Energy Audit Summary Report
AEE INTEC
Audit no. 28 – AUT08
Bakery

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. 28 – AUT08

1. Data of the auditor

1.1. Contact data of the auditor

Jürgen Fluch, Matthäus Hubmann

Number of audits preformed: 19

Date of the audit: 15.06.2012

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	Bakery
Products	Baked goods
No. of employees	n.a. (not available)
Current primary energy consumption	10,694 [MWh/a]

3.2. Flow sheet of the whole manufacturing side

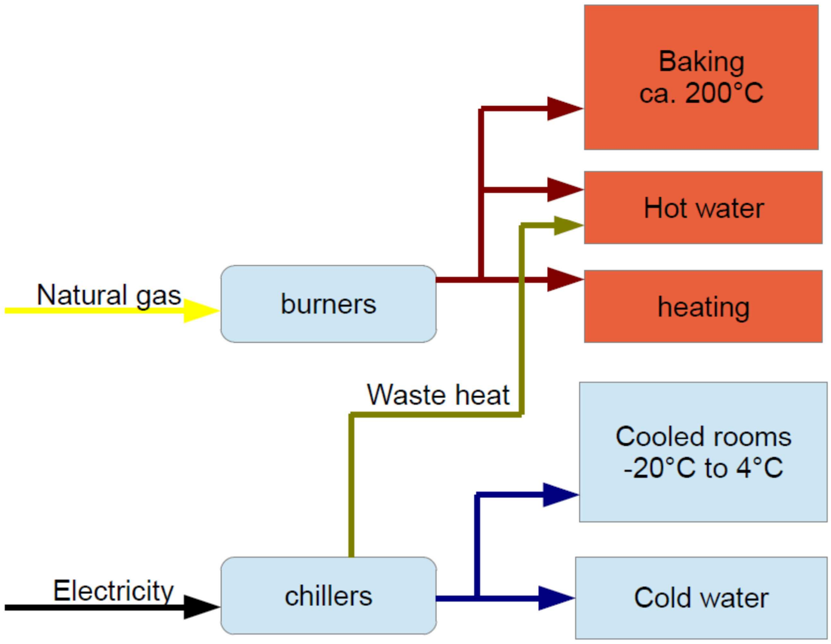

Figure 1: Flow sheet of the factory

3.3. Description of the existing system

- **Energy Supply:**

The factory is mainly consuming energy for heating purposes during the production. In addition it has electrical consumption for cooling all year long.

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	4,840	45.30	4,840	56.20
Total electricity	5,854	54.70	3,767	43.80
	10,694	**100.00**	**8,607**	**100.00**

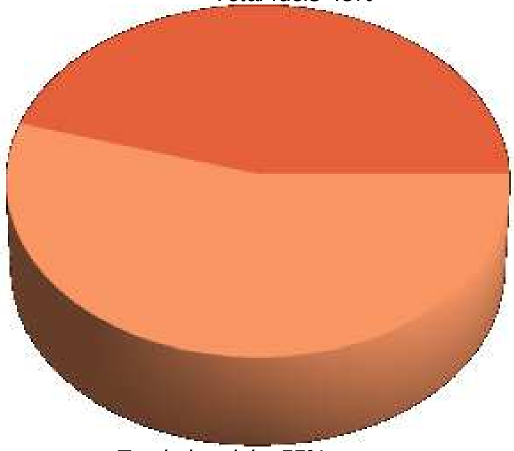

Figure 2: distribution of PEC by fuel type

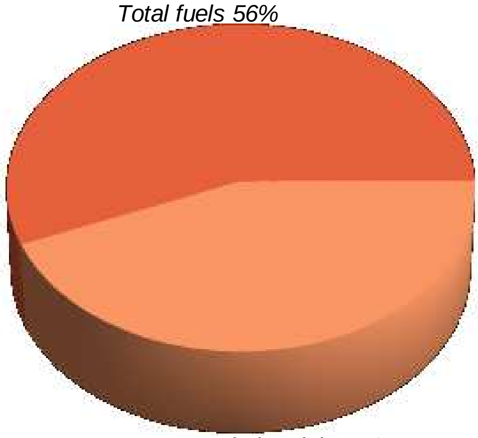

Figure 3: distribution of PET by fuel type

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	4,400	68.60	4,400	77.20
Electricity	2,019	31.40	1,299	22.80
Total	6,419	100.00	5,699	100.00

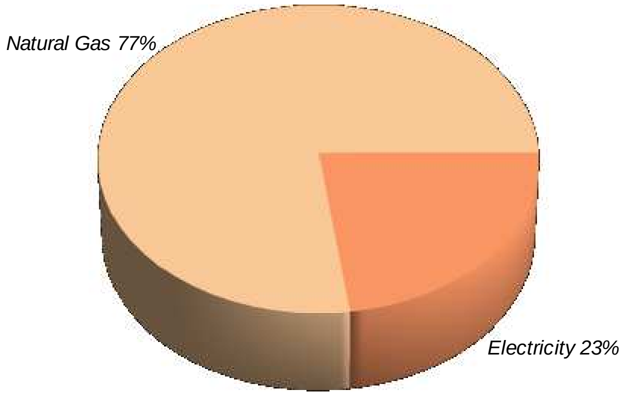

Figure 4: Total final energy consumption for thermal use (FET)

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

Equipment	Fuel type	FET by equipment [MWh]	[% of Total]
Koenig K1	Natural gas	345	6.10
Daub	Natural gas	1,298	22.80
Hoval ZH	Natural gas	402	7.10
Dampfkessel GAS	Natural gas	1,222	21.50
cold water cooling	Natural gas	5	0.10
Koenig EG	Natural gas	464	8.20
Monsun EG	Natural gas	371	6.50
Gaerraum	Electricity	116	2.00
Brenner (Krapfen)	Natural gas	298	5.20
MROG1 (4grad)	Electricity	35	0.60
MROG1 (-20grad)	Electricity	318	5.60
MROG1 (-26grad)	Electricity	475	8.30
MROG1 (4grad)	Electricity	71	1.20
MROG2 (-20grad)	Electricity	123	2.20
MROG2 (23grad)	Electricity	146	2.60
		5,689	**100.00**

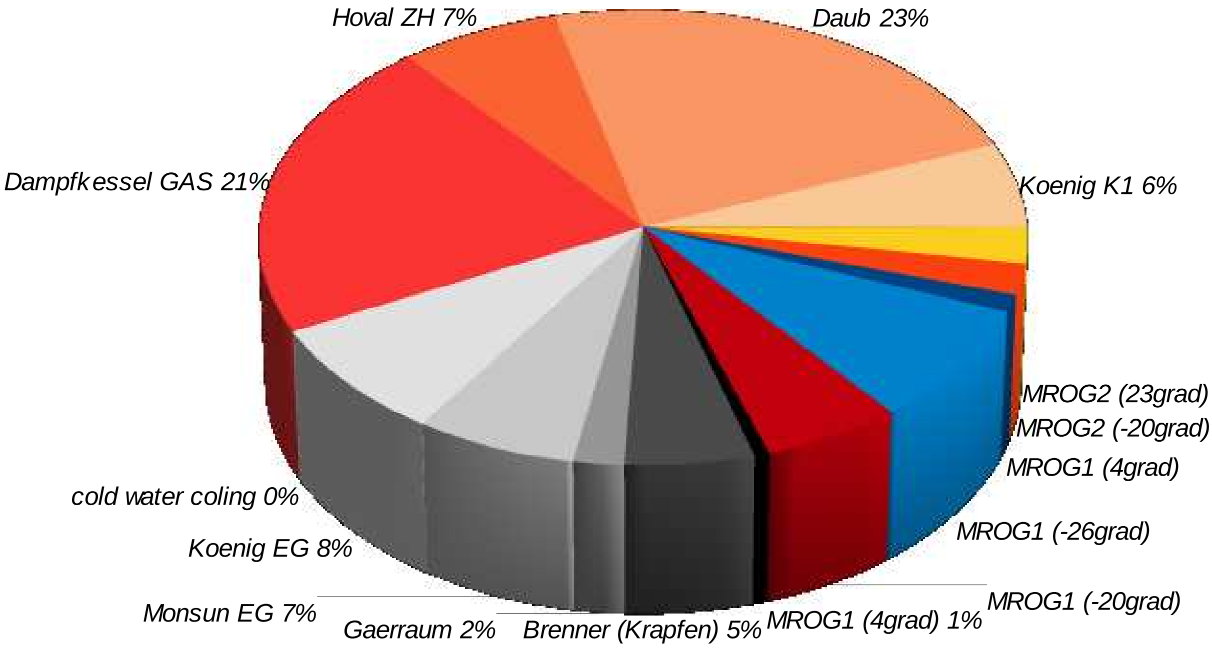

Figure 5: Final energy consumption for thermal use (FET) by equipment

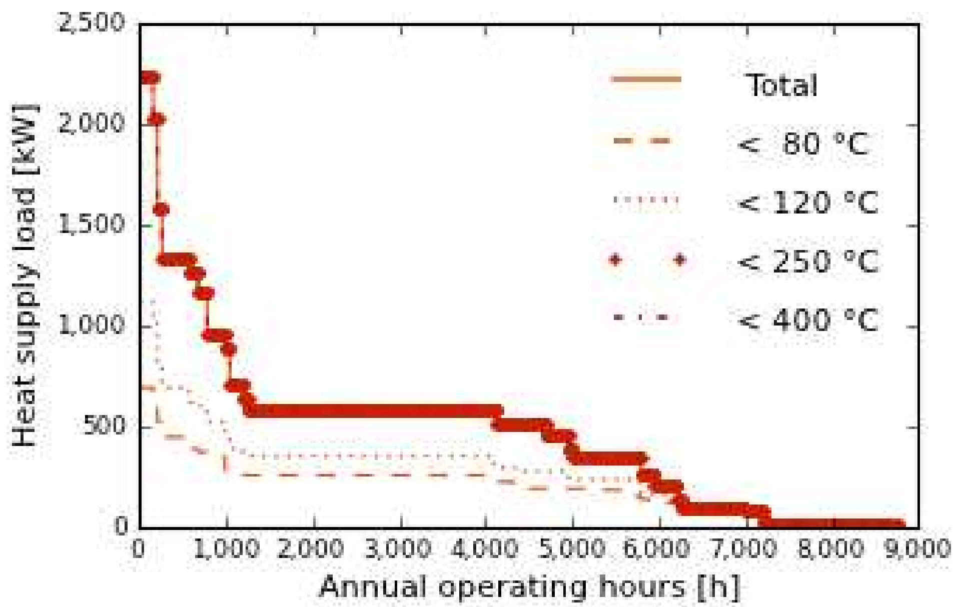

Figure 6: Distribution of supply heat by temperature levels and annual operating hours. Present state.

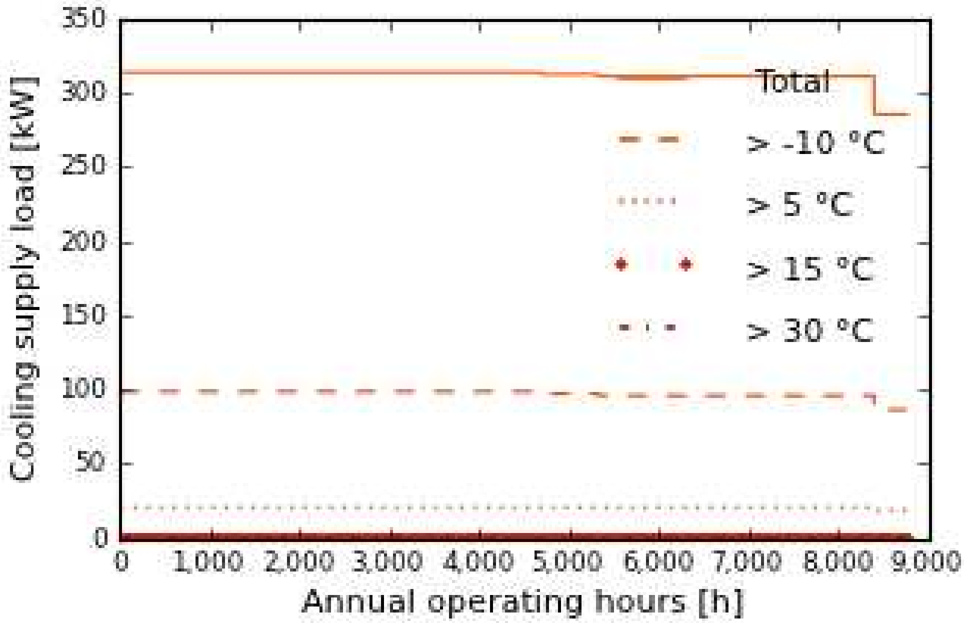

Figure 7: Distribution of supply cooling by temperature levels and annual operating hours. Present state.

