered energy

Heat Exchanger	Power	Heat Source	Heat Sink	Heat transferred	
	[kW]			[MWh]	[%]
HX chiller	4	cold water chiller	Waermebahn	26	58.09
HX Kessel	3	hot water boiler	Rohrheizung	19	41.91

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 (evacuated tubes)	o==hot water==o	121	87	19.29
Hot water boiler	hot water boiler	o==hot water==o	50	101	22.40
Cold water chiller	compression chiller (water cooled)	o==cold water==o	40	253	56.21
Chiller Kuehlung	compression chiller (water cooled)	o==cold air==o	3	10	2.11
Total			**213**	**451**	**100**

5.1.3. 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	138	18.33	138	45.38
Total electricity	617	81.67	167	54.62
Total (fuels + electricity)	**755**	**100.00**	**305**	**100.00**

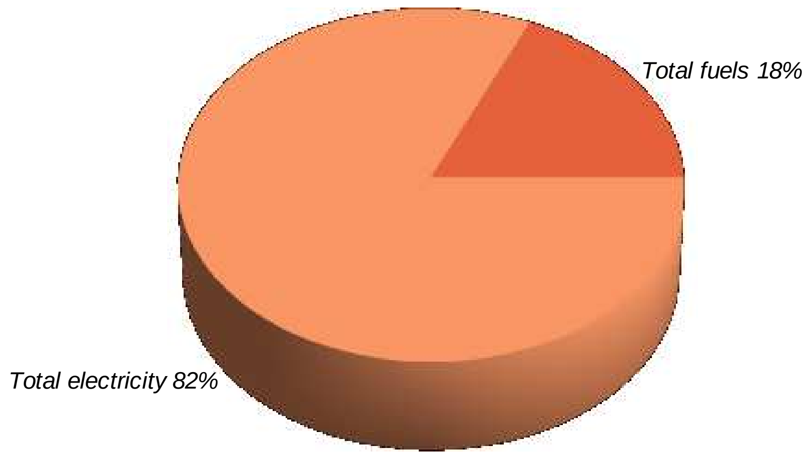

Figure 29: Distribution of PEC by fuel type

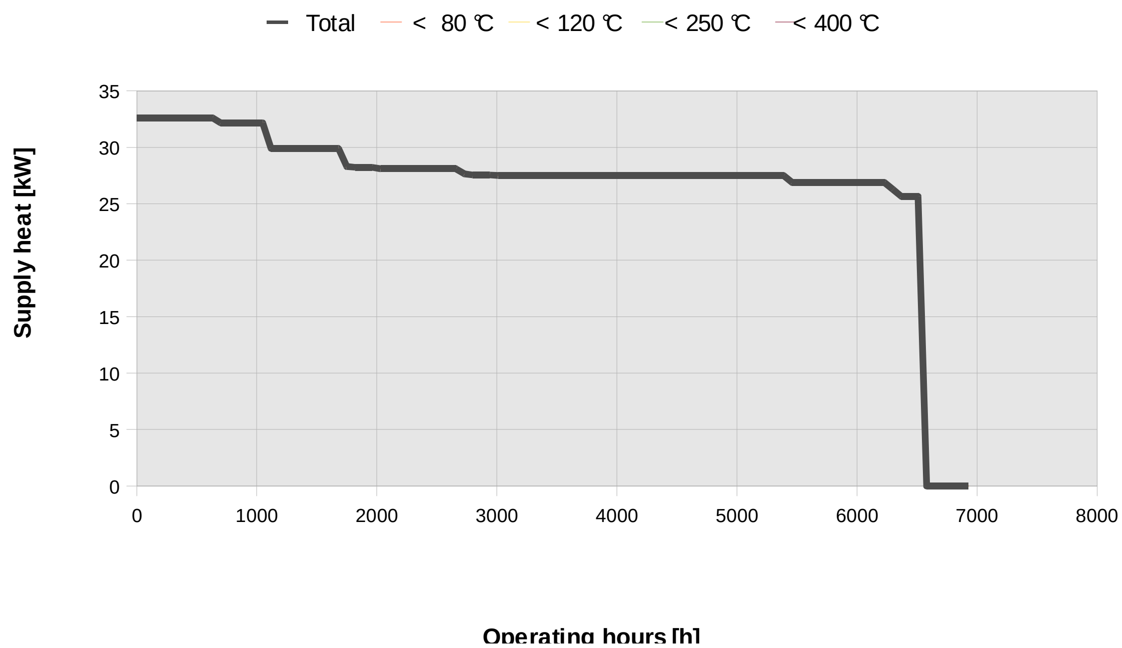

Figure 30: Distribution of supply heat by temperature levels and annual operating hours. Proposed final solution.