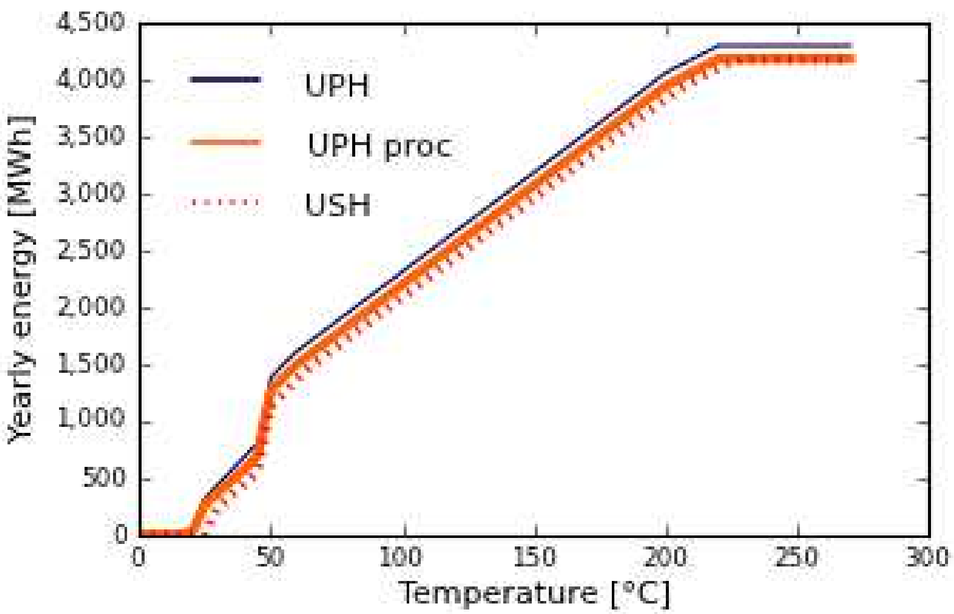

Figure 8: Distribution of the heat demand by temperature levels

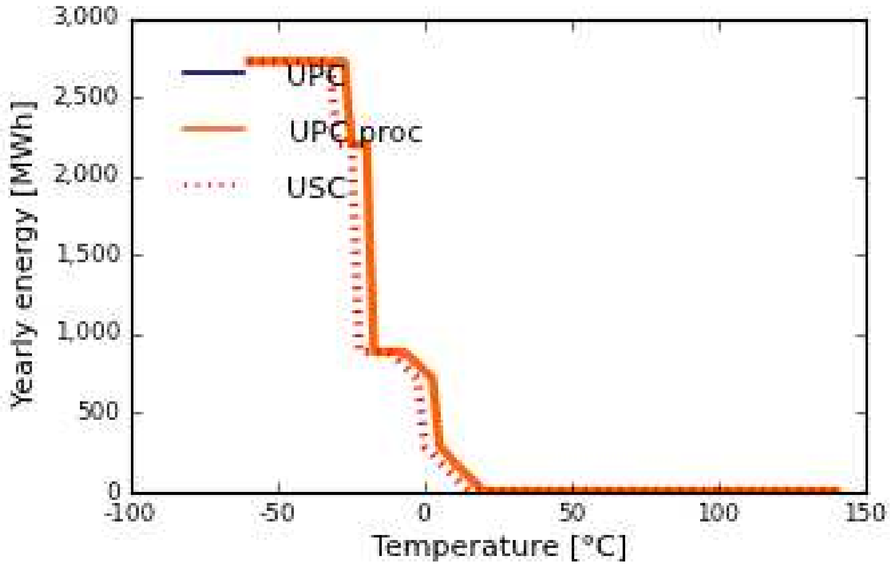

Figure 9: Distribution of the cooling demand by temperature levels

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

Equipment	USH by equipment	
	[MWh]	[% of Total]
Koenig K1	303	7.50
Daub	1,136	27.90
Hoval ZH	374	9.20
Dampfkessel GAS	1,139	28.00
Koenig EG	416	10.20
Monsun EG	295	7.20
Brenner (Krapfen)	259	6.40
MROG2 (23grad)	146	3.60
	4,068	**100.00**

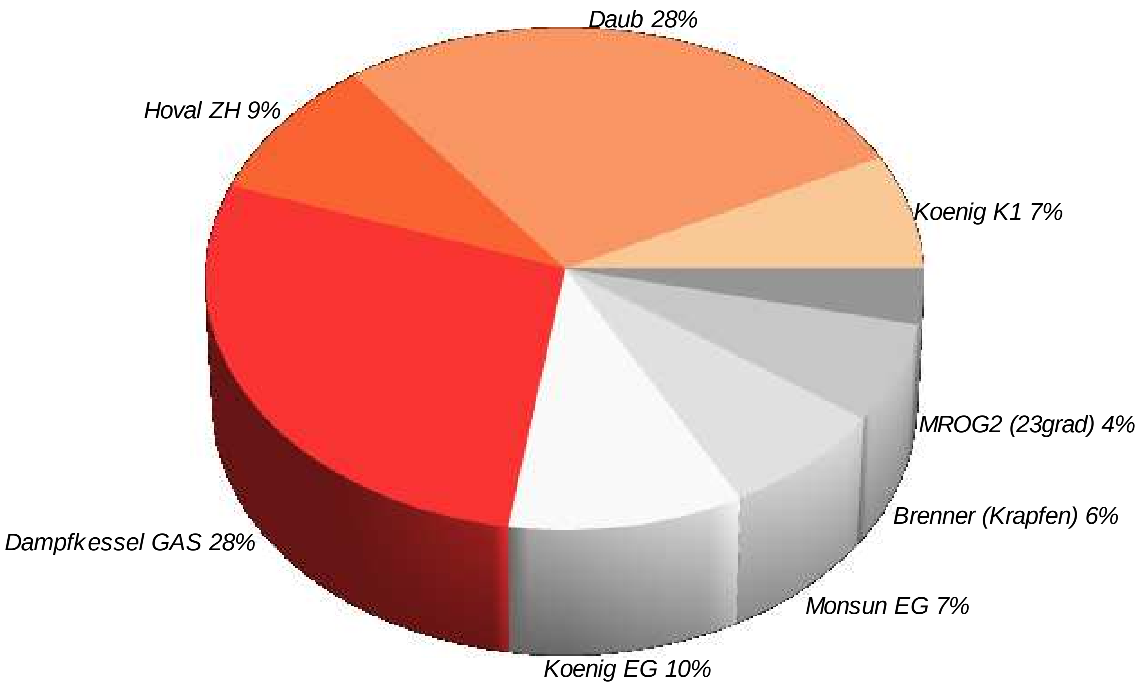

Figure 10: Useful supply heat (USH) by equipment. Present state

Table 5: Heat exchangers and amount of recovered energy

Heat Exchanger	Power	Heat Source	Heat Sink	Amount of recovered energy	
	[kW]			[MWh]	[%]
HX_WRG_Kaelteanlagen	18	WRG Kaelteanlagen	HW_Sorger	115	49.73

Table 6: Useful process heat (UPH) by process

	Process	UPH Total [MWh]	Share [%]	Circulation [MWh]	Maintenance [MWh]	Start-Up [MWh]	Process Temp. [°C]
1	Koenig 1-4	303.31	7.24	303.31	0.00	0.00	220.00
2	Daub 1-2	1136.13	27.13	1136.13	0.00	0.00	220.00
3	HW_Sorger	171.57	4.10	171.57	0.00	0.00	57.00
4	Brenner 1-5 (Krapfen)	258.93	6.18	258.93	0.00	0.00	220.00
5	Koenig 1-5 EG	416.13	9.94	416.13	0.00	0.00	220.00
6	Monsun 1-6 EG	294.65	7.04	294.65	0.00	0.00	220.00
7	DK Beschwadung	583.95	13.94	583.95	0.00	0.00	200.00
8	DK Gaerraum	194.65	4.65	194.65	0.00	0.00	200.00
9	DK KistenWM	145.99	3.49	145.99	0.00	0.00	60.00
10	DK Knoedelproduktion	82.73	1.98	144.27	0.00	0.00	200.00
11	Sorger Produktion_heating	287.97	6.88	0.00	287.97	0.00	22.00
10	DK Knoedelproduktion	82.73	1.98	144.27	0.00	0.00	200.00
11	Sorger Produktion_heating	287.97	6.88	0.00	287.97	0.00	22.00
12	Sorger buero_heating	165.91	3.96	0.00	165.91	0.00	22.00
13	MROG2 23GradC	146.00	3.49	0.00	146.00	0.00	23.00
14	Total	4187.93	100.00				

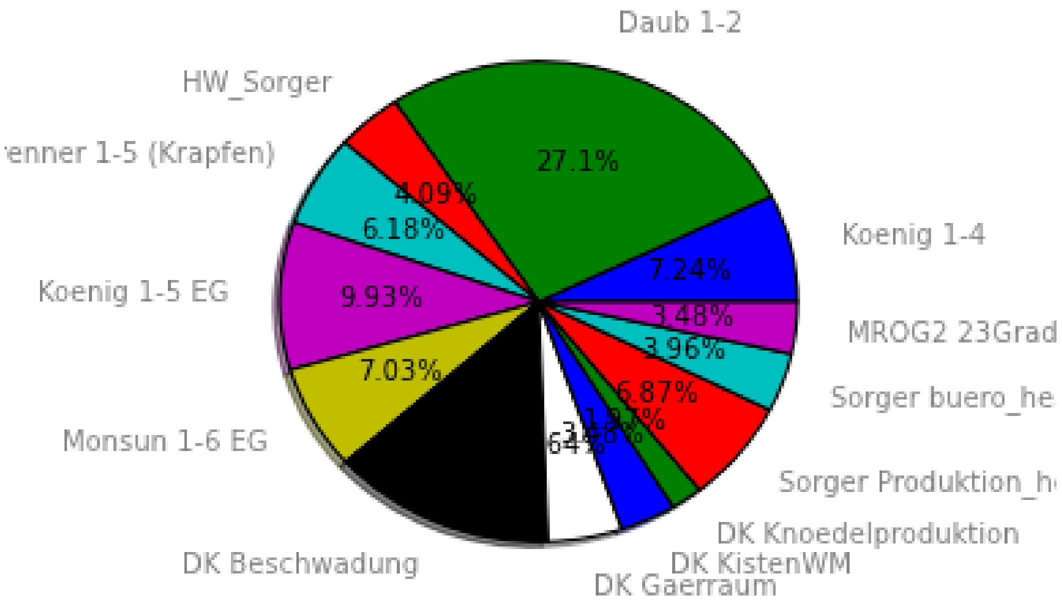

Figure 11: Useful process heat (UPH) by process

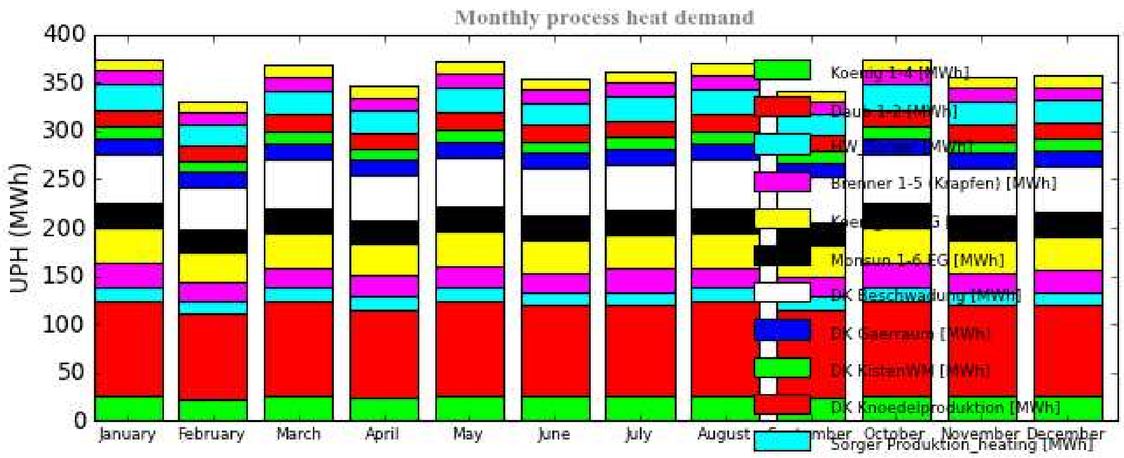

Figure 12: Distribution of useful process heat demand per month

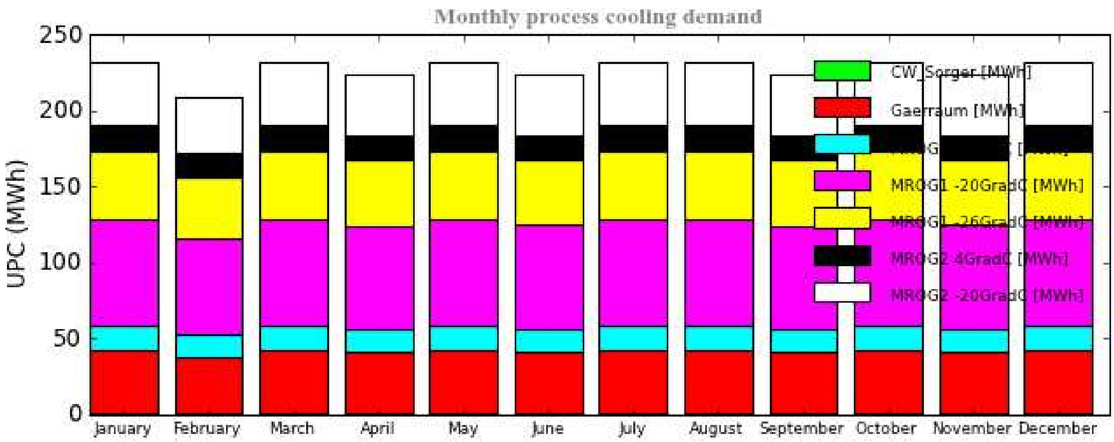

Figure 13: Distribution of useful process cooling demand per month

3.4. General

- The target room temperature during winter is 25 °C for the production hall and from -20°C to -4 °C in storage rooms.

4. <u>Comparative study</u>

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. The third proposal focuses on the installation of additional heat exchangers and the implementation of solar thermal system. In the fourth proposal a new CHP (combined heat and power plant) is installed.

Table 7: Overview of the alternative proposals studied

Short Name	Description
New HX	based on present state the installation of additional heat exchangers is suggested
Solar FPC	based on present state a solar thermal system with flat plate collectors (FPC) is suggested
HX + solar	based on present state the installation of additional heat exchangers and in addition a solar thermal system with flat plate collectors (FPC) is suggested
CHP	based on present state the installation of an CHP (combined heat and power) plant is suggested

4.1.1. Heat Supply

- **New HX (additional heat exchangers):**

Heat exchanger type: finned tubes; plate heat exchangers

In the following the heat exchanger network design of this alternative is presented.

Table 8: Heat exchangers and amount of recovered energy

Heat Exchanger	Power	Heat Source	Heat Sink	Amount of recovered energy	
	[kW]			[MWh]	[%]
HX_WRG_Kaelteanlagen	18	WRG Kaelteanlagen	HW_Sorger	115	49.73
HX_Daub	13	DAUB_waste heat	DAUB_combustion air	63	27.50
HX_Dampfkessel	5	Dampfkessel_waste heat	Dampfkessel_combustion air	36	15.46
HX_Koenig K	3	Koenig K_waste heat	Koenig K_combustion air	17	7.31

Table 9: Final energy consumption for thermal use (FET) by equipment

Equipment	Type	Contribution to total heat and cooling supply [MWh]	[%]
Koenig K1	Natural gas	345	6.20
Daub	Natural gas	1,298	23.33
Hoval ZH	Natural gas	371	6.67
Dampfkessel GAS	Natural gas	1,384	24.87
cold water cooling	Natural gas	3	0.05
Koenig EG	Natural gas	427	7.67
Monsun EG	Natural gas	364	6.54
Gaerraum	Electricity	98	1.76
Brenner (Krapfen)	Natural gas	298	5.36
MROG1 (4grad)	Electricity	26	0.47
MROG1 (-20grad)	Electricity	260	4.67
MROG1 (-26grad)	Electricity	379	6.81
MROG1 (4grad)	Electricity	49	0.88
MROG2 (-20grad)	Electricity	116	2.08
MROG2 (23grad)	Electricity	146	2.62
		5,564	**100**

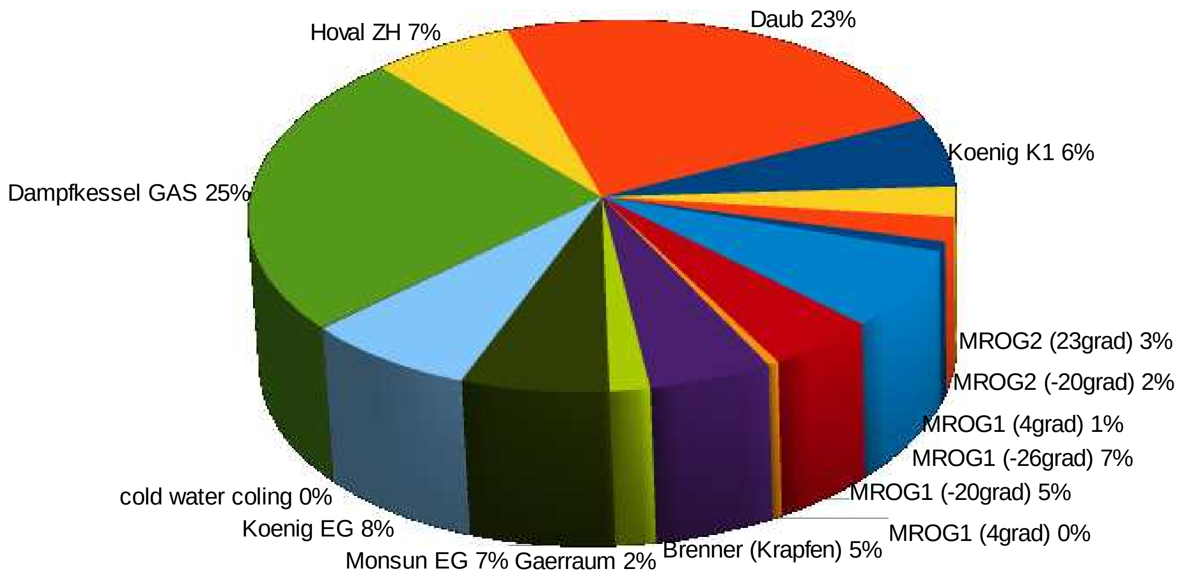

Figure 14: Final energy consumption for thermal use (FET) by equipment

- graphic: heat demand covered by the equipment:

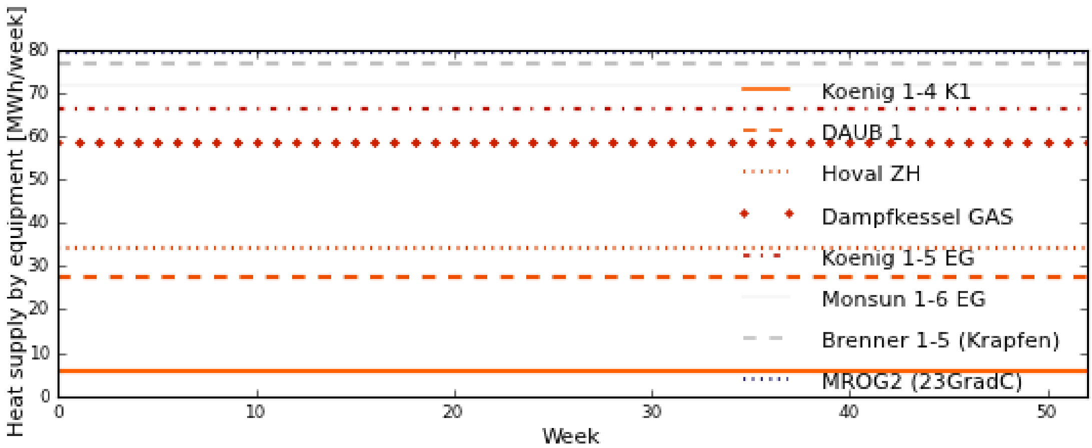

Figure 15: Daily heat supply by equipment

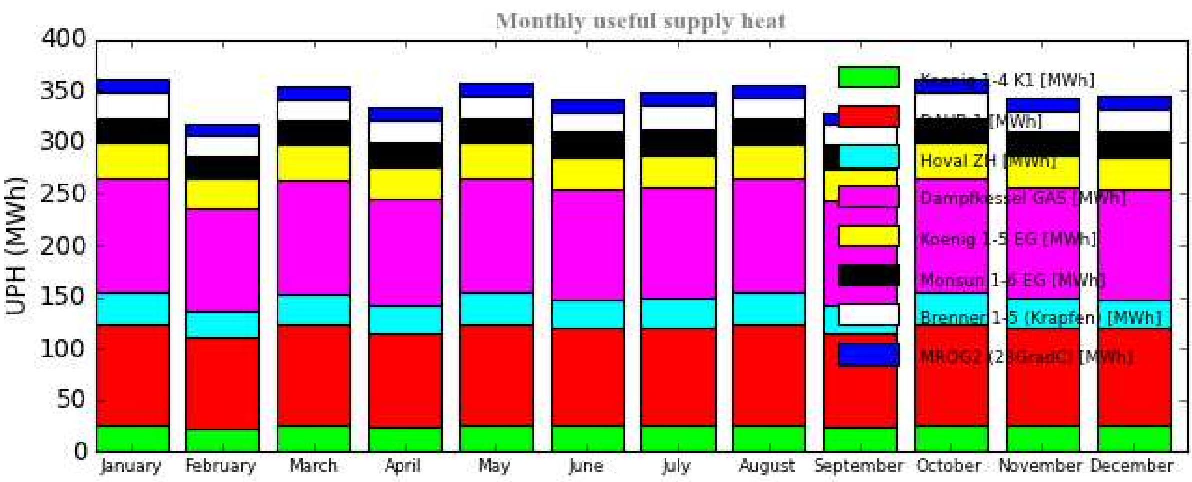

Figure 16: Distribution of useful process heat supply per month

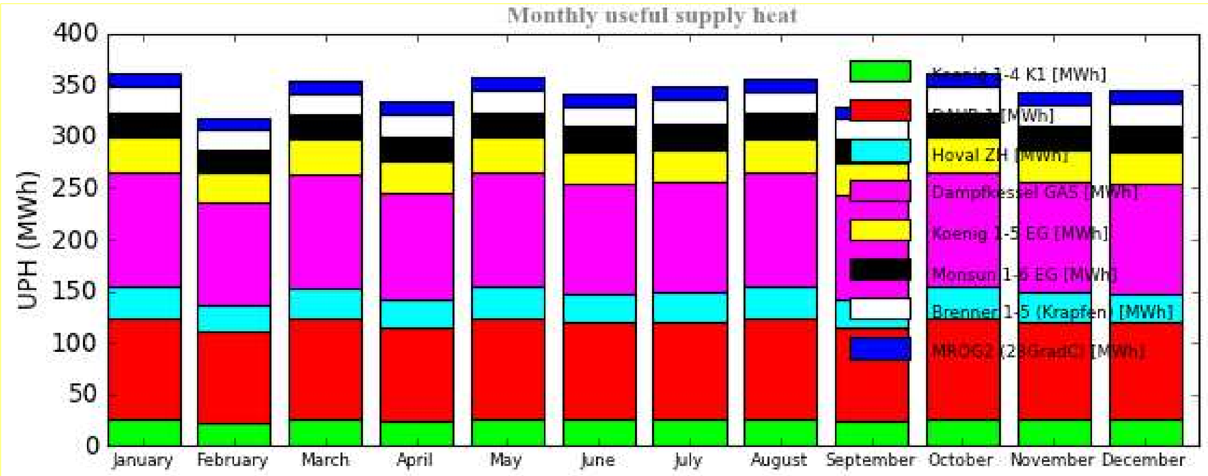

Figure 17: Distribution of useful process cooling supply per month

- **Solar (FPC):**

Collector type:	FPC (flat plate collectors)
Installed capacity:	388.50 kW
Installed collector area:	555 m²
Solar buffer storage volume:	27.75 m³
Solar fraction:	40.96 %
Annual energy yield:	363.93 kWh/kWa

Table 10: Heat exchangers and amount of recovered energy

Heat Exchanger	Power	Heat Source	Heat Sink	Amount of recovered energy	
	[kW]			[MWh]	[%]
HX_WRG_Kaelteanlagen	18	WRG Kaelteanlagen	HW_Sorger	115	100.00

Table 11: Final energy consumption for thermal use (FET) by equipment

Equipment	Type	Contribution to total heat and cooling supply	
		[MWh]	[%]
Koenig K1	Natural gas	345	6.37
Daub	Natural gas	1,298	23.98
Hoval ZH	Natural gas	219	4.05
Dampfkessel GAS	Natural gas	1,384	25.57
cold water cooling	Natural gas	3	0.06
Koenig EG	Natural gas	427	7.89
Monsun EG	Natural gas	364	6.72
Gaerraum	Electricity	98	1.81
Brenner (Krapfen)	Natural gas	298	5.51
MROG1 (4grad)	Electricity	26	0.48
MROG1 (-20grad)	Electricity	260	4.80
MROG1 (-26grad)	Electricity	379	7.00
MROG1 (4grad)	Electricity	49	0.91
MROG2 (-20grad)	Electricity	116	2.14
MROG2 (23grad)	Electricity	146	2.70
solar thermal system	Electricity	1	0.02
		5,413	**100**

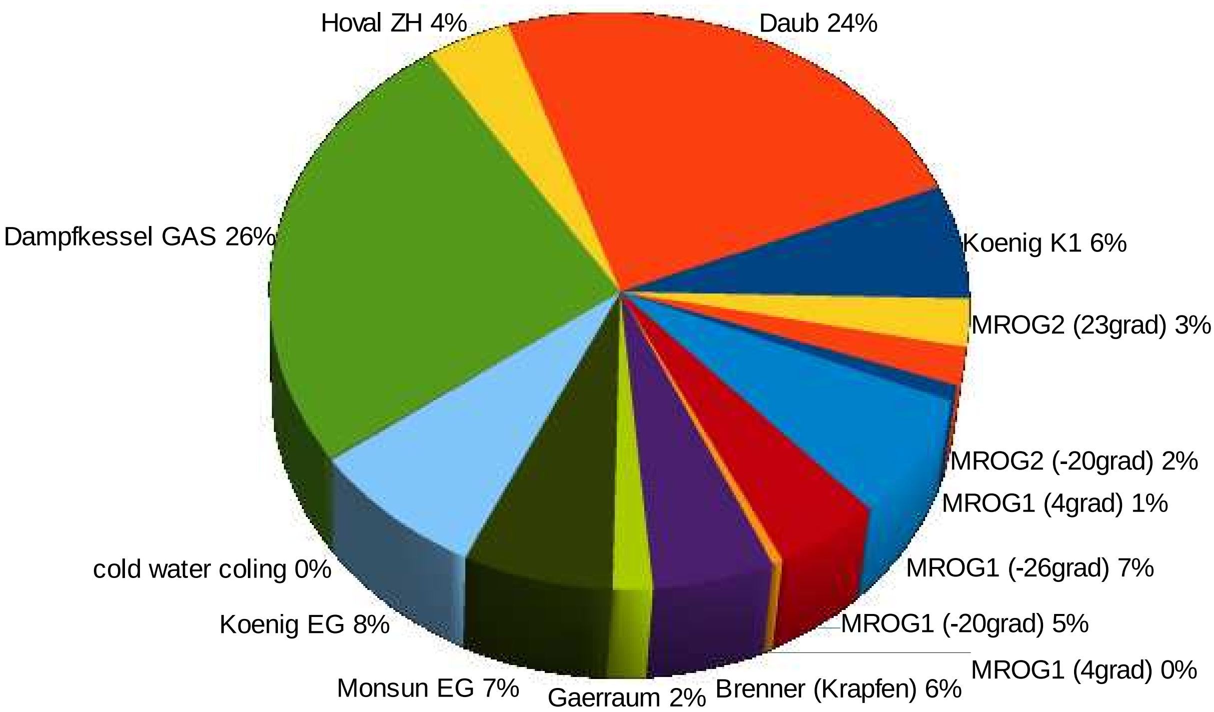

Figure 18: Final energy consumption for thermal use (FET) by equipment

- graphic: heat demand covered by solar thermal system:

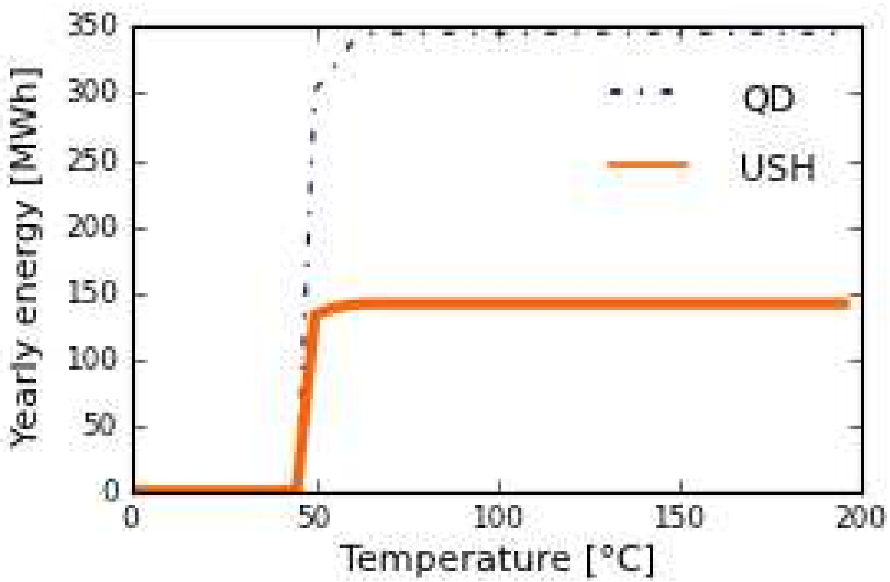

Figure 19: Heat demand and solar contribution

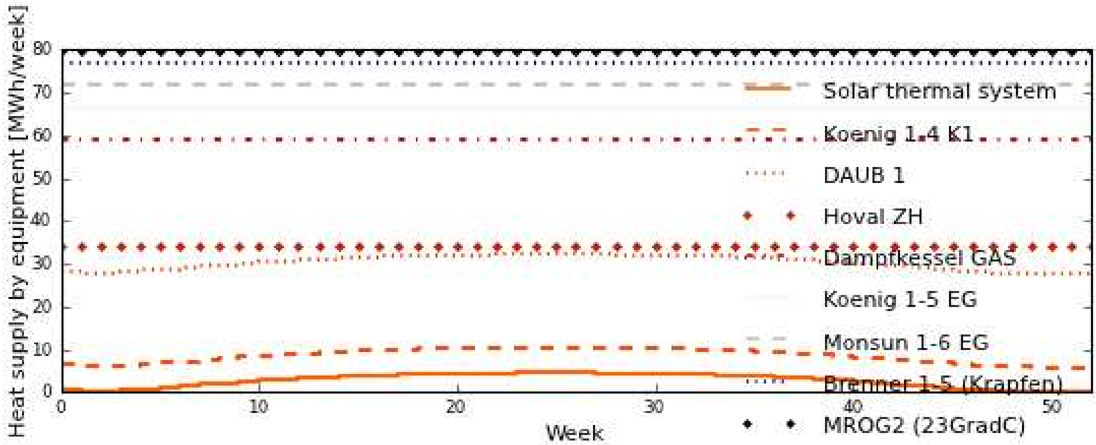

Figure 20: Daily heat supply by equipment

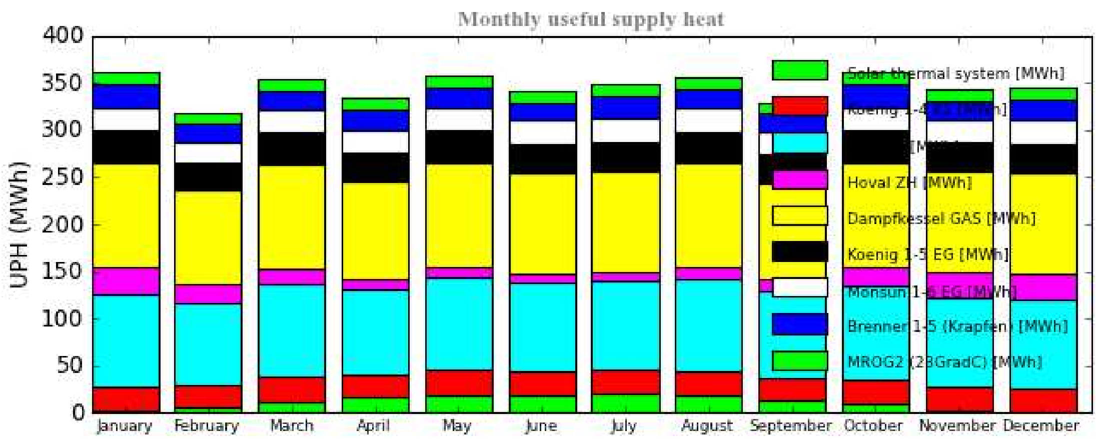

Figure 21: Distribution of useful process heat supply per month

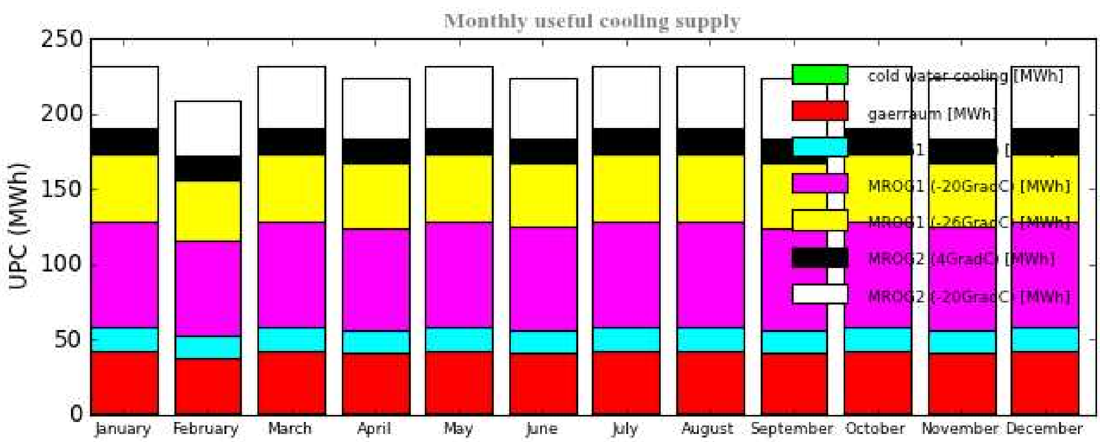

Figure 22: Distribution of useful process heat supply per month

- **HX + Solar:**

Collector type: FPC (flat plate collectors)