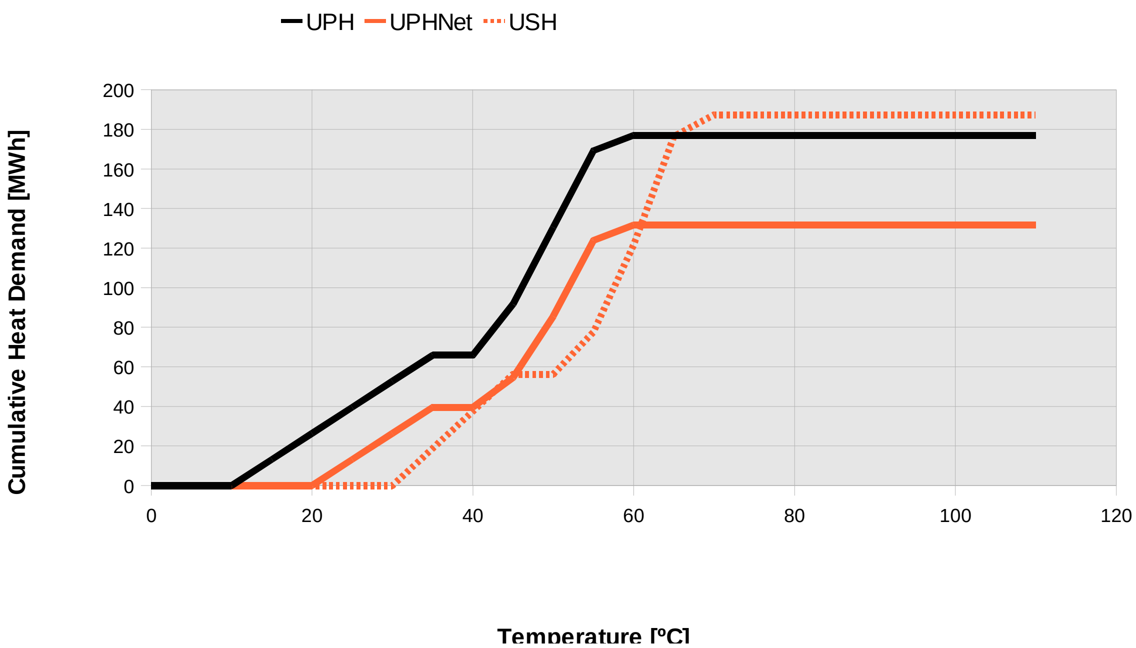

Figure 31: Distribution of the heat demand by temperature levels

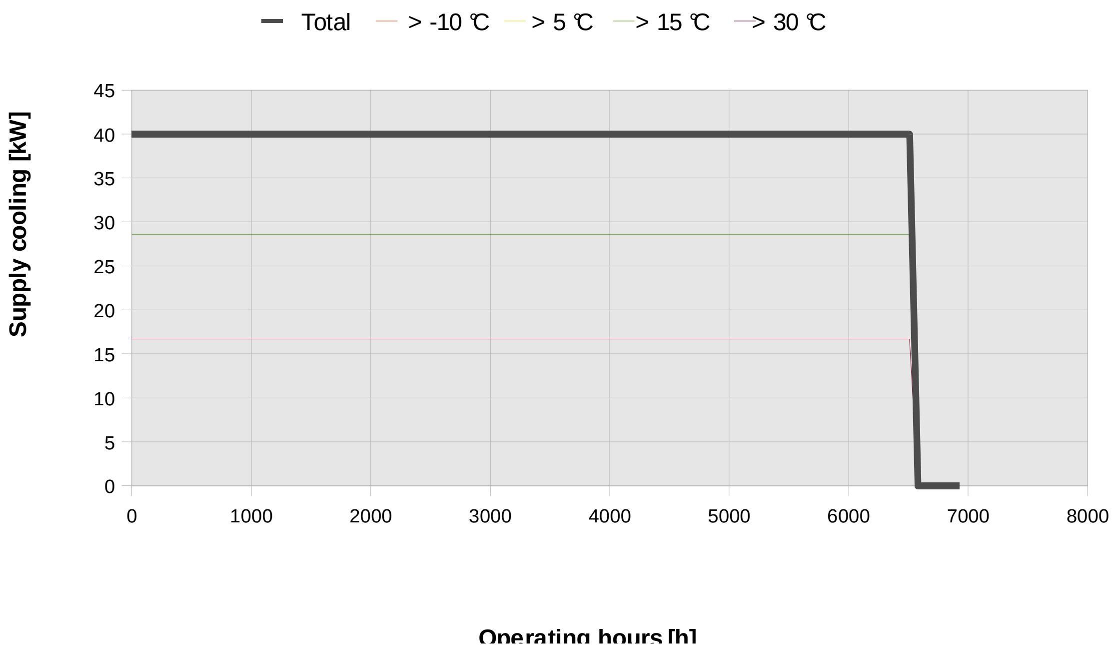

Figure 32: Distribution of supply cooling by temperature levels and annual operating hours. Proposed final solution.

5.2. Comparative study and conclusions

5.2.1. Energy and environmental analysis

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

5.2.2. Economic analysis

The payback period of about 8.5 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]	960	755	205	21%
- fuels	[MWh]	346	138	208	60%
- electricity	[MWh]	614	614	0	0%
Primary energy saving due to renewable energy	[MWh]		92		
CO2 emissions	[t/a]	181	134	47	26%
Annual energy system cost (2)	[EUR]	28,418	21,166	7,252	26%
Total investment costs	[EUR]		120,000		
Payback period (3)	[years]		8.5		

(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

- 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.