Installed capacity: 388.5 kW

Installed collector area: 555 m²

Solar buffer storage volume: 27.75 m³

Solar fraction: 40.96 %

Annual energy yield: 363.9 kWh/kWa

Table 12: Heat exchangers and amount of recovered energy

Heat Exchanger	Power	Heat Source	Heat Sink	Amount of recovered energy	
	[kW]			[MWh]	[%]
HX_WRG_Kaelteanlagen	18	WRG Kaelteanlagen	HW_Sorger	115	49.73
HX_Daub	13	DAUB_waste heat	DAUB_combustion air	63	27.50
HX_Dampfkessel	5	Dampfkessel_waste heat	Dampfkessel_combustion air	36	15.46
HX_Koenig K	3	Koenig K_waste heat	Koenig K_combustion air	17	7.31

Table 13: Final energy consumption for thermal use (FET) by equipment

Equipment	Type	Contribution to total heat and cooling supply	
		[MWh]	[%]
Koenig K1	Natural gas	345	6.37
Daub	Natural gas	1,298	23.98
Hoval ZH	Natural gas	219	4.05
Dampfkessel GAS	Natural gas	1,384	25.57
cold water cooling	Natural gas	3	0.06
Koenig EG	Natural gas	427	7.89
Monsun EG	Natural gas	364	6.72
Gaerraum	Electricity	98	1.81
Brenner (Krapfen)	Natural gas	298	5.51
MROG1 (4grad)	Electricity	26	0.48
MROG1 (-20grad)	Electricity	260	4.80
MROG1 (-26grad)	Electricity	379	7.00
MROG1 (4grad)	Electricity	49	0.91
MROG2 (-20grad)	Electricity	116	2.14
MROG2 (23grad)	Electricity	146	2.70
solar thermal system	Electricity	1	0.02
		5,413	**100**

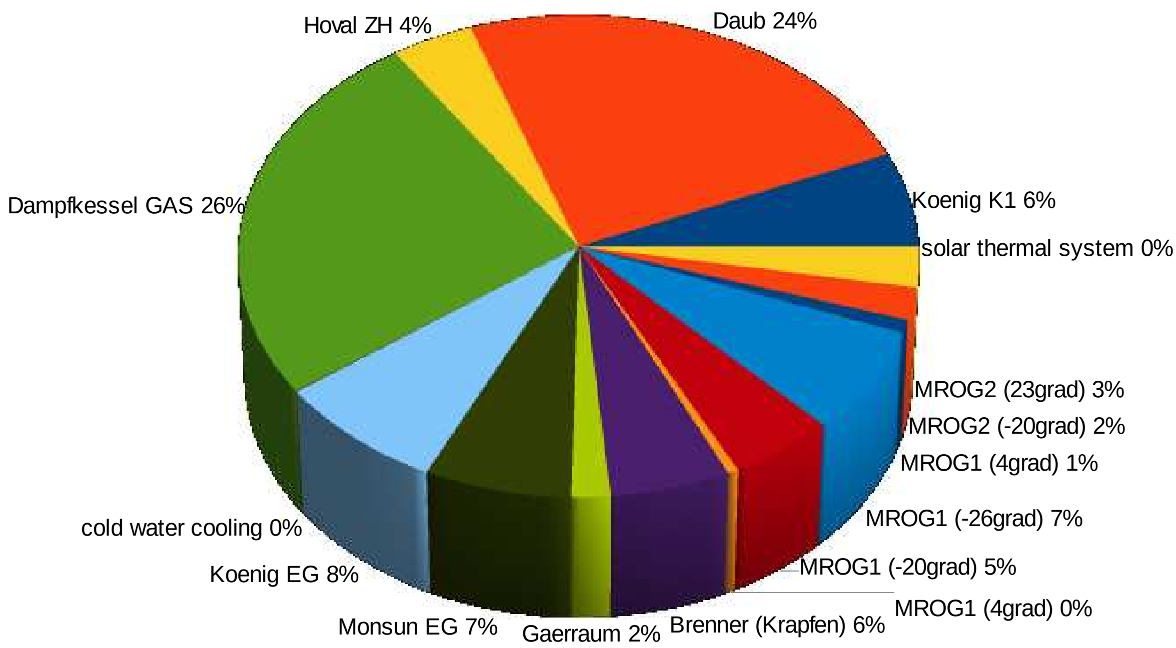

Figure 23: Final energy consumption for thermal use (FET) by equipment

- graphic: heat demand covered by solar thermal system:

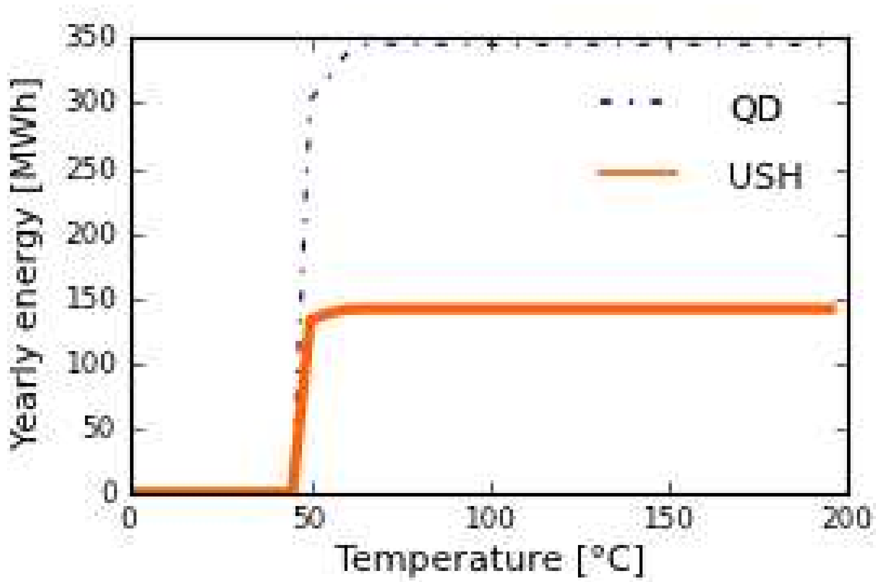

Figure 24: Heat demand and solar contribution

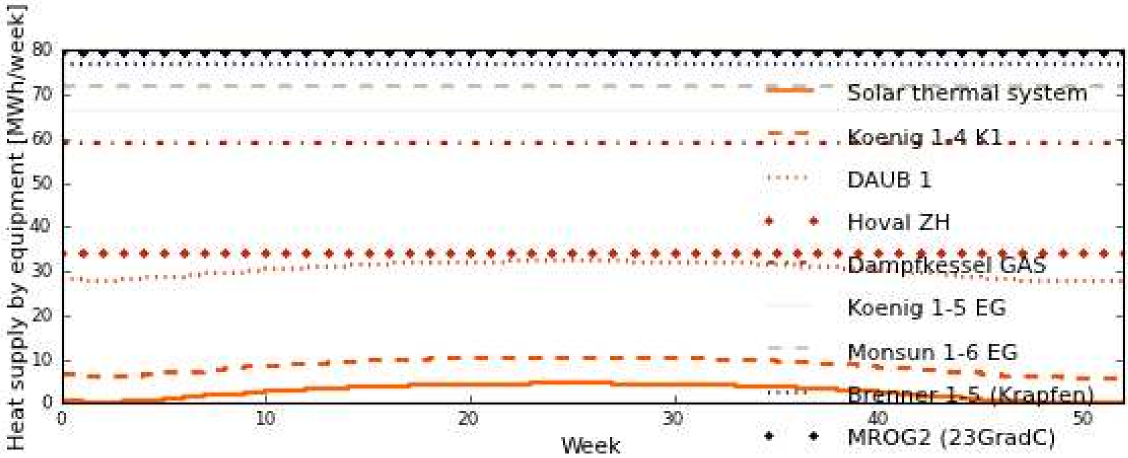

Figure 25: Daily heat supply by equipment

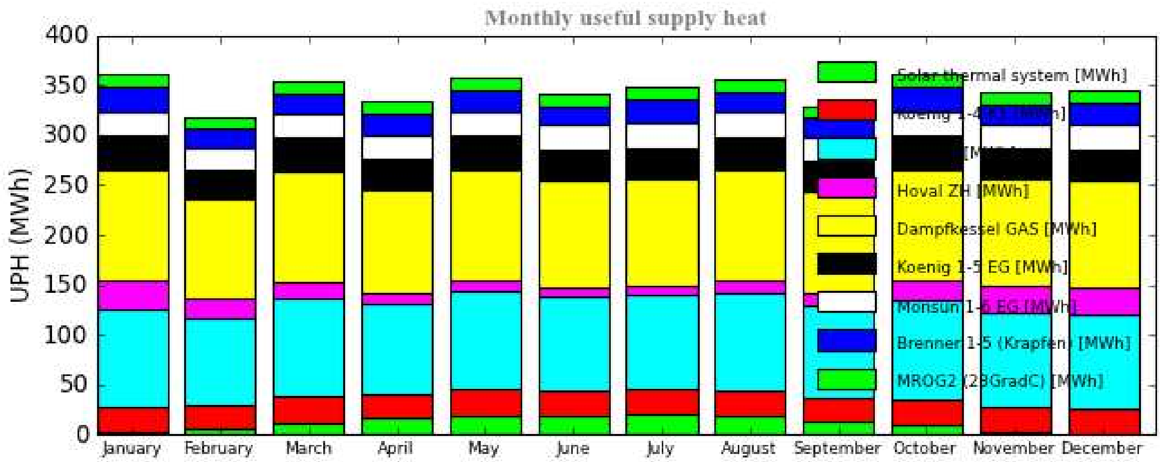

Figure 26: Distribution of useful process heat supply per month

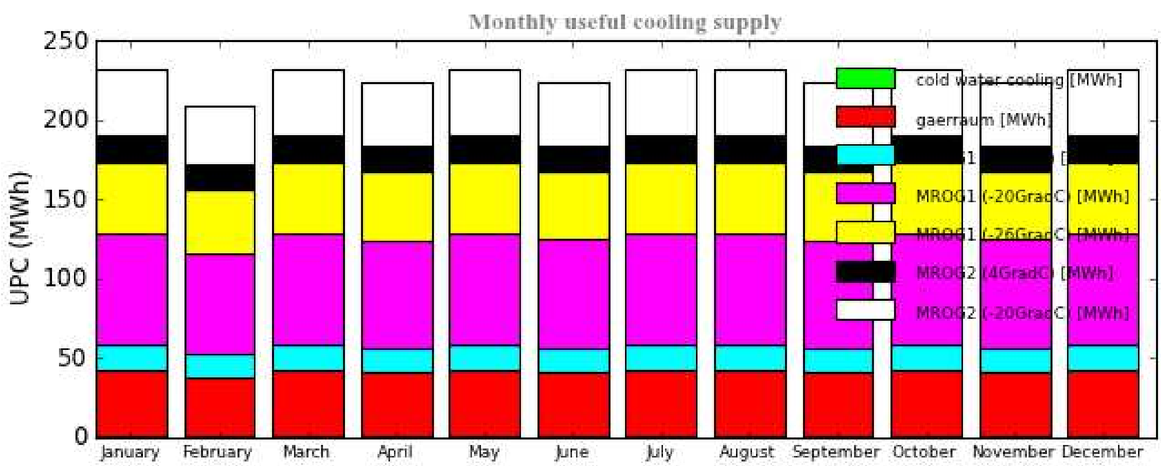

Figure 27: Distribution of useful process cooling supply per month

- **CHP:**

Type	CHP engine
Nominal thermal power	176 kW
Nominal electrical power	100 kW
Thermal efficiency	0.51
Electrical efficiency	0.29
Operating hours	7,044 h

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

Equipment	Type	Contribution to total heat and cooling supply	
		[MWh]	[%]
Koenig K1	Natural gas	345	5.65
Daub	Natural gas	561	9.19
Hoval ZH	Natural gas	106	1.74
Dampfkessel GAS	Natural gas	1,384	22.67
cold water cooling	Natural gas	3	0.05
Koenig EG	Natural gas	427	7.00
Monsun EG	Natural gas	364	5.96
Gaerraum	Electricity	98	1.61
Brenner (Krapfen)	Natural gas	298	4.88
MROG1 (4grad)	Electricity	33	0.54
MROG1 (-20grad)	Electricity	382	6.26
MROG1 (-26grad)	Electricity	428	7.01
MROG1 (4grad)	Electricity	70	1.15
MROG2 (-20grad)	Electricity	146	2.39
MROG2 (23grad)	Electricity	146	2.39
New CHP 1	Natural gas	1,313	21.51
		6,104	**100**

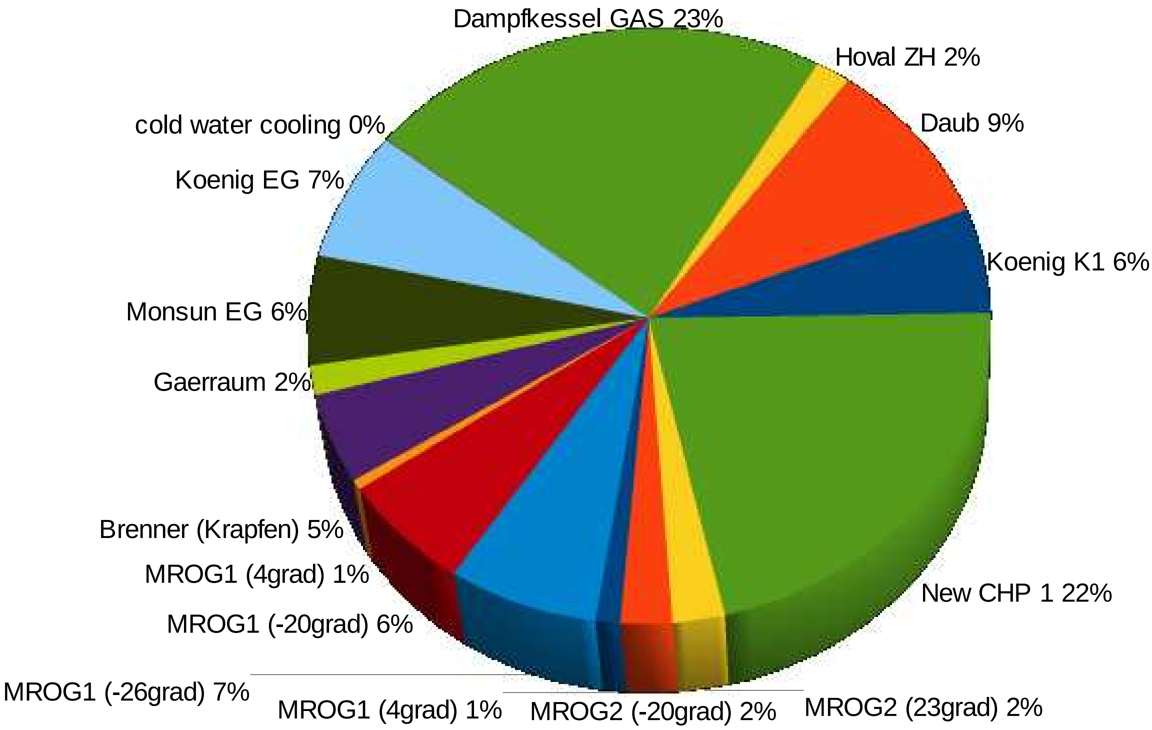

Figure 28: Final energy consumption for thermal use (FET) by equipment

- graphic: heat demand covered by CHP:

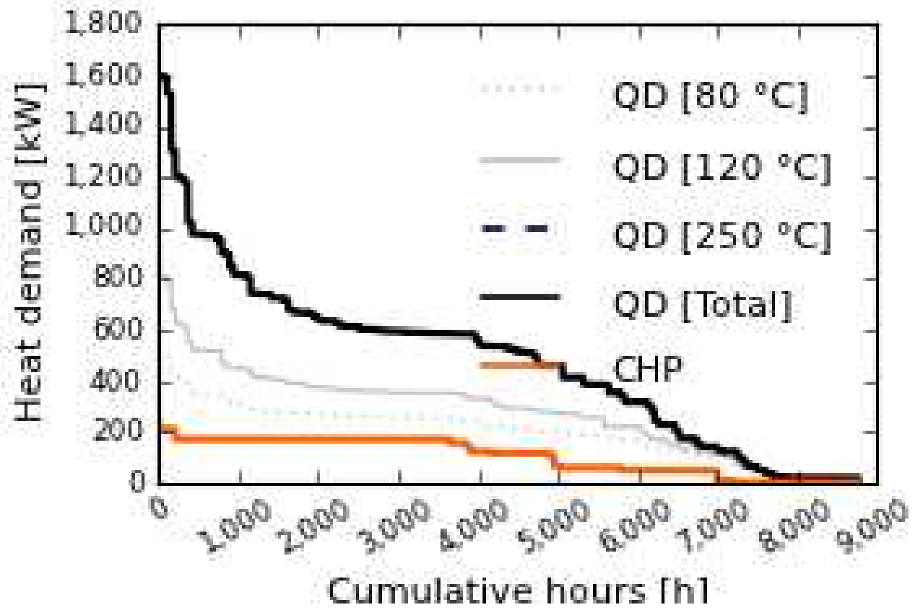

Figure 29: Cumulative heat supply to be covered by CHP

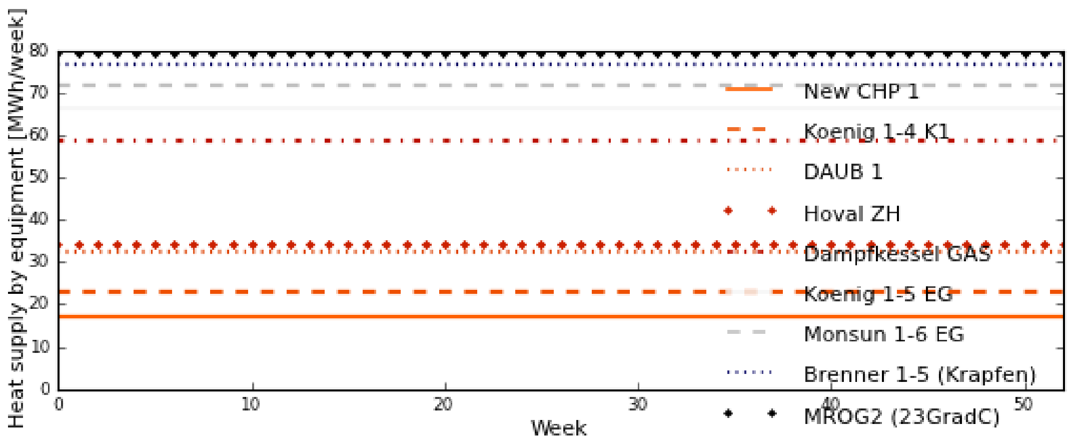

Figure 30: Daily heat supply by equipment

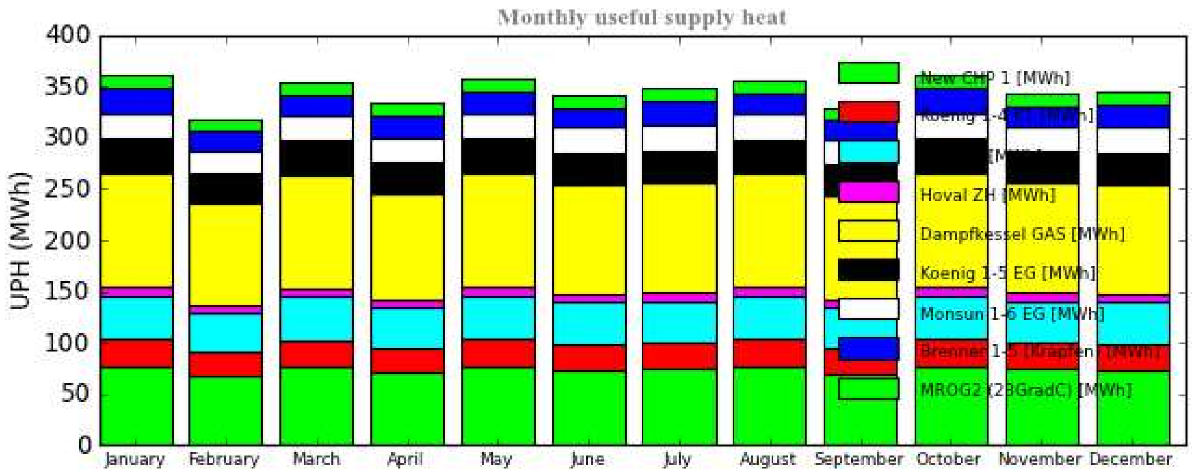

Figure 31: Distribution of useful process heat supply per month

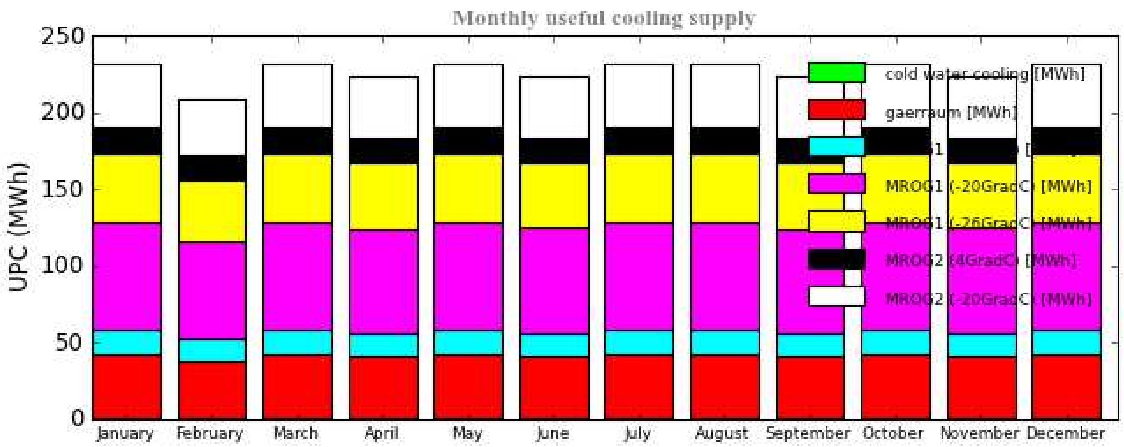

Figure 32: Distribution of useful process cooling supply per month

- Primary energy consumption (PEC)

Table 15: primary energy consumption and savings

Alternative	Primary energy consumption	Savings	
	[MWh]	[MWh]	[%]
present state	10,694		
new HX	10,085	609	5.69
solar	9,922	772	7.22
HX + solar	9,313	1,380	12.91
CHP	10,130	564	5.27

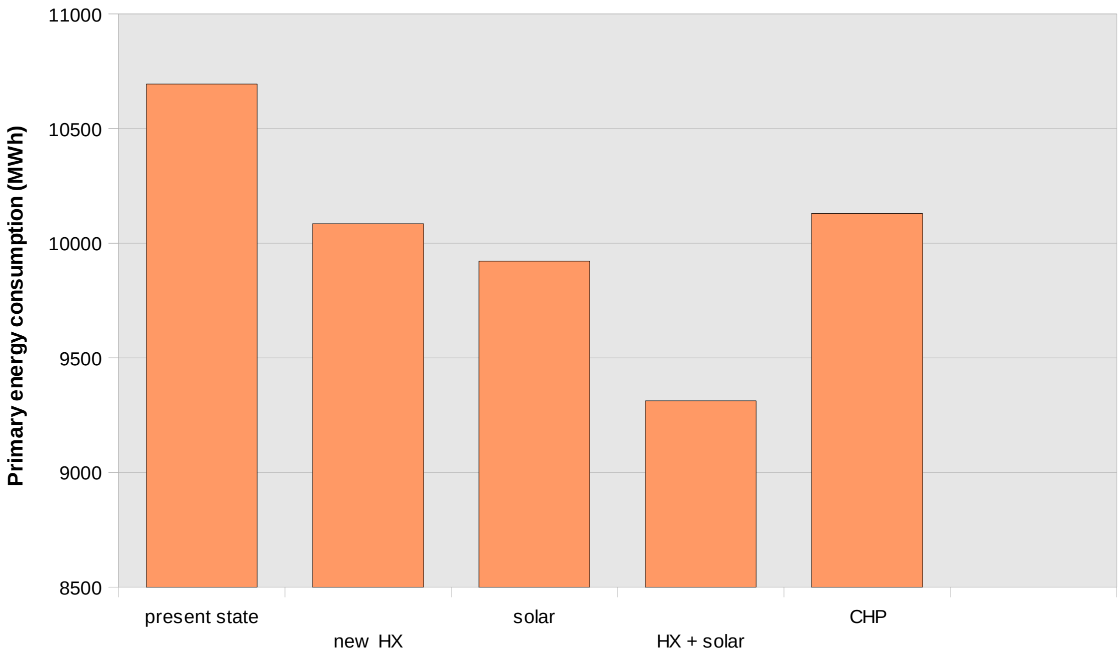

Figure 33: Comparison of alternatives: primary energy consumption

- 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) [MWh]	Savings UPH [MWh]	Useful supply heat (USH) [MWh]	Savings USH [MWh]
present state	4,309		4,066	
new HX	4,309	0	4,066	0
solar	4,309	0	4,066	0
HX + solar	4,309	0	4,066	0
CHP	4,309	0	4,066	0

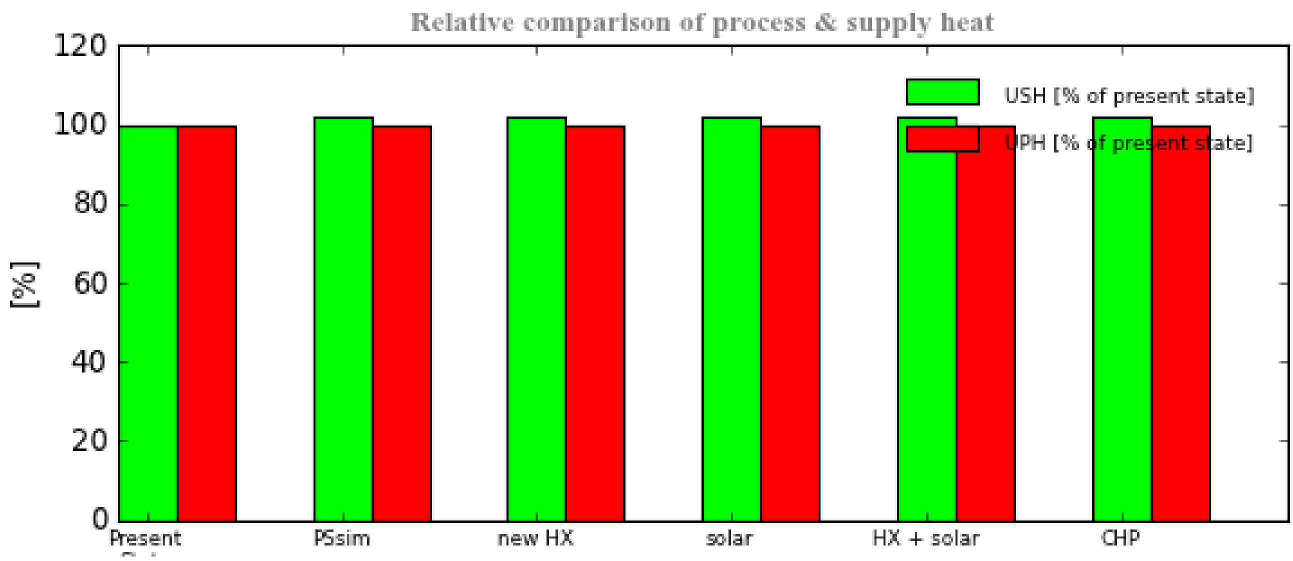

Figure 34: Comparison of alternatives: useful process heat supply

- Environmental impact

Table 17: CO2 production and CO2 savings per year

Alternative	Production of CO2 [t]	Savings of CO2 [t]
present state	2,311	
new HX	2,187	123.95
solar	2,150	161.11
HX + solar	2,026	285.06
CHP	2,215	95.63

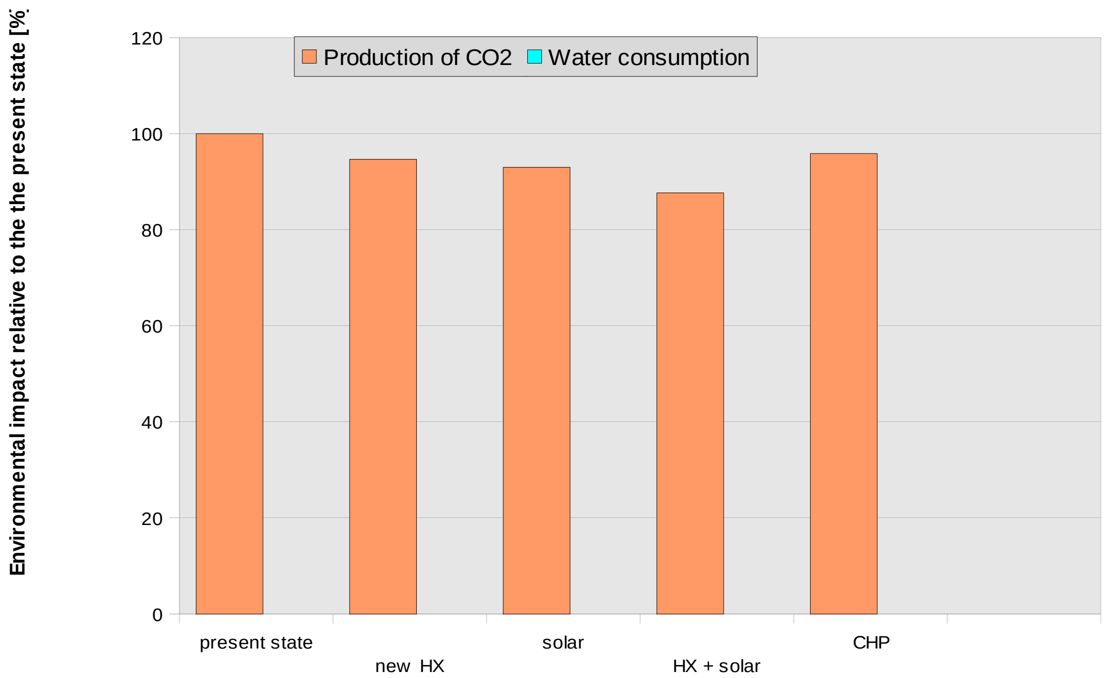

Figure 35: Comparison of alternatives: environmental impact

Table 18: Investment costs and subsidies of the proposals

Alternative	Total investment [€]	Own investment [€]	Subsidies [€]
present state			
new HX	12,400	12,400	0
solar	277,500	194,250	83,250
HX + solar	289,900	206,650	83,250
CHP	200,000	200,000	0

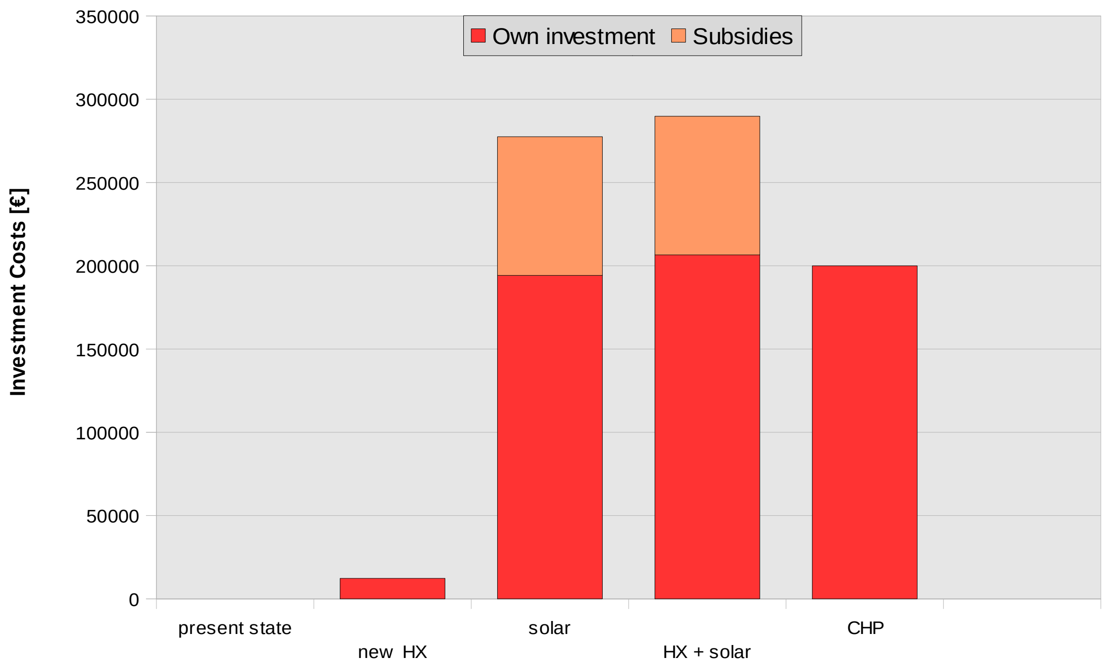

Figure 36: Comparison of alternatives investment cost

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:	388.5 kW
Installed collector area:	555 m²
Solar buffer storage volume:	27.75 m³
Solar fraction:	40.96 %
Annual energy yield:	363.9 kWh/kWa

Table 19: Heat exchangers and amount of recovered energy

Heat Exchanger	Power	Heat Source	Heat Sink	Amount of recovered energy	
	[kW]			[MWh]	[%]
HX_WRG_Kaelteanlagen	18	WRG Kaelteanlagen	HW_Sorger	115	49.73
HX_Daub	13	DAUB_waste heat	DAUB_combustion air	63	27.50
HX_Dampfkessel	5	Dampfkessel_waste heat	Dampfkessel_combustion air	36	15.46
HX_Koenig K	3	Koenig K_waste heat	Koenig K_combustion air	17	7.31

Table 20: Final energy consumption for thermal use (FET) by equipment

Equipment	Type	Contribution to total heat and cooling supply	
		[MWh]	[%]
Koenig K1	Natural gas	345	6.37
Daub	Natural gas	1,298	23.98
Hoval ZH	Natural gas	219	4.05
Dampfkessel GAS	Natural gas	1,384	25.57
cold water cooling	Natural gas	3	0.06
Koenig EG	Natural gas	427	7.89
Monsun EG	Natural gas	364	6.72
Gaerraum	Electricity	98	1.81
Brenner (Krapfen)	Natural gas	298	5.51
MROG1 (4grad)	Electricity	26	0.48
MROG1 (-20grad)	Electricity	260	4.80
MROG1 (-26grad)	Electricity	379	7.00
MROG1 (4grad)	Electricity	49	0.91
MROG2 (-20grad)	Electricity	116	2.14
MROG2 (23grad)	Electricity	146	2.70
solar thermal system	Electricity	1	0.02
		5,413	**100**

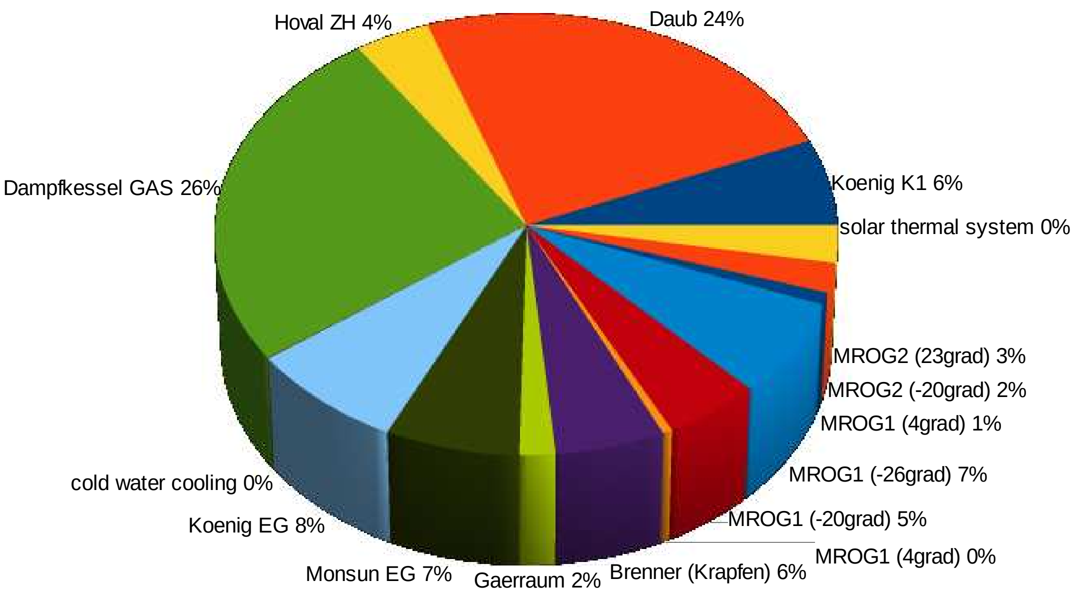

Figure 37: Final energy consumption for thermal use (FET) by equipment

5.1.3. Energy Consumption

Table 21: Total primary energy consumption (PEC) and primary energy consumption for thermal use (PET)

Energy type (fuels / electricity)	PEC	
	[MWh]	[% of Total]
Total fuels	4,161	44.68
Total electricity	5,152	55.32
Total (fuels + electricity)	**9,313**	**100.00**

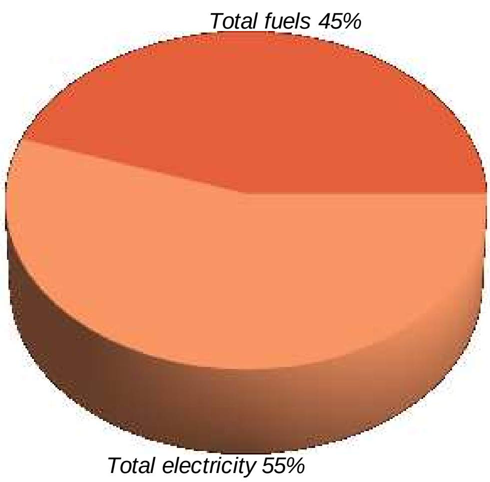

Figure 38: Distribution of PEC by fuel type

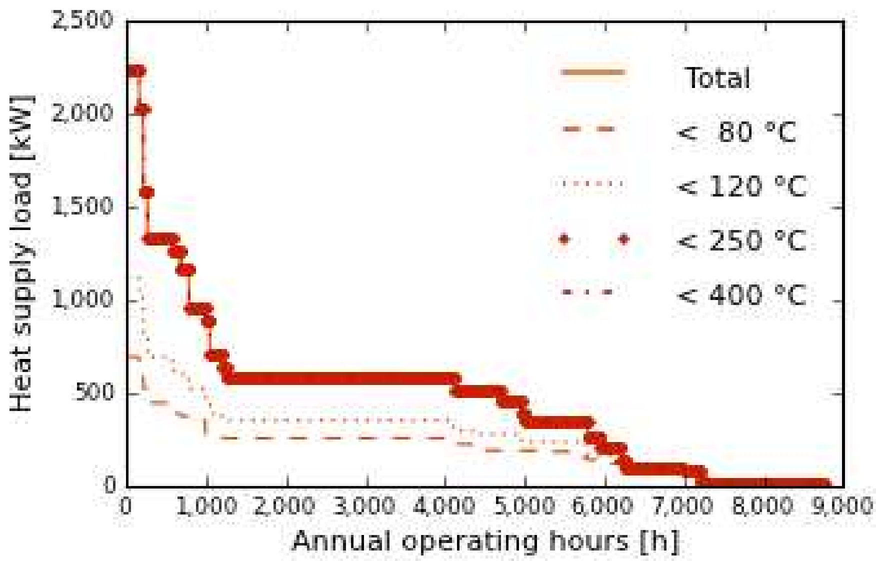

Figure 39: Distribution of supply heat by temperature levels and annual operating hours. Proposed final solution.

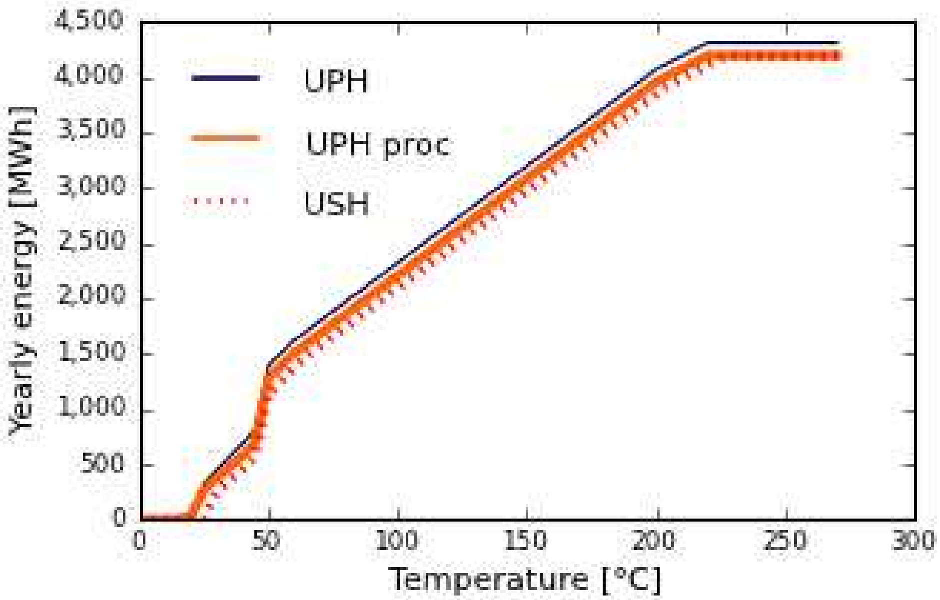

Figure 40: Distribution of the heat demand by temperature levels

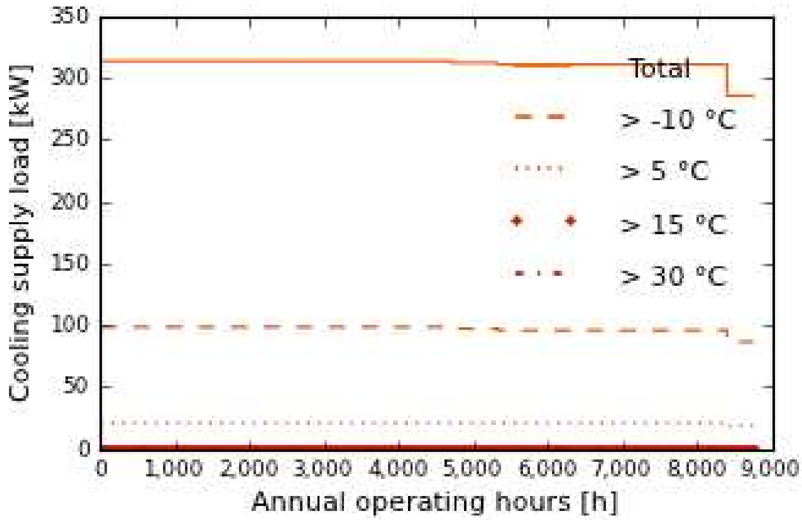

Figure 41: Distribution of supply cooling by temperature levels and annual operating hours. Proposed final solution.

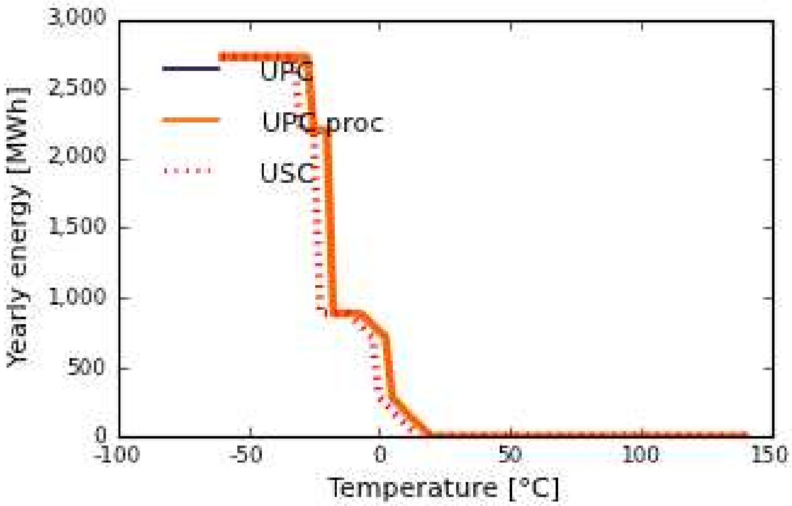

Figure 42: Distribution of the cooling demand by temperature levels

5.2. Comparative study and conclusions

5.2.1. Energy and environmental analysis

In the proposed alternative around 12 % of the CO_2 pollution can be saved.

5.2.2. Economic analysis

The payback period of about 8 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.

Table 22: Savings of the proposed alternative in comparison to the present state

		Present state	Alternative	Saving	[% savings]
Total primary energy consumption (1)					
- total	[MWh]	10,694	9,313	1,381	13%
- fuels	[MWh]	4,908	4,161	747	15%
- electricity	[MWh]	5,787	5,152	635	11%
Primary energy saving due to renewable energy	[MWh]		1,381		
CO2 emissions	[t/a]	2,311	2,026	285	12%
Annual energy system cost (2)	[EUR]	370,227	343,605	26,622	7%
Total investment costs	[EUR]		289,900		
Payback period (3)	[years]		8		

(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 data provided by the bakery.
- The consumption of the different boilers, burners (equipment) is based on 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 equipment 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